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# ENGINEERING HISTORY PAPER #65

# "Sketches from Engineering History"

**by Andrew H. Wilson**

(previously produced as Cedargrove Series #40/2016 – February 2016)

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EIC HISTORY AND ARCHIVES

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**Abstract**

In times past, when speaking to, or writing for, audiences of engineers, I have usually pontificated at some length on subjects with unifying themes, like the Trent-Severn Waterway, the Stevenson family of lighthouse builders, and disasters. In contrast, this paper is a collection of short, unconnected examples from the history of engineering intended to demonstrate the breadth and depth of this history, with particular reference to Canada.

**About the Series**

Principally, the Cedargrove Series is intended to preserve some of the research, writings and oral presentations that the author has completed over the past half-century or so, but has not yet published. It is, therefore, the modern-day variant of the privately published books and pamphlets written by his forebears, such as his paternal grandfather and grandmother and his grandfather's brother John.

**About the Author**

He is a graduate in mechanical engineering and the liberal arts and has held technical, administrative, research and management positions in industry in the United Kingdom and the public service of Canada, from which he retired almost 30 years ago.

He became actively interested in the history of engineering on his appointment to chair the first history committee of the Canadian Society for Mechanical Engineering in 1975 and has been active ever since in research, editing and writing on behalf of that Society, the Engineering Institute of Canada and the Canadian Society of Senior Engineers. He has also served as president of EIC and CSME.

**To introduce…**

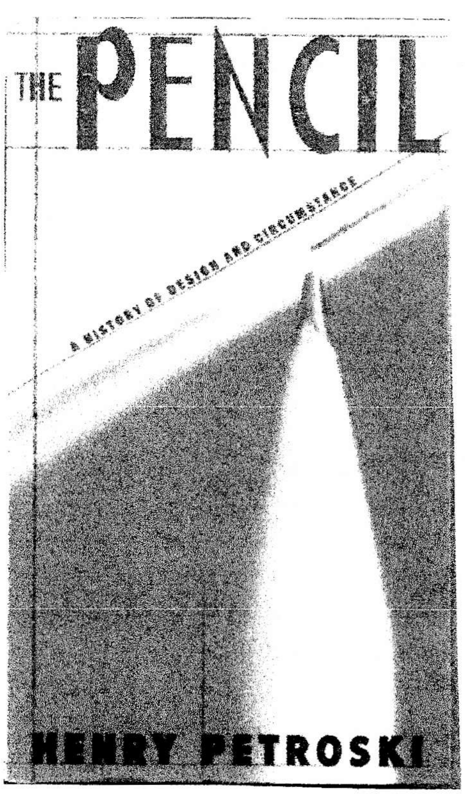
This paper is an extended version of a talk with the same title I gave to the Ottawa Branch of the Canadian Society of Senior Engineers on January 19, 2016.

In past talks and papers, I have discussed subjects, at length, with unifying themes. This time I want to talk much more briefly about a dozen or so subjects, each of which has something notable about it. Time-wise, they will range mostly from the early 19th to mid-20th centuries. Subject-wise, they are mostly Canadian and include a railway locomotive, a car, and a lighthouse.

**Petroski and the Pencil**

American engineer Henry Petroski has written an enormous amount about engineering history, mostly in the United States, but also all over the world. The subject of one of his books, published by Alfred A. Knopf in 1993, is the humble pencil.

A piece of engineering history? In the preface to his book, Petroski writes:




All made objects owe their very existence to some kind of engineering, which is essential for civilization. Even the commonest and oldest of artifacts are no less the products of primitive engineering than the artifacts of high technology are the products of modern scientific engineering. But while the practice of engineering has certainly evolved since ancient times, it has also maintained a family resemblance to its ancestors. Although engineers today tend to be more formally mathematical and scientific than their counterparts a century ago, there are still essential elements of engineering that all ages have in common. A modern engineer and an ancient, even if called an architect or master builder or master craftsman, would find plenty to talk about, and each would be able to learn something from the other.....

We all know from childhood what a pencil is and is for, but where did the pencil come from and how is it made? Are today's pencils the same as they were two hundred years ago? Are our pencils as good as we can make them?

Interestingly, the bibliography for Petroski's book on the pencil has something like 500 references, and there are over 400 footnotes...and 350 pages.

Originally, in Greek and Roman times, a pencil was a pointed stylus made of metal that left a mark on papyrus. They also used thin brushes of animal hairs, inserted into hollow reeds, and a form of ink. And they were aware that lead sticks could be used for writing.

The breakthrough came around 1564 when a graphite deposit was found at Borrowdale, in England and was eventually found to be useful in dry, dark sticks, for writing that was legible, durable, did not smudge, could be erased, and could be inked over. The first pencils were wrapped in string. The wooden wrapping came later. Over the next 200 years, contributions to the engineering of pencil production and to the design of the products were made in Germany, Austria and France as well as England.

Pencils were first produced in large quantities in Germany in the late 1600s. With time, the so-called 'lead' pencils used a ground-up mixture of graphite and clay, and the wooden casings were round, and square as well as hexagonal. Wood-encased pencils had become the rule by the early 19$^{th}$ century. Red cedar was the wood of choice since it did not splinter during the sharpening process. Later, non-graphite-coloured pencils also appeared, using coloured pigments, wax and other fillers. Especially in Europe, pencils were painted in a variety of colours. The famous hexagonal yellow pencil originated with the Faber Company in the 1890s. By this time, also, it was being produced in standard lengths of 7½ inches and ¼ inch hex, some with attached erasers, principally by the Eversharp Company. Because of their lower cost, slate tablets with slate pencils or chalk were still in common use, in schools and businesses, throughout the 19$^{th}$ century and into the 20$^{th}$. Experiments with mechanical, or propelling, pencils were begun in the 19$^{th}$ century, but they were not made in quantity until the 20$^{th}$, The 'HB' classification for pencils originated in England in the early 20$^{th}$ century.

In his book, Petroski discusses the activities of the Thoreau family, and in particular father John and son Henry David, in large scale and successful pencil-making. Apparently, Henry's involvement began when he resigned from the other family activity, teaching, in the 1840s. Petroski also makes some interesting comments on American engineering in Henry's time. He writes, in part:

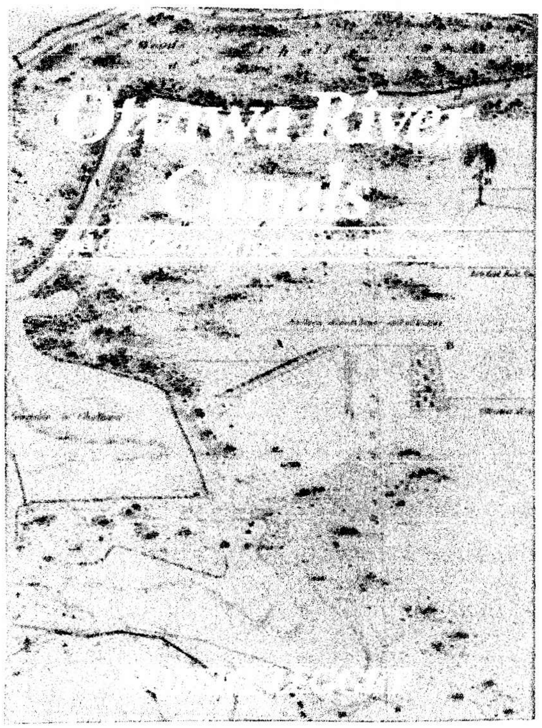
> Thoreau's story, especially his involvement in the manufacturing of pencils, is helpful for understanding the nature of nineteenth-century engineers and engineering for several reasons. First, an engineer before mid-century, like the alumnus Thoreau, would not necessarily be certain that his activity was a profession, for it was not yet 'learned.' Furthermore, the story of Thoreau shows again that one does not have to study engineering to practice it.... Those who practiced and advanced engineering in the first half of the nineteenth century had come to it largely through the crafts and the apprenticeship system...

Second, the story of Thoreau is instructive because it is a reminder that innovative and creative engineering was done by those who were interested in a wide variety of subjects beyond the technical...

Third, like Thoreau, innovative engineers tended to be a bit iconoclastic and rebellious, rejecting traditions and rules...

Fourth, like Thoreau's involvement in pencil making, engineering was practiced with the tongue and the pencil, and there was very little written of it or about it before the middle decades of the nineteenth century. Thus there was little left to tell posterity the technical story of how and why certain designs or processes were developed or chosen over others. The truths of the theories of the pioneer engineers were demonstrated by the successful erection of a solid bridge or an efficacious process of producing a good pencil.

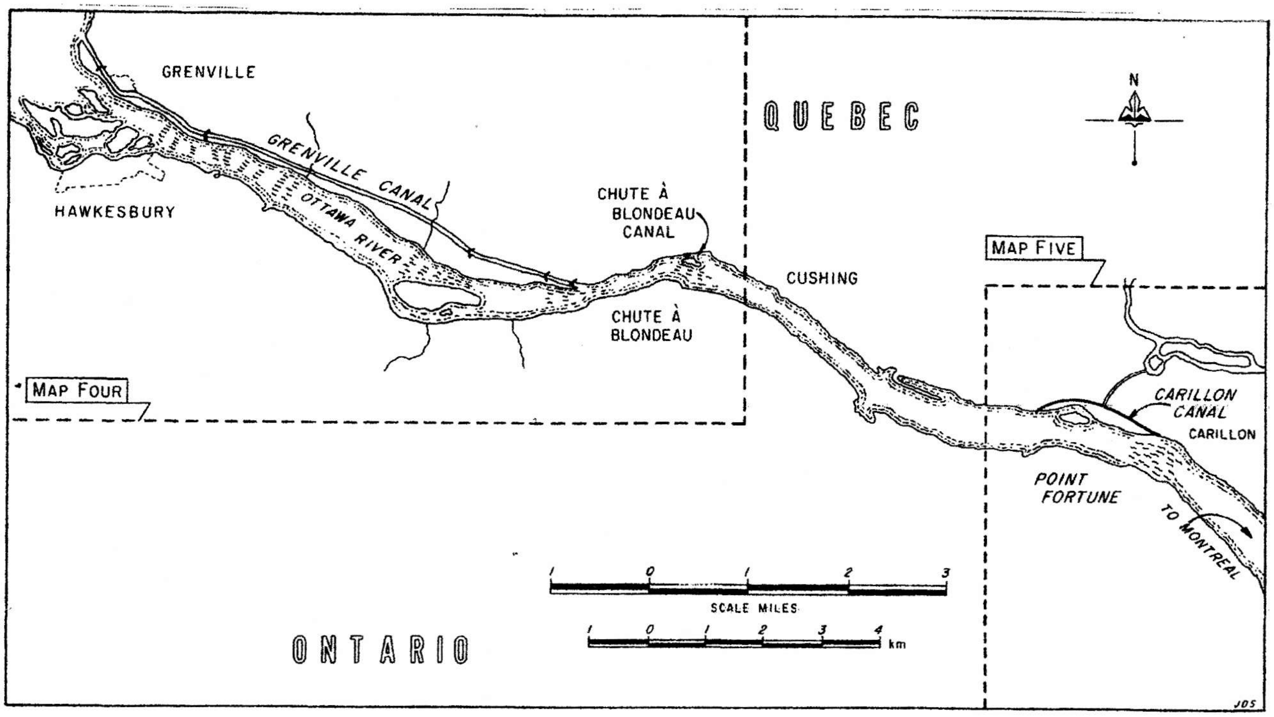
**Legget and the Ottawa River Canals**



All told, three of Robert Legget's books describe the building of the Ottawa River canals.

These canals date from the same period as the Rideau Canal - the 1820s and 1830s - and were parts of the same post-1812 defence system proposals that provided an alternative route from Montréal to Lake Ontario that was remote from American territory. The canals were needed because the Ottawa River part of the route was impeded by the six-mile Long Sault rapids beginning at Grenville and the much smaller rapids downstream at Chute à Blondeau and Carillon. It is a dozen miles or so from Grenville to Carillon. The Dukes of Richmond and Wellington both took an active interest in the building of these canals as military projects, the first as the Governor of the Canadas, and the second as the Master General of Ordnance in England. The Government was also becoming aware of the contributions the new works could make to immigration to the Ottawa Valley and in support of the rafting of timber from the Upper Valley to the St. Lawrence for shipment to Europe.

