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"Recognition of Engineers and Engineering Achievements: The Hall of Fame of the Canadian Museum of Science and Technology"

by Andrew H. Wilson
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Abstract

This paper presents brief biographical sketches of 16 people - engineers or directly associated with engineering achievements - who have been elected to the Hall of Fame of the Canadian Museum of Science and Technology.

Its objective is to expand the list, begun in other papers in the Cedargrove Series, of those who might be considered to be 'heroes' or 'notables' of Canadian engineering.

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 in the public service of Canada, from which he retired over 20 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, has served both CSME and the Engineering Institute of Canada in this capacity for varying periods of time until 2003, and has since provided history-related advice to EIC and the Canadian Society for Senior Engineers. He has researched, written and edited historical material for EIC and CSME organizations, and is a past president of both.

Introduction

There are a number of ways in which engineers and those directly associated with engineering achievements may receive national recognition for their contributions to the field and the profession, to the management of these, and to the development of Canada. They may, for example, be elected to the Science and Engineering Hall of Fame at the Canadian Museum of Science and Technology (CMST), designated by the Historic Sites and Monuments Board of Canada (HSMBC) as being 'persons of national historic significance,' or receive the Order of Canada. They may also be recipients of senior medals or awards from Canadian institutions, such as the Sir John Kennedy Medal of the Engineering Institute of Canada and the Gold Medal of Engineers Canada (formerly the Canadian Council of Professional Engineers). Or, spreading the net more widely still, they may be elected to the Canadian Academy of Engineering or the Royal Society of Canada. Among those so identified may be some who can be judged eligible for consideration as 'heroes' or 'notables'of Canadian engineering. This judgement, however, is being left to others.

The Canadian Museum of Science and Technology was established by the Government of Ca nada, following the recommendation by the Massey Royal Commission in 1951 that it do more to support work in the arts and sciences in this country by establishing a national museum to collect, preserve, research and interpret its technical heritage. The Canadian Science and Engineering Hall of Fame was established originally in 1991 by the Museum in partnership with the National Research Council, Industry Canada and the Association of Partners in Education to mark NRC's 75th Anniversary. Prior to1996, the Council took responsibility for the nomination, selection and induction process. The Hall then became the responsibility of the Museum, which now organizes this process for it. It is also an integral part of the *Innovation Canada* exhibit within the Museum. Basically, each nominee must have contributed in an exceptional way to the advancement of science or engineering in Canada, must have demonstrated leadership, and their contributions must have brought great benefits to society. A Selection Committee presides over the selection of nominees for induction. Unlike designation by the Historic Sites and Monuments Board, those nominated for the Hall may still be living.

This paper is not the first in the Cedargrove Series to attempt to identify notables to join Sandford Fleming, Thomas C. Keefer and Casimir S. Gzowski in a Canadian pantheon, but it is likely the last one I will do. As it happens, the three engineers just mentioned have already been designated by the Historic Sites and Monuments Board, but so far only Fleming has been included among the inductees to the Hall. The others included in this paper who belong to both are Armand Bombardier, Sir William Dawson, Reginald A. Fessenden, Wallace R. Turnbull and, I have recently discovered, Elsie Gregory MacGill.

The present (2009) membership of the Hall stands at 42, of whom 16 have been included in this paper. The biographical material about them has been arranged in alphabetical order. It is synoptic rather than definitive since, for most of the inductees, fuller biographies can be found in books, articles and through the Internet. The biographies in this paper vary in length, for a variety of reasons. Of the 16, six were members of the Engineering Institute of Canada: Fleming, MacGill, Mackenzie, McNaughton, Ouimet and Turnbull.

The Biographies

Canada must share **Alexander Graham Bell's** fame in engineering achievement with the United States. He was born in March 1847 in a third country - Scotland - in the city of Edinburgh, the second son of Alexander Melville and Eliza Bell. Both his father and grandfather were well-known practitioners of the science of phonetics and teachers of elocution.

As a young man in the late 1830s, his father had spent several years in Newfoundland escaping the damp, sooty atmosphere of Edinburgh and clearing up persistent respiratory infections. He became a strong believer in North America's healthy climate. Married in 1844, the Bells' eldest son, Melville, was born a year later, then Alec, and a third son, Edward, in 1848. Alec's interest in 'things scientific' began when he was a boy, stimulated by everyday problems he found around him and by his father's, and his brother Melville's, enthusiasm for the science of speech. Brother Edward, less so, as he was in indifferent health much of the time. Also, their mother was deaf and Alec, in particular, became expert in conveying the content of conversations to her using the manual alphabet. Alec was not enthused by his school, which followed the classical tradition of education, preferring instead activities that were related to science and to the outside of a classroom.

