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"Engineering History: Recognize It?"

by Andrew H. Wilson
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Abstract

This paper was presented originally by the author to the Friday Luncheon Discussion Club of Ottawa on March 30, 2012. The version now printed has been slightly expanded from the original presentation. It does not, however, include the illustrations that were used during the talk.

The objects of this paper are to discuss very briefly the history of engineering world-wide, but with special reference to Canada, and to identify the sources that someone new to the subject of Canadian engineering history might find useful when pursuing it.

About this 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, a 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 over 25 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 served both CSME and the Engineering Institute of Canada in this capacity for varying periods of time until 2003. He has researched, written and edited historical material for both organizations, and is a past president of both.

In today's world, it is actually quite easy to recognize the results of engineering. As noted in a *Letter* published by the Royal Bank of Canada in 1986:

> We in the developed countries live in the realm of the engineer. From the moment we turn on the water in the morning until we turn off the lights at night, we are surrounded by engineered structures, systems, products and processes. They help to feed, clothe, shelter, transport, comfort and entertain us, and allow us to communicate invisibly with one another. No matter what we do for a living, much of our work is done with things made by engineers.

In practice, it is the *history* part that is more difficult.

When I speak of 'engineering' I am not speaking of technology or applied science, with which it is frequently confused. Technology and applied science are bodies of knowledge. Engineering is an activity, with visible results, which has several sub-activities such as design, development, production, manufacturing, research, consulting, building and construction, maintenance and operations. It also has at least two active partners: customers and financiers. It has a lot to do with experience, safety and the assessment of risk. From time to time elements of disfavour creep into the picture - for example, when there has been a serious accident involving something that has been engineered, or when the fruits of the military variety are used for destructive purposes.

As an activity, it is also a lot older than the use of the specific terms 'engineering' and 'engineers.' Its earliest manifestation was the discovery that some materials were harder than others and could be used to make tools and weapons of various kinds, which helped in the human struggle for survival. It progressed through the discovery that fire could be put to work to change the shape and composition of materials, make better weapons, and keep people warm. Our forebears also developed uses for wedges, levers and wheels. They learned to use oxen to draw ploughs, how to make sails for boats, and how to make glass. But change for them was slow and evolutionary.

Before 3000 BC, the Sumerians had drained the marshes along the lower Euphrates and irrigated drier land, and the Egyptians had begun to build their pyramids. Around 1400 BC the latter were cutting stones from quarries to make obelisks, principally for the decoration of temples. Some of these great stones wound up many centuries later being transported across the sea, to be re-erected in cities such as Rome, Paris, London and New York. Around 530 BC, Eupalinus built an aqueduct and water system, with a tunnel, for the city of Megara in Greece. Around 350 BC the Romans built the *Via Appia* and brought the first water to Rome by aqueduct from springs 16 km away. Sometime later the Greek, Archimedes, developed his screw pump and the Chinese invented cast iron. Around 260 BC they began to build their *Great Wall* and about a century later made the first paper. Around 100 BC the Romans discovered that possolana volcanic ash made excellent concrete that could even be used under water. During the first century BC they built the aqueduct and high bridge at Nimes, in France. During this century, also, Vitruvius - another Roman - wrote what is believed to be the earliest surviving book on engineering. In the first century AD, Emperor Vespasian ordered the construction of the Colosseum in Rome. The earliest known windmills were built in Persia around 600 AD.

Let me now jump to the Middle Ages, to the 11th to the 15th centuries, when living in Europe could be far from pleasant and the Black Death decimated the population. Engineering-wise, however, these were times in which some magnificent structures were built - principally fortresses and houses of worship - when metal cannon replaced catapults, and gunpowder could be used to propel their missiles. These were the days of the master builders, who were both engineers and architects, of the earliest recognized military engineers, and of the development of the first water-driven mills, flying buttresses, large mechanical clocks, and printing.

Then came the Renaissance, which might even be regarded principally as an Italian phenomenon. It also coincided with the disappearance in Europe of slave labour and, in its place, the use of wind- and water-power, pulleys, gears and devices for sawing, grinding and mining. It was the time of da Vinci, who is usually considered to have been part-engineer, although his main talents in this regard were in descriptive design and model-building. Brunelleschi constructed the dome of the Cathedral at Florence, designed the Trinità Bridge and began the construction of the Pitti Palace. Michelangelo also did some engineering, while Galileo dabbled in theoretical mechanics. Pallidio may have designed the first effective trussed bridge. Marchi and Vauban built fortresses. Agricola wrote his famous book *De Re Metallica*. Ramelli wrote his book on machinery, and a treatise on hydraulics was written by the Dutchman, Simon Stevin. It was also the age of discovery when explorers, buccaneers and pirates sailed the oceans in search of new lands, new resources and easy booty, and when the transfer of engineering know-how from Europe to the Americas began.

It has been remarked that the first Canadian 'engineers' were the beavers, who built dams and lodges with underwater entrances. However, in real terms, the Aboriginal peoples were the first. In keeping with the rigours of survival in our climates, the need for food, and travel across long distances, they gave us the igloo, the snowshoe, the kayak, the canoe and the toggle-headed harpoon. They built dams and weirs to trap fish. But first they had to develop effective tools for chopping, cutting and sewing and to learn how to use fire. Later, they built stockades as protection against human and animal enemies.