The three canals bypassing the rapids were built on the north shore of the Ottawa River by the Royal Staff Corps (RSC), not the Corps of Royal Engineers (CRE). This little known regiment of the British Army was founded in 1799 to supplement the work of the CRE, but was disbanded in 1829 as an economy measure. It had previously built the Winchelsea Canal in England. The Ottawa work was under the command of Captain, later Lt. Col., Henry Du Vernet, who was posted from England to supervise the work. At least two surveys of the river had been done by military officers prior to the decision to build the canals, a decision that was 'muddied' by the sudden death of the Duke of Richmond while on his way to inspect the area of the river where the work would be done. As a result, Du Vernet had little guidance on the job he was to do. The work began in 1819 but was not finished, on all three canals, until 1834.




The building of the canal at Grenville began with a guard lock at the upper end that took care of river level fluctuations, with a second one nearby, followed by a long stretch of canal through level country, ending with a drop of 43 feet through the remaining three locks.

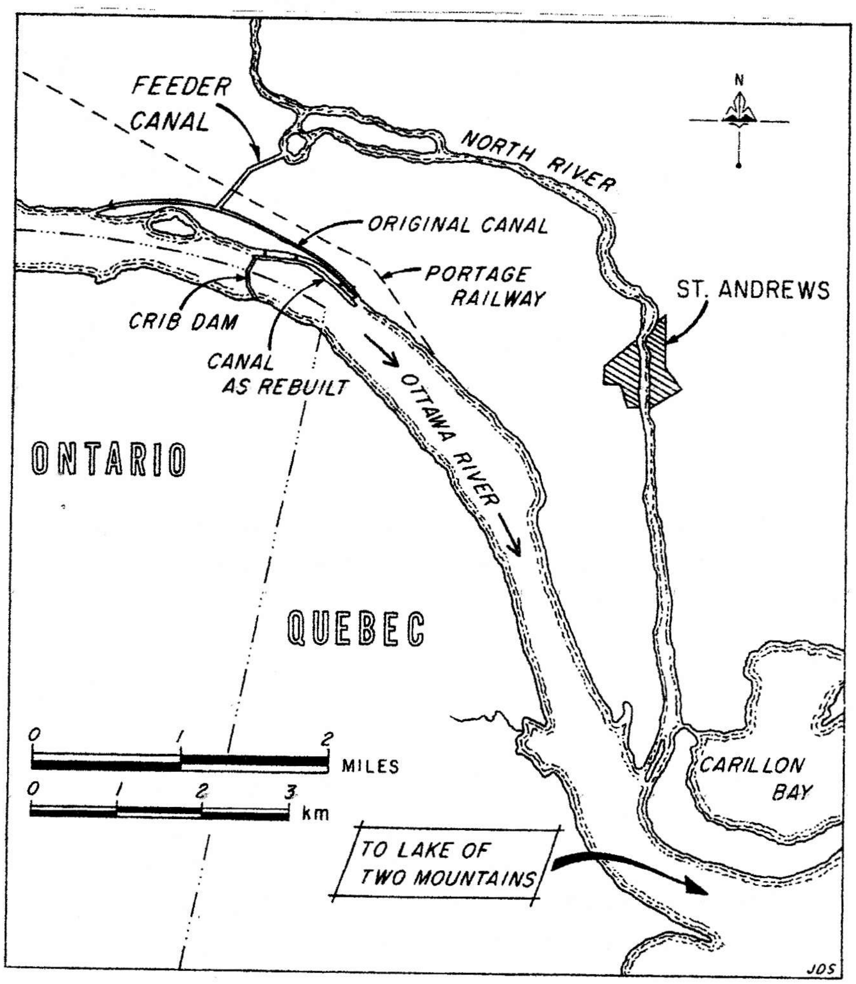
The Chute à Blondeau Canal consisted of an 800 ft cut, almost all through solid rock, with a single lock at its mid-point. The fall was only four feet.

The site for the original Carillon Canal was almost two miles long, and was complicated by having to cross higher ground in the middle to avoid time-consuming rock excavations. The entrance lock, therefore, raised - rather than lowered - the water level by 13 feet. At the other end, two locks brought the canal back to the river level, which was only 10 feet below that at the entrance. Since the Carillon was losing water in both directions, it also had a feeder channel from the North River to help maintain its water level.

The size of the masonry locks originally was set to mirror those of the Lachine Canal, in the days of Durham boats, bateaux, barges and canoes and before steamboats. The ones at the western end of the Grenville were built originally at roughly 107 feet long and 19 feet wide. The remaining locks were roughly 128 feet long and 32 feet wide, smaller than Col. By's locks on the Rideau, which had anticipated the coming of steamboats.

The masonry lock at Ste. Anne, at the junction of the Ottawa and St. Lawrence Rivers, was completed in 1842, making complete the passage from Montreal to Kingston by way of Bytown.

When first in operation, passengers and freight from Montréal could also travel by steamboat from Lachine to Carillon and were then conveyed by stagecoach to Grenville, where they re-embarked on a second steamboat for the trip up river to Bytown. Then, in 1854, a short (12 mile) portage railway was built between the two ends of the canals. It used a 5-foot, six-inch gauge rather than the one that later became the standard. This railway remained in operation until the 1920s

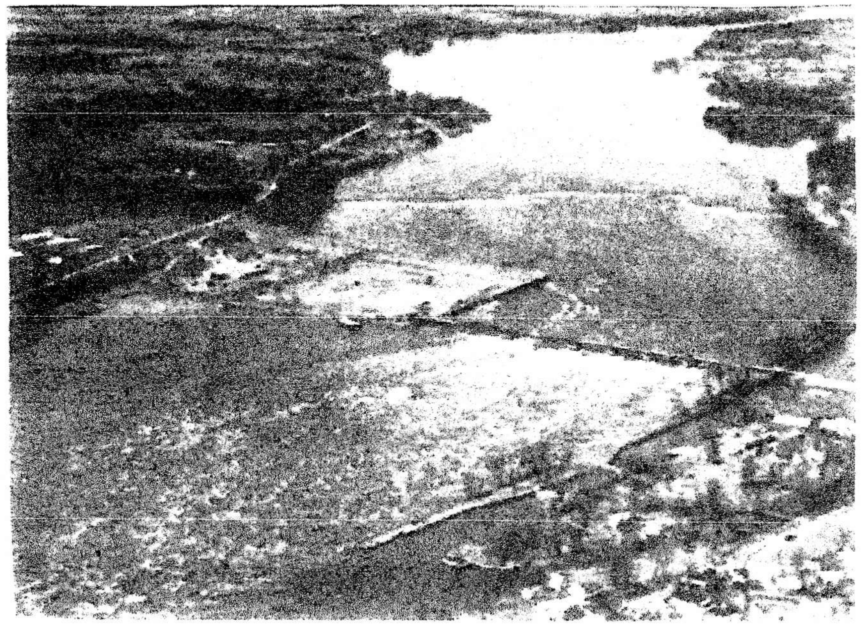


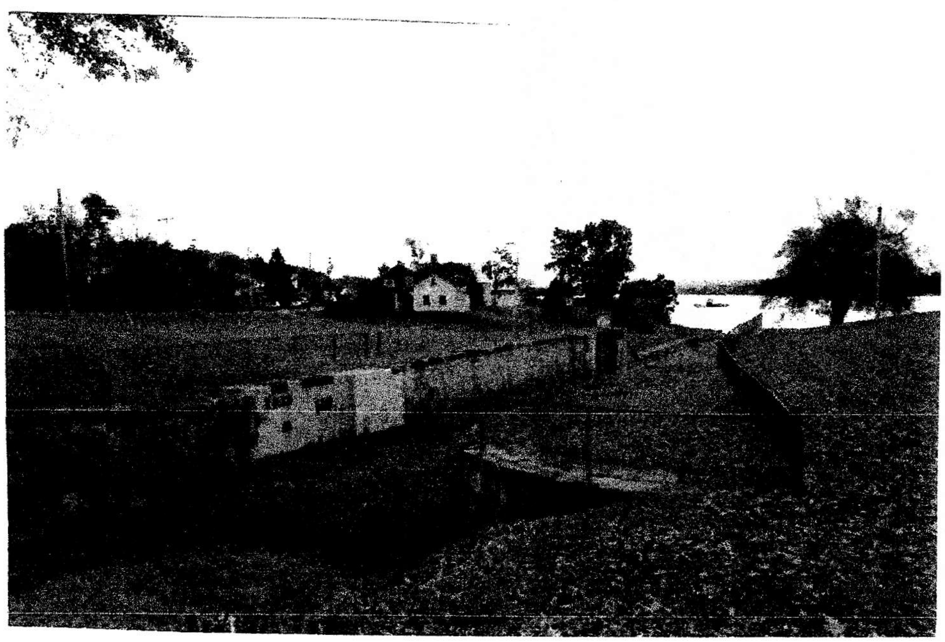

In 1870 a special commission was appointed to review Canadian canals. One of its recommendations was that the Ottawa River Canals be rebuilt. The entire system was affected, between 1870 and 1882. Those locks that remained were enlarged to a length of 200 feet and a width of 45 feet, with nine feet of water over the sills. The Grenville Canal had five locks. The Carillon was rebuilt, with two locks, and its route moved nearer the river. For the benefit of logging operations, a crib dam was constructed across the river, raising the level above it high enough to eliminate the need for a lock at Chute à Blondeau.

In the early 1960s, a massive new dam and hydro power plant were built at Carillon by Hydro Québec flooding the remaining two rapids as well as some land traversed by the canals. A short canal and a single lock at the downstream end at Carillon, with a lift of over 60 feet. Only the guard lock remained at

Grenville, open at both ends.

Cofferdam built across southern half of the river at Carillon for the building of this half of the (1960) hydro dam; (1870) crib dam can be seen upstream