In the 1860s the Bells moved to London. In 1867 his brother Edward died at the age of 18. However, Alec was able to take advantage of the city to further his experience in teaching the deaf as well as his formal education and making experiments. But in late May 1970 his brother Melville died of tuberculosis at the age of 25. In July of that year the surviving Bells sailed for North America - and its healthier climate. They settled near Brantford, Ontario, Canada.

Bell's first job, however, was teaching in schools for the deaf in Boston, which became his headquarters for many years to come, although he would visit Brantford during the summers. He also began experimenting again, in the evenings in a basement workshop - and acquired a reputation for overworking himself - endangering the good health he had been brought to North America to preserve! He opened his own school in 1872 and, a year later, transferred his classes to Boston University, where he was appointed professor of vocal physiology and elocution. Among his students was Helen Keller - blind, deaf and dumb - who later credited Bell with helping humanize her life. Another was Mabel Hubbard, daughter of the prominent Boston patent lawyer, Gardiner Hubbard.

Away from his students, Bell worked in a basement laboratory on the 'harmonic' or 'multiple' telegraph and on 'electric speech' or the 'transmission of sound through telegraphy'. But he found he lacked the time and the skill to make mechanical parts for the apparatus he was developing, and sought help. He found it in Thomas Watson, who was only a few years younger than Bell himself. And so began a fruitful collaboration that would last for a very long time, result in the invention of the telephone, and bring both men fortune and renown.

Bell spent the summer vacation of 1874 at Brantford. August 10 of that year was the day, he later wrote, the idea of the telephone was conceived. The work continued. Later the following year he convinced Hubbard of the value of his invention, obtained his support, and a patent was filed in Washington, only hours before a filing by Elisha Gray, his rival in this enterprise.

At the Centennial Exhibition at Philadelphia in 1876, Bell demonstrated his invention and, with the fortuitous intervention of the Emperor of Brazil whom he had met previously in connection with his work with deaf children, he was given the Centennial Award for it by the judges in the electrical area. The following year, Bell married Mabel Hubbard and sailed for England on his wedding trip, where he took time to introduce Queen Victoria to the telephone. In 1878 the Bells returned to the United States and moved to Washington. Much of Alec's time was taken up defending his telephone patents in lawsuits. He took relatively little part in the business of promoting and selling his invention, instead establishing a laboratory and busying himself with experiments and scientific discussions. He was interested , for example, in the photoelectric cell, the iron lung, the desalination of sea water and the phonograph, where he was in competition with Edison.

During the summer of 1885, the Bells first saw Cape Breton Island and travelled on Bras d'Or Lake by steamer. The following year, negotiations were begun to purchase property on a headland across from the town of Baddeck. In 1890 a tract of land was acquired and the Bienn Bhreagh estate established. This would provide a family summer home for the rest of their lives. Bell's first experiments were on several forms and configurations of kites - and the scientific breeding of sheep. Mabel had her own research - in horticulture. The ultimate man-carrying kite was launched in December 1907, and flew steadily, carrying a passenger.

In 1907 the Bells founded, and financed, the Aerial Experimental Association to carry out a program of aeronautical research. The ideas and enthusiasm behind the AEA came from the Bells, but the work was done by a group of young engineers - Canadians Douglas McCurdy and F.W. Baldwin, and Americans Glenn Curtiss and Thomas Selfridge. AEA built several 'pusher-engined' biplanes in 1908-09, the first of which was based on a tetrahedral configuration, derived from the kites. Next was the *Red Wing*, which was flown in March 1908 by Baldwin at Hammondsport, New York - making him the first Canadian to fly a heavier-than-air aircraft. After it had made a number of flights but had crashed, this plane was rebuilt and renamed the *June Bug*, which flew in June 1908 at Hammondsport. Selfridge died while testing a plane for the Wright Brothers in September 1908, after which the AEA moved back to Baddeck. The fourth AEA machine was the *Silver Dart*, flying which Douglas McCurdy became the first Canadian to fly in Canada in February 1909. Attempts to use floats on the *June Bug* were not successful.

Later in 1909, after the AEA had been wound up, Bell's research began with the failed floats experiment. He went on to develop hydrofoils, the first of which was completed in 1911. A later hydrofoil, the *HD-4,* launched in October 1918, was the most successful. In September 1919, it established a speed record which was not broken for another 20 years. The *HD-5* was the last Bell hydrofoil, launched in September 1921.

Alec Bell continued working for another year but, on August 2, 1922, he died in Washington at the age of 75. His wife died five months later. He was inducted into the Hall by NRC, prior to 1996.