When the Europeans began to arrive in Newfoundland and Eastern Canada in the 16th and 17th centuries they brought their own technologies with them. But the inland regions, especially, were vast wildernesses, replete with physical obstacles and with larger climatic variations than they had been accustomed to. So they still had to learn from the Aboriginal people and adapt the native technologies for their own use in order to survive. With their own and these external resources, they engineered dwellings and other buildings, as well as docks, wharves and fortifications. They introduced water-driven flour, saw and grist mills and the skills of the millwright, the mechanic and the shipwright. Rivers and lakes became their highways. Timber was felled and fish caught and exported back to Europe.

The next notable periods in the history of engineering are what I call *The Three Industrial Revolutions*. Between them, they bring us up to the present day.

The First Revolution lasted roughly from 1750 until 1850, and was dominated by the British. Its principal engineering achievements were the building and operation of canals, the use of steam and steam-driven engines, including those developed by Savery, Newcomen and Watt, the widespread use of iron, and the machine tools and other devices built by Maudslay, Nasmyth, Whitworth and others. The first use of term *civil engineer* - in contrast with the military one - dates from the late 18th century. John Smeaton is usually credited with being the first to use it. He was also the first to encourage engineers to hold evening meetings when the successes and failures of engineering were discussed. This led to the founding in England, in 1818, some years after Smeaton's death, of the Institution of Civil Engineers, which was followed in turn by the Institution of Mechanical Engineers in 1847. In the United States, the first professional engineering groups met under the auspices of the Franklin Institute in Philadelphia, founded in 1824. The American Civil Engineering Society followed in 1852.

France contributed significantly to the beginnings of formal education in engineering. Back in 1747 it had established *L'École Nationale des Ponts et Chausées*. As noted in the 1959 edition of *Encyclopaedia Britannica*:

> ...the graduates of this school were responsible for a rapid improvement in the art and science of bridge building in France but also in other countries, especially England, and were responsible also for advances in hydraulics and hydraulic engineering and other branches of civil engineering. It has been said that the French were the leaders of engineering in the 17th and 18th centuries.

This school was followed, in France in 1829, by *L'École Centrale des Arts et de Manufactures*. By then the French army had also developed special units with engineering roles.

In Britain, where practical training through the apprenticeship or pupil routes were held to be preferable, the first Regius Chair of Engineering was not established until 1845, at the University of Glasgow. Both the French and British systems influenced early American engineering training and education, and particularly at the first school - at West Point - in the early 19th century and at the first public institution to offer it - Rensselaer Polytechnic. Canada's early professional engineers were mostly trained in France, Britain or the United States. At first, and for most of the 19th century, those trained in Canada took the apprenticeship-pupilage routes. University-level education began very slowly and very modestly at the University of New Brunswick and McGill University in the 1850s.

The Canadian colonies almost missed participating in the first of the Industrial Revolutions. However, changes brought about by the Treaty of Paris led to different attitudes to trade and commerce. The American Revolution also brought settlers to Canada with new skills and enterprise. The freight canoe was developed to carry heavier loads, as were the York and Durham boats for the shallow rivers and lakes. To help clear more land faster for agriculture, horse- and ox-driven stone-boats and stump-pullers were developed. Later, as settlement spread westward, an agricultural machinery industry was born, the best-known name in these early years being Massey. The marshy land bordering the Bay of Fundy was drained using *aboiteaux* - locally-developed one-way sluice gates let into the dykes that held back the Bay's water. The first steamboat for the St. Lawrence trade – the *Accommodation* – was built for John Molson. Canal-building began with the Schubenacadie, in Nova Scotia, and the first Lachine, Welland and Sault Ste Marie Canals and the Rideau, in Québec and Ontario. The first railway ran from La Prairie on the St. Lawrence to St. Jean-sur-Richelieu. The first train to travel this route did so on 21 July 1836, at an average speed of 14.5 miles-per-hour.

The Second Industrial Revolution lasted from around 1850 until around 1950 and included both World Wars. It was dominated at first by the British but, towards the end of the 19th century, dominance crossed the Atlantic to the United States. It began with the development and expansion of railroads and the increasing use of steel to replace iron. It gave birth to the steam turbine, the automobile and heavier-than-air aircraft, to large hydro-electric and fossil fuel generating plants, to large cities with extensive networks of streets, sewers and public transportation, and to the large-scale production of metals and chemicals. While the contributions to engineering of the two World Wars included a great deal that was warlike, they provided opportunities for the growth of manufacturing in Canada, and the years between them accelerated progress in areas such as transportation, communications and new kinds of chemicals. But they also included the Great Depression in Europe and North America, which slowed down technical progress and enterprise.

Canada was better able to participate in this Second Revolution. It had a growing number of engineers to get the work done.. It shared advances in the same fields as Britain and the United States, although not perhaps to the same extent. Let me mention just three aspects of engineering in this country during this period.