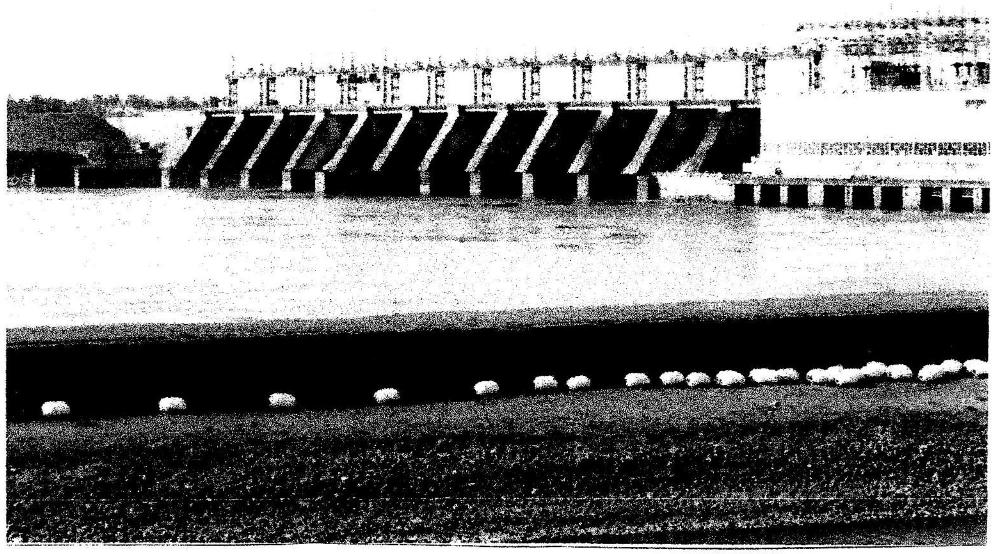


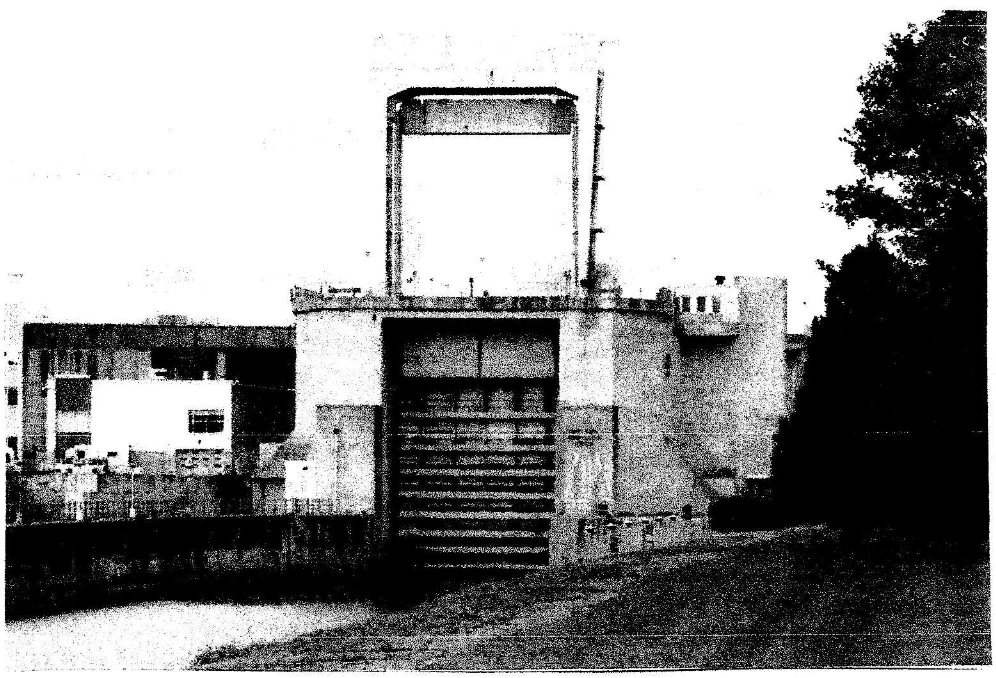


Remains of the 1870 lock at Carillon

1960 dam and hydro plant

at Carillon



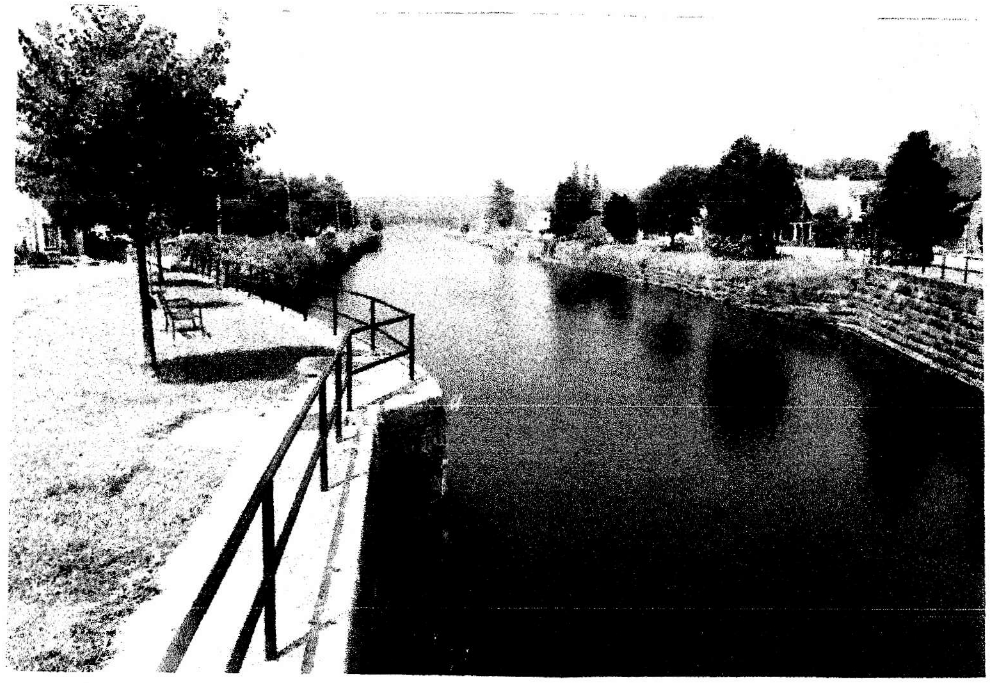


1960 sluice-type lock gate

at Carrillon

Guard lock at Grenville

looking north, in 2015



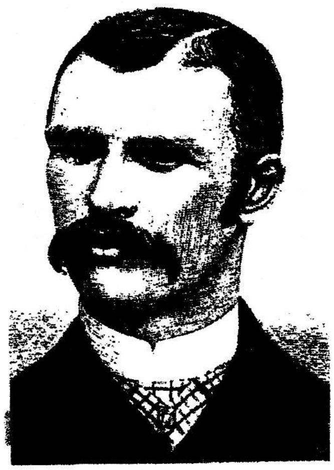
Guard lock at Grenville

looking south, in 2015

The Ottawa River Canals were commemorated by the Canadian Society for Civil Engineering as national historic civil engineering sites in 1984.

**The Brockville Chaffeys**

The 200-year history that was written by Brian Carroll for the Institute of Engineers (Australia) has a chapter on "The Chaffey Brothers: Pioneers of Irrigation." The brothers in question were George and William, Canadian-born at Brockville, Ontario, in 1848 and 1856. But they were *not* related to the Samuel Chaffey family that was associated with the Rideau Canal and Chaffey's Lock.



William Chaffey

George Chaffey

The father of the brothers was a contractor on the Victoria Bridge in Montréal but was also a shipbuilder at Brockville. Son George followed his father and became a marine engineer and ship designer. But his interest switched to irrigation engineering after a visit to his retired father in California in 1880. By 1886, he and his engineer brother William had established themselves successfully in the irrigation business in the Etiwanda district of California, expanding to an even larger project at Ontario, California. George was also interested in electric lighting and was hired by the city of Los Angeles to install its first street lights.

The South Australian and Victorian governments, however, heard about their irrigation work and in 1886 invited the brothers to undertake projects near the new Murray Valley towns of Mildura and Renmark on the borders of the two states, to help grow grapes and other fruit.

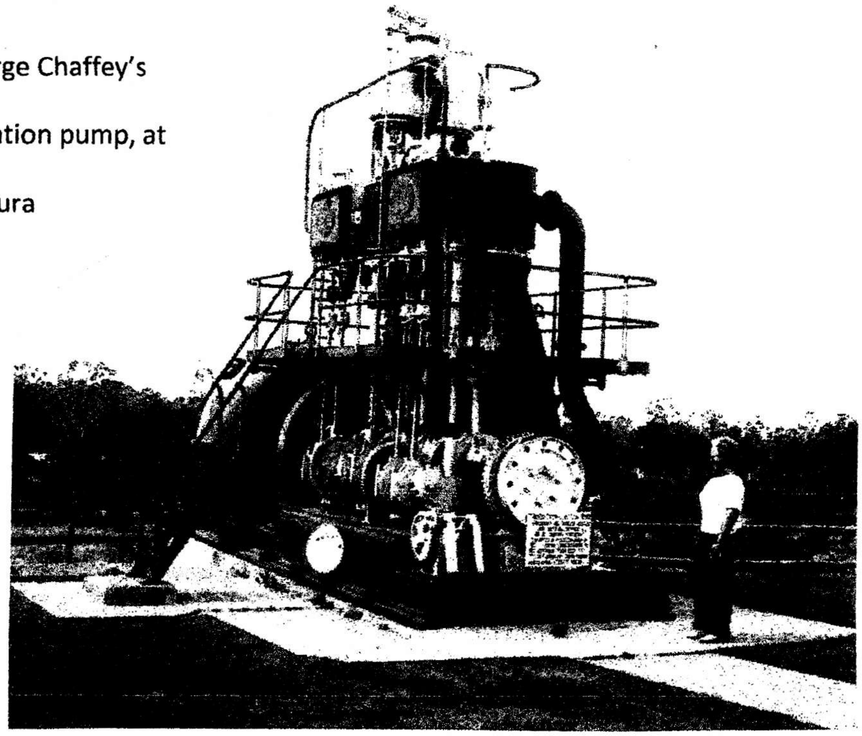
At first apparently successful, logistic and other problems at Mildura with the growing and marketing of the fruit led eventually to financial failure in 1893. George was blamed for the problems. In 1896, he returned to California, where he continued to do successful irrigation projects. He died in 1932, a wealthy man.

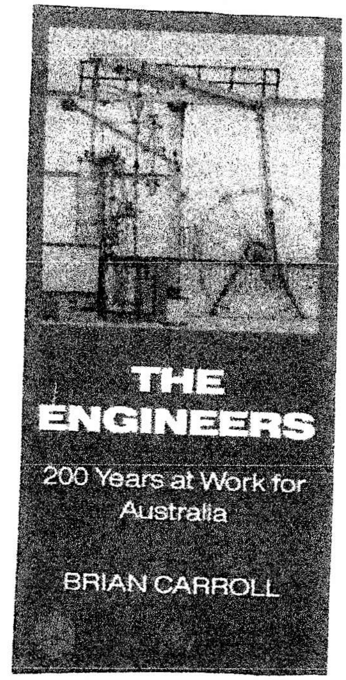
One of George Chaffey's contributions while in Australia was the design and construction of an irrigation pump for Mildura. A triple expansion steam engine drove the centrifugal pumps. Critics said it would not work, but it did, and remained in operation from 1889 until 1955. It was later put on display at Rio Vista Park, Mildura.

George Chaffey's

irrigation pump, at

Mildura






Carroll's book

William remained at Mildura, persisted, went into the fruit farming business with his sons and, by 1919, was successful. He restored the Chaffeys' good name, and was elected Mildura's first mayor in 1920.

The Renmark farms were smaller and less affected by Mildura's problems.

**The Locomotive and the Dinner**

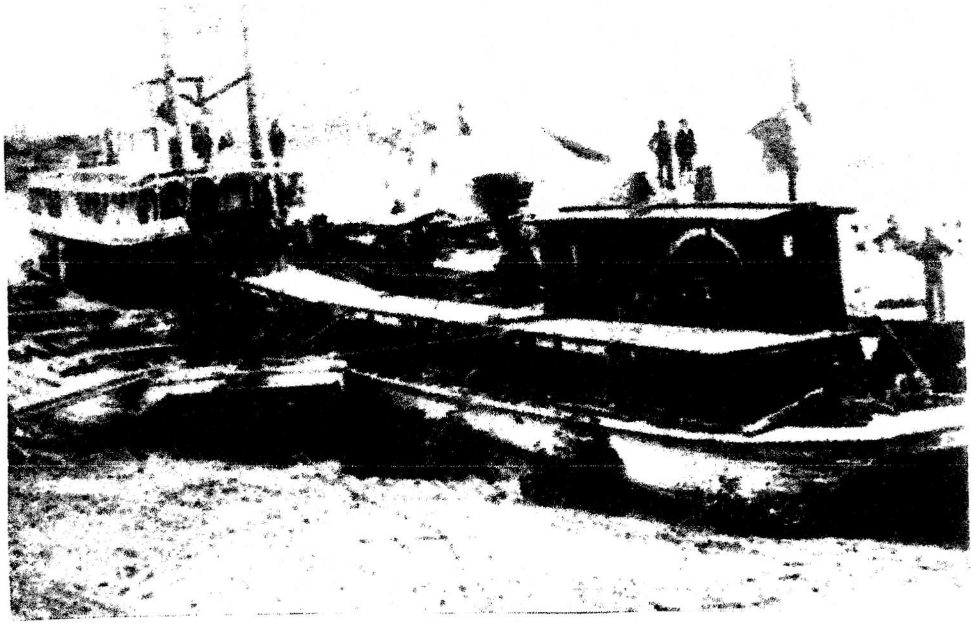
It isn't often that a dinner is held for a locomotive!

One was held on October 10, 2002, at the Fort Garry Hotel in Winnipeg to honour the 125$^{th}$ anniversary of the arrival of *The Lady in Black* in Manitoba. Properly known as *The Countess of Dufferin, The Lady* was the first locomotive to arrive in the Canadian Northwest.

Named by its first Canadian owner in honour of the wife of a Canadian Governor General, this wood-burning locomotive was built at a cost of around $10,000 in 1872 at the Baldwin Locomotive Works in Philadelphia. Owned initially by the Northern Pacific Railway, from 1872 until 1875, it operated in Minnesota and the Dakota Territories, but was sold for about half that amount to CPR contractor Joseph Whitehead in 1877 to help ease the NPR's financial problems. In October of that year *The Countess,* several flatcars and a caboose arrived on the Red River at Winnipeg by barge to become part of the new Pembina Branch of the CPR between the U.S. border at Emerson and Selkirk, north of Winnipeg.

