

BUILDING FOR TRANSPORTATION IN THE NINETEENTH CENTURY*

As Canada is a land of vast dimensions and difficult terrain, uniting the country physically has always posed enormous problems. Military, economic, and political needs have made the establishment of workable systems of communication and transportation high among the country's priorities. Water travel enabled the fur trade to develop as Canada's first industry. But the great rivers, which innumerable Europeans commented on as a distinctive (and sublime) attribute of North America, also constituted a formidable challenge because of their "irresistible weight and velocity... tearing through and overpowering the obstacles opposed to their course."¹ Eventually it was a railroad that consolidated the nation, uniting it from sea to sea. Some of the many structures and buildings devised to meet the country's varied transportation needs in the nineteenth century — by water, road and rail — are outlined here.

Most building for transportation falls into the discipline usually described as engineering. The distinction between architecture and engineering is a modern one. The profession of civil engineering may be said to have been established with the organization in Paris in 1747 of the *Ecole des ponts et chaussées*. For the first time, builders of bridges were trained separately from designers of buildings. The foundation of the *Ecole Polytechnique* a half-century later reinforced the new direction, and the reorganization by Napoleon in 1806 of the *Ecole des beaux-arts* for the education of architects created a seemingly irrevocable schism. In the British Isles there were comparable distinctions in practice. John Ruskin best articulated this split — and the supposed artistic superiority of architecture — when he insisted as his first premise in *The Seven Lamps of Architecture* (London: 1849) that "architecture concerns itself only with those characters of an edifice which are above and beyond its common use." Still more sweeping was James Fergusson, who defined civil engineering as "the art of disposing the most suitable materials in the most economical but scientific manner to attain a given utilitarian end" and architecture as "nothing more or less than the art of *ornamental and ornamented construction*."² Occasionally decoration was introduced consciously so that engineering might emulate architecture. But in the development of building for transportation in nineteenth-century Canada it is particularly interesting to observe how infrequently this hap-

*This brief survey of a broad but generally neglected area in the history of built form in Canada is excerpted from a comprehensive collection of essays by various authors, *A Concise History of Canadian Architecture*, edited by Douglas Richardson, to be published by Oxford University Press in 1977. Messrs. Kalman and Richardson are particularly indebted to Ralph Greenhill for many valuable suggestions and help with illustrations in connection with the present essay.



Fig. 1. Lighthouse, Sambro Island, N.S. (Photo: Nova Scotia Communication & Information Centre).

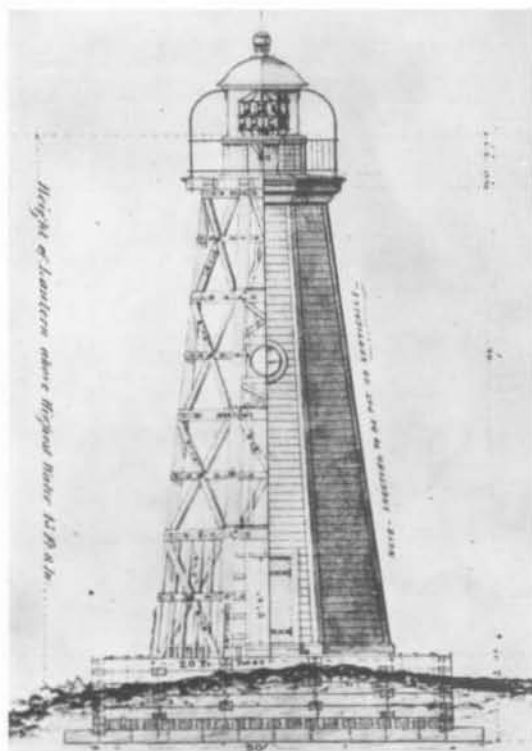


Fig. 2. Lighthouse for Marysburg, Ont. (Photo: Public Archives of Canada).

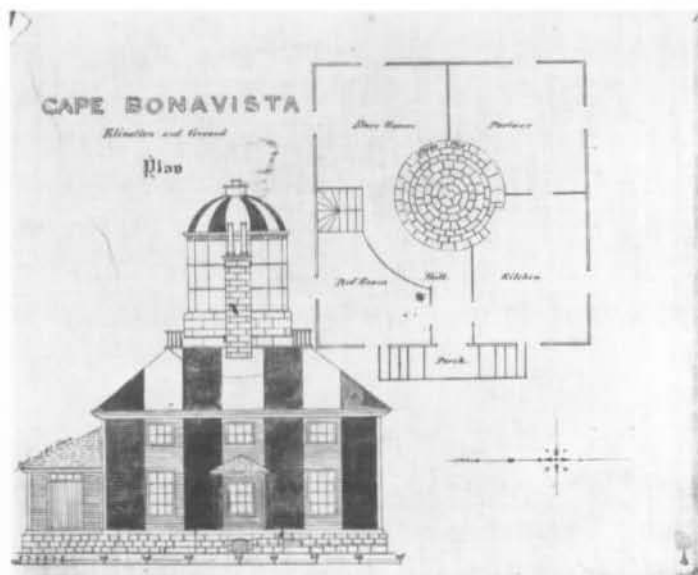


Fig. 3. Lighthouse, Cape Bonavista, Nfld. (Photo: Public Archives of Canada).

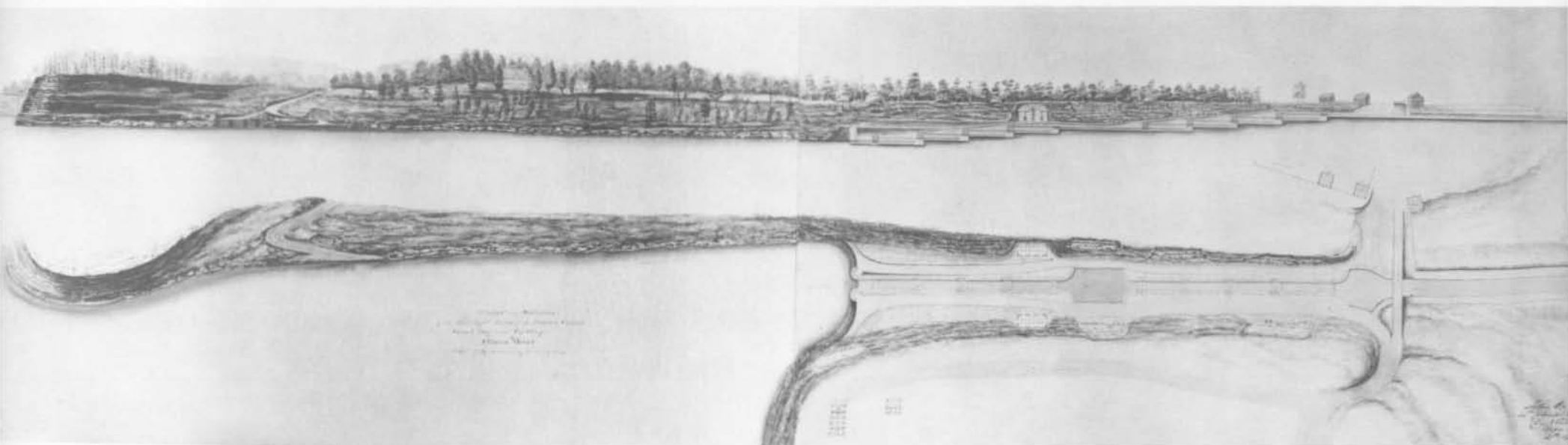


Fig. 4. The first Eight Locks on the Rideau Canal, Ottawa. (Photo: Royal Ontario Museum).

pened here; apparently economy and the old concept of architectural congruity — the matching of appropriate forms to the character of the locale — dictated works to match the grandeur, but also the severity, of the Canadian landscape.

The earliest structures known to have been built in this country in connection with transportation were lighthouses, which were recognized as essential navigational aids. The loss of life due to shipwreck was fearful in some areas until comparatively recent times: in 1833 alone no fewer than ten ships were lost on the outer shore of Cape Breton Island at a cost of six hundred and three lives.³ A lighthouse consists of two essential parts: a superstructure with some form of lamp in a weather-proof housing; and a base whose function is to elevate the lamp, form a stable support for it, and provide access to it so that it may be tended properly. Canada's first coastal lighthouse was built in stone by the French, *La Tour de la Lanterne, Louisbourg, N.S.*, in 1731-4.⁴ The British authorities erected another, this one with a protective covering of shingles, the *lighthouse at Sambro Island, N.S.* (Fig. 1), by the entrance to Halifax harbour. Built between 1758 and 1760, it is the oldest surviving lighthouse in Canada and was financed by a special lottery and a tax on "spirituous liquors" that was also used to finish the interior of St Paul's Church in Halifax.⁵ Originally 62 feet high, it was later raised to 80 feet because the effective range of a lighthouse depends on its elevation above the water as well as the intensity of its light.

There was a strong tendency to simplify the form and construction of lighthouses. The Louisbourg tower had been circular, but the Sambro light was octagonal, an easier form to build. Later, lighthouses on both the coasts and the Great Lakes often abandoned expensive masonry for wood, which was more readily worked. The wooden lights were either octagonal, like the *lighthouse for Marysburg, Ont.* (Fig. 2), or square. In this design of 1864, a traditional heavy timber frame, cross-braced against the force of the wind, is shown in the section of the interior (the left half) while the exterior elevation (the right half) is simply clapboarded. A number of structures erected in Newfoundland had prefabricated metal towers.

The lighthouse tower was frequently attached to the dwelling of the keeper because of the difficulty he might otherwise have reaching it when the need was greatest — on dark and stormy nights. Sometimes the two were totally integrated. Once again, some Newfoundland light-

houses were of unique form, completely enclosing the bulk of the tower, with the beacon simply protruding like a cupola from the top of the house, as in the *Cape Bonavista Lighthouse* (Fig. 3), built in 1842 and put into operation the following year.⁶ The house itself is a characteristic Newfoundland type externally: covered with clapboard, with a small enclosed porch, symmetrical openings and stunted "foot windows" on the upper floor. Only the large dimensions overall — by Newfoundland standards — and the square plan (with the stairhall swinging around the central stone pier) strike an unfamiliar note in this province. It survives, hardly altered, perched on a rocky promontory between Trinity Bay and Bonavista Bay, with its walls still painted in broad red and white bands for maximum visibility.