The first is the design and construction of a waterworks at Hamilton Ontario. In the 1850s, cholera outbreaks were common. One of the cities seriously affected was Hamilton. To improve citizens' health, provide pure drinking water as well as water for fighting fires, the city fathers decided that such a plant should be built. It was designed by Thomas C. Keefer, a celebrated name in Canadian engineering history. It drew a supply of water from out in Lake Ontario and pumped it up to a storage reservoir above the city. The main beam pumping engines were designed and built on the James Watt model by John Gartshore's company in nearby Ancaster.

The second concerns bridges. By the 1850s it was clear that a bridge was needed to carry the railroad directly across the St. Lawrence River to link Montréal with the East Coast. The original Victoria Bridge was built for this purpose. Another notable Canadian bridge was built downstream, at Quebec, around sixty years later. However, this one suffered two major mishaps during construction in which lives were lost. A wire cable suspension bridge was built for the Great Western Railway of Canada over the Niagara Gorge and opened in the 1860s. A bridge to carry the railroad over the Oldman River was built at Lethbridge, Alberta, and opened in 1908. It is one mile in length and over 300 feet high. The Broadway Bridge at Saskatoon was built as a relief project during the Depression. The Lion's Gate Bridge at Vancouver was built to link the city with the suburb of West Vancouver and was opened in 1938.

The third aspect illustrates how engineering can affect the daily routines of some members of society - in this case, in-shore fishermen in the Province of Nova Scotia. It was mentioned in a piece by Heather-Anne Getson that appeared in 1996 in the Mechanical Engineering Society's book *From Steam to Space*.

The introduction of small two-cycle gasoline engines - known as 'make-or-breaks' or 'putt-putts' - brought about the first major change in fishing methods that had lasted for a hundred years at least and turned the in-shore industry on its ear. Many of these engines were made locally. The nicknames, by the way, came from their ignition system. Around 1902, fishermen began buying them. So, instead of having to row his boat laboriously out to where the fish were, the fisherman putt-putted there in no time flat, did his fishing, returned to harbour in time to catch the early market and the best prices, and had the rest of the day in which to pursue an on-shore job. Also, the putt-putt had the reputation of being indestructible and might, in an emergency, be removed from its mounting and, with a length of rope, used as an emergency anchor. And when bolted back into its place, it would work!

The third Industrial Revolution began more or less when World War II ended and the expected post-war recession did not take place. This Revolution is still in progress. Its driving forces have included air and space engineering, electronics, communications and computers, construction – including very tall buildings – oil exploration, new chemicals, extensive highway systems and power generation. The dominant country has continued to be the United States. Once again, Canada has participated actively, due in part to the post-war growth in engineering schools and, in the early years, significant immigration of engineering and technical people. There have been both successes and disappointments for us. To take just one field as an example - aircraft production. The successes include the CF-100 all-weather fighter and the numerous 'bush' and STOL aircraft, and the most visible failure was the CF-105, the *Arrow*.

In addition to going for a ride in a steam train, admiring an old downtown skyscraper, or upgrading your personal computer, what other easy ways are available for recognizing more about the history of engineering in Canada? There are at least a half-dozen, and I will limit myself to them in this paper.

The first way is to read a book or a magazine article that discusses the subject in general, or some particular aspect of it.

No one has so far written a definitive history of engineering for Canada and I very much doubt if anyone ever will. But there are a surprising number of books that contribute something to it. Some cover specific aspects, time periods or particular constructions or devices. There are histories of companies that have made engineered products, and of consulting companies in the field. There are some biographies, but there have been very few engineers who have written about their careers or specific projects. Lamentably, the engineering profession has paid very little attention to its own history although, occasionally, an association or society will produce a history book to commemorate an anniversary. And there have been, and still are, a very few Canadian engineer-historians, among whom the late Robert F. Legget is notable.

Unfortunately, also, the history profession has done the same as the engineering one. As Norman Ball writes in 1988 in his contribution to the second edition of Hurtig's *Canadian Encyclopedia*:

> Although engineering is (now) a major Canadian industry, profession and export, its history has attracted little interest from the country's scholars or cultural institutions. Notwithstanding the fact that two of the world's ten largest engineering firms are of Canadian origin and ownership, there are more Canadian university courses and positions in the history of mediaeval technology than the history of Canadian engineering and technology.

Nor do the professionals care much for Pierre Berton's books on Canadian history, including the one on *Niagara*, which has some content that is related to engineering. Occasionally, inspired teachers - such as George Richardson at Queen's, Hugh McQueen at Concordia, and Trevor Hodge at Carleton - have given history courses to engineering undergraduates. But apart from these rare instances, most new graduates leave university without knowing much about the history of the profession they have just entered. Also, the awareness of media people and the general public is very low indeed - in spite of efforts that have been made to change this situation. The media constantly confuse engineering with science, giving the credit to science and only the blame to engineering.