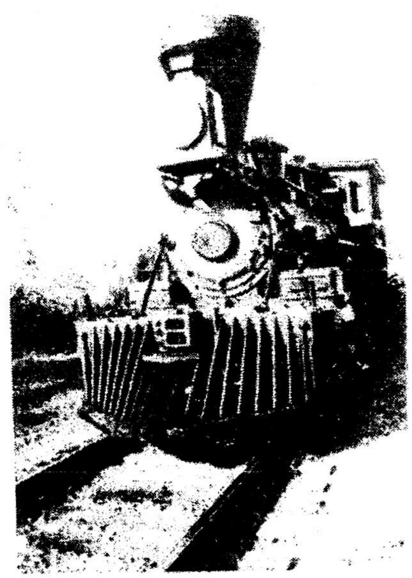
*The Countess* served in Northwestern Ontario and west from Winnipeg to the British Columbia interior between 1877 and 1907, ending its working life belonging to William Mackenzie and Donald Mann of the Canadian Northern Railway and working for a lumber company. It was found disassembled at the lumber yard by accident, apparently, in 1909. The city of Winnipeg decided to acquire it. However, one of the major shareholders of the CNR, which still owned the locomotive, donated it to the city. With the cooperation of the CPR, it was reassembled and put on open-air public display in 1910. In 1944 it was moved to another nearby location. But by 1970, it had suffered damage from the weather an vandals and was restored with the help of the Richardson family and again put on open-air display, until 1977 - its western centennial - when it was moved indoors again. In 1993, *The Countess* was put on display at the VIA Rail, Canada depot at Main and Broadway.

It is now located in the Winnipeg Railway Museum.



*The Countess* arriving at Winnipeg

by barge, 1877



Invitation to the dinner,

Winnipeg, 2002

The Lady in Black
125th Anniversary Dinner
October 10th, 2002
Fort Garry Hotel
Broadway at Fort
Winnipeg, Manitoba

**The History of Fluid Mechanics**

My source for information on this topic is a paper written by mechanical engineering professor K.C. Cheng of the University of Alberta that was originally delivered at an international conference in Hawaii in 1992. As Cheng notes:

> The modern theoretical and experimental results in fluid mechanics represent the products of long intellectual processes performed by pioneers and research workers, and the pursuit of new knowledge is still continuing today because of new applications, new environmental problems and many unsolved problems or existing flow phenomena which are still not well understood. With the availability of new experimental techniques and modern computers, one observes exponential growth in research efforts over the past several decades resulting in considerable progress and advances in fluid mechanics.

Speaking of computers, Cheng ends his paper around 1960 when what is now known as computational fluid dynamics (CFD) was just beginning. He starts with the period from 250 BC to roughly 1700 AD, from Archimedes to Newton, covering such developments as irrigation, windmills and sailing ships, Archimedes' principle and his screw pump, Hero's steam turbine, the work of da Vinci, Stevin's treatise on hydrostatics, Galileo's work with falling bodies, and the work of Torricelli, Pascal, von Guericke, Hooke, Boyle and Pitot.

The next period takes him from Newton's own work to that of Lagrange in the early 1800s. With regard to Newton, whose dates were 1643 to 1727, Cheng notes:

> One is impressed with the scope of fluid mechanics problems proposed by (him). (He) recognized the nature of resistance to fluid flow and developed his famous law of viscosity relating shear force or stress, viscosity, and relative motion of one layer of fluid adjacent to another layer.

Also included in this period are Euler's early work on sound and on the physics of air, on the fluid dynamics of gunnery and on the theory of the friction of fluids; D'Alembert's work on the theory of the resistance of fluids, the motion of rivers, and the general principals of the motion of fluids; the Euler and Lagrange researches on the propagation of sound; and Daniel Bernoulli's theorem. Cheng comments that the concept of fluid flow was applied to electricity, magnetism and heat in physics in the 18$^{th}$ century, and that Joseph Black proposed the concept of heat capacity in 1760 and discovered latent heat in 1761.

The next period involves the mid-late 19$^{th}$ century contributions to 'modern' fluid mechanics as well as to the solution of practical engineering problems, including the work of Navier and Stokes and the study of elasticity and viscosity in moving fluids, and the work of Fourier and Poisson, Venturi, Coulomb, Saint-Venat, Lilienthal, William and Robert Froude, Rayleigh and Kelvin, Clausius and James Clerk Maxwell, Kirchoff and Helmholtz.

Finally, there is Cheng's modern period - from 1900 to 1960, which he divided into four sub-periods:

low speed aerodynamics (1900-1935), including Prandtl's boundary layer theory and finite wing theory, and the work on turbulent flow by von Karman, Taylor and others;

aerothermodynamics (1935-1950), including subsonic to supersonic speeds, compressability and shock waves;

the physics of fluids (1950-1960), including dissociation, ionization, thermal radiation, magnetohydrodynamics, plasma and radiation gas dynamics; and

the new era of fluid dynamics (1960 onwards), including two-phase flow, heat transfer, rheology, superfluids and bio-fluid mechanics.

Cheng comments that, during the 20$^{th}$ century, the speed of aircraft increased from about 40 km/hr to Mach 3, and that the escape velocity of a rocket was about 11 km/second.

**The Gun Man and His Flying Machines**

Hiram Maxim was born in 1840, in Maine in the United States, but lived much of his life in Britain, and wound up with a knighthood. He had only a few years of schooling, was apprenticed to a carriage-maker, but became the chief engineer of the U.S. Electric Lighting Company with no formal training in engineering. He represented this company at the Paris International Exposition of 1881. He was a prolific inventor, inventing (in 1885) a machine gun that stored and re-used its recoil energy and was both automatic and fully portable. He patented the gun, and started a company to make it...and his fortune. Among his other patented inventions was a mousetrap.

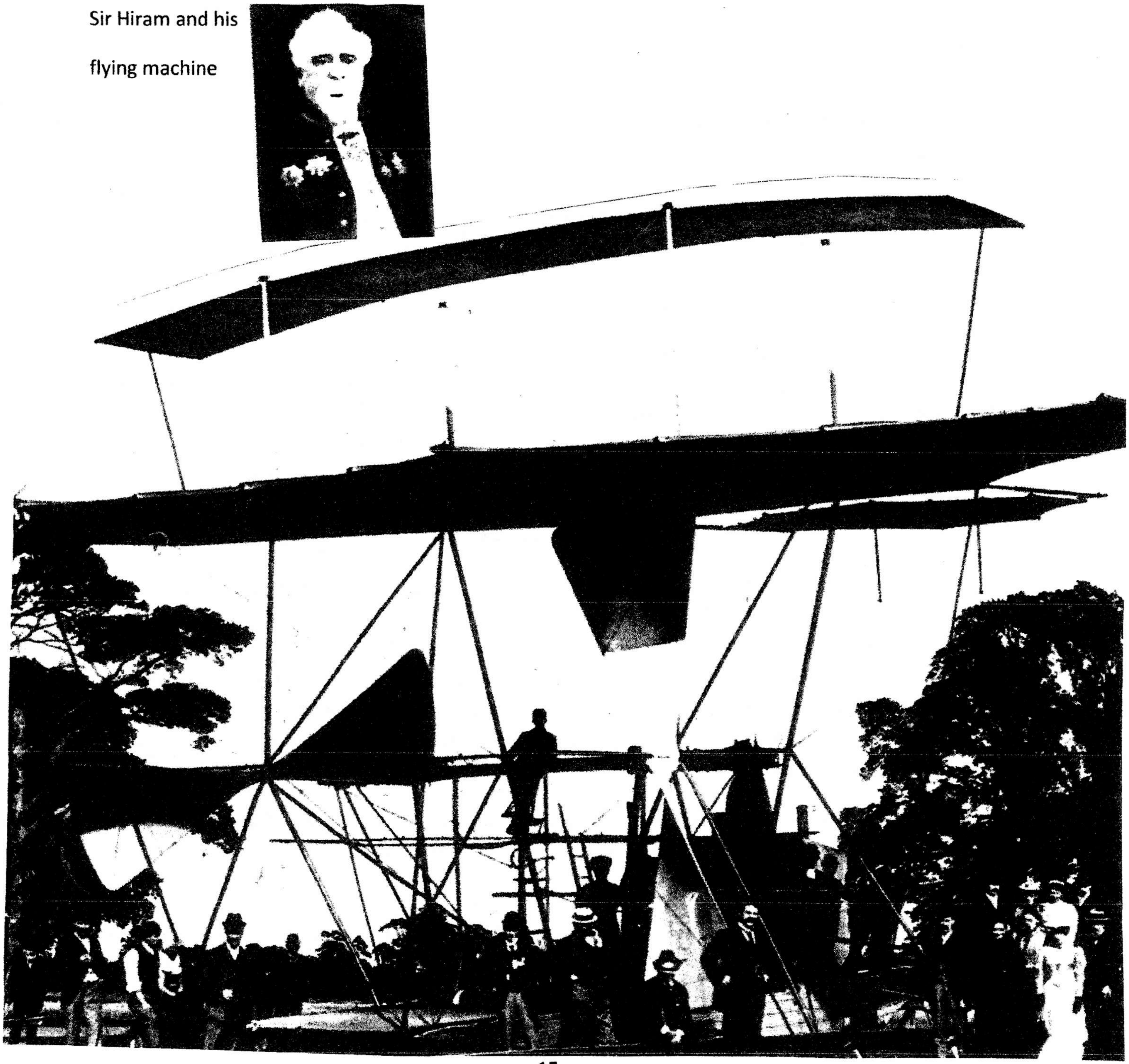
The income from the gun, which both sides used in World War I, allowed him to devote time to activities that interested him particularly - like heavier-than-air flying machines. He developed plans in the 1870s for helicopters but, unfortunately, the engines available to power them were unequal to the task. He also tested aerofoil sections and propeller designs. In his view, while birds used their wings for both, in flying machines these two functions should be separated...wings to produce lift and propellers to provide propulsion.

His first flying machine, however, had wings. In the late 1880s-early 1890s he built this machine. It was 40 feet long, with a wingspan of 100 feet, weighed around 3.5 tons, and was powered by two 180 hp steam engines, which turned two large propellers. It was not intended to fly. It was essentially a wheeled platform that ran along a 1,800-foot rail track and had outriggers fitted to prevent take-off. However, this was not fully effective and initially some track was pulled up. The first test 'flight' in 1894 had to be aborted to prevent a disaster. But things settled down. Visitors came to see the machine and, perhaps, to ride on it.

Maxim subsequently abandoned his experiments with this machine. Instead, he designed another as a revenue-generating amusement park ride for the Earl's Court Exhibition of 1904, which doubled as an experimental apparatus. It consisted of a large spinning frame from which cars were hung. As the frame spun, the cars swung outwards through the air in imitation of flight. Several versions were built for other fairgrounds. Similar machines are still in use in midways today.

Sir Hiram and his

flying machine



**Competition for the CSCE**

I would guess that few of you have heard of the Dominion Institute of Amalgamated Engineering, the DIAE. It existed in Canada for a few years at the turn of the 20th century. My own awareness of it is due to the research of Larry McNally, retired science and engineering archivist of Library and Archives Canada.

Back then, the engineering profession was embroiled in a debate over the recognition of professional competence and status, which had actually been initiated by Alan MacDougall at the time of the founding of the Canadian Society of Civil Engineers in 1887. Some ten or so years later, the debate was back in full swing. On the logic that the BNA Act allocated responsibility for the professions to the provinces, the CSCE - with its federal charter - was deemed not to be the organization to have charge of what amounted to the licencing of engineers. Accordingly, three provinces, Ontario, Québec and Manitoba, with CSCE support, devised legislation to accomplish this. None was ever passed in Ontario. It was, in the other two provinces, but was not enacted.

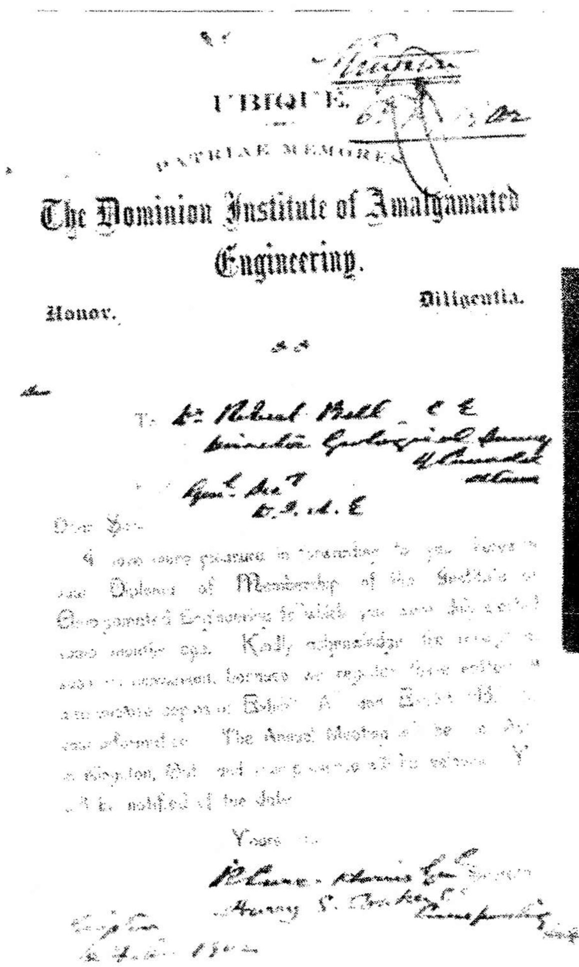
As well, by the century's turn, some members of the CSCE, and some who could not achieve election to it, became suspicious of the undue influence of the headquarters city members in Montréal on Society affairs, including elections to membership. So, in 1898, the DIAE was formed to act as a counterweight to the CSCE, with fewer restrictions on membership. It described itself as "an organization of engineers of every kind of engineering, having for its objects the treatment of all engineering matters with an enlightenment liberality consistent with the spirit of the age." It also became a focal point of opposition to the CSCE's support for the provincial legislative proposals, called the 'close incorporation' bills.