The first settlements were all located along the bays and rivers of the Atlantic Coast and the St Lawrence Valley, and voyageurs travelled from the St Lawrence River into the interior by canoe or bateau, but the many rapids throughout the river system made transportation difficult. As early as the seventeenth century the authorities in New France proposed improving inland navigation with canals. Financial and administrative difficulties, however, prevented the completion of any canals begun during the French régime.⁷ The British were more successful. In 1779 work began on a series of four short canals on the St Lawrence above Montreal to aid the shipping of military supplies to posts upriver. The subsequent construction of the *Lachine Canal, Montreal* (in 1821-4), the *Welland Canal* bypassing Niagara Falls (largely built in 1825-9), and smaller channels elsewhere on the St Lawrence permitted ships from Montreal to reach the American "West" — Cleveland, Toledo and Detroit.

Military considerations predominated in the decision to undertake this extensive system of canals in the years following the War of 1812, and the most ambitious single project was the *Rideau Canal*, connecting Kingston with the Ottawa River (Figs. 4-6). This 124-mile waterway, considered a "stupendous undertaking" in 1831,⁸ was conceived as part of a transportation route that would carry military traffic between Montreal and Kingston beyond the range of American artillery. Lieutenant Colonel John By (1779-1836), of the Royal Engineers, was sent out from England in 1826 to design and supervise construction of the canal. He had received his professional training at the Royal Military Academy at Woolwich and with the Engineers had been involved in work on the fortifications at Quebec; he had experience with canal work on the St

Lawrence during the earlier tour of duty in Canada. Sir Richard Bonycastle, who was an Engineer himself, constantly used superlatives to describe the work in *The Canadas in 1841*, concluding that "If ever any man deserved to be immortalized in this utilitarian age, it was Colonel John By. Difficulties which no one can form any idea of... were continually in his way; and... the splendid canal he executed, perhaps one of the finest works of the kind in the world, was executed in a very short time, in a world where forest and flood... had before reigned undisturbed."

The waterway is based on a chain of lakes, rivers, and creeks connected by 46 locks, 18 dams, and 18 miles of excavated canal: "Works," in By's words, "both durable and ornamental."⁹ Strictly speaking, it is not a canal but a canalized river system. Private contractors assumed responsibility for construction. Supporting works were begun in 1826 and the canal contracts were let in 1827. In addition to large numbers of civilian labourers, perhaps as many as two thousand of them Irish immigrants, two companies of eighty-one men each were specially recruited from the Royal Sappers and Miners. The work was carried out by manpower — pick, axe, and wheelbarrow for the excavation — with very few oxen for haulage. Though progress was hampered by summer outbreaks of malaria that killed hundreds of labourers and almost cost By his own life, it was completed in 1832 at a cost of £800,000. But it was never called upon to fill its defensive role. Instead of military traffic it served a limited commercial flow at first; even this dwindled after the railways reached Ottawa (in 1854) and Perth (in 1859). It functions now as a recreational amenity.

Particularly impressive is the northern entrance to the canal (Fig. 4) at Bytown, the small settlement named after Colonel By that assumed a form of its river's Indian name, Outaouais or Ottawa, in 1854. The series of eight locks there was contracted by Scottish mason Thomas MacKay from Montreal. They span the seventy-nine-foot change of level between the rocky plateau on which the city stands and the large river basin below in the deep cleft between Parliament Hill and Nepean Point (where By's own house was situated; it is seen to the left in this drawing signed by him). The result was a breathtaking sequence distantly resembling a cascade in a well-developed European garden, enlarged to truly colossal proportions (Fig. 5). The locks here and elsewhere were built — with foresight (but not without controversy) — to steamboat specifica-

tions (33 by 134 feet with a depth of five and a half feet) of large blocks of rough-faced stone.

The largest structure in the canal system, however, is the great arched dam at Jones Falls, deep in the forest (Fig. 6).¹⁰ Immense blocks of local sandstone (four by six feet and 18 inches deep) are unusually set in vertical courses to a height of sixty-two feet to make a dam far higher than anything built previously in North America. The masonry is more than twenty feet thick, backed by waterproof fill that carries a road, and is 350 feet wide at the crest of the horseshoe-shaped dam. It is a work of moving simplicity and power, a thing of unexpected beauty not conveyed in this watercolour view of 1841 by Thomas Burrowes, By's clerk-of-the-works. The dam was the work of MacKay and another Scottish mason and contractor, John Redpath. (Redpath went on to a career as a business tycoon; his name survives on the sugar produced at his Montreal refinery.) They had previously worked together in Montreal on the Lachine Canal and at the Church of Notre-Dame. The defensive works intended to complete the canal system were not needed and few were executed. But the influx of skilled masons brought into the area by MacKay and Redpath (and two other principal contractors) had a lasting effect, resulting in the development of a particularly fine stone architecture in the Rideau Valley.

By's first concern when he began the canal had been the movement of supplies to the site of construction from a village on the opposite shore of the Ottawa River. The bridge he constructed in 1826-8 across the turbulent Chaudière Falls (Fig. 7) linked Bytown with Wright's Town — today's Ottawa and Hull — and provided what was probably the first span across a major river in Canada. It was therefore a pioneer attempt to supplement water travel with a land transportation system. This *Union Bridge* also provided the first land link between Lower and Upper Canada, and the name was more than descriptive: it was meant to be both symbolic and prophetic. One of the Royal Engineers, John Mactaggart quoted a letter he had read in the press: "This bridge on the Chaudiere is the only point where the two Provinces can be connected on their water boundary. This, therefore is a *solid* step to the union of the Provinces, a question long in agitation among our politicians."¹¹

The bridge skipped across the falls from one rocky island to another in seven independent stages, varying in design according to the conditions. The extemporaneous design was directed by Engineers John Mac-



Fig. 5. The first Eight Locks on the Rideau Canal, Ottawa. (Photo: Royal Ontario Museum).



Fig. 6. The Jones Falls Dam on the Rideau Canal. (Photo: Ontario Archives).

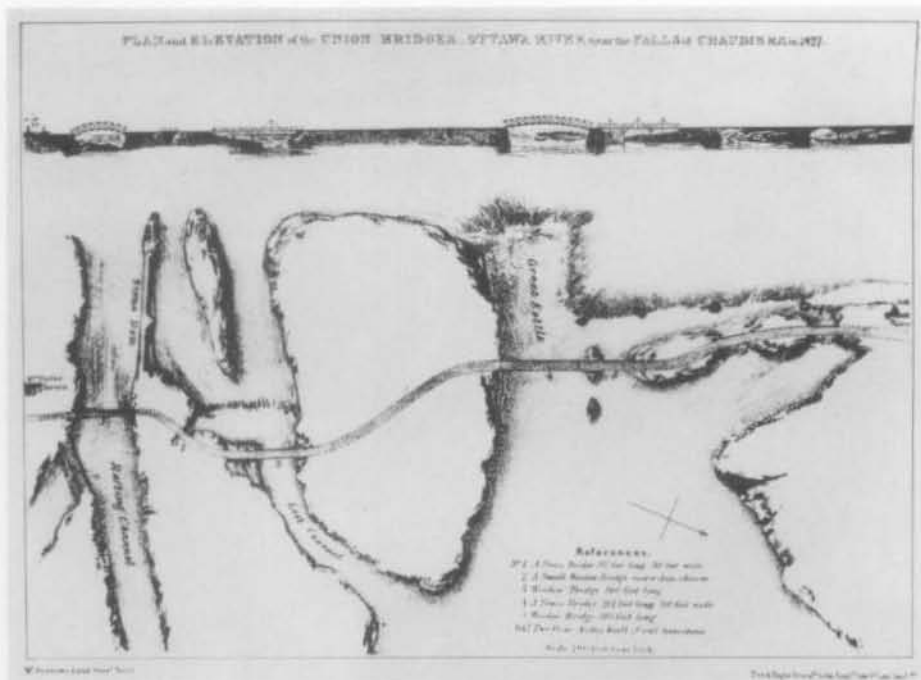


Fig. 7. The Union Bridge across the Ottawa River. (Bouchette, *The British Dominions in North America*).



Fig. 8. Covered Bridge, Hartland, N.B. (Photos: Canadian Government Office of Tourism).

taggart (1791-1830), quoted above, and Thomas Burrowes (1796-1846?), the "Sunday painter" of the Rideau. They used stone and wood, the classic materials of the bridge-builder. The two northernmost spans were stone arches of cut limestone, one dry masonry and the other mortared, built by Hull's founder, Philemon Wright, after an arch by canal mason Thomas MacKay had failed. The other gaps were crossed with wooden truss bridges, three flat and two arched, all built by contractor Robert Drummond. The longest span, 212 feet across the "Great Kettle," was a daring arched truss. It had been preceded by a temporary rope suspension bridge described (and illustrated) by Bouchette as a "hempen bridge, consisting of four three-inch... cables... swung across the river, forming an inverted segment, the lowest point of which stood about 7 feet above the dark and swift stream, whilst its extremities were elevated upwards of 32 feet;" he said it was safe to cross "although the attempt... was not made without some consciousness of danger."¹² The "permanent" bridge of wood — erected with the help of iron chains — collapsed during construction, was rebuilt, and held for seven years before its final tumble into the white water below.

In order to protect structural timbers from such rapid weathering and failure, wooden bridges were often covered (Fig. 8).¹³ The roof was a conventional gable. The trusswork followed systems already in use, but was sheathed with vertical board siding that sometimes stopped just short of the roof to admit light yet keep out moisture. Half of Canada's nearly 300 surviving covered bridges are in New Brunswick. The *covered bridge at Hartland, N.B.*, built in 1896 to cross the Saint John River in seven spans with a total length of 1,282 feet, is the longest in the world.

Covered or not, however, wooden bridges are still subject to rapid deterioration and their trusses were therefore often rebuilt in iron (and later steel). Iron also lent itself to other principles of construction, notably the suspension bridge that had been possible only in rope previously (as in the temporary bridge at Ottawa). The metal suspension bridge had been developed in Britain and the United States at the turn of the century. Canada's first bridge on this new principle was the *Union Suspension Bridge* (Fig. 9) built over the Chaudière in 1843 to replace Mactaggart and Burrowes' structure. The designer was Samuel Keefer (1811-90), one of Canada's first professional engineers (possibly the most talented and prolific early civil engineer in this century) and the elder half-brother of Thomas C. Keefer. Samuel Keefer served as chief engi-

neer to the Department of Public Works between 1841 and 1853. He was later official government inspector of the nation's railways and Deputy Commissioner of Public Works, in which capacity he supervised the competition for the Dominion Parliament Buildings.

In the Union Suspension Bridge two pairs of towers were erected and cables three inches in diameter were suspended from each tower. The roadway, stiffened by a light metal truss, was hung from these and spanned 243 feet. The design resembled that of the first successful wire-cable suspension bridge in North America, the Fairmount Park Bridge in Philadelphia, which had been built just the previous year.