Let me give you a sample of Canadian books about engineering history: Norman Ball's *Mind, Heart and Vision: Professional Engineering in Canada, 1887 to 1987*; Ball, Legget, Hurst and Rose's *A History of Public Works;* Dianne Newall and Ralph Greenhill's *Survivals; Aspects of Industrial Archeology in Ontario*; Robert Legget's *Rideau Waterway*, and the other books on the Rideau Canal by Robert Passfield and Mark Andrews; Robert Passfield's book on the Sault Ste Marie canals; *History of the Canadian Pacific Railway* by W. Kaye Lamb; Roy Minter's *White Pass Railway: Gateway to the Klondike*; William and Evelyn M. James's *The Story of Hamilton's Old Pumphouse*; Jerry Disher and E.A.W. Smith's *By Design: The Role of the Engineer in the History of the Hamilton-Burlington Area*; Larry Milberry's *Aviation in Canada*; Warrington and Newbold's *Chemical Canada*; Lorne Green's biography of Sandford Fleming and Bothwell and Kilbourn's biography of C.D. Howe; E.V. Buchanan's autobiography *Roses in December*; Jack Sexton's *Monenco: The First 75 Years*; and Richard White`s *Gentlemen Engineers: The Working Lives of Frank and Walter Shanly*. Hurtig's *Canadian Encyclopedia* has sections devoted to engineering and to technology, as well as short biographies of distinguished Canadian engineers. The *Dictionary of Canadian Biography* might also be consulted.

You could also try fiction, but there's not very much of it, and it will not add to the story in Canada. For example, there's Conan Doyle's *Hatter's Castle*, which includes the Tay Bridge disaster, and Ken Follett's *The Pillars of the Almighty*, one of whose themes is the building of a cathedral in the Middle Ages. Neville Shute wrote *No Highway* about material failure, as well as *The Trustee in the Toolroom*. Ayn Rand wrote *The Fountainhead* and *Atlas Shrugged*, John Hershey wrote *A Single Pebble* about engineering in China, and Robert Byrne wrote five books between 1977 and 1995, none of which remain in print.

Regarding magazines, there are some that may carry articles that discuss specific projects or aspects of engineering. But you should note that a magazine devoted to a specialized non-engineering subject may carry from time to time articles bearing on engineering and its history. One such is the *Canadian Geographic*. Some years ago, I analysed the subject matter in the issues of it between 1966 and 1992 for engineering history content and found that there were some 308 of them – roughly a dozen a year. Around one-third of them were `historical` at the time of publication and the others had become of historical interest since publication. There were, for example, articles about the Schubenacadie Canal, windmills, covered bridges, the CPR`s spiral tunnels and the *Royal Hudson* locomotives.

The second way to learn more about engineering history is to visit museums. In Ottawa, we are relatively spoiled in this regard, having the Canada Science and Technology, Aviation and Agriculture Museums and, at Carp, the Diefenbunker. The Museum of Civilization has, for example, a model of an Acadian *aboiteau*. Across the country, there are hundreds of others, some large, some small and many have at least some engineering-related exhibits. The larger ones may also have research staffs producing papers that include engineering subjects. For example, the Canada Science and Technology Museum publishes a Transformation Series. Its fourth report is *A History of Shipbuilding in Canada* by Garth Wilson.

Speaking of museums, you never really know what you may find in them. For example, in the Aviation one in Ottawa there is a full-scale model of the *Silver Dart*, the first heavier-than-air craft to fly in Canada. In the Museum of Science and Industry in Manchester, England, I found a full-scale model of the *Triplane I* designed and built by Alliott Verdon Roe, which was also one of the very first to fly, in 1909. And in the Museum of Transportation and Technology in Auckland, New Zealand, I found a full-scale model of the aircraft built – engine and all – by Richard Pearse, a farmer from the Christchurch area, which may have flown even before the Wright Brothers machine at Kittyhawk in 1903. Historians of aviation, however, refuse to recognize Pearse's feat.

The third way to learn more is to look to the professional associations and societies, and to their publications in particular. Most still have regularly published magazines, often with electronic versions as well. Although these are normally devoted to current material, they do from time to time include engineering history articles. Also, much of the material published many years ago by - for example - the Canadian Society of Civil Engineers, the Engineering Institute of Canada and the Canadian Institute of Mining and Metallurgy has by now become a valuable historical asset in its own right. These societies, and others, as I mentioned a moment ago, have also published historical volumes, mostly to commemorate anniversaries. This has been done in recent years by the Canadian Societies for Mechanical, Civil and Chemical Engineering, the Canadian Geotechnical Society, the Canadian Region of the Institute of Electrical and Electronics Engineers, and the Professional Associations in Quebec, Newfoundland and Saskatchewan. In most cases the material they contain was written by engineers. The Canadian Institute of Mining, Metallurgy and Petroleum has also published a number of articles of historical interest. Dr. Fathi Habashi of Université Laval has also written a number of books on the history of metallurgy.

Some of the organizations I have mentioned also have active History Committees and some have newsletters or bulletins that carry occasional historical articles. For example, during the 1990s the Mechanical Engineering Society's *Bulletin* carried a series of these. Time will not allow me to say much about these articles, but I would like to summarize just two as examples.