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In his 'piece' in the Hall of Fame website, **Joseph-Armand Bombardier** wrote:

> From the time I was young, I dreamed of inventing a machine that would conquer the snow. In those days, of course, there were no snow ploughs in rural areas, so when winter set in, people were trapped. Farmers couldn't get outside to save stranded cattle; police cars, ambulances and fire trucks couldn't get through the drifts; people even had difficulty getting such basics as mail and food supplies.
>
> I used to experiment at home, so when I was 15 my father gave me an old Model-T Ford to divert my attention from the family car. I promptly removed the engine, bolted it to a modified sleigh frame and attached a hand-whittled propeller to the motor's drive shaft. I had built my first snowmobile. Unfortunately, the experiment went no further. Shortly after its first successful test run, my father forced me to dismantle the machine, fearing that the open propeller would decapitate one of my brothers or sisters.

Bombardier was born in April 1907 at Valcourt, near Sherbrooke, Québec, 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 13, for example, he built a miniature locomotive driven by clockwork, followed by tractors, boats and other mechanical toys. He built steam engines out of old sewing machine parts. He also began to develop as an entrepreneur. And, as noted above, was 15 when he built his first snowmobile.

Intended at age 14 for the priesthood, by the age of 17 he was an apprentice at a local garage, but left to work in Montréal and take night-school courses in mechanics and electrical engineering. At 19, he was employed as a garage mechanic in Valcourt. Then he opened his own small garage. It was not long before his expertise became known around the Eastern Townships. At the age of 22, he married and, with his wife, had six children. In his spare time, and making use of the then snow-bound winters, he pursued his ambition of developing and building 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, since it could move troops over sand and in swamps as well as over snow and ice. Several hundred of this type were built in his own factory. In 1942, he built a larger version, to hold 12 passengers, with independent suspension on each axle - the production of which continued for several decades. That same year, 1942, he incorporated himself and founded the company - Auto-Neige Bombardier Inc. As noted below, at the end of World War II he served as a civilian consultant on vehicles for the Arctic and sub-Arctic as part of Exercise Musk Ox, in which John Tuzo Wilson also participated.

When the Québec government decided to plough country roads in 1949, Bombardier lost much of his market for the B-12-type vehicles. He responded by building all-terrain tracked vehicle for oil and mining exploration and the logging industries. At the end of the 1950s, he developed an individual-use snow vehicle that became famous as the trade-marked Ski-Doo.

In doing so, Armand Bombardier fulfilled his original dream and, at the same time, gave birth to a new industry. He died in 1964 at the age of 56. By 1974, more than a million Ski-Doos were in use and the Bombardier Corporation was on its way to becoming a significant player internationally, manufacturing railway transport equipment and aeroplanes as well as recreational vehicles, having plants and representatives throughout the wörld and employing thousands of people. Bombardier was inducted into the Hall by the National Research Council.

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John William Dawson's principal claim to fame was as a scientist and, in particular, as a geologist. As has often been reported, he was the first Canadian-born scientist to achieve a world-wide reputation for his research and publications. His contributions to science and engineering education in Canada were also notable. The basis of his achievements in engineering stems from these contributions.

Dawson was born at Pictou, Nova Scotia, in October 1820. His education began there, at the Academy. In 1840, he went to Scotland, to the University of Edinburgh, where he studied geology. - a subject that had engaged his interest as a boy and as an avid collector - as well as taxidermy and the preparation of fossils for examination under the microscope. But, due to financial problems, he returned to Pictou in 1841 without completing a degree. Over the next few years he undertook practical work in his native province and in Lower and Upper Canada, much of it in mining, geology and mineralogy. Some of his fieldwork was published through the Geological Society of London. He also taught at Pictou Academy and Dalhousie College in Halifax. During this time he met and became friends with Charles Lyell, an internationally known geologist. They teamed up to do pioneering work in Nova Scotia.

In 1850, Dawson was appointed superintendent of education for Nova Scotia. This was also the year in which he completed his monumental work on Acadian geology, which was subsequently published in Edinburgh and London. Even without the completion of his course work, the University of Edinburgh awarded him an MA degree in 1856, partly as a result of his publications. By this time, he was an experienced educator, a prolific and popular author and a brilliant lecturer. He was also a vigorous and determined man.

Dawson was appointed by Sir Edmund Walker Head in 1853 as a member of the Commission of Inquiry into King's College in Fredericton (before it became the University of New Brunswick). The members were asked to advise on how its courses of instruction could be made more practical. This the Commission did, proposing among other things that diplomas be awarded in civil engineering and land surveying. As a result, the first regular instruction in engineering in British North America began in February 1854. The curriculum covered the elements of railway engineering and civil, mechanical and electrical engineering as they were then known. Also in 1854, Head was appointed Governor General of Canada. At his suggestion, the Council of McGill College in Montréal appointed the 35-year old Dawson to be its fifth principal. In his inaugural speech in November 1855, Dawson announced plans to initiate a course of lectures in civil engineering, with a diploma course to follow, based on the one he had helped to develop at Fredericton. At his insistence, a Department of Practical Science was formed in 1871 at McGill, and thus began in embryo the Faculty of Applied Science, founded in 1875, when the first full engineering programs in Canada with degrees in civil, mechanical and mining engineering became available. McGill went on to establish its high reputation as an engineering school, and Montréal as one of the major centres of Canadian engineering.