Keefer's tapering towers with wide-flaring cornice, in the Egyptian style, were an attempt to add "architectural" quality to a work of engineering — one of several instances of Egyptian designs for Canadian bridges. Keefer offered a range of exotic types in the unexecuted designs of 1844 and 1845 for a *projected suspension bridge at Bout de l'Ile, Que.* (Fig. 10), above Montreal, proposing Egyptian towers once again, and also "an arched tower" (i.e. Roman Revival) among other designs. Decorating a bridge with features of an architecture that had withstood the test of time was clearly an attempt to instil public confidence in the suspension bridge, which was built on a principle as yet scarcely tested. The Egyptian mode was particularly popular because of its associations with wisdom, strength, stability, and permanence: this is especially apparent in the Bout de l'Ile design, since the tower is not only intricately detailed in the Egyptian manner, but specifically resembles the well-preserved pylons of gateways at Karnak on the ceremonial way. The pylon and the arched form were also appropriate functionally, however, in that they had a cross-bracing member, unlike the earlier Union Bridge towers, and made for a stiffer bridge. For his bold *Niagara Suspension Bridge* over the Niagara Gorge, 1851-5, with an upper deck supporting a railway track and a lower deck for horse-drawn vehicles and pedestrians, the American engineer John A. Roebling likewise adopted what he called "imposing gateways erected in the massive Egyptian style."¹⁴

Other suspension bridges were erected in the 1850s, but public suspicion of the type was apparently well justified because some early ones were singularly short-lived. The *suspension bridge over the Saint John River, N.B.*, built in 1852 by engineer Edward Serrell lasted five years before requiring rebuilding. The *Montmorency Falls Suspension Bridge*, of 1853-6, near Quebec collapsed a week to the day after its opening. (The bridge



Fig. 9. The Union Suspension Bridge across the Ottawa River.



Fig. 11. The Alexandra Suspension Bridge and the Cariboo Wagon Road at Spuzzum, B.C. (Photo: Archives of British Columbia).

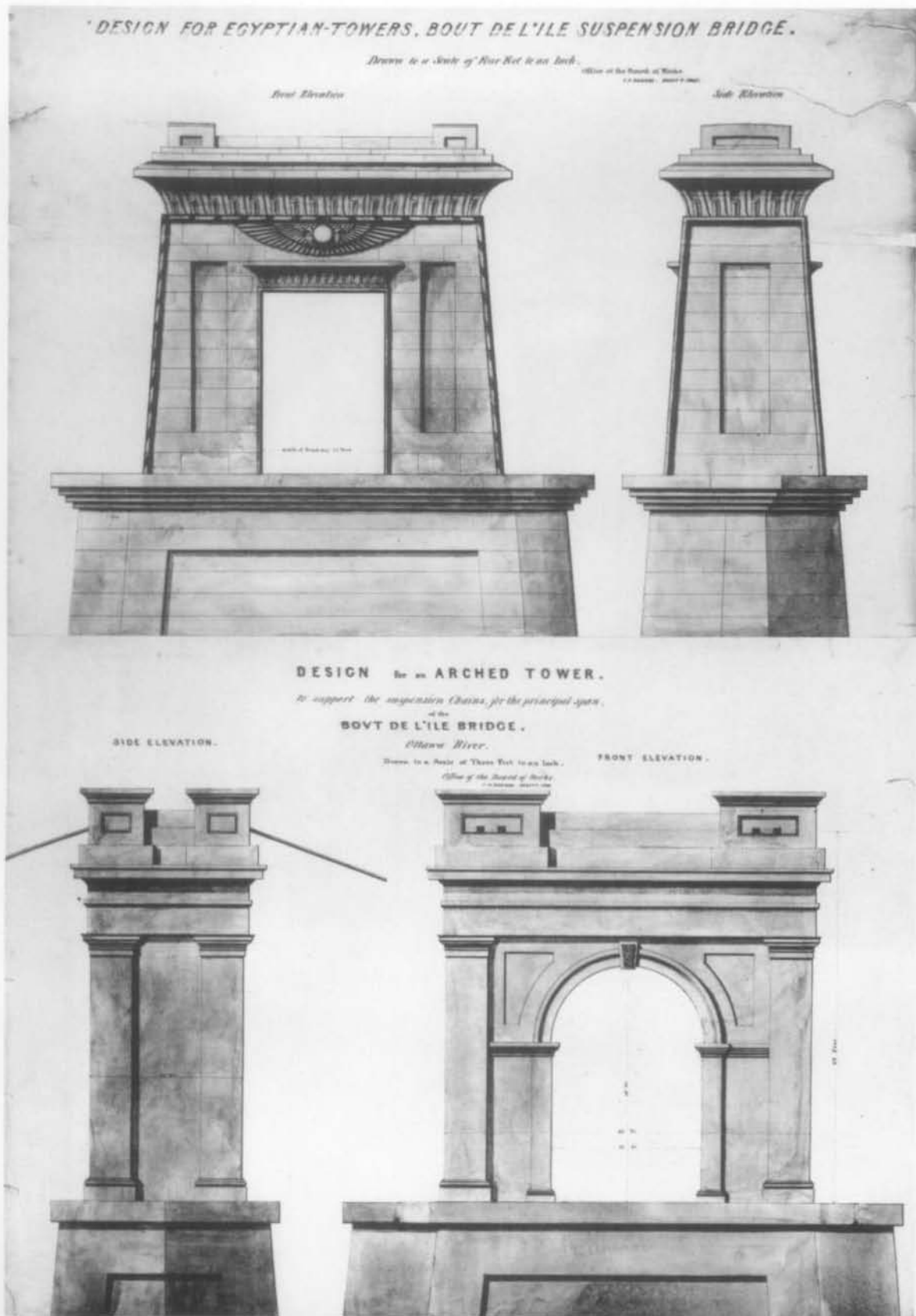


Fig. 10. Projects for a suspension bridge at Bout de L'Ile, Que. (Photo: Public Archives of Canada).

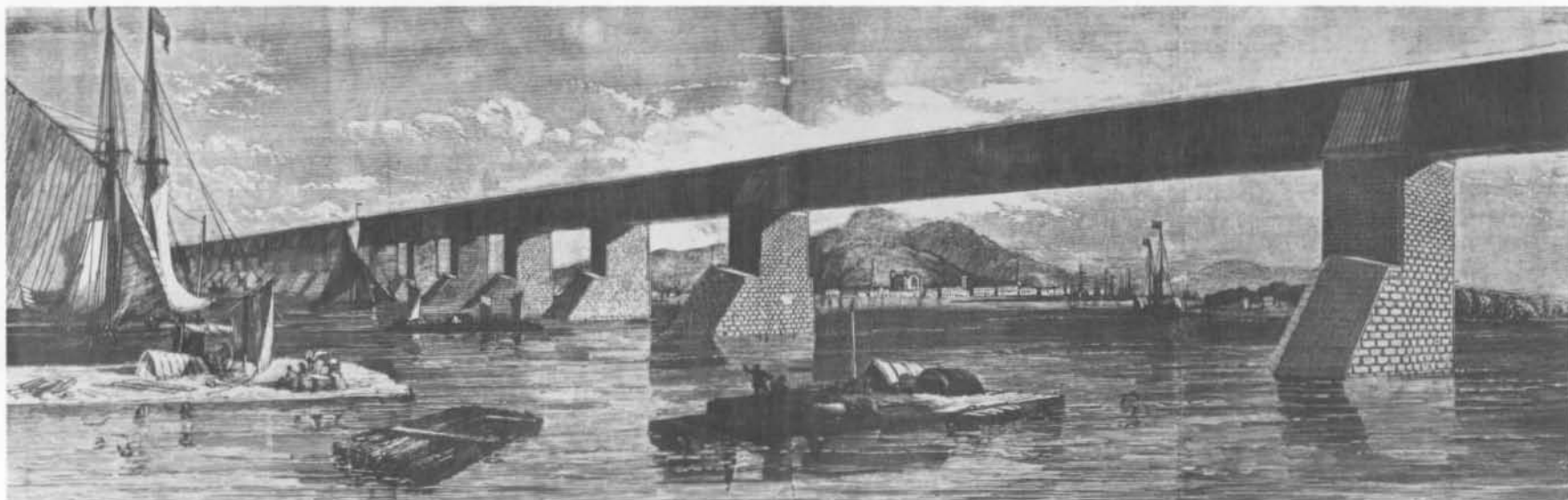


Fig. 12. The Victoria Bridge, Montreal. (*Harper's Weekly*, 1860).

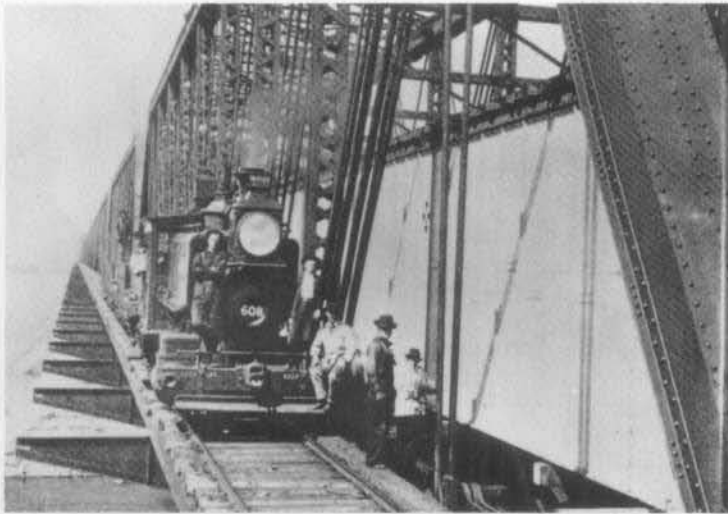


Fig. 13. Alterations to the Victoria Bridge, Montreal.
(Photo: Canadian National).



Fig. 15. CPR Bridge across the Saint John River, Saint John, N.B. (Photo: Ivan Harris col., courtesy of Ralph Greenhill).