The first recalls the history and development of the shipyard at Collingwood, Ontario, now closed. It appeared in the February 1994 issue of the *Bulletin*. This shipyard began operations in 1858. In 1883 a drydock was added. Among the vessels built were schooners, wooden steamers and barges. The last Collingwood-built wooden steamer was launched in April 1899, after which the facility was rebuilt. Hull #1 of the new shipyard was the steel-hulled *Huronia* - launched in September 1901 as a freight/passenger steamer. This ship was the first of 208 new vessels and

8 conversions that appear in the company's books, the last of which was the *Paterson* – a large laker that was launched in April 1985. Employment at this shipyard, whose last business name was Collship, at one time averaged 800. It closed in September 1986. It gained fame not only for the quality of its ships, but also for its practice of sideways launching, where the hull was built on the level on a slipway that sloped down at right angles to the water's edge. At launching, the completed ship slid down this slope into the basin beyond. After 1983, Collingwood was the only Great Lakes shipyard that still sideways launched 700 ft long Seaway-size lakers. The physical evidence of the existence of this shipyard no longer exists. However, as a memorial to it, the surface of the pathway along what used to be the east side of the launching basin now has plaques with the names of all 208 steel-hulled vessels embedded in its surface.

The second article appeared in the May 1994 issue of the *Bulletin* and recalled the rather strange and ill-fated World War II *Project Habbakuk* in which Canada was involved. Since this project was kept secret during and immediately following the War, hard information about it only became available when it was declassified in the early 1980s. Dr Lorne Gold of NRC, one of Canada's experts on the 'engineering' of ice, was then asked to write a book about it. The book eventually appeared in 1993, published by the International Glaciological Society of Cambridge, England. The *Bulletin* article was based on the book, and this present account is based on the article.

Winston Churchill had the original idea. He wanted to 'calve' a piece of Arctic ice - 'a lozenge of ice' - large enough to support a floating airfield from which short-range fighter aircraft could attack German-held areas of Northwest Europe they would not otherwise be able to reach. The idea for the actual, manufactured, 'bergship' - whose construction was the object of *Habbakuk* - belonged to a British scientist, Geoffrey Pyke. He was at the time the scientific adviser to Lord Louis Mountbatten, Chief of Combined Operations. The 2000 foot-long vessel was to be made of 'pycrete' - a combination of sea ice and wood pulp and named after Pyke, its inventor. It would be self-propelled, at slow speed, with supplementary refrigeration, anti-aircraft guns and aircraft repair facilities of its own....and would be unsinkable. It would therefore be less vulnerable to enemy attack than an aircraft carrier. The first of a projected three bergships was to be ready for service by the spring of 1944, in time for the Second Front.

Mountbatten was enthusiastic and enlisted the support of the noted British scientist, Professor J.D. Bernal. Together, they 'sold' the idea to Churchill, in December 1942. Committees were set up in January 1943. Feasibility studies were quickly done (in Britain), with warnings given on the problems that lay ahead and about the research that would be needed. Canada was officially asked to participate, and agreed to do so. C.J. Mackenzie, acting president of NRC, took responsibility for the Canadian work. He believed it to be an engineering project, not a science one, as did Bernal and Pyke. They visited Canada, and Mackenzie, in March after work had begun at NRC in Ottawa and in three Prairie universities, mostly on the properties of ice and pycrete, and at Patricia Lake at Jasper, where a 1:50 scale model of the bergship was being built and tested. However, after this visit, Mackenzie became more pessimistic about the outcome than he had been. Bernal and Pyke remained optimistic.

Mackenzie wanted a Canadian engineering consultant to review the project and got his wish when the Montreal Engineering Company was appointed. Meanwhile, possible sites for the building of the full scale bergships were examined, but no decision was taken. The MEC's report was submitted quickly. It estimated that 35,000 shaft horsepower would be needed to drive the vessel at seven knots, that it would need a draft of 150 feet and 50 feet of freeboard, and that the design alone would take nine months to complete. The first bergship would not therefore be ready until the spring of 1945. This, of course, was not acceptable to Churchill.

However, work continued throughout the summer of 1943 at Patricia Lake and elsewhere. Meetings were held in London, which Mackenzie attended. The matter was raised at the Québec Conference of Allied Leaders in August. Some changes were made, but there was now less enthusiasm for the project. Alternatives were also discussed. Finally, in December 1943, the decision was made that the idea was simply not practical and it was abandoned. The skeleton of the Patricia Lake model was also abandoned and the wooden support structure for it was allowed to sink to the bottom - and forgotten. That was until many years later, when it was discovered by scuba divers. As it turned out, Churchill's *original* idea was not an impossible one. The problem was that, in the absence of a suitable 'calf-able' piece of ice, it would take several thousand years for Nature to produce one!

Before leaving the professional associations and societies, I should say something about the Engineering Institute of Canada. Founded as a learned society in 1887 and named the Canadian Society of Civil Engineers, although its members were drawn from the non-military branches of the profession, and especially from the civil one. As it grew, the Society's membership changed, with the result that in 1918 it was renamed the Engineering Institute to recognize, among other things, the inclusion of all disciplines. Nowadays, the Institute is a federation of 11 autonomous learned societies covering most of the disciplines within the profession. In its lifetime, the Institute has played a role in the establishment of the other three principal 'arms' of the profession.

One of these arms is what is now known as Engineers Canada, formerly the Canadian Council of Professional Engineers, which serves as the federation for the 10 provincial and 2 territorial licencing bodies. The Engineering Institute was responsible in 1919 for devising and approving a model law on which the individual associations could base their own legislation.