A very small number of CSCE members joined DIAE, led by Sir Sandford Fleming, who had expressed concerns about CSCE and had only joined it a few years previously, and by Sir Cornelius Van Horne, who was not an engineer but was an associate member of the civil engineers' Society. The DIAE's leader appears to have been its general secretary, Professor Robert Carr-Harris of the Department of Mining at Queen's University. One membership list I have seen includes only a dozen names, including Fleming and Van Horne. Another has around 160, including quite a few who were obviously not professional engineers. DIAE, when asked, claimed to have a much larger membership.

For several years I had in my archives the DIAE membership certificate for William Thompson, a transportation engineer, but it was eventually claimed by a member of his family.

The DIAE probably disappeared around 1906. By 1918, after a war that had changed much about engineering in Canada, the CSCE had also changed. It became the Engineering Institute of Canada and, as a result of a paper by F.H. Peters and the report of a committee chaired by C.E.W. Dowdswell, a Model Law for provincial control of the licensing of engineers was proposed. And so the provincial associations were born.

Example of DIAE letterhead, and inset of Sir Sandford Fleming


UBIQUE.

PATRIAE MEMORES

The Dominion Institute of Amalgamated Engineering.

Honor. Diligentia.

**Baldwin…and Bell**

Frederick Walker (Casey) Baldwin was born in January 1882, the grandson of Robert Baldwin who, with Hippolite Lafontaine, led the Reform Ministry in the United Provinces of Canada in the 1840s. Casey graduated with a diploma in mechanical and electrical engineering from the SPS at the University of Toronto in 1906, following a distinguished athletic career at the University. Visiting the Bell estate and laboratory at Baddeck, Nova Scotia, that summer with fellow student J.A.D. (Douglas) McCurdy, he met Alexander Graham Bell and went to work for him at the laboratory in the fall of that same year. Indeed, he and McCurdy were also colleagues there from 1907, when McCurdy graduated, until 1915, when he went back to establish an aviation school in Toronto.

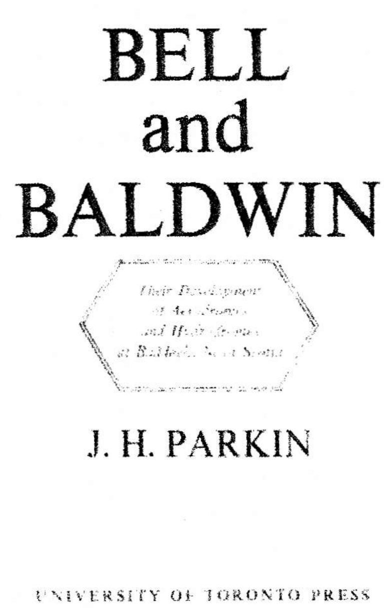
Baldwin never left Baddeck. His career has been described in considerable detail by J.H. Parkin, himself a Canadian aviation pioneer, in his long book *Bell and Baldwin* published in 1964 by the UofT Press. The remarks I wish to make about Baldwin's career are based principally on material in this book.

The Bell laboratory at Beinn Bhreagh was established in the 1890s and was concerned principally with the study of kites, although the eventual aim was to have a man fly in an engine-driven machine. Bell's experience with the telephone and the business of patenting it also led to his insistence that detailed records of the Baddeck work should be kept. Baldwin, and McCurdy, also contributed special papers on elements of their research from time to time. Hence the enormous detail available in Parkin's book!

It should be noted that Bell contributed more than prestige to the work at Beinn Bhreagh. As Parkin writes in his *Preface*:

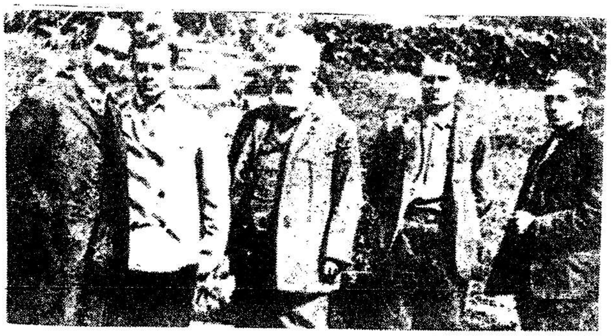
> Dr. Bell, the elderly scientist, and Baldwin, the young engineer, complemented each other to constitute a singularly effective team. Baldwin acted as a foil to Bell's active brain, and his sound, down-to-earth, practical approach served to bring some of Bell's more exuberant proposals within the range of achievement...
>
> ...Certainly, theirs was an association of a rare kind, and from it and in it came the dawn of Canadian aviation...
>
> ...Unselfish and self-effacing, he (Baldwin) resisted Dr. Bell's attempts to thrust him into the foreground...

When he first joined the Bell team at Beinn Bhreagh, Baldwin worked mostly on experiments with tetrahedral cell kites. Then in October 1907, Dr. Bell - with financial support from his wife - formed the Aerial Experimental Association (AEA) which bound together the Canadian-American team of young aviation enthusiasts around him. Bell served as its chairman, Baldwin as the chief engineer, McCurdy as the treasurer and assistant engineer, Lieut. Thomas Selfridge of the U.S. Army as secretary, and Glenn H. Curtiss, a motorcycle manufacturer from Hammondsport, New York, as the 'director of experiments' but, in reality, as the engineer principally responsible for the engine side of the experiments.




F.W. (Casey)

Baldwin



Curtiss, Baldwin, Bell, Selfridge, McCurdy: the AEA... ...Ms. Bell

Based on contemporary knowledge of flying machines that had been built or proposed, each member of the team (except Dr. Bell) then took responsibility for the design and trials of an 'aerodrome' which was the name Bell used to describe a powered, heavier-than-air aircraft. Selfridge's *Red Wing* biplane, with a 44-foot wing span, and 6-cylinder air-cooled V engine and a pusher propeller, was the first. Work on it began at Hammondsport in January 1908 and was completed two months later. It was test flown, off ice on Lake Keuka, just over 300 feet, by Baldwin on 12 March. He therefore made the first *public* flight (the Wrights' had been private) in a heavier-than-air machine in America and was the first Canadian to fly in one. Baldwin flew the *Red Wing* again on 17 March, but crashed. He was not hurt.

The second AEA plane was Baldwin's *White Wing*. Also a Hammondsport product, it was slightly smaller than its predecessor, but had the same engine and a pusher propeller and a steerable tricycle undercarriage. It was first flown on 14 May, 1908, by Selfridge, from a race track, not the lake. Selfridge flew it again on 17 May, but problems were showing up. On 18 May, Baldwin himself flew it 300 feet, 10 feet off the ground. Selfridge made two more flights the next day and Curtiss flew it on 21 May. McCurdy made the last *White Wing* flight. It crashed, but McCurdy was not injured.

Baldwin's *White Wing*

Undamaged parts of *White Wing* were salvaged for the next plane...which was Curtiss' *June Bug.* About the same size as Baldwin's, and with the same engine and pusher propeller, work on the *June Bug* began on 24 May at Hammondsport and was completed four weeks later. It made the first of over 50 flights on 21 June, on land, some with Curtiss as pilot, most with McCurdy, and a few by Selfridge. Baldwin never did fly it. Strangely, the main problem with this plane was engine overheating - a problem that would recur with later machines.

The fourth machine, McCurdy's *Silver Dart,* was also built at Hammondsport. Work began on 10 July 1908 and was completed by 31 October. It was larger than the other three, had a larger engine that was water-cooled. It was flown by McCurdy several times at Hammondsport in December 1908. It was then transported to Baddeck, to fly off ice, and to establish McCurdy as the first Canadian to fly a powered aircraft in Canada, if not also the first citizen to do so in the British Empire. It made around 30 flights at Baddeck, Baldwin flying four of them. In August 1908 the *Silver Dart* crashed when on military trials at Petawawa.

Before the AEA was dissolved, Bell and Baldwin became involved in experiments with hydrofoils, aimed at getting a man, in a powered vehicle, into the air from the surface of the water.

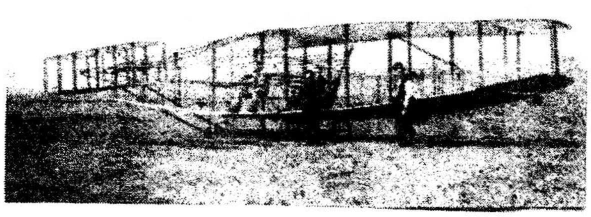
The life of the AEA was originally to be one year. However, it was extended to 18 months, with Mrs. Bell's continued financial support, and was finally dissolved on 31 March, 1909. Selfridge had been killed in an accident - flying with Orville Wright - on 17 September, 1908, at Fort Myers, Virginia and was the first U.S. Army officer to die in a heavier-than-air aircraft accident. His father represented him at the dissolution. At that time, Dr. Bell took title to the surviving assets and paid the debts of the Association. The *June Bug* and equipment associated with it was given to Curtiss.

When the AEA dissolved, the Beinn Bhreagh laboratory went back to the design, construction and testing of a variety of kites, its objective being to build one that would be stable, controllable, powered and carry a man...and eventually would become an 'aerodrome.'

Meanwhile, and in addition to their work in the laboratory, Bell offered Baldwin and McCurdy the opportunity to design and build aircraft, based on the *Silver Dart*, for possible sale to the Canadian and other governments. As a result, the two engineers formed the Canadian Aerodrome Company, based in Baddeck. CAC was possibly the first commercial enterprise in the British Empire to design and manufacture its own aircraft.

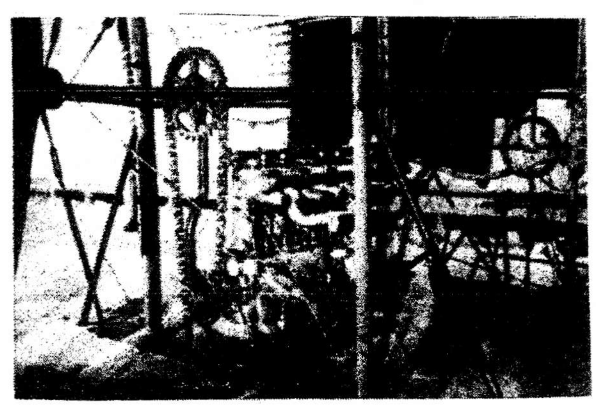
So the *Baddeck No. 1* was started in May 1909 and completed in July. It was a biplane, had a Kirkham water-cooled pusher engine and propeller and a wheeled undercarriage. McCurdy flew it at Petawawa on 12 August 1909. McCurdy was also the pilot when it crashed at Montréal in June 1910.

The *Baddeck No. 2* was also started in May 1909 and was completed in September. It flew many times, between then and June 1910, from land and from ice, at Baddeck. McCurdy was often the pilot, Baldwin on occasions. Take-off from water was also attempted, unsuccessfully, in June 1910.