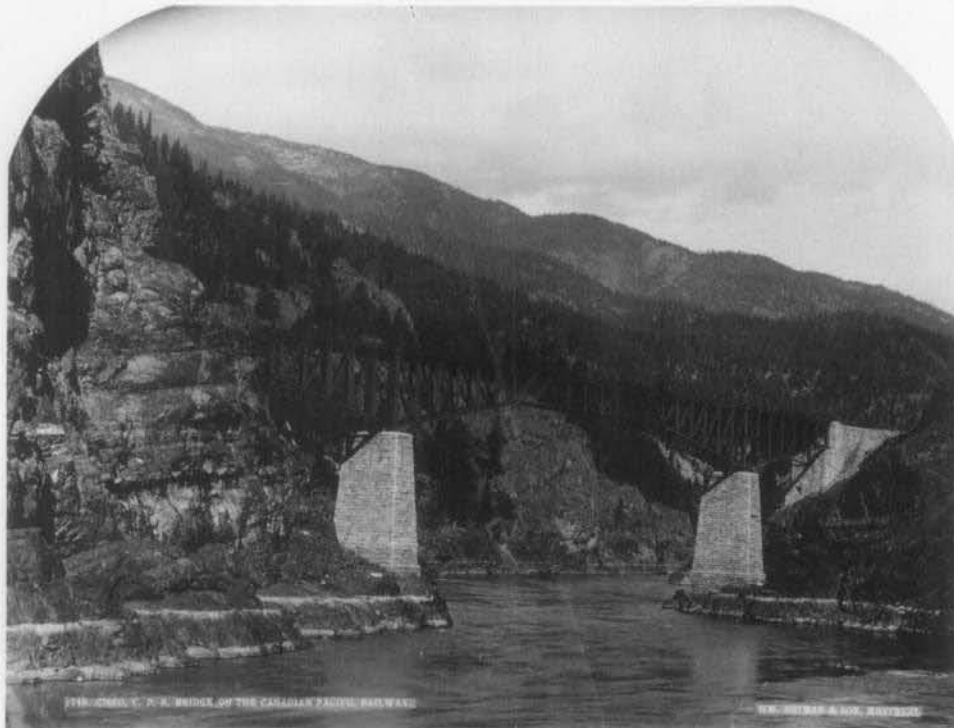


Fig. 14. CPR Bridge, Cisco, B.C. (Photo: Notman Photographic Archives).

was designed by Samuel Keefer but faultily constructed by the contractor.) Anthony Trollope reported five years later that "the supporting, or rather non-supporting, pillars are still to be seen. But the bridge fell down one day into the river; and, alas, alas! with the bridge fell down an old woman, and a boy, and a cart, — a cart and horse, — and all found a watery grave together in the spray."¹⁵

The first suspension bridge in the West was the *Alexandra Bridge, Spuzzum, B.C.* (Fig. 11), built over the Fraser Canyon in 1863. Engineer Andrew S. Hallidie (1836-1900), a manufacturer of wire rope who developed the first cable-car system in San Francisco, designed the bridge for contractor Joseph William Trutch. (Trutch later became first Lieutenant-Governor of the province.) Connected pyramidal towers made of immense wooden timbers — note the figure on the bridge for comparative scale — supported twin 4½-inch cables that carried a roadway having a clear span of 268 feet. The towers made no pretense to architectural style; their more direct, blunt, open approach to construction and their reliance on the virgin timber of the west coast are noteworthy.

The Alexandra Bridge formed a vital link in the 400-mile-long *Cariboo Wagon Road*, which allowed the first wagons and coaches to reach the Cariboo gold fields. (It is visible across the river in the photo of the last bridge.) As with the Rideau Canal, construction was supervised by the Royal Engineers. A force of fifty-three sappers (the Corps of the Royal Sappers and Miners had been incorporated into the Corps of Royal Engineers in 1856) under Captain John Marshall Grant (1822?-1902) built the difficult first six miles of roadway north of Yale in 1862. Much of the road was blasted out of solid rock or built out over the canyon upon wooden "cribs" — structures of logs fitted together by partially notching their ends. The rest of the road was let to private contractors, except for a twenty-one-mile stretch north of Lytton, which was also built by the Engineers. J. W. Trutch contracted to build the canyon section from Chapman's Bar to Boston Bar as well as the Alexandra Bridge. In partial compensation for this he received a seven-year license to collect tolls.¹⁶

The railway made its debut in Canada in 1836 with the Champlain and St Lawrence Railroad, fourteen and a half miles long, which linked Saint-Jean, Quebec, with Laprairie to provide more rapid connection between the St Lawrence and Lake Champlain. Early railways were generally considered as links in a water-based communication system.

Only in the 1850s did our railways come into their own as an independent mode of transportation.

The advent of the railway placed great demands on the engineering profession. Routes had to be chosen carefully, not only to service existing centres and tie in with other modes of transportation and shipment, but also to minimize grades, make river crossings at appropriate points, and avoid other natural hazards. Bridge-building in particular received a considerable boost; railway bridges had to be strong and reliable. Iron, first proposed as a serious building material in the late eighteenth century with the development of a new smelting process, had come into use in the 1840s for Canadian bridges such as the Union Suspension Bridge. In 1871 Sandford Fleming's insistence that the superstructures of all bridges on the Intercolonial Railway be built of iron was upheld by the government.

Suspension bridges were ideally suited for long spans above turbulent waters or deep gorges where intermediate piers could not be built but, lacking rigidity, they were impractical for railway use. (Roebling's bridge over the Niagara was unique in North America in this respect.) A different solution was therefore called for when the Grand Trunk Railway determined to span the great St Lawrence river from Montreal to Longueuil. (The railway extended from Longueuil to Montreal's winter port at Portland, Maine.) Not only was the St Lawrence broad and rough here; the individual spans had also to be high enough to clear the shipping and wide enough to accommodate immense timber rafts that were floated down the river. A tubular bridge, which trains could cross at speed, was indicated. Following a survey and report prepared in 1851 by Thomas Keefer that indicated the best site as well as the most appropriate principles on which to build, the famous English engineer Robert Stephenson (1803-59), assisted as usual by his architectural specialist Francis Thompson (active 1839-54), responded with the remarkable *Victoria Bridge, Montreal* (Fig. 12). In fact an army of talent and labour was involved in the work, including Alexander M. Ross (d. 1862), Chief Engineer to the Grand Trunk Railway, and James Hodges (1814-79), Engineer to Peto, Brassey & Betts, the English contractors.¹⁷ Planned in 1853, built in 1854-9, and officially opened in 1860 — the reason for the Prince of Wales' famous Canadian visit of that year — it was notable for the novel form of construction as well as the length and height of its many spans. *Harper's Weekly* (25 August 1860) called it "one of the noblest

works of engineering in the world and in its way perfectly unique." In fact, like numerous works before and since, it was hailed as the "eighth wonder of the world."¹⁸ The Victoria Bridge was seen as the key to a great nation "when Canada will extend to the confines of the Pacific Ocean and be covered with a network of railways all converging to this point of crossing the St Lawrence."¹⁹

While the Prince of Wales spoke of the bridge conventionally as "unsurpassed by the grandeur of Egypt or of Rome,"²⁰ and thus recalled the historical references in earlier bridges, it is the magnificent directness of the Victoria's design, more than its staggering scale, that still commands respect. It was not an open bridge but a large tube composed of wrought-iron plates riveted to form an enclosed box girder of great strength high above the river.

Twenty-five spans extending some 6,592 feet — and approaches bringing the total length to nearly two miles — were required for the wide crossing, making the Victoria Bridge the longest in the world. Stephenson had employed this tubular principle a decade earlier in his Britannia Bridge across the Menai Straits in Wales (where Thompson had designed the stone towers). Efforts on both sides of the Atlantic were pooled in the actual fabrication. In Montreal, Hodges devised the elaborate coffer dams within which the stone piers were erected and the immense timber staging or scaffolds between the piers on which the metal tubes were then bolted together and riveted. But the ironwork itself was almost entirely prefabricated in England. One hundred and eighteen thousand separate pieces — "punched, marked, and ready for putting together" — were transported to Montreal, for assembly on the site.²¹

Trollope, who thought the Victoria Bridge the only thing worth mentioning in Montreal, explained that "to the eye there appeared to be twenty-five tubes; but each of the six side tubes is (a double tube) supported by a pier in the middle. A great part of the expense of the bridge," which was prodigious — some £1,300,000 — "was incurred in sinking the shafts for these piers."²² The Victoria Bridge's stone piers were asymmetrically designed, with massive cutwaters to break and then withstand the crushing force of the ice-floes that form the extraordinary "shove" of a field of roughly 500 square miles of ice during the spring thaw. (The form of these piers and the profile of their cutwater subsequently became standard in eastern Canada.) The result was some-

thing that looks, a century later, almost like minimalist sculpture: identical angular masses in apparently endless succession, with a smooth, heavy, unarticulated horizontal member joining them. On a purely formal level, the bridge might be regarded as the perfect transition from the relatively flat lands south of the St Lawrence Valley to the hilly setting of Montreal itself and the region to the north. In any case, it is an impressive monument, a striking symbol of its time. Built in open defiance of all the challenges of nature, the Victoria Bridge is a vast image of the power and expansion of modern industry as represented by the railway.

The tube was a structural success but a traveller's nightmare. Ventilation and lighting were negligible. One observer, unable to resist yet another comparison between modern bridges on the St Lawrence and the ancient architecture of the Nile, described the "Egyptian darkness" of the smoke and steam-filled tube.²³ Complaints of discomfort went unheeded however. The tube of the Victoria Bridge was replaced only when the traffic limitations of its single track made it obsolete. In 1897-8 a more conventional open steel truss, wide enough for a double track, was constructed around the tube (Fig. 13), the tube itself was dismantled, the piers were widened, and roadways were carried on brackets outside the trusses.

In the 1870s, steel had begun to replace iron as a structural material. Its greater strength allowed more daring designs and encouraged the use of a new type, the cantilever truss. This differs from the simple truss in that the bridge is built by cantilevering the superstructure outward from both abutments, or from a pair of piers, to a point of meeting at midstream. In a very long bridge the outstretched arms of the cantilevers are linked by a suspended truss of conventional design. Prototypes for the cantilever principle may be found in a variety of older wooden bridges, including some built by natives of the West Coast.²⁴ The first modern cantilever bridge in North America, and the first railway cantilever bridge in the world, was the iron Kentucky River Bridge of 1877. In the early 1880s the three earliest mature cantilever designs in steel on this continent occurred almost simultaneously, all in Canada, two of them to designs by the noted engineer Charles Conrad Schneider (1843-1916).

In 1882 Schneider designed a cantilever span for the *bridge at Cisco, B.C.* (Fig. 14), that carried the ambitious transcontinental line of the Canadian Pacific Railway over the Fraser Canyon. (The building of the

rail-line destroyed parts of the earlier Cariboo wagon road.) But construction of the Cisco Creek Bridge was delayed almost four years because of the length of time it took for the metal work to cross the Atlantic. It was completed in 1885.

In the meantime Schneider built a longer *cantilever bridge over the Niagara Gorge* for the Canada Southern Railway (a subsidiary of the Michigan Central). This bridge, with a 470-foot central span, made engineering history when it was erected in the short space of eight months in 1883, parallel to Roebling's earlier suspension bridge.