In 1857, Dawson had also established a Normal School at McGill and served as principal instructor in science for 13 years, teaching mainly chemistry and physics. He also oversaw the rebuilding of the McGill campus. And he built strong ties to distinguished and influential scientists and universities in the fields of geology and paleontology at home and overseas. It has been said that he built McGill and laid the foundations for the renown it gained in the 20th century and for the influence it had in Canada and abroad.

Dawson received many honours. For example, in 1854 he was elected a Fellow of the Geological Society of London and was awarded its Lyell Medal in 1881 for his outstanding research. That same year, the Governor General, the Marquis of Lorne, called on him to help establish the Royal Society of Canada, and he became its founding president. He was, in the 1880s, the only person to have held the presidencies of the American and British Societies for the Advancement of Science. He was the president of the Geological Society of America. He received honorary degrees from both McGill and Edinburgh. He was made a Commander of the Order of St. Michael and St. George (CMG) in 1881 and was knighted in 1884. Sir William remained principal of McGill until 1893. He died in Montréal in 1899. He was inducted into the Hall in 2004.

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Reginald Aubrey Fessenden is another Canadian whose fame must be shared with the United States. Born, on 6 October 1866 at East Bolton, Québec, and educated at Trinity College School at Port Hope, Ontario, and Bishop's College School and University at Lennoxville, Québec, he left the latter without a degree. Instead, for the next two years, he taught school in Bermuda.

In 1886, at the age of 20, he moved to New York, hoping - in spite of a largely classical education - to gain employment with Thomas A. Edison. With perseverence he managed this, and was employed as a semi-skilled assistant tester at the Edison Machine Works, then involved in laying underground cables in New York City. A fast learner, he was soon promoted. By late 1886 he was working for Edison at his laboratory at West Orange, New Jersey, where he tackled problems involving electricity, chemistry and metallurgy. But in 1890, facing financial problems, he and many others were let go by Edison.

Fessenden was able to find employment with a series of manufacturing companies and, in 1892, was appointed a professor in the newly formed Department of Electrical Engineering at Purdue University in Indiana. He continued to work for Westinghouse, at the 1893 World Exhibition at Chicago, after which George Westinghouse recruited hin for the position of chair of the Department of Electrical Engineering at what later became the University of Pittsburgh.

Inspired by the work of Marconi in radio, Fessenden began his own experiments in the late 1890s. In 1900, he left Pittsburgh to work for the United States' Weather Bureau to investigate the possibilities for the radio, versus telegraphic, transmission of coastal weather data, using devices he had invented. The work was done initially at Cobb Island in the Potomac River. He was successful and, in the process, developed the heterodyne principle. It was there, in December 1900, that he transmitted speech by radio for the first time, paving the way for commercially feasible transmissions of radio signals. But as a result of disputes with management over the ownership of patents, he left the Bureau in August 1902.

Fessenden, however, was able to carry on his research work with the support of two wealthy Pittsburgh businessmen, who financed the formation of the National Electric Signal Company (NESCO). The work was done at Brant Rock, Massachusetts, and involved low-power and high-power transmitters for both telegraphic and radio transmission. In January 1906 he made the first successful two-way trans-Atlantic rotary-spark transmission using Morse code. Unfortunately, this work had to be terminated when the radio tower at the Scottish end collapsed. In mid-December 1906, Fessenden demonstrated a new alternator-transmitter at Brant Rock and on Christmas Eve used it to send out a short radio program, and a second one on New Year's Eve - both of which were picked up by so few listeners that their importance was quickly downplayed and forgotten.

Unfortunately, also, the technical work of NESCO was not financially successful. Meanwhile, Fessenden himself had started a company in Montréal in 1906. But friction between him and his backers rose to the extent that Fessenden was fired in January 1911. Lawsuits followed, the end result being that the company was sold to Westinghouse in 1920 and in 1921 its assets - including important patents awarded to Fessenden - were sold to RCA. The lawsuits went too, and it was not until 1928 that he settled with RCA, receiving a large cash payment.

The work on the alternator-transmitter was continued, however, at the General Electric Company and, by 1916, the Fessenden-Alexanderson alternator was more reliable for trans-Atlantic communication than the spark apparatus. After 1920, radio broadcasting became widespread, using vacuum tube transmitters, rather than the alternator and employing continuous-wave AM signals that Fessenden had introduced in 1906.

Even before leaving NESCO in 1911, Fessenden had switched his attention to other fields. For example, he helped engineer the Niagara Falls power plant for the Hydro-Electric Power Commission of Ontario in 1904. Later, he developed the 'Fessenden oscillator' for signalling between submarines and for locating icebergs. At the outbreak of World War I he volunteered his services to the Canadian government and was sent to England, where he worked on a device for detecting submarines and enemy artillery. He patented basic ideas in seismology and invented a sonar device, television apparatus, tracer bullets, and a turbo-electric drive for ships.