*Baddeck II and*

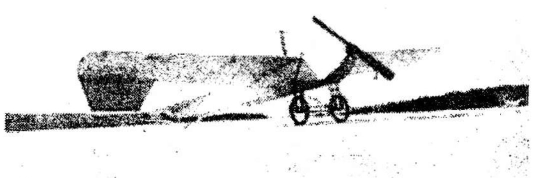
*its engine*



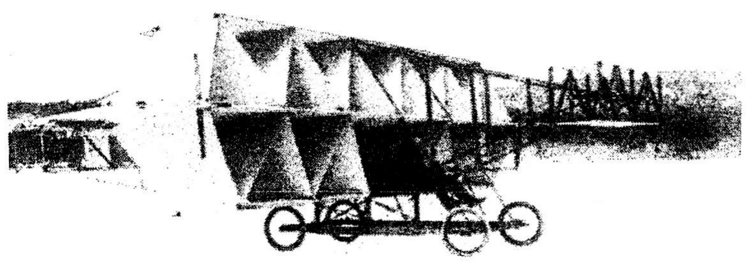
A third aeroplane, a monoplane on the Blériot model called the *Hubbard,* was commissioned from the CAC by G.G. Hubbard II and built. It was designed by Baldwin. It also had a Kirkham engine, mounted inside the nose of its body, and flap ailerons. It was built mostly during January-March 1910. Several trial runs on ice were attempted with Hubbard as pilot. It flew several times in early April 1910, raised clear of the ice several times for a few seconds each time, but crashed on the last one and was damaged. There is no record of it having flown again.

The CAC was dissolved later in 1910. Thereafter Bell, Baldwin and McCurdy again turned their attention to hydrofoils and hydroplanes. Throughout his life, Baldwin was an enthusiastic and knowledgeable yachtsman, designing and sailing yachts, winning races, and applying his sailing experience to hydrofoils, hydroplanes and other sea-related machines associated with his aeronautical work.

The Bell-Baldwin kite/hydrofoil/hydroplane work from 1909 to 1922 centred around Bell's unsuccessful attempts to transform tetrahedral cell kites into powered flying machines, or *aerodromes*, that could carry a man, and Baldwin's more successful attempts to develop water-borne hydrofoils and hydroplanes. It was during this period that Baldwin designed, built and ran the famous HD-4 *hydrodrome* that set, in 1919 and retained for many years, the international marine speed record of 71 mph. During World War I, the laboratory at Beinn Bhreagh began building boats of various kinds in support of wartime activities but also for peaceful purposes, and for Dr. Bell!

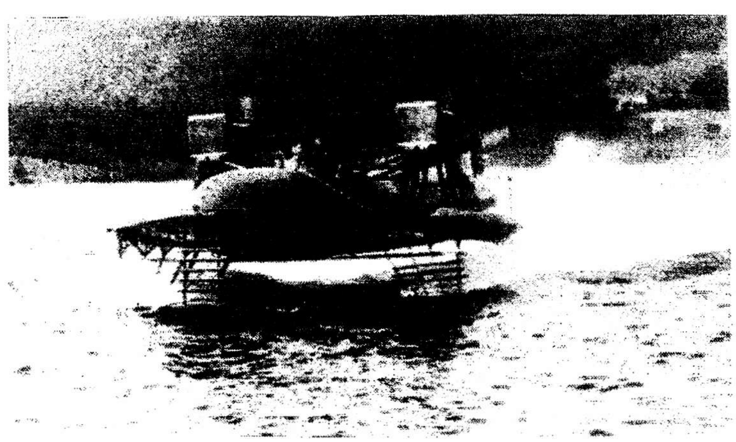


Baldwin's *Hubbard*



Bell's powered, man-carrying tetrahedral 'aerodrome'

HD-4 hydrofoil, holder of the world water speed record



Also, during World War I, McCurdy's vision problems grounded him. However, in 1915 he established the first aviation school in Canada, at Toronto, which he operated until 1919. In 1928 he established the Reid Aircraft Company in Montreal, and was its president.

Alexander Graham Bell died in August 1922, Mrs. Bell five months later. For some 16 years after graduating from the SPS, Baldwin had lived at Beinn Bhreagh and worked in close association with Dr. Bell. Consequently, Bell's death had a profound effect on him. But Casey, like Bell, was an amateur among professionals when it came to the *business* of aviation. As a result, he was blamed for commercial failures that were not his fault. From 1922 until the 1940s, Baldwin managed the laboratory and related work at Beinn Bhreagh and Baddeck.

Parkin notes that the idea of a target for naval gunnery practice carried on hydrofoils occurred to Baldwin during the early HD work and, in September 1920 work began on a 100-foot towing target, based on Bell's tetrahedral cell structure. Work on these targets continued until 1924. Work on improved designs for them began again in 1940 and lasted for several years.

In 1933 Baldwin had run for political office, winning the Victoria County seat in the Nova Scotia Legislature. He was defeated four years later and left politics.

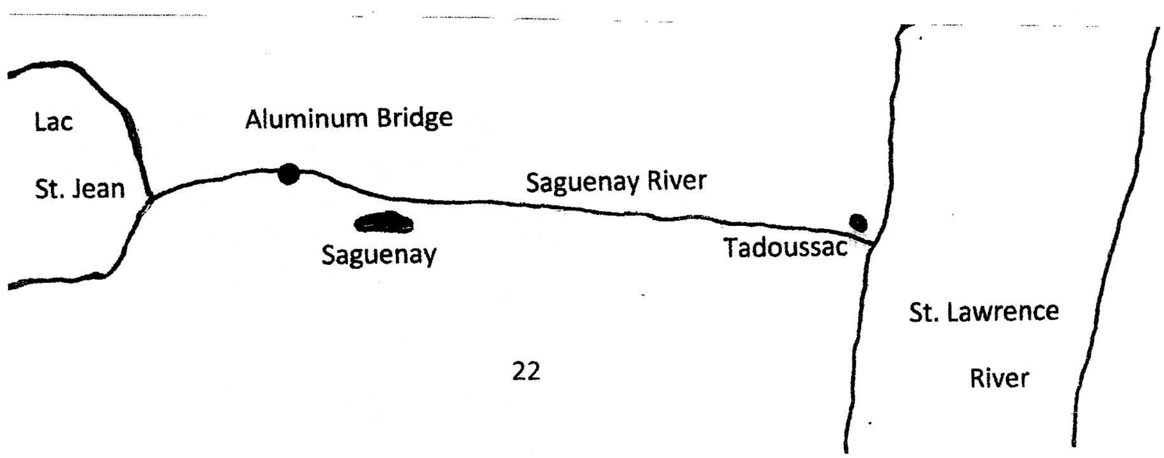
During World War II, Douglas McCurdy was a senior executive responsible for aircraft production. In 1947 he was appointed Lieutenant Governor of Nova Scotia. He died in 1961.

Casey Baldwin died at Beinn Bhreagh in August 1948 at the age of 66.

**The Aluminum Bridge**

While I have visited, and photographed this bridge, the seminal paper on it was written by Hugh McQueen and published by the Canadian Institute of Mining, Metallurgy and Petroleum.

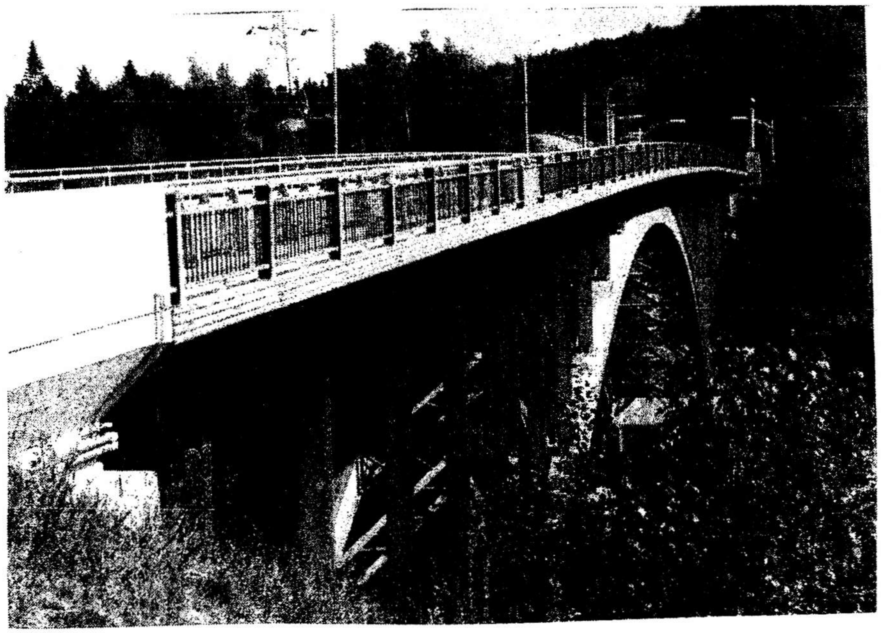
The Arvida aluminum alloy circular arch road bridge, with the deck above the arch, was built between 1949 and 1950 to connect the town of Arvida with the hydro-electric power plant and suburb at Shipshaw. The bridge crosses the Saguenay River after it exits from Lac Saint Jean. The bridge is just over 500 feet long, and the arch span 310 feet. The deck is 36 feet wide, slopes 5 degrees over its length, and is 110 feet above the valley. Its weight was half of that of a comparable steel bridge.



Work on the research, design and construction for the bridge began during World War II at the Alcoa Laboratories and was stimulated by the successful use of aluminum alloys in the construction of wartime aircraft. Alcan brought the Dominion Bridge Company into the design process. A steel as well as an aluminum bridge was proposed. The latter was chosen. Component parts for the bridge were fabricated by Dominion Bridge. Erection was by Pic Construction of Jonquiére, with supervision by SNC. The only steel used attached the bridge to its concrete footings.

Arvida

Bridge



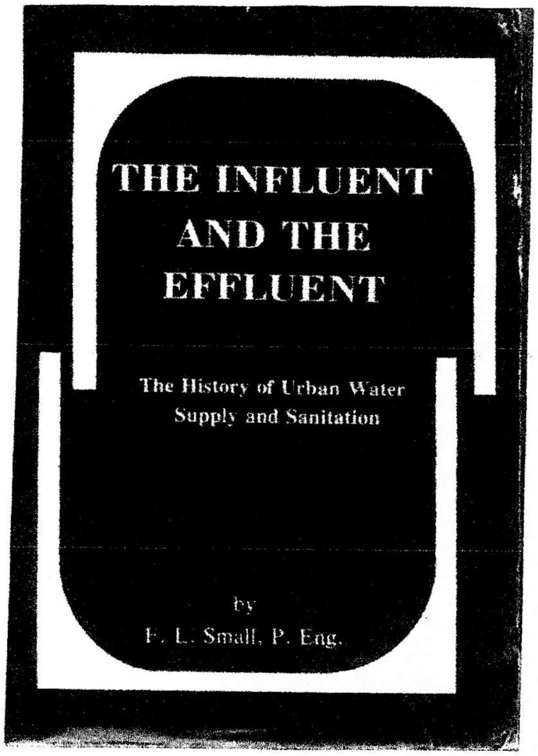
In his paper, McQueen summarises in part:

> The aluminum arch bridge across the Saguenay has served effectively with a grand appearance for over half a century. The careful transfer of design and techniques from steel to precipitation hardening Al-Cu-Mg alloys was totally successful. Rapid hot riveting in the shop and cold riveting with annular heads were carried out efficiently; saw cutting and rivet hole drilling, with cooling lubricant, were easily performed. Unfortunately, it is not clear that these techniques are suitable for the future in competition with the welding of bridge steels with strength much greater than in 1950.

A few other aluminum bridges were built at the same time as the Arvida one, and all were very much smaller. Since then, only a handful have been built, mostly in Europe.

The Arvida bridge was commemorated by the Canadian Society for Civil Engineering as a national historic civil engineering site in 2005.

**The Influent and the Effluent**




A book with this title, written by consulting engineer Fred L. Small, was published by his employers, Underwood McLellan and Associates of Winnipeg, in 1974. It is a history of urbanized water supply and sanitation, an unusual subject even for a technical book, but unusual also because the author was then blind. A 1932 graduate in civil engineering from the University of Saskatchewan, Small spent his entire career with this Prairie firm, serving as president from 1955 to 1961, when his failed eyesight forced him to step down. However, using Braille, he continued to serve as administrative assistant to the president until 1972, retiring the following year. Effectively, he had 40 years experience in the field covered by his book, and he supplemented this with extensive historical research.

The book traces the course of urbanization (cities), public water supply engineering (influent) and public sanitation engineering (effluent) from Neolithic times to 500 AD, through the Middle Ages (500 AD to 1500 AD), to the Modern Era (since 1500 AD). The coverage is international and wide-ranging. All three subject areas and the first time period are dominated by Rome, although cities in Greece, the Middle East, China, India and the Americas are covered. *North* America is not underrepresented. In addition to references in the main text, several of its largest cities, including Toronto and Montréal, receive special attention in two appendices. There are many technical descriptions and explanatory drawings in the book.