Another arm is the Association of Consulting Engineers of Canada, which was established in 1925 to provide a platform for consulting engineers to persuade the federal government to send more of its business to them rather than to consulting firms in the United States. Initially,the ACEC had individual members, rather than companies, as is now the case. To qualify for membership, these individuals had to be corporate members of the Institute.

The third arm is the Canadian Academy of Engineering, established in 1987, the 100th anniversary of the profession in Canada. While calls for a Canadian academy had been made in years past, nothing was done about it until the Engineering Institute established a task force in 1980 to do the 'grunt work' that would bring an academy into existence.

The Institute, indirectly, also had a significant role in the establishment of the ceremony in which Canadian engineers participate and which leads them to wear, on the little fingers of their writing hands, an iron ring, actually made of steel. The story began in 1922 when seven past presidents of the Institute met in Montréal. They were addressed by Herbert Haultain, a vice-president of EIC and a professor of mining engineering at the University of Toronto. He suggested that engineers, like medical people, should subscribe to an *obligation* of service, or statement of ethics, that would also serve to bind the members of the profession more closely together. The past presidents agreed. They then discussed the form that this obligation might take and how it might be administered by means of a ceremony. But who could devise such a ceremony? Haultain suggested Rudyard Kipling and, as someone who knew him, volunteered to make the proposal. Kipling was enthusiastic and, in short order, produced texts for the ceremony and the obligation.

And so was born the Iron Ring Ceremony - the Ritual of the Calling of the Engineer - that has, for almost 90 years, been administered to graduating engineers before they leave their universities. It is supervised on a national basis by the Corporation of Seven Wardens, independently of the Institute, the professional associations and the universities, and is organized annually by 21 Camps based in cities around the country. The Ottawa Camp is #12 and serves both Ottawa and Carleton Universities. The ceremony was completely private until a few years ago when several Camps decided to permit relatives of the new engineers to witness it. The story goes that the original rings were made from metal taken from surviving pieces of the Quebec Bridge, which collapsed in 1907. Not so. It was provided by a Toronto scrap dealer that Professor Haultain happened to know!

The fourth way to learn more about engineering history is to go out to the movies or to stay home and watch television. In 1991, the regular magazine of the American Society of Mechanical Engineers published an article by Michael Valenti on *Engineers on the Silver Screen*. Apparently, several film scholars were asked to discuss Hollywood's portrayal of engineers over the previous 60 years. The results showed that the 1930s were good years for them. One thing that helped, apparently, was that Herbert Hoover - a mining engineer - was U.S. president during the first half of the decade. Others were the construction of the Hoover Dam and the establishment of the Tennessee Valley Authority. Also, the public still associated engineers with being 'hands-on' people who got things done. The films' titles, however, did not always mirror the engineering content. For example, *I was a Fugitive from the Chain Gang* was about someone in this position who worked his way up from labourer to engineer. And *Carbine*

Williams, starring James Stewart - made in 1952 but chronicling a Depression story - was about the designer of the M1 carbine. From World War II came, for example, *The Fighting Seabees* and from the post-war, *Thunder Bay*, again starring Stewart as the engineer who built the first offshore drilling rig. But perhaps the best known 'engineering' movies have been *20,000 Leagues Under the Sea*, *The Bridge Over the River Kwai*, the *Titanic* - and the Tom Hanks' movie about the accident within Apollo 13 on its way to the moon.

Television appears to offer less fictive and more realistic views of engineering history. I have in mind the series on mega-structures, on large specially-built ships, on *How It's Made*, on *Inventions that Changed the World*, and on engineering as practiced in the ancient civilizations of Greece, Rome, China, Egypt and Carthage, and the Byzantine, Mayan and Aztec Empires. I particularly remember seeing shows that described the construction of such places as Angkor Wat, the Hagia Sophia, the Alhambra in Spain, Machu Picchu, postwar Berlin, the St. Lawrence Seaway, and a variety of oil rigs. These shows have appeared on the Discovery and History Channels and on TVO.

The next way involves the careers of the people who might be called 'engineering heroes.' I don't like the word 'heroes' since it conjures up visions of 'knights in shining armour' or of people who have just rescued someone else from disaster. The term 'engineers of distinction' has a better ring to it.

But speaking of knights leads us to one source of identifying Canadian engineers of distinction who, prior to it being forbidden by the Nickle Resolution in Parliament in 1919, could receive the British accolade of knighthood. They include Casimir Gzowski, Sandford Fleming, John Kennedy, Collingwood Schreiber, Alexander Bertram and Percy Girouard. You are likely familiar with some of these names but, most likely, you may not have heard of Girouard, since he lived most of his life outside Canada.