After settling the RCA law-suit, Fessenden retired to a small estate in Bermuda, where he died in 1932. Over his lifetime, he held over 500 patents. He also received a number of awards for his work. For example, in 1921 the Institute of Radio Engineers presented him with its Medal of Honor and in 1922 the City of Philadelphia its John Scott Medal. In 1929 he received the Scientific American Gold Medal for his device to determine the depth of water for a submerged object.

Fessenden has been called the 'father of radio broadcasting.' For his pioneer work in radio communications and sonar devices, he was named a 'person of national historic significance' by the Historic Sites and Monuments Board of Canada in 1943. He was inducted into the CMST Hall of Fame by NRC.

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Sandford Fleming was born on the other side of Scotland's Firth of Forth from Alec Bell - at Kirkaldy - twenty years before him, in 1827. He presently shares, with Fessenden and four other members of the CMST's Hall of Fame, the HSMBC's designation as a 'person of national historic significance,' which he achieved in 1950.

Fleming came to Canada in 1845 and, having studied engineering on both sides of the Atlantic, was appointed to the staff of the Ontario, Simcoe and Huron Railway. In 1857 he was named chief engineer of its successor, the Northern Railway. The article on Fleming in Hurtig's *Canadian Encyclopedia* continues the story:

> In 1863 the Canadian government appointed Fleming chief surveyor of the first portion of the proposed railway from Quebec City to Halifax and Saint John. Subsequently built as the Intercolonial Railway, he was its chief engineer. In 1871 he was appointed engineer of the proposed new Canadian railway from Montréal to the Pacific Coast and was in charge of the major surveys across the Prairies and through the Rocky Mountains. He proposed constructing the railway along a northerly route through Edmonton and the Yellowhead Pass and then turning south to Burrard Inlet and the Pacific. Although his specific recommendations regarding the route were not followed, his extensive survey work of various routes, including the Kicking Horse Pass through which the Canadian Pacific main line was built, greatly facilitated Canadian railway construction. In the early

years of the 20th century, Canadian Northern's railway was built along the survey route advocated by Fleming.

Fleming retired from the CPR when the Canadian government turned over the project to a private syndicate in 1880, but he continued to do consultative railway work. He also turned his attention to other projects. He was strong advocate of a telecommunications cable from Canada to Australia, which he believed would become a vital communications link of the British Empire. The Pacific cable was successfully laid in 1902. He was also interested in the development of a satisfactory world system for keeping time.

The railway had made obsolete the old system where every major centre set its clocks according to local astronomical conditions. Fleming advocated the adoption of a standard mean time and hourly variations from that according to established time zones. He was instrumental in convening an International Prime Meridian Conference in Washington in 1884 at which the system of international standard time - still in use today - was adopted. Fleming also designed the first Canadian postage stamp.

Fleming also carried out the first survey for a railroad across Newfoundland. It was later built and operated by the Reid Company. He was part of the famous photograph - identifiable as the tall man in the middle with the square, white beard - taken in November 1885 at the 'Last Spike' ceremony for the trans-continental CPR.

Although not himself a university graduate, but as a result of his friendship with Principal Grant, Fleming was appointed Chancellor of Queen's University (the Kingston one) and served for 35 years. He also received a number of degrees from academic institutions in Canada, the United States and Britain. He was president of the Royal Society of Canada. Fleming was created a Commander of the Order of St. Michael and St. George (CMG) in 1877 and raised to the rank of Knight Commander (KCMG) in 1915. He was inducted into the Hall by NRC.

It has been noted before that, somewhat surprisingly, Fleming was not among the founding members of the Canadian Society of Civil Engineers in 1887. He had indeed been a founding member and leading light many years earlier in the first attempt to organize a national technical society, which later became the Royal Canadian Institute. He also supported the formation of the short-lived Dominion Institute of Amalgamated Engineering. He did, in fact, join CSCE - but not until 1896, and was never president. He was, however, elected to honorary membership before his death in 1915 at the age of 88.

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Gerald Robert Heffernan was honoured for his pioneering work in metallurgy by his induction into to the Hall of Fame by the National Research Council.

Alberta born in 1919, he received his engineering training in the Faculty of Applied Science and Engineering at the University of Toronto, graduating in 1943 in metallurgy and materials science. He was one of the many whose call-up to the army preceded their convocation ceremony. This was accomplished at a special ceremony in April 2007, over 60 years later, when he was 87, by which time he had received several honorary degrees - for example, from Queen's and Toronto.