Let me summarize the contents very briefly by quoting from the concluding chapters of each of the three subject areas, remembering that the author was not able to include developments, both good and bad, that have taken place over the past 40 years.

With regard to urbanization...

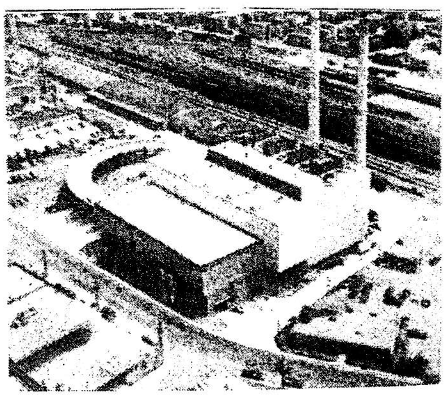
> The progressive urbanization of a rapidly expanding world population has produced serious urban environmental problems of housing, transportation, water supply, sanitation, air and water pollution. Housing accommodation is a major deficiency in all large cities, especially in the older industrialized cities, and perhaps most of all in the rapidly growing cities of the developing nations...

With regard to water supplies...

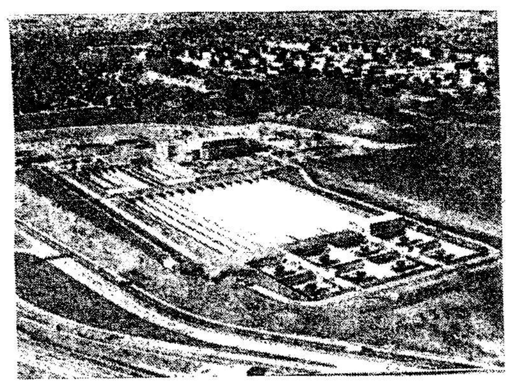
> The treatment of public water supplies is becoming increasingly complex and difficult as urbanization and industrialization continue to pollute the world's water sources with ever-increasing kinds and volumes of contamination. The scientific research and study which made possible the present advanced state of water treatment technology will undoubtedly have to be extended and intensified in the future if the world's urban population is to continue to enjoy the benefits of adequate supplies of potable water.

With regard to sanitation...

> Over the past hundred years, a variety of processes and practices have been employed for the handling and disposal of solid wastes in Europe and America, but incineration and sanitary landfill are still the most widely used methods. As yet, however, there is no one disposal method which is entirely satisfactory, from the standpoint of sanitation, conservation and economy.



Montréal incinerator



Toronto sewage plant

**Tucker and his Torpedo**

Who has heard of Preston Tucker and his car? Who has seen the 1988 biopic, with Jeff Bridges in the title role, directed by Francis Ford Coppola? I have unearthed two articles on the man and his car: one from the Scripps Howard News Service, published by the Ottawa *Citizen* in September 1, 1988; and the other by Bill Vance from the May 12, 2000, edition of the same newspaper.

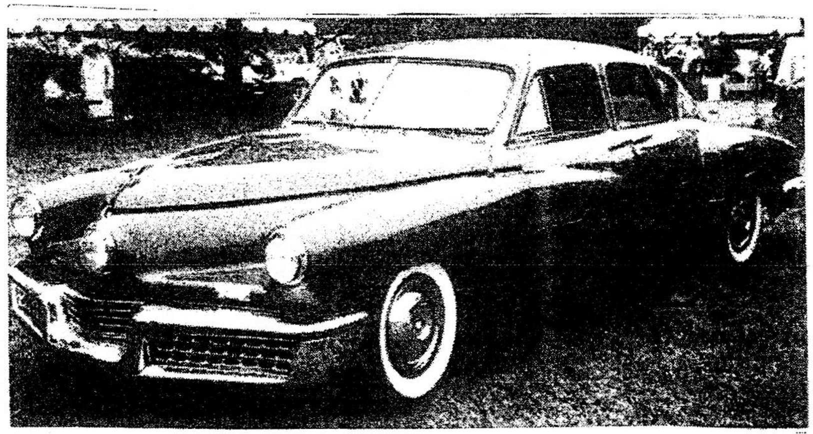
Basically, after the Depression and World War II, American entrepreneur Preston Tucker wanted to design, build and sell a new kind of car that incorporated the latest in automotive engineering, with appearance, performance and attractive cost. Opinion appears to be divided on the technical and marketing aspects of Tucker's vehicle, the Tucker *Torpedo,* and later the Tucker 48 - which he himself called 'the car of tomorrow.'

Tucker grew up around Detroit, worked for a time as a car salesman and was a race car fan. During the war, his company made gun turrets, the only part of the combat car he had developed in which the Army was interested. His large, low, six-passenger sedan originally had many technical features new to the auto industry: a powerful six-cylinder, 150 hp engine mounted over the rear wheels; a four-wheel independent suspension, disc brakes, a padded dash, and a 'cyclops' headlight that turned with the steering wheel. Apparently, he also wanted (but didn't get) automatic transmission, seat belts and fuel injection.

Blame for Tucker's failure to exploit his new car has been variously assigned...for example: to the opposition/jealousy of the Big Three automakers; his inability to raise the necessary capital to produce his car in quantity - only 51 were ever made; and to divided opinion on its technical merits.

The Tucker

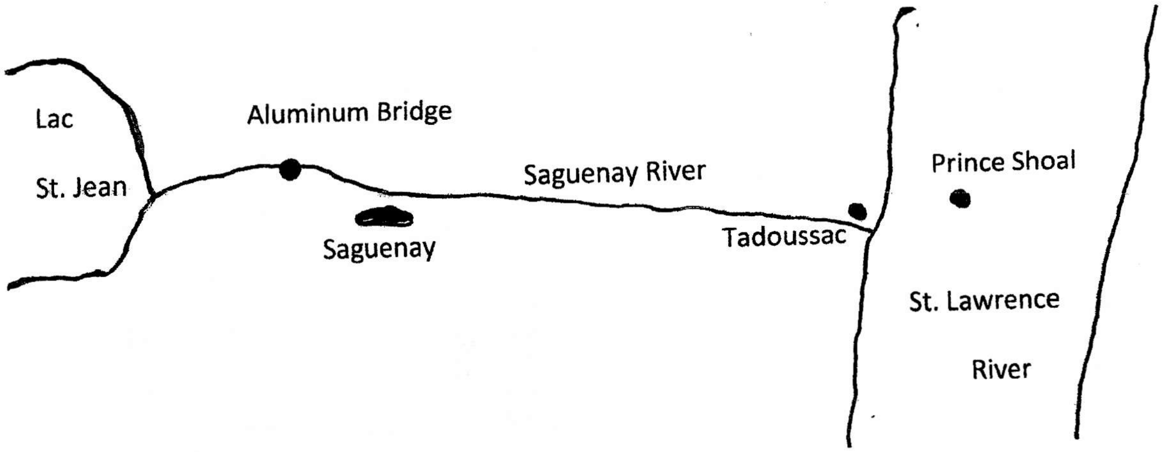
*Torpedo*



**The Prince and the Lighthouse**

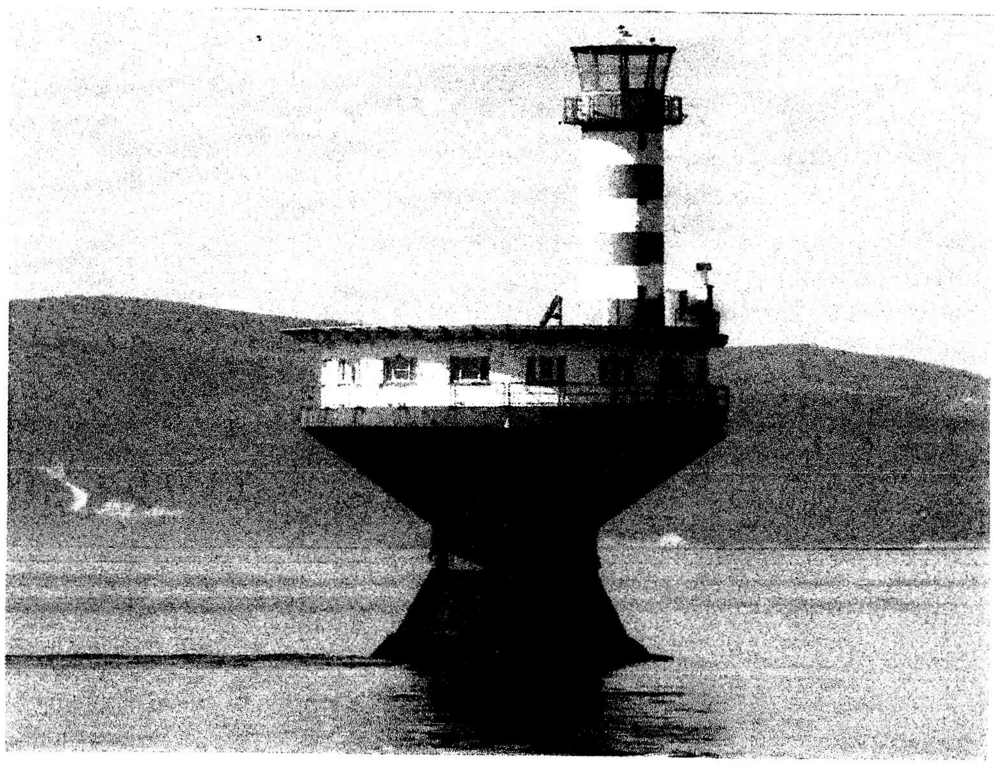
In 1860, the Prince of Wales (later King Edward VII) opened the Victoria Bridge, the first structure to span the St. Lawrence at Montréal. Substituting for his Mother, the Queen, who had been invited to open the bridge, he gave it her name rather than his own. This went, instead, to one of the most dangerous shoals in the lower St. Lawrence, the one opposite Tadoussac and the mouth of the Saguenay River. On his way to Montréal, the Prince's ship ran aground on the shoal. It was named after him.

A Prince Shoal Lightship Station was established there in 1905 to warn passing vessels of the undersea hazard in the area, replacing the buoy that had been marking it. The Station was replaced by another in 1956 and, in 1963, by an hour-glass-shaped, caisson-based structure, built at the Champlain Drydock at Lévis, Québec. Four tugboats pulled the structure the 105 miles down-river to its destination. When the tide was right, the caisson valves were opened and the structure was allowed to sink on to a specially-built foundation on the riverbed. Crushed rock was then fed into the caisson, replacing the water. Concrete was then poured in on top of the rock and sheet piling added around the caisson for added



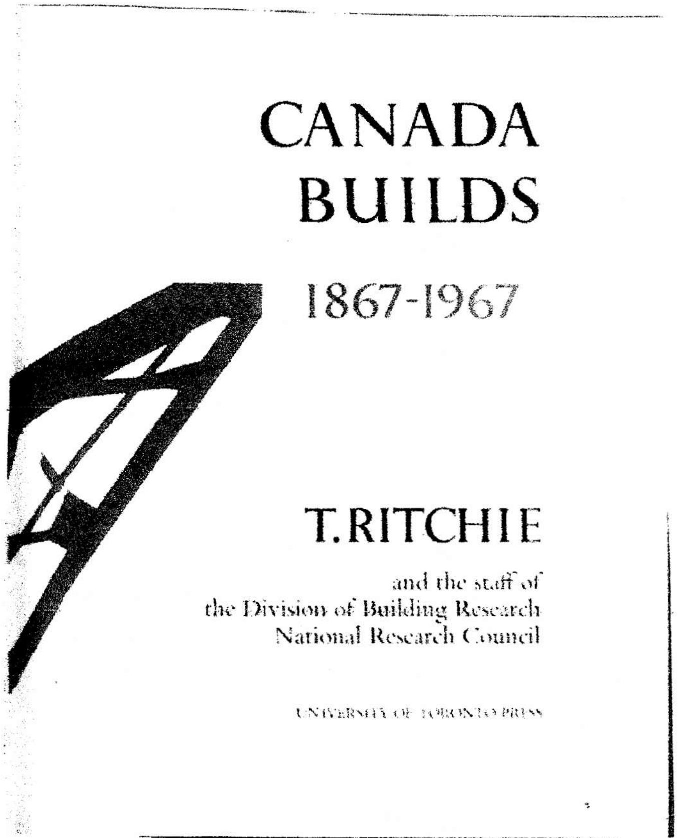

protection. In 1964 the upper circular section, housing the equipment rooms and living quarters, was completed above the caisson. Finally, a 39-foot high and 12-foot diameter tower and a helipad were added. The slope of the lower cone helped break up spring ice. The slope of the upper one helped disperse the energy of waves striking the structure, which was designed to withstand the 25-foot variety. The lighthouse can be accessed from the helipad or through doors in the narrow part of the structure, which was rebuilt in 2002.