Both of Schneider's bridges were deck cantilevers: the track was carried on top of the trusses. The first through-cantilever span in North America (with the track passing through the trusses) was designed for the New Brunswick and Intercolonial Railways by Ralph Johnson for the *bridge over the Reversing Falls of the Saint John River at Saint John, N.B.* (Fig. 15).²⁵ Completed in 1884, it was 812½ feet long. It was replaced in 1922.

The cantilever principle stimulated bridge builders to try for longer and longer steel spans. The *ne plus ultra* was reached shortly after 1900, when work began on a double-track railway bridge over the St Lawrence River at Quebec. The *Quebec Bridge* was planned by P. J. Szlapka and Theodore Cooper on the cantilever principle, with members of stupendous dimensions and an enormous 1800-foot central span. In the summer of 1907, two years after work had begun on the superstructure, the south arm of the still incomplete bridge collapsed (Fig. 16), killing eighty-two persons. A subsequent inquiry found the engineers at fault in their design. The error lay in their calculations, not in the principle of the bridge. Shortly after the disaster a new Quebec Bridge was built on the same system, although stronger in design and with a different method of construction. This time the calculations of five collaborating engineers were correct, but a faulty jack caused the loss of the central suspended section and eleven more lives. Finally, in 1917, the Quebec Bridge was successfully completed (Fig. 17).²⁶ It remains in use today as the longest trussed span in the world, though the graceful Pierre Laporte highway bridge built recently beside it dwarfs the earlier achievement. (The Laporte Bridge was built of concrete; a discussion of this material as well as of other metal bridge types such as the steel arch and moveable bridges — with lift and swing spans — belongs with a history of twentieth century engineering.)

Spans that carry railways across depressions in the land where there is little water are trestles or viaducts rather than bridges. The structural problem here is one of height and length rather than clear span, since foundations can be located almost anywhere along the generally dry land below. While trestles are open structures of either metal or wood, viaducts consist of free-standing piers in various materials.

The Grand Trunk Railway built several impressive viaducts in Canada West — at Port Hope, Georgetown, and St Mary's — in which a superstructure of iron was placed on tall stone piers. Though its superstructure was replaced early in the present century, the best preserved of the group is the *GTR Viaduct at Georgetown, Ont.* (Fig. 18), of 1854-5. This crossed the Credit Valley — 2,000 feet wide — 115 feet above the river with a structure 931 feet long (not counting the embankments) it aroused an enthusiastic response: the view reproduced here was painted by William Armstrong in 1855, after the bridge had been completed but before this part of the line had been opened, which suggests the appeal such monuments exercised. (Armstrong, remembered primarily as an artist, was trained as a civil engineer and had worked for various railway companies.) F. W. Cumberland, who is better known as the architect of numerous public buildings in or near Toronto, wrote about the viaduct and related works for this railway at some length — wearing his other hat as Chief Engineer of the Ontario, Simcoe and Huron Railway.²⁷ In good English fashion, he admired GTR construction generally for displaying "more substantial character than had previously obtained either in the United States or Canada, [being] founded indeed on the British system." But what particularly impressed him was the simplicity and the economy of the system, comprised of tubular girders seven feet square (since replaced), forming eight spans of 96 feet each, sitting on rough-faced piers of local sandstone. Cumberland compared this with relatively recent British work involving "much more intricacy of design, vastly more material, and far heavier expense," all unnecessarily, he thought.

Cumberland's one regret about the Canadian work was artistic, that of a High Victorian sensible to the Picturesque taste of his time: "they are undoubtedly less pleasing to the eye and altogether injurious... [to] the picturesque, for their outline consists of two [i.e. too] hard horizontal lines, without relief, break or beauty of any description, a form indeed which how grand soever the structures in themselves, will, I suspect, mar every landscape and paralyze the hand of the most soulless artist."



Fig. 16. The collapse of the Quebec Bridge while under construction.
(Photo: National Museum of History & Technology, Smithsonian
Institution).



Fig. 17. The Quebec Bridge. (Photo: Canadian National).



Fig. 18 GTR Viaduct,
Georgetown, Ont.
(Photo: Royal Ontario
Museum).

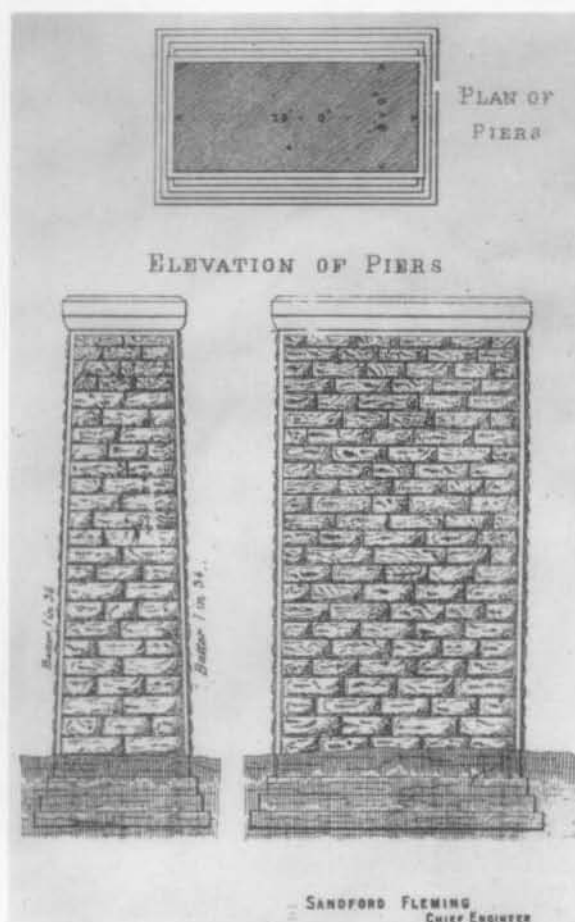


Fig. 19. Piers illustrated in the
Intercolonial Railway's *General
Plans...* (Photo: Public Archives
of Canada).

Armstrong proved him wrong in this watercolour view. With a lingering appetite for the Sublime, he obviously savoured the soaring horizontal as an image of human civilization conquering and uniting the natural "wilderness" — every bit as much as the unidentified artist of the Victoria Bridge view.

The treatment of the masonry that Cumberland admired at Georgetown because it gave "complete assurance to the mind of permanent stability, and . . . satisfaction to the eye by the play of colour on its face" — was one that his colleague Sandford Fleming (1827-1915) made a standard feature of Canadian railway construction (Fig. 19). A multi-faceted Scot who was later knighted, Fleming is known nationally for designing the first Canadian postage stamp and internationally for devising the world-wide system of standard time zones, but this civil engineer was also responsible for the Intercolonial Railway's *General Plans of the Most Commonly Occurring Structures, &c.* (Ottawa: 1869), one of exceedingly few sources published in Canada for architecture or engineering.²⁸ The illustration of piers is taken from this book of designs and, as in the Georgetown Viaduct or the Victoria Bridge at Montreal, the stone is so roughly hewn that it may be spoken of as rock-faced rather than rough-faced. The contrast is enhanced by the smoothly finished corners of the whole, and by the treatment of the top course of masonry with mouldings that produce a profile like the capital of a Doric column. The appeal of the primitive demonstrated earlier by North American buildings in Greek Revival style is recalled in more sophisticated form here. It is appropriately combined in these great engineering works with a show of raw strength.

The Canadian Pacific Railway intended to use stone and iron for its trestles and bridges over the difficult terrain north of Lake Superior and through the mountains of British Columbia, but the combination of the great number required and the approaching financial crisis of 1884, forced the general manager, William Van Horne, to order the substitution of wood. Some six hundred trestles and bridges were required — one hundred of them in a thirty-mile section of the Fraser Canyon above Yale, B.C. Many of the wooden trestles were also uncommonly large. Beginning about 1883, they were partially prefabricated: the plan was standardized and the timber stockpiled, numbered and pre-cut, for shipment and rapid assembly. The *trestle at North Bend, B.C.* (Fig. 20), was typical. Apart from the trussed span that was suspended in the

centre, it was a basketwork of hefty members, tapering from a broad base to the narrow railbed, with cross bracing at every level. The men standing on it seem Lilliputian. But this sort of effort seemed almost insignificant next to the *Mountain Creek Trestle near Glacier, B.C.*, more than 200 miles east of the Fraser Canyon. It was erected in 1885, one of several great bridges pressed to completion in the same year that saw the first train cross to the Pacific, in November. The Mountain Creek Trestle was among the largest wooden structures ever built. Passing 164 feet above the Illecillewaet River, it was 1086 feet long and is said to have contained more than 2,000,000 board feet of lumber.²⁹

Trestles such as these were eventually filled in, relocated, or replaced with steel. In the *CPR Viaduct, near Lethbridge, Alta.*, for example, J. E. Schwitzer used steel to build the world's longest and heaviest viaduct. Completed in 1909, it extended some 5,327 feet over the Old Man River.

The *CPR snowsheds near Glacier, B.C.* (Figs. 21, 22), erected to protect mountain lines from snowslides, drifts, or heavy snowfalls, were related to the timber trestles. Thirty-one sheds, with a combined length of more than five miles, were required in one sixteen-mile section through the Selkirks alone. Built in 1886-87, such snowsheds were a particularly impressive tribute to the disruptive power of snow and to the abundance of large timber available to meet the challenge in these powerfully constructed works.³⁰

Canada's first *railway tunnel, at Brockville, Ont.*, was built in 1854-60 to provide access through a steep bluff to the St Lawrence River waterfront and represents another area of significant engineering endeavour. The engineer George Dixson, assisted by Samuel Keefer, designed an arched tunnel 1721 feet long with doors at each end that were locked at night to maintain an even temperature and to keep out stray animals.

But railways must do more than build road beds, bridges, and tunnels to carry their track; they must provide facilities for freight and passengers. Grain elevators, the best-known freight facilities, were generally built by the grain handlers rather than the rail companies. The passenger stations, on the other hand, were built by the railways. They fall into two categories: depots that serve as stops along a line and major city stations that provide terminal facilities.

Like the trestles, the stations along the line were often standardized, simple, and utilitarian structures that could be erected quickly and cheaply. They provided a link between the pragmatic approach of the



Fig. 20. CPR Trestle, North Bend B.C. (Photo: Stanley Triggs col.).