Heffernan has received many other honours and awards. For example: he was elected a Fellow of the American Society for Metals, the Canadian Institute of Mining and Metallurgy, and the Canadian Academy of Engineering; he has received the UofT Engineering Alumni Medal, the Gold Medal of the Association of Professional Engineers of Ontario, and the McGill Achievement Award; he has also received the Benjamin E. Fairless Award of the American Institute for his leadership in steelmaking, and the U.K. Institute of Metals' Bessemer Gold Medal for technological innovation in the steel industry. Through his companies, Heffernan has supported postgraduate fellowships within the Faculty of Applied Science at the University of Toronto. A Chair bearing his name in materials processing was created in 2000, with his financial support.

Heffernan is renowned world-wide as a founder and developer of major steelmaking organizations and as a highly skilled engineer and scientist and is remembered in particular for pioneering the mini-mill steel manufacturing process. He has served as chairman of Co-Steel International Ltd., a company formed from two of his many highly successful ventures, Premier Steel Mills in Alberta and Lake Ontario Steel Company Ltd. at Whitby, begun by him in the 1950s and 1960s respectively, businesses that expanded into the United States and Great Britain. He founded, and was president of, G.R. Heffernan & Associates of Toronto, and has had several other company directorships.

After leaving UofT, Heffernan was commissioned in the Corps of the Royal Canadian Engineers and served in Canada, training combat engineers in combat, bridge building and mine clearing. After the war, he attended graduate school at the University of British Columbia before entering the steel industry. He founded his first company (Premier) in 1955, the year he built his first steel mill..

Heffernan, himself, has provided a 'quick view' of his career highlights in the text that accompanied his entry in the Hall of Fame website. He said:

> I guess you would say that I helped reshape the world's steel industries. I didn't start out to do that. I was just trying to create a better product at a better price, but the outcome was revolutionary.
>
> My education prepared me for a career in metallurgy. One of my first jobs was to 'soup up' the electric arc furnaces in a Vancouver steel manufacturing plant. Gaining a detailed knowledge of these furnaces, which are better than blast furnaces at melting scrap steel, stood me in good stead when I ventured out on my own. After that company went

> bankrupt, I got another job building and operating an electric arc furnace plant to cast ingots - large bars of steel that are created by pouring the refined, molten steel into moulds. When management rejected my proposal to locate a plant in Edmonton, the heart of the burgeoning oil industry, I quit and decided to build the plant myself.
>
> With several partners, I managed to raise the capital and within nine months the plant was built. But I was bothered by certain aspects of the traditional steel-making process. It seemed to me that rolling steel ingots to lengthen them was expensive and inefficient, so I began to investigate continuous casting.
>
> We installed one of the first commercially successful continuous casting plants. Then, by combining continuous casting with the use of enhanced electric arc furnaces annd cheap scrap metal, I was able to sell my steel at well below the price being charged by large integrated mills.
>
> This new process, referred to as mini-mill steel manufacturing, not only allowed smaller regional mills to become cost effective but, by replacing the dirty coke ovens and blast furnaces, as well as recycling scrap steel, my manufacturing process had clear environmental benefits......

Gerald Heffernan became an Officer of the Order of Canada in 1987. He has also been elected a member of the Canadian Business Hall of Fame, was appointed to the Council of Advisers of the Canadian Institute for Advanced Research, was a member of the Policy Committee of the Business Council on National Issues (as it then was), and chaired its task force on taxation policy. He was inducted into the Hall by NRC.

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Canada shares **James Hillier** with the United States, and engineering shares him with physics. Born in August 1915 at Brantford, Ontario, he graduated in physics from the University of Toronto in 1937. He received his master's and doctorate degrees from the same university in 1938 and 1941.

Both Canada and the United States can claim to be the first countries in which the electron microscope - whose principles were developed in Germany - was made practical. Hillier and his colleague, Albert Prebus, constructed the first one in Canada, with high resolution and a magnification of 7000 times, while studying at Toronto under the guidance of Professor Eli Burton. On completing his doctorate, Hillier went south to join RCA at Camden, New Jersey, where he spent many years developing production models and marketing them. Hillier also discovered the principle of the stigmator for correcting the astigmatism of electron microscope objective lenses, invented the electron microprobe microanalyser, and was the first to picture tobacco viruses and an ultra-thin section of a single bacterium.

Hillier had a long and successful career at the RCA laboratories at Princeton, New Jersey, becoming general manager of the Laboratories in 1957 and reaching the position of executive vice-president and chief scientist in 1976. Major projects with which he was associated during his career included the electron optics that led to the 90 degree deflection, 25-inch colour kinescope, the Electrofax process for copying printed matter, and the RCA *SelectaVision* videodisc system. He received over 40 patents for the devices and processes he invented while working at RCA, and published more than 150 technical papers.

Hillier retired in 1977, after which he took on the role of technology adviser, serving countries in the Third World and promoting science education.