Percy Girouard was born in Montréal in 1867 and graduated from RMC in Kingston in 1886. He then worked briefly as an assistant engineer for the CPR. But since there was at that time no standing army in Canada, he went to Britain in 1888 to join the Corps of Royal Engineers, was commissioned, and attended the School of Military Engineering. In 1896 he was sent to the Sudan, where he served under Lord Kitchener and was assigned to direct railway transportation. He showed exceptional ingenuity in making possible the building of a railway through 500 miles of desert. His construction of a by-pass line was considered to have made Kitchener's victory at Omdurman possible. His next appointment was as president of the Egyptian Railway Board. This ended when Kitchener sent him to South Africa when the War broke out, again to take charge of the railways. At War's end, he received a knighthood for his services. In 1907, Girouard became Governor of Northern Nigeria and, subsequently, of Kenya. In 1913, having resigned from military and political service, he established Armstrong-Whitworth of Canada at Longueuil, Quebec. He remained with this company in Canada and Britain - apart from serving in World War I - until his death in 1932. A plaque has been erected in his memory on the campus of RMC at Kingston.

Another place you might look for distinguished engineers is the list of 'persons of national historic significance' who have been commemorated by the Historic Sites and Monuments Board of Canada. The list includes Gzowski, Fleming, Kennedy and Girouard - again - as well as Thomas Coltrin Keefer, C.D. Howe, Charles Camsell, Charles A. Magrath, Rupert Turnbull, Philip Pratley and Elsie Gregory MacGill. Of the latter, Keefer was involved in the design and construction of, for example, the original Victoria Bridge at Montréal and waterworks at Hamilton, Ottawa and Montréal. Howe was Mackenzie King's 'Minister of Everything,' Camsell was a mining engineer and a long-time deputy minister of mines in Ottawa, Magrath was associated with the extensive irrigation works in Southern Alberta, Turnbull made major contributions to aeronautics, Pratley was a notable bridge designer, and Elsie MacGill was the first distinguished Canadian lady engineer, of whom more in a moment.

And you might also look at the engineer-inductees in the CSTM's Science and Engineering Hall of Fame. It was established in 1991 by the Museum in partnership with the National Research Council and other sponsors to help celebrate the 75th anniversary of NRC's founding. Up until now (early 2012), 51 individuals have been inducted, all but 17 of them scientists. Among the 17 who were/are engineers or people associated with engineering, are Alexander Graham Bell, Sandford Fleming, C.J. Mackenzie, A.G.L. McNaughton and Elsie MacGill, as well as Armand Bombardier and George Klein. You may be quite familiar with the Bombardier name and the company, but know little of Armand's background. I would also guess that George Klein and Elsie MacGill are less well known. Let me give you quick bio for each.

Joseph-Armand Bombardier was born in April 1907 at Valcourt, Quebec, the eldest of eight children whose parents farmed and ran a general store. From a very young age, he showed a talent and passion for machines. At age 15 he built his first snowmobile. Intended originally for the priesthood, by the age of 17 he had been apprenticed to a local garage, but left to work in Montréal and to take night courses in mechanics and electrical engineering. At 19 he was back at Valcourt working as a garage mechanic. He then opened his own garage, and it was not long before his expertise became known in the Eastern Townships. At age 22 he married and with his wife had six children. In his spare time, and making use of the then snow-bound winters, he developed and built vehicles that could save rural communities from isolation during the winter months.

In 1937 Bombardier built a seven-passenger vehicle and obtained a patent for the track-and-sprocket drive system that was incorporated into this and all his future snow vehicles. In 1940, the military took an interest in this vehicle, which proved to be useful over sand and swamps as well as snow and ice. Several hundred were built in his own factory. By the end of World War II, he was serving as a civilian consultant on vehicles for the Arctic and sub-Arctic. With the end of the War, and after the Quebec government decided in 1949 to plough country roads, Bombardier lost much of his original market. He responded by developing an all-terrain tracked vehicle for the oil, mining and forest industries and, at the end of the 1950s, developed the now-famous individual-use snow vehicle that became known as the Ski-Doo.

Bombardier died in 1964 at the early age of 56. By 1974, more than a million Ski-Doos were in use and the Bombardier Corporation was on its way to becoming an internationally-known supplier of railway equipment and aircraft as well as recreational vehicles.

George Johann Klein was born in Hamilton in 1904, the son of a jeweller, and became known in the family as 'the inventor.' There was a workshop in the basement of the Klein house and young George made good use of it. He was a member of the mechanical engineering class of 1928 at the University of Toronto. On graduation, he chose to remain at the University, working as a demonstrator under one of his professors, John H. Parkin, who had built the UofT wind tunnel. However, in 1929 Parkin joined the staff of the new NRC laboratories in Ottawa. Shortly thereafter Klein followed him.

Klein's first job at NRC was, with colleagues, to design, build and test a wind tunnel and a towing tank for the Council's original John Street Laboratory. During the 1930s, he collaborated with John J. Green in work that influenced the design of the CNR and CPR locomotives that drew the Royal Visit trains across Canada in 1939. He also worked on improving the aerodynamic performance of aircraft skis, examined their interaction with snow and ice, and designed a kit for measuring the properties of these materials. During World War II, Klein participated in the design and testing of the *Weasel* - a personnel-carrying tracked vehicle originally intended for use by the famous U.S.-Canadian *Devil's Brigade* in snow, but was so versatile it could be used in mud as well. Before the War ended, he became involved in the design and construction of the ZEEP reactor, at Chalk River, which went critical in September 1945.