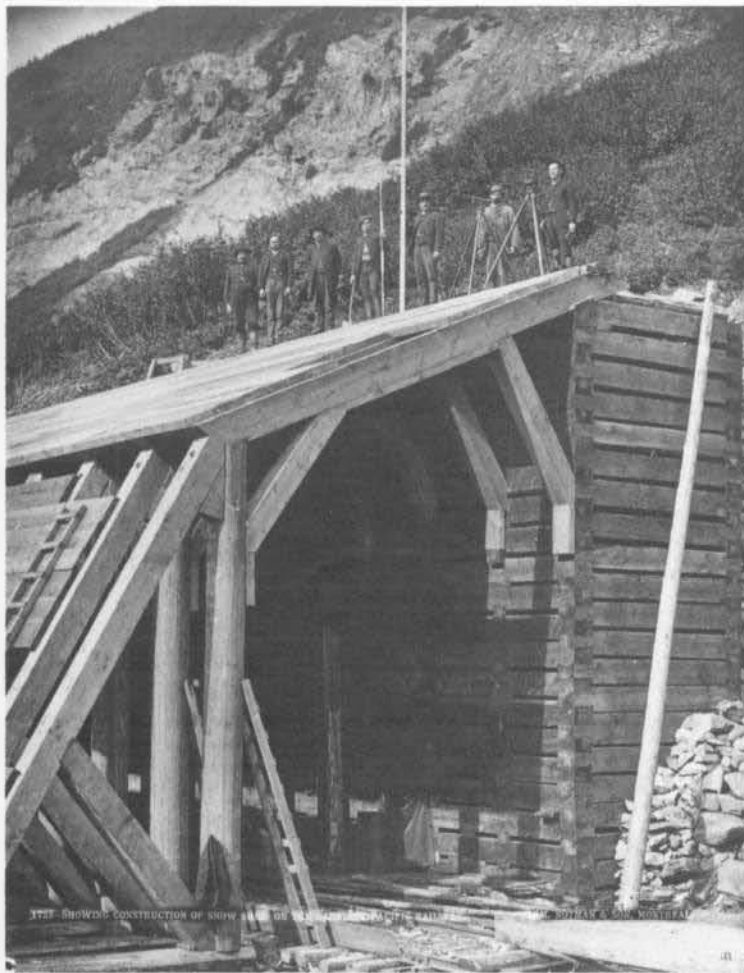


Fig. 21. CPR Snowsheds near Glacier, B.C. (Photo: Notman Photographic Archives).

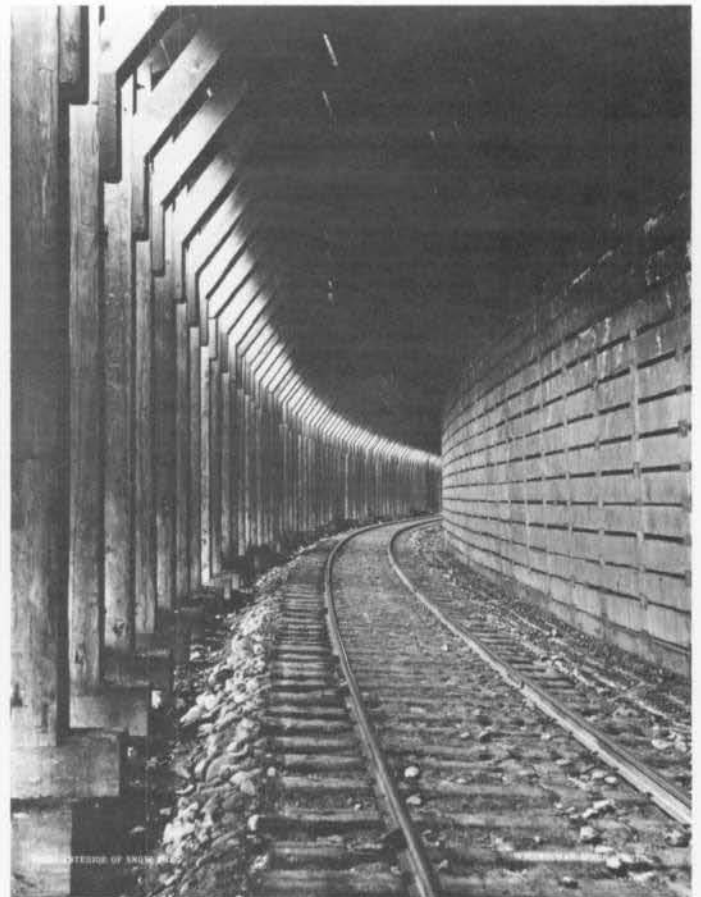


Fig. 22. CPR Snowsheds near Glacier, B.C. (Photo: Notman Photographic Archives).



Fig. 23. GTR Station, St Mary's Junction, Ont.
(Photo: Ralph Greenhill).

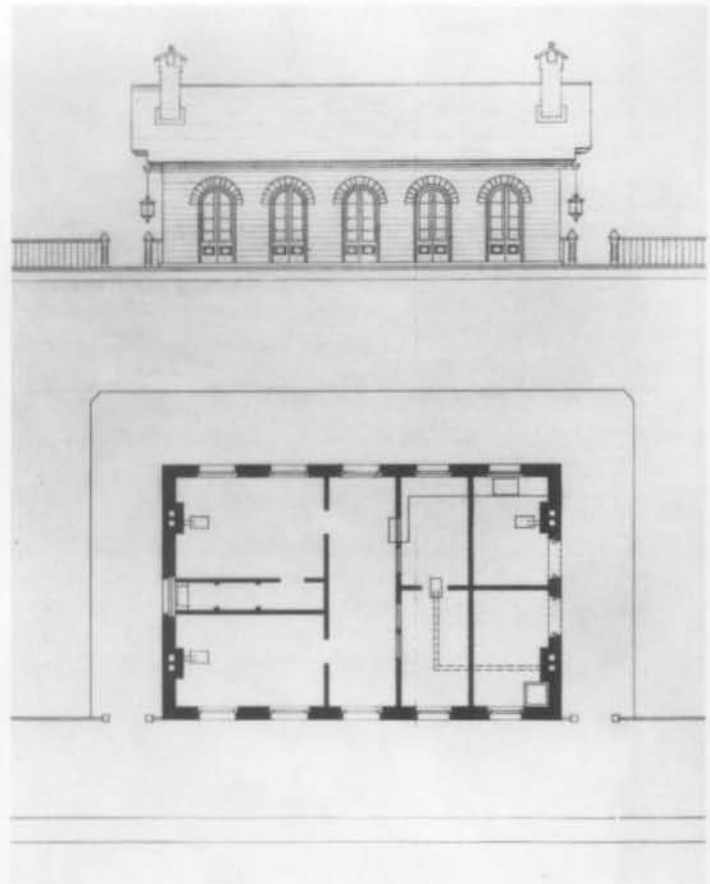


Fig. 24. GTR Station,
Georgetown, Ont. (redrawn
from original in Public
Archives of Canada).



Fig. 25. CPR Station, Port Arthur, Ont. (Photo: C.D. Stockdill col.).



Fig. 26. TH&B Railway Station, Hamilton.
(Photo: Ontario Archives).

engineer and the more design-conscious approach of the architects. Well known are the many similar depots built in Ontario by the Grand Trunk Railway in the 1850s. It seems incredible that in recent years some of these important and symbolic structures have been demolished while others still appear threatened by disuse and neglect. Of those that survive, all but one is on the line between Montreal and Toronto that was completed in 1856. The exception is the *GTR Station, St Mary's Junction, Ont.* (Fig. 23), built in 1854, and derelict — but one of the best-preserved of all these remarkable survivors of early history.

They are compact buildings, generally thick-walled, with deep, regular and beautiful courses of stone, punctured by series of round-arched openings and protected by low-pitched gabled roofs, with deep overhanging eaves to shelter the surrounding platforms. Original drawings for other stations (in the Public Archives of Canada and in the Shanly Papers in the Province of Ontario Archives; Walter Shanly was Chief Engineer of the Western Section of the GTR during the period it was constructed) show that the openings were originally fitted with French doors. The exterior was symmetrical and uniformly treated, without giving a hint of the different functions assigned to the subdivided interior spaces. To the left of the entrance lobby the *GTR Station at Georgetown, Ont.*, as originally arranged (Fig. 24), provided a general waiting room next to the track, and behind this, with toilet adjoining, a waiting room for ladies; to the right of the lobby was the telegraph office with the ticket office behind it, while the baggage and storeroom were at the end of the building. Four box stoves were served by the four chimneys projecting from the roof. (This station survives, altogether altered.) What little pretense the stations had to high architectural style was indebted to the Italianate mode, a manner often adopted for industrial buildings, presumably because of its strong appearance. The solidity of even the "second class way side station," as the standard type was called, certainly advertised the quality of the line, which was promoted as a first-class English road.

Basically the stations derived from a single design but variations occurred from building to building, according to local needs. The number of openings (and hence the size) differed. Brick was substituted for stone in some of them. Larger towns received large stations: there was a second storey, with hotel accommodations, housed in the mansard roof of the *Grand Trunk depots at Kingston and Belleville*, both of which still

survive. The designer was possibly Thomas S. Scott (d. 1895), who was identified in 1858 as architect to the railway, or A.M. Ross, the GTR's Chief Engineer, who was said to have "designed all the important works of art" erected along the line.³¹ The builders Peto, Brassey & Betts, a British consortium, were responsible for the entire Montreal-to-Toronto line; the extension westward from Toronto to Sarnia, including the station at St Mary's Junction, was built by the firm of Gzowski and Company.

A generation later the Canadian Pacific Railway employed numerous designers for its many stations along with the transcontinental line, which were now composed on very different principles. One was Thomas Charles Sorby (1836-1924), an accomplished English architect who migrated to Canada in 1883 and immediately found work with the CPR and other prestigious Montreal clients.³² Sorby's stations reflected the acceptance of the rational and picturesque system of High Victorian design. His *CPR depot for Port Arthur, Ont.* (Fig. 25), 1883, was an asymmetrical gabled structure. The individual functions housed within the one building are now identifiable externally; because they are designed with particular needs in mind, they are expressed separately but grouped to advantage visually. The baggage and storage portion requires ready access for heavy goods but no heat and little light: it therefore has large doors to a one-storey block with no chimneys and relatively few windows. The waiting room has a smaller entrance, and is associated with the station master's quarters above in a more domestic-looking unit, with plentiful windows and a chimney stack. As trains were now dispatched by telegraph, and the telegraph operator required a clear view of the track, a separate bay is provided. And so on. In principle, the result is rather like the picturesque design of High Victorian churches, with their asymmetric composition of chancel, nave, tower, porch, and vestry.