In 1945 Hillier served as president of the Electron Microscope Society of America, the year he became an American citizen. He received numerous awards - for example, the Albert Lasker Award for basic medical research in 1960, the IEEE David Sarnoff Award in 1967, the Commonwealth Award in 1980, the same year that he was inducted into the U.S. National Inventors Hall of Fame. In 1981 he received the Founder's Medal from the Institute of Electrical and Electronic Engineers. He was awarded honorary doctorates by the University of Toronto and the New Jersey Institute of Technology, was a member of the U.S. National Academy of Engineering, and was appointed to the Order of Canada. He was inducted into the Hall of Fame in 2002.

Although holding U.S. Citizenship, he remained involved with the Brantford community throughout his life. In 1950, for example, a public school named after him was opened at Brantford. In 1993, the James Hillier Foundation was established to award annual scholarships to Brant County students pursuing education in science.

James Hillier died at Princeton in January 2007 at the age of 91.

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John Alexander Hopps is known as the 'father of biomedical engineering in Canada.' He was one of the pioneers in the development of artificial pacemakers, which improved the lives of many people around the world, and was honoured for this and other achievements in several ways.

Jack Hopps was born in Winnipeg in 1919. He graduated in electrical engineering from the University of Manitoba in 1941 and joined the staff of Radio and Electrical Engineering Division (REED) of the National Research Council in 1942. His early work was studying the pasteurization of beer using microwave re-warming. In 1949 he was seconded briefly to the Banting and Best Institute laboratory in Toronto to work with Drs. William Bigelow and John Callaghan, who were studying how extreme cold could slow the human heart rate, making open heart surgery possible. Their problem was to re-start the heart if it stopped, and they were considering using a re-warming device. Hopps took up this story in his autobiographical Hall of Fame website remarks:

> We managed to develop a 'bipolar' catheter electrode to stimulate the lining of the heart without needing to open the patient's chest. Back in Ottawa, I built an efficient portable pacemaker unit, incorporating the desired electrical features with a suitable electric circuit. Portable didn't mean that you could carry the pacemaker around with you; however, in 1950, it was still considered 'portable'!
>
> Today, pacemakers are implanted under the skin, as they have been since 1959, but transistors had to be invented before the necessary miniaturization could occur. Those transistors have enabled many, including me, to live a normal life, thanks to pacemaker technology.

The first surgical implantation of a pacemaker in a human was performed in Sweden..

Hopps was one of the first to establish biomedical engineering as a separate discipline in Canada, in which he participated for almost half a century. As head of the medical engineering section of the REED, he led - among other activities - further research in the cardiovascular field, assistance for blind people and those with muscular disabilities, and in the diagnostic uses of ultrasound, which led to the development of an impressive list of devices.

In 1965, Hopps founded, and became the first president of the Canadian Medical and Biomedical Engineering Society, and was elected a Fellow of the Society. He was also a leader in the international development of his discipline and a member of the International Federation of these Societies, of which he served as president from 1971 to 1973 and as secretary general from 1976 until 1985, becoming an Honorary Life member of it. From 1985 to 1988 he was secretary general of the International Union for Physical and Engineering Science in Medicine and received its Award of Merit.

Hopps continued his involvement with his discipline after retirement in 1979. For example, he wrote on its subject matter, worked with school children, and served as president of the Ontario Heart Foundation's Ottawa Chapter. In 1984 he himself received a pacemaker. The original one served him for 13 years. He died in November 1998.

In 1976 the University of Manitoba conferred a DSc degree on him in recognition of his pacemaker work and his leadership in biomedical engineering. He received the McNaughton Award of the Institute of Electrical and Electronic Engineers and the Distinguished Scientist Award of the North American Society for Pacing and Electrophysiology. He was also appointed an Officer of the Order of Canada in 1986, and was inducted into the Hall of Fame in 2005.

Early in 1999, the Executive Committee of the National Engineering Week - after extensive research and consultation - compiled a list of five of the most significant Canadian engineering achievements of the 20th century. An Angus Reid poll was subsequently conducted among 1500 people to determine which of the five "made them most proud to be a Canadian." The winner was the Hopps pacemaker.

***

George Klein I, originally an Alsatian, was a farmer/settler who arrived in Perth County, Ontario in 1835. He was killed in late 1852 in an accident involving a threshing machine. His son, George II, born in 1842, was originally a farmer, used to machinery, but lost an arm in another threshing machine accident at the time the Civil War was raging in the United States and just before Canada was to become a Dominion. Unable to farm, this George created a business for himself transporting milk from local farms to the cheese factory. He was successful and was able to buy a valuable piece of machinery that few farmers bothered about - a clock. In 1883, the clock needed repair. So teen-aged George III was entrusted with taking it into Stratford, to a jeweller's. As events turned out, he got the clock repaired, and was also offered a part-time job - keeping the store open during lunch-hours. This soon became a full-time one and George began his life's work among the mechanical clocks and watches handled in the watchmaking business. He went to the United States for training, returning to Canada to the city of Hamilton in the mid-1890s. With a partner, he set up in business. It thrived. In 1903, this George married. In August 1904, his wife gave birth to George IV - **George Johann Klein.** Of the four George Kleins, this one became known as 'the inventor.'