After the War, Klein continued to work on aircraft skis, adapting them for the de Havilland *Beaver*. He was also involved in producing the first practical electric wheelchair specifically designed for quadriplegics, and was asked by the RCMP to suggest improvements to their heavy dog-sleds. He was also involved with proximity fuses, the microsurgical staple gun, the *Hedgehog* antisubmarine system, and a wide range of gearing systems. And he was involved in the design of equipment for satellites and space, notably the *STEM* antenna and the *Canadarms*. Within NRC, Klein became 'the man to go to' for advice when in any kind of mechanical trouble and he solved hundreds of his colleagues' problems. He was not a conventional NRC researcher. He looked after the 'D' in 'R&D.' Nevertheless, he became known nationally and internationally for his talent and ability to solve mechanical problems. He received honorary degrees and was appointed to the Order of Canada. He retired from NRC in 1969 and died in 1992 at the age of 88.

Elizabeth Muriel Gregory MacGill was born in Vancouver in 1905. Both she and her mother, the formidable Judge Emma Gregory MacGill, made a habit of being the first women to do new things. Elsie was the first in Canada to receive an electrical engineering degree, from the University of Toronto, in 1927 and, in 1929, became the first woman in North America to hold a degree in aeronautical engineering, from the University of Michigan. However, just before receiving it, she contracted polio and wrote her final exams in her hospital bed. Apart altogether from losing her mobility, having to use a wheelchair and, later, canes to get around, her illness delayed her return to work. In 1932 she went to M.I.T. to take doctoral studies, but dropped out late in 1934 to join Fairchild Aircraft Limited at Longueuil, Québec. Between then and May 1938 when she left Fairchild, she participated in design work related to a number of the company's aircraft and in their test flights. Had her legs not been weak, she might well have become a pilot. She also worked with aeronautical researchers at NRC in Ottawa.

At Fairchild, she met Bill Soulsby and his wife. A professional manager, Bill left the company in 1937 and moved to Fort William, where he became a manager at the Canadian Car and Foundry Company, which was in the process of developing a place for itself in the Canadian aviation industry. He encouraged Elsie to make a similar move, which she did in 1938, becoming the chief aeronautical engineer of the company. She worked initially on the production of the U.S.-designed Grumman *G23* planes, and then on the design of the all-metal *Gregor* fighter. She then became the first woman to design, build and test her own aircraft - the *Maple Leaf II* - a trainer intended for the military market, which incorporated aerobatic capabilities and was suitable for flying in Canadian weather conditions. It was test flown in late October 1939, with Elsie on board. However, the RCAF preferred British-designed trainers to Elsie's plane and a market for it never materialized.

Meanwhile, Can-Car contracted to build the British Hawker *Hurricane* fighter, in quantity. Elsie and her colleagues became deeply involved in the engineering needed to support this work and to adapt the original design for Canadian conditions, to allow for a U.S.-made engine, and to accommodate successive versions of the plane. In 1942, as orders for the *Hurricane* declined, the company turned to building Curtiss-Wright *Helldivers* for the U.S. Navy, again presenting formidable engineering challenges.

Elsie was the first woman to be elected to corporate membership in the Engineering Institute of Canada and the first to serve on the Institute's Council. For a paper she gave on her work at Fort William, she was the first to receive the Institute's Gzowski Medal. Later, she would be the first to receive its Julian C. Smith Medal for contributions to Canada's development and to be elected a Fellow of the Canadian Aeronautics Institute.

But a personal problem arose. Bill Soulsby's wife died in September 1942, leaving him with two young children. His friendship with Elsie became a problem that apparently affected the Can-Car plant morale. Suffice it to say that both he and Elsie were dismissed by the company in May 1943. A month later they were married in the United States and moved as a family to Toronto. Bill joined Victory Aircraft, which became A.V. Roe Canada, and was later associated with Orenda Engines. Elsie, who retained her maiden name, established a consulting practice and became the first woman consulting engineer in this country. Among her clients were Trans-Canada Airlines and the de Havilland Aircraft Company at Downsview. She was also involved with NRC technical committees dealing with aeronautical research and undertook public speaking engagements, all of which led to international recognition for her work.

In 1953, Elsie broke a leg in an accident at home. During her recuperation she wrote a book about her mother, and thought a great deal about the roles of women in society. From this emerged her second career - advocacy for women - which led to her serving on the Royal Commission on the Status of Women. She was awarded the rank of Officer in the Order of Canada, and was the first woman engineer to receive the Gold Medal of the Association of Professional Engineers of Ontario. She died in October 1980.

Lastly, among the things you might do to better recognize the history of engineering - in Canada and elsewhere - you might simply 'Google' it. The Internet has a lot of it. Indeed, just about all of the material I have covered today can be found in some website or other. You might even begin with the Engineering Institute of Canada's own website – www.eic-ici.ca – and by clicking on the *History* section. When you do so, you would do well to remember some words that James Kip Finch included in the preface to his book *The Story of Engineering*, published some 50 years ago:

> From the engineering standpoint, so rapidly do techniques and economic and other factors change that, at first sight, the story of the past seems to offer little of professional value in meeting the problems of the present. Yet, the history of engineering, in addition to satisfying the professional's natural curiosity about the background and traditions of the profession, offers many lessons of value.

In this context, I wish you good hunting, good reading, good viewing, good times........and good luck!

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