Stations in the cities were generally very much more urban in appearance than the intermediate depots. Their greater passenger traffic required larger public facilities and their role as terminals necessitated more trackage, protective train sheds, and administrative offices. Equally important, their downtown locations in major urban centres dictated impressive architectural design. They fall clearly into the mainstream of public and commercial architecture in their time; in fact the need to symbolize "progress" often made stations the vehicles for the latest in

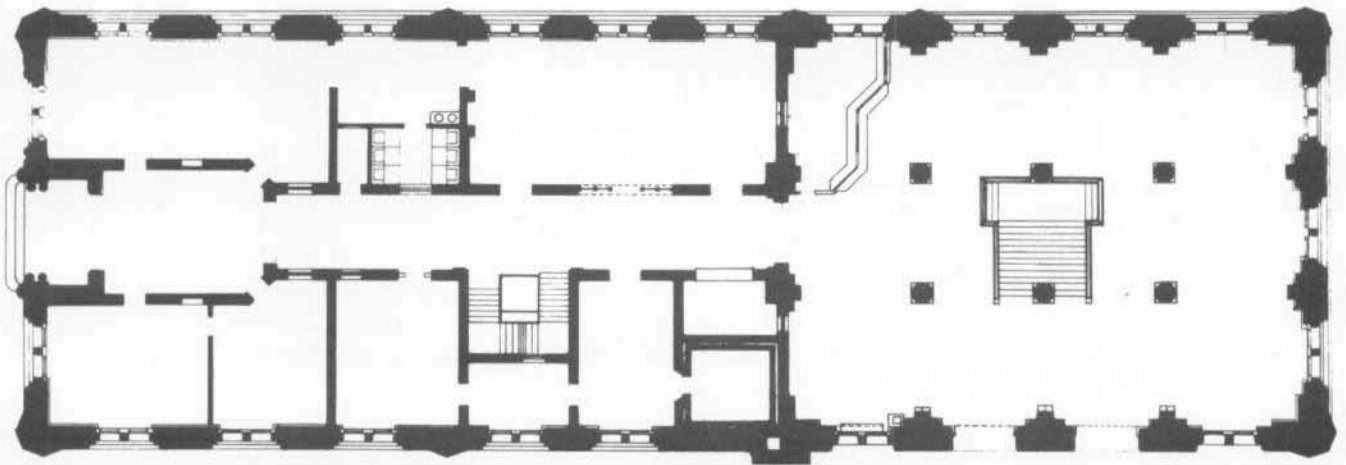


Fig. 27. Windsor Station, Montreal. (main floor plan redrawn from original in Canadian Pacific Archives).



Fig. 28. Windsor Station, Montreal. (Photo: Notman Photographic Archives).



Fig. 29. Windsor Station, Montreal. (Photo: Notman Photographic Archives).



Fig. 30. Glacier House, B.C. (Photo: Canadian Pacific).

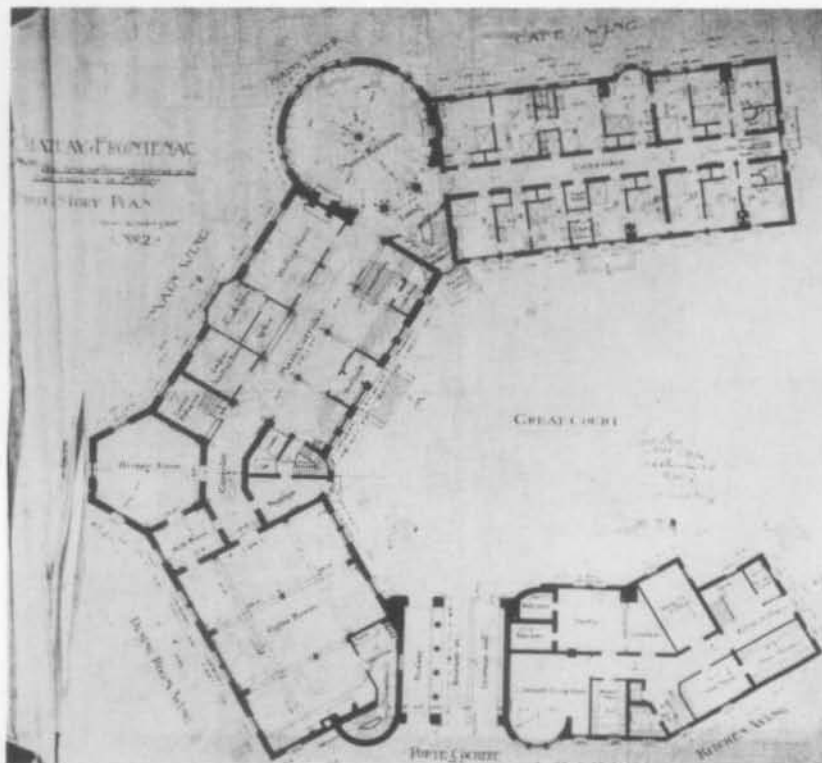


Fig. 31. Château Frontenac, Quebec: main floor plan.
(Photo: Canadian Pacific).

architectural styles. Their great importance in Victorian life is best illustrated in a passage of 1877 quoted from *Building News* by C.L.V. Meeks on the title-page of his basic study, *The Railroad Station* (New Haven: 1956): "Railway termini and hotels are to the nineteenth century what monasteries and cathedrals were to the thirteenth century. They are truly the only real representative building we possess."

When E. P. Hannaford (1834-1902), the British-trained chief engineer of the GTR, built the *second Union Station, Toronto*, in 1871-3, for the joint use of the CPR and the GTR, he used a full-dress version of the Italianate mode. The rusticated arches, pilasters, and three tall cupolas of this depot (removed half a century ago) all proudly announced the station as the symbolic gateway to the growing metropolis, an image perpetuated in its twentieth-century successor. Hannaford's station was also unusual in that it straddled the line and had a partially glazed roof, in the British manner, unlike other Canadian stations.³³

Picturesque eclecticism often flowered in the major and minor terminals of the late nineteenth century. The long-demolished *Toronto, Hamilton, & Buffalo Railway Station in Hamilton* (Fig. 26), completed in 1896 by William Stewart & Sons, though a large depot, was also representative of smaller stations of the last decade in this respect: very asymmetric and irregular in profile, it was built of stone and brick, all carved, moulded, corbelled, gabled, dormered, and dominated by a wildly Romantic tall corner tower whose function was purely visual.

Perhaps the most celebrated depot was *Windsor Station, Montreal* (Figs. 27-29), erected by the CPR in 1888-9 as the terminus of its transcontinental line and its administrative headquarters. (The object of a prolonged preservation controversy, the station is now to be retained alongside new development.) In 1886 the railway's vice-president, William Van Horne, had selected the prestigious New York architect Bruce Price (1845-1903) to design the building. The impressive stone structure displays the arch-and-spandrel treatment of grouped window openings and other Romanesque Revival detail popularized by the recently deceased giant of American architecture, H. H. Richardson. Windsor Station stands as one of the earliest major monuments in Canada of the Richardsonian Romanesque manner. Originally the principal waiting room filled much of the main floor of the station and continued the Romanesque theme in the short, thick, polished marble columns with ornate capitals that carried an almost Piranesian succession of arches in this tall

space. Van Horne recognized the progressive qualities of the building. Upon its completion he shocked Montreal with a sign proudly proclaiming in six-foot-high letters: "Beats All Creation — the New C.P.R. Station."³⁴

An extensive train shed was built adjacent to the terminal. It was rather low and dark, with trussed steel girders supporting a broad roof. Canadian station designers rarely sought the grand spaciousness of the more impressive train sheds of England that Hannaford attempted in the second Union Station, Toronto. Instead, the separation of train shed from passenger facilities in nineteenth-century station design on this continent underscored the accepted divorce of engineering and architecture.

Van Horne also recognized the tourist potential of the magnificent mountain scenery of Alberta and British Columbia through which the CPR line passed. "Since we can't export the scenery," he remarked, "we shall have to import the tourists."³⁵ The railway commissioned architects Sorby and Price to construct a series of mountain hotels — called dining stations — to attract traffic as well as to provide restaurant stops for through trains. In 1885 T.C. Sorby designed hotels of similar plan at Glacier, Field, and North Bend in British Columbia. The *Glacier House* (Fig. 30) is representative of all three: it was asymmetrical, three storeys high, and featured a shingled and slightly projecting top floor that was intended to suggest a Swiss chalet. In fact, it is the Port Arthur station design (Fig. 25) rendered in a slightly more picturesque mode appropriate for the new mountain location: the station and restaurant occupied the ground floor; the small hotel the upper storeys.

These intimate hotels were the first in an extensive system that was to have monumental consequences for Canadian architecture. Their stylistic successor was the larger *Banff Springs Hotel*, 1886-8, also by Bruce Price. The original frame structure (long since replaced by W. S. Painter's masonry building of 1912-3, with additions by J. W. Orrock in 1926-8) was characterized by steep roofs, pointed dormer windows, corner turrets, and oriels — all features that were distantly derived from the picturesque castellated architecture of Europe, more particularly the French château of the Loire River, and translated into wood.

Price's third great building for the CPR, the *Château Frontenac, Quebec* (Figs. 31-33), 1892-3, marked the definitive establishment of the Château style as a manner for railway hotels. It rose majestically on the heights



Fig. 32. Château Frontenac, Quebec. (Photo: Notman Photographic Archives).



Fig. 33. Château Frontenac, Quebec. (Photo: Canadian Pacific).



Fig. 34. Château Laurier, Ottawa. (Photo: Canadian National).

above Quebec on the site of the old Château Saint-Louis, the Governor's residence. A rambling but carefully organized building, the Château Frontenac was laid out as four and a half sides of a larger hexagon around a "Great Court." Although patently in fancy dress and executed in stone-trimmed orange brick walls, the original six-storey building with steep dormered roofs accorded almost perfectly with its surroundings. From a distance its silhouette was enlivened by prominent towers that marked the junction of the main wings and the location of the principal rooms with a view over the Dufferin Terrace. This luxurious hotel quickly became a national institution. Price's original building — a fraction of its present size — was supplemented by numerous additions, some by Price, others by W. S. Painter. The climax, the apotheosis, was the imperious seventeen-storey tower built in 1920-4 to the designs of Edward & W. S. Maxwell, better known for their legislative buildings in Regina.

Canada's other railroads soon followed the CPR in erecting hotels in the Château style. The best known is probably the *Château Laurier, Ottawa* (Fig. 34), built in two stages (1908-12 and 1927-9) and begun by Ross & Macfarlane for the Grand Trunk Railway.

In the last flowering of eclecticism, the château style was felt to be appropriate to Canadian conditions; so much so, indeed, that the federal government advocated it as the manner to be adopted for all public buildings in Ottawa. A factor in this decision was its sympathy with the High Victorian Gothic style of the Parliament Buildings. The Federal Plan Commission of 1915 recommended that any new government buildings be based on "the external architecture of the Chateau Laurier;" another commission of 1920 urged the adoption of the "Northern French Gothic (French Chateau)" style; a third report asked in 1927 for "the adoption of the French Chateau style of architecture, of which the Chateau Laurier is a modernized type." A number of buildings in Ottawa were indeed carried out in this new national style. Their story, however, comprises part of the history of the architecture of our own century.³⁶

From their bridges to their hotels, the builders of the nation's railways played a major part in the development of the Canadian built environment. It is hard to know whom to value more: the engineers who led the way in structural innovation, creating numerous monuments of world

significance; or the railways' architects who pointed the way to a public architecture that raised our self-awareness and that was to be promulgated as a national style for all of Canada.