The Prince Shoal Lighthouse in 2015



**Tom Rtchie and his Buildings**

Tom Ritchie was a professional engineer in the Division of Building Research at the National Research Council for many years. One of his particular skills was writing technical descriptions in language suited for general understanding. He was also interested in engineering history, and in particular the


CANADA BUILDS

1867-1967

T. RITCHIE

and the staff of
the Division of Building Research
National Research Council

UNIVERSITY OF TORONTO PRESS


Tom Ritchie

building/construction parts of it. So, in addition to the reports, brochures and pamphlets he wrote as part of his normal DBR work, he also wrote or co-wrote several books, one of which was *Canada Builds 1867-1967* - a Centennial project - published in 1967 by the University of Toronto Press.

The foreword to *Canada Builds* was written by Robert F. Legget, in 1967 the Director of DBR. He suggests that the book can only provide a 'glimpse' of the full story of building in Canada.

In 1867, the principal building material was wood but churches, public buildings and large houses were of usually of stone. Steam-driven shovels, pile drivers and rock drills were starting to appear, although most of the grunt work was still being done by men and horses. Public water supplies and garbage disposal were primitive and confined to the larger cities. Fires were a constant hazard and water to fight them not always available when needed. The national capital was now Ottawa and it was there that the most spectacular building complex had been put up - the Centre, East and West Blocks on Parliament Hill, with the Library following in 1877. Ritchie estimates that, around this time, there were 25 practicing architects in Montréal, 15 in Toronto and nine in Halifax. About winter construction, he notes that techniques had not yet been developed for working on buildings during the coldest months of the year. Only a few jobs, like stone-cutting, could proceed under cover during winter.

Ritchie goes farther back than 1867 to discuss each of the principal building materials. For wood, he begins with settlers' first cabins and notes that many of them adapted construction methods learned in their native countries. In then-settled Canada, however, this material was plentiful. As with most materials, the manufacture and use of wood changed. Square logs replaced round ones, several kinds of corner notching were used, and the connections between pieces became more complex. There were some very large wooden buildings put up. Large steam- and water-driven saws replaced manual ones. The wood-short Prairie provinces saw the building of many sod houses as 'first cabins'. More recently, plywood, fibreboard and laminates were developed and used in construction.

The use of stone is also traced back to the beginnings of settlement. The first stone of the Ursline Convent in Québec was laid in 1641, around the same time as the first limestone houses. The use of stone also meant the use of mortar, and that caused problems in both construction and appearance. The roofs were of wood and the panelling of inner walls were sometimes of it, as were many floors. The Scottish stone-building techniques and designs were also in evidence in 18th century settlements in Nova Scotia. Suffice it to say that stone masonry became more ornate and sophisticated with time, as the Parliament Building in Ottawa have demonstrated.

Clay bricks were used by French settlers for building chimneys and fireplaces at Ile de Sainte Croix on the Bay of Fundy around 1605 and continued after they had moved across the Bay to Port Royal the following year. Some bricks were eventually used in the Fundy settlements for the corners of buildings. They were, however, handmade and only about 1½ inches thick at this time. As the settlements spread up the St. Lawrence River, brickmaking followed. They were used for walls at Québec around 1674 and, along with stone, in the fort at Louisbourg some years later. However, they tended to be expensive and of poor quality.

With time, brickmaking spread to Nova Scotia and New Brunswick. The first Ontario brickyard was at Trenton, in the late 18th century. Brick was used for a few early buildings at York. Lime-based mortar was also used. Its production was a 'cottage' industry, and heavily labour-intensive. Technical advances in clay mixing and brickmaking in the 19th century led to processes powered by horses. As costs were reduced, more bricks were used in buildings.

Modern brickmaking is much changed from earlier days and brick usage has increased enormously.

John Smeaton and others re-invented Roman cement (pozzolana) in the 18th century. From this, modern concrete evolved from the addition of sand and stones. Ritchie notes that French military engineers were the first to use cement in Canada. A variety of cements were subsequently developed in Portland and natural cement plants. By the late 19th century, the manufacturing technology had also evolved.

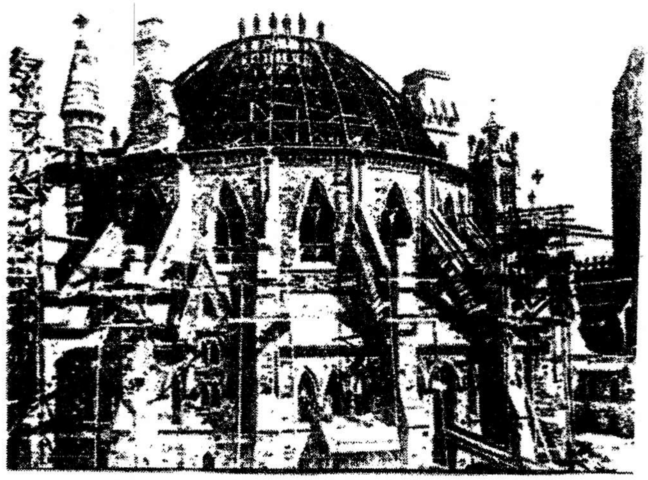
Concrete was used in the building of the foundations for the original Parliament Buildings in Ottawa. It was subsequently used in the construction of grain elevators in Montréal and by 1896 for building construction in Toronto and for sewer construction in Victoria, B.C.. Concrete block machines were developed around 1900. Machinery for the mixing of concrete in Canada also arrived with the 20th century. Transit mixers had appeared by the 1940s, but were not in general use until later.

Reinforced concrete building in Canada began in the early 1900s.

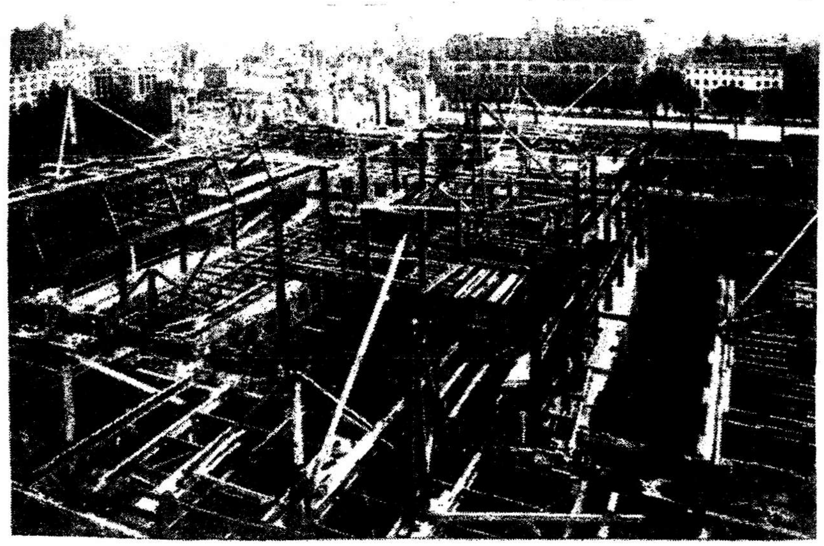
Iron production from bog ore in Canada began in the mid-18th century at Les Forges St. Maurice. Among its products were items such as stoves, nails, axeheads and kettles. Production at the Marmora mines in Ontario began in 1822. By the mid-19th century, the growth and production of the industry were benefitting from the development for products for railroads, bridges, agriculture, and for girders in buildings, such as (again) the Parliament Buildings in Ottawa.

Steel products were first manufactured commercially in the 1880s, notably at Hamilton and Sault Ste Marie, Ontario, and Sydney, Nova Scotia. Buildings having steel frames, instead of masonry, became taller. The Centre Block of Parliament, rebuilt after the 1916 fire, had a steel-frame structure. One advantage of using steel was that components could be prefabricated in a plant rather than made on-site. Welding, as opposed to riveting, also helped promote steel structures, as did bolting when it replaced welding. Exterior curtain walls replaced masonry ones. Nowadays, reinforced concrete can replace steel structures and provide many of the accessory elements in buildings, such as stairways, heating ducts and window frames.

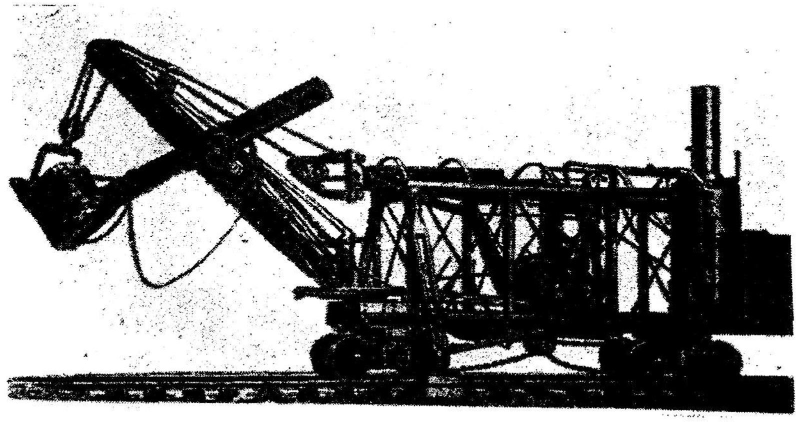
Building the Library of Parliament, Ottawa, 1877



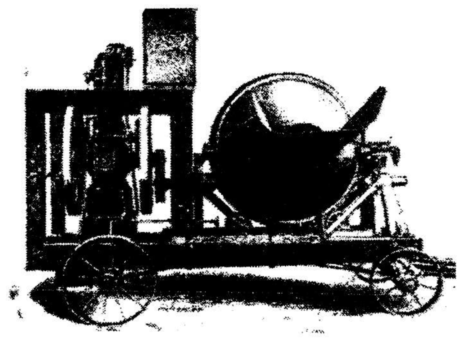
Rebuilding the Centre Block of the Parliament Buildings, Ottawa, 1917



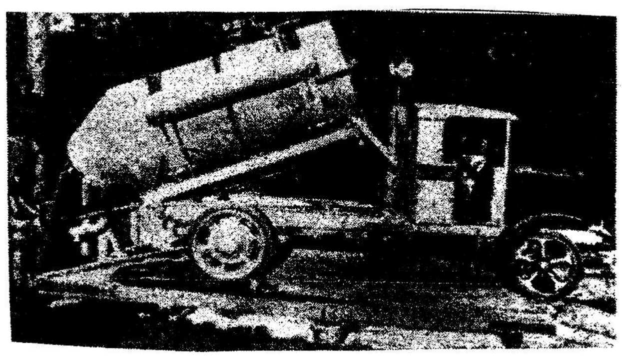
Early steam shovel



Early cement mixer



Early transit mixer



**Thank you for your kind attention...**

**Acknowledgement:** To the Ottawa branch of the Canadian Society of Senior Engineers for the opportunity to present material from this paper.

**Sources:** Most are identified in the text. Additional ones include:

Robert F. Legget: *Canals of Canada* (Douglas, David & Charles, Vancouver, 1976); and *Ottawa Waterway* (UofT Press, 1975)

David J. Harris: *Countess of Dufferin*, (Midwestern Rail Association, 2002)

Ed. Adam Hart-Davis: *Engineers* (Hiram Maxim, DK Publishing, New York, 2012)

Larry McNally: Private Communication re DIAE

Wikipedia: Ottawa River Canals; Chaffey Brothers; Hiram Maxim; Bell, Baldwin, McCurdy, AEA, CAC; Arvida Bridge; Prince Shoal lighthouse

**Photo Credits:**

Sources listed in text or Sources above: Petroski; Legget; Chaffey Brothers; *Dufferin* locomotive; Maxim; Baldwin, Bell and others, except AEA group; Small; Ritchie

Ottawa *Citizen*, July 15, 1991: Sandford Fleming

Ottawa *Citizen,* May 12, 2002: Tucker Torpedo;

Ottawa *Citizen,* October 15, 2014: Tom Ritchie

Wikipedia: William Chaffey; AEA group

Photographs by the Author: Grenville and Carillon; *Dufferin* Dinner Invitation; DIAE Letterhead; Saguenay River outlines; Arvida Bridge; Prince Shoal lighthouse

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