Having a father with a fascination for things mechanical helped George Johann as he was growing up. There was a workshop at home, in the basement, which encouraged his inventiveness. It was also the time of Edison, Bell, Westinghouse, Fessenden, Marconi and the Wright Brothers - and of the flights of Canadians Casey Baldwin and Douglas McCurdy. It appears that seven-year-old George shook McCurdy's hand when he later visited Hamilton. But during World War I, George's teen-age inventiveness got him into trouble with the law. He had been tinkering with radio equipment and a message he had sent was picked up hundreds of miles away. It was traced back to the Klein home. The Police suspected it was an attempt to contact the enemy. George III knew differently and told the them so. The equipment was confiscated, but George IV continued tinkering - with mechanical rather than electrical devices.

George's parents, recognizing his technical interests and apparent ability, decided he should enroll at Hamilton Technical High School, from which he graduated in June 1924, but with a rather so-so academic record. He was fortunate, however, that his jeweller father could afford to send him to the School of Practical Science at the University in Toronto, since McMaster had not then moved to Hamilton. He was a member of the Class of 1928, graduating in mechanical engineering. One of his professors was John H. Parkin, a Canadian aeronautical research pioneer, who built and operated the UofT wind tunnel - a source of attraction for good students, which then included Klein. Before his undergraduate days were over, he had co-authored research papers with Parkin.

While he did summer jobs in Hamilton as an undergraduate, Klein chose on graduation to accept a demonstration and research job at the University. It allowed him to continue the his wind tunnel work and collaboration with Parkin. However, during the summer of 1929, Parkin joined the staff of the new laboratories of the National Research Council in Ottawa as assistant director of the Division of Physics and Engineering Physics, his appointment having been helped by the fact that

Bell

Bombardier

Dawson

Fessenden

Fleming

Heffernan

Hillier

Hopps

Klein

Le Caine

MacGill

Mackenzie

McNaughton

Ouimet

Turnbull

Wilson

aeronautical research was expected to be an integral part of the new Division's purview. In September, Klein accepted a job at the Council, working under his former mentor.

The John Street Laboratory buildings, formerly a sawmill, became Klein's working home for the next decade. They were situated to the east of the new and significant laboratory building then in the process of erection for the Council on Sussex Drive. Klein's first jobs, along with a handful of colleagues, were to design, build and test a wind tunnel and a marine towing tank in these old buildings. And so began a career that would establish him as a versatile engineering designer, inventor and innovator of superior ability. The first research paper published by the NRC Physics and Engineering Division was Klein's - on the design of vanes and other innovations for the wind tunnel. The tunnel and the tank were finished in 1931 and were put to use for research.

The 1930s were tough times for Klein's family in Hamilton, but he had a secure job at NRC. The main laboratory building was finished in 1932. In 1935, an engineer, General A.G.L. McNaughton, was appointed president of the Council. In 1936, NRC split off the engineering function from physics and formed the Division of Mechanical Engineering, with Parkin as director. In 1939, C.J. Mackenzie - another engineer - took over as acting president of NRC when McNaughton returned to service duty. He became president in 1944.

Meanwhile, Klein's talents were used wherever they could be useful. For example, in the early 1930s, he participated in the project lead by his colleague, J.J. Green, that resulted in the building of the streamlined CNR and CPR locomotives that drew the Royal Visit trains in 1939 across Canada. His main challenge, however, was to improve the aerodynamic performance of aircraft skis and examine their interaction with snow, with which he included basic work on the properties of snow and ice. This work continued throughout the War, and after it, when he was involved in adapting skis to suit the Canadian-designed *Beaver* aircraft. He also developed a method for classifying the different types of snow, designed and developed a kit for testing its properties, and participated actively in Canada's first official snow survey. He became a recognized expert in these fields, acknowledged both nationally and internationally. During World War II, Klein also participated in the design and testing of an innovative, personnel-carrying tracked vehicle that acquired the name of *Weasel*, intended originally for use by the so-called U.S.-Canadian *Devil's Brigade* under snow conditions. As events unfolded, the vehicle was widely used, both before and after the War, since it was equally useful in mud as in snow.

Before the War ended, Klein became involved in the design and construction of the experimental zero-energy ZEEP reactor at the new Chalk River Laboratories, then under NRC management. It was to be used for experiments linked to the design of the NRX reactor, then also under construction. ZEEP went critical in September 1945.

In addition to his continuing work on snow and ice in the immediate post-war years, Klein took a leading role in the designing of what