Harold Kalman
Consultant in the
History and Conservation
of Architecture
Ottawa, Ont.
and
Douglas Richardson
Department of Fine Art
University of Toronto
Toronto, Ont.

Notes:

- ¹ George Heriot, *Travels Through the Canadas* (London: 1807), p. 35.
- ² James Fergusson, *The Illustrated Handbook of Architecture* (London: 1859), pp. xxvii, xviii.
- ³ Edward F. Bush, "The Canadian Lighthouse," *Canadian Historic Sites: Occasional Papers in Archaeology and History*, no. 9 (1974), p. 39.
- ⁴ This is illustrated and discussed in *ibid.*, pp. 30, 32-5, and Dudley Witney, *The Lighthouse* (Toronto: 1975), especially pp. 17, 28, 100-01.
- ⁵ Bush, "The Canadian Lighthouse," p. 34.
- ⁶ The drawing is taken from a manuscript, in the Public Archives of Canada, by Robert Oke, "Plans of the several light houses in the colony of Newfoundland Taken from authentic Documents by G. F. Baillairgé at St John's... 1865."
- ⁷ John P. Heisler, "The Canals of Canada," *Canadian Historic Sites: Occasional Papers in Archaeology and History*, no. 8 (1973), p. 14 ff.
- ⁸ Joseph Bouchette, *The British Dominions in North America* (London: 1831), I, p. 82.
- ⁹ Ontario, Department of Energy and Resources Management, *History of the Rideau Waterway* (Toronto: 1970), p. 40. For further material on this canal, see Heisler, "The Canals of Canada," *passim*; Robert Legget, *Rideau Waterway*, rev. ed. (Toronto: 1972); and William D. Naftel, *The Rideau Waterway*, Society of Industrial Archaeology: Occasional Publications, no. 1 (Apr. 1973). Many sheets of drawings for the Rideau Canal are preserved in the Public Archives of Canada, though the oversize example illustrated here is in the Royal Ontario Museum.
- ¹⁰ On this subject, see Robert F. Legget, *The Jones Falls Dam on the Rideau Canal, Ontario Canada*, Technical Paper No. 128 of the Division of Building Research (Ottawa: 1961).
- ¹¹ John Mactaggart, *Three Years in Canada* (London: 1829), I, p. 345.
- ¹² Bouchette, *The British Dominions*, Vol. 1, p. 193. For more information on the various Union Bridges, see A. H. D. Ross, *Ottawa Past and Present* (Toronto: 1927), p. 71 ff.
- ¹³ The most comprehensive survey of bridges of all sorts in Canada and the United States is that by David Plowden, *Bridges: The Spans of North America* (New York: 1974), which discusses covered bridges, for example, on pp. 36-40. This work has been consulted extensively for the discussion of many of the examples of bridge building that follow; as it is well indexed but not annotated, our notes are limited to those examples not discussed by Plowden, to source materials, or to new information.

¹⁴ The Bout de L'Ile designs and others are preserved in the Public Archives of Canada in a large folio entitled "A Series of diagrams, plans, elevations, sections and details illustrative of the various local public improvements authorized by the Legislature of the Province of Canada and carried into execution and completed by the Provincial Board of Works." The designs were drafted by F. P. Rubidge at various dates but the folio is signed and dated by Samuel Keefer in 1844. The suspension bridge by Roebling is discussed in Ralph Greenhill and Thomas D. Mahoney, *Niagara* (Toronto: 1969), pp. 61-64.

¹⁵ Anthony Trollope, *North America* (New York: 1862), p. 59. Documents and drawings from the hearing that followed the collapse of the bridge are in the Public Archives of Canada.

¹⁶ For the building of the Cariboo Road and its bridges, see F. W. Howay, *The Work of the Royal Engineers in British Columbia, 1858 to 1863* (Victoria: 1910) and Frances M. Woodward, "The Influence of the Royal Engineers on the Development of British Columbia," *B. C. Studies*, no. 24 (Winter 1974-75), pp. 3-51. See also Barry V. Downs, "The Royal Engineers in British Columbia," *Canadian Collector*, 11, no. 3 (May-June 1976), pp. 42-46.

¹⁷ Much was made in the Provincial Parliament of the fact that "the English engineer [Stephenson] should not receive the whole... credit, an equal portion of which was due the Canadian [Keefer]," quoted from *The Canadian Engineer of the Victoria Bridge by a Montrealer* (Montreal: 1860) in Bruce Sinclair, Norman R. Ball, and James O. Peterson, eds., *Let Us Be Honest and Modest: Technology and Society in Canadian History* (Toronto: 1974), p. 84. Thompson's role has also been consistently overlooked, although documented in Charles Legge, *A Glance at the Victoria Bridge and the Men Who Built It* (Montreal: 1860), p. 127. James Hodges produced a sumptuously illustrated work (in two folio volumes with 17 colour plates), the most elegant and lavish monograph ever produced on a Canadian structure, detailing the technical aspects especially: *Construction of the Great Victoria Bridge in Canada* (London: 1860).

¹⁸ Legge, *A Glance at the Victoria Bridge*, p. 153.

¹⁹ *The Tour of H. R. H. The Prince of Wales Through British America and the United States. By a British Canadian* (Montreal: 1860), p. 13.

²⁰ *Ibid.*, p. 99.

²¹ Regarding coffer dams, scaffolding, and prefabrication, see Legge, *A Glance at the Victoria Bridge*, pp. 93 ff., 111 ff., and 118 respectively.

²² Trollope, *North America*, p. 59. Legge, *A Glance at the Victoria Bridge*, p. 64, resolves the common confusion as to the actual number of the spans versus that of the tubes. He says explicitly that "The superstructure... consists of 25 tubes, or, rather, as one continuous tube extends over two spans, of 12 double tubes, and the large central one over the channel." In other words, there are 13 tubes, though the 24 piers between the two abutments define 25 spans.

²³ Jean-Claude Marsan, *Montréal en évolution* (Montréal: 1974), p. 254.

²⁴ For example, see Charles Horetzky's 1872 photo of an Indian bridge over the Wotsonqua River near the forks of the Skeena River, B.C., reproduced by Andrew J. Birrell, "Classic Survey Photos of the Early West," *Canadian Geographical Journal*, 91, no. 4 (Oct. 1975), p. 17.

²⁵ The Saint John bridge, credited by Plowden to Job Abbot and P. S. Archibald, is identified as Johnson's work in the *Perth Courier*, 15 Jan. 1886, p. 4, a reference we owe to Diane Newell and Ralph Greenhill.

²⁶ There is a monograph devoted to the bridge: Canada, Department of Railways and Canals, *The Quebec Bridge over the St Lawrence River near the City of Quebec On the Line of the Canadian National Railways*, 2 vols. (Ottawa: 1919).

²⁷ The text of the address by Fred. Cumberland, 'Some Notes of a Visit to the Works of the Grand Trunk Railway, west of Toronto, February, 1855' was "Read before the Canadian Institute [which had been founded by Sandford Fleming, and was the important forerunner of the Royal Canadian Institute], March 31st" and reprinted in *The Canadian Journal*, III (May 1855), pp. 225-27.

²⁸ There is a copy in the Public Archives of Canada. Fleming also compiled a detailed and illustrated work on *The Intercolonial. A Historical Sketch of the Inception, Location, Construction and Completion of the Line of Railway uniting the Inland and Atlantic Provinces of the Dominion...* (Montreal: 1876).

²⁹ See the most detailed account of the construction of the CPR, that by Omer Lavallée, *Van Horne's Road* (Montreal: 1974), pp. 173-222, regarding bridge building in the Rockies and Selkirks. Pierre Berton, *The Last Spike: The Great Railway, 1881-1885* (Toronto: 1971), pp. 187, 206-7, notes the number of bridges and trestles on the CPR line, and ascribes the prefabrication to Michael J. Haney, the Irishman put in charge of construction from Port Moody to Kamloops, B.C., in 1883.

³⁰ Snowsheds for railways in both Western Canada and the American North-West are discussed (with references to other literature) in Walter G. Berg, *Buildings & Structures of American Railroads* (1893; rpt. Novato, Cal., 1973 as the *Train Shed Cyclopedia*, no. 7), pp. 33-38. See also Lavallée, *Van Horne's Road*, pp. 239-42.

³¹ Regarding the possibility that Scott was responsible for designing the stations, see Ralph Greenhill, Ken Macpherson and Douglas Richardson, *Ontario Towns* (n.p., n.d. [Ottawa, 1974]), unpaginated (section on "Commerce, Industry & The Railway"). The best preserved of all the GTR stations until its wanton destruction recently by the Canadian National, the one at Shannonville, Ont., is also illustrated in *ibid.*, pl. 48. The ambiguous reference to Ross is from J. Castell Hopkins, *Canada: An Encyclopaedia of the Country* (Toronto: 1898), II, p. 136.

³² Sorby's work has been discussed by Harold Kalman, in a paper entitled "The Canadianization of Thomas Charles Sorby" delivered to the Society for the Study of Architecture in Canada, at Quebec, 27 May 1976.

³³ For views of the second Union Station, see *Canadian Illustrated News*, 8 (2 Aug. 1873), pp. 72-73. Its successor (not discussed here because it belongs to the twentieth century) is the subject of a monograph: Richard Bébout, ed., *The Open Gate: Toronto Union Station* (Toronto: 1972), with a detailed architectural history by Douglas Richardson, "A Blessed Sense of Civic Excess; The Architecture of Union Station," pp. 60-95 and 119-22.

³⁴ Omer Lavallée, "Windsor Station 1889-1964," *Canadian Rail*, 152 (Feb. 1964), p. 27. The evolution of the design and its relationship to Richardson's work is summarized by Harold D. Kalman in *The Railway Hotels and the Development of the Château Style in Canada*, University of Victoria Maltwood Museum Studies in Architectural History, no. 1 (Victoria: 1968), pp. 7-9.

³⁵ John Murray Gibbon, *Steel of Empire: The Romantic History of the Canadian Pacific* (Indianapolis: 1935), p. 304.

³⁶ The rise of the mode in general is dealt with by Kalman in *The Railway Hotels and the Development of the Château Style in Canada*; its advocacy as a national style specifically is discussed on pp. 23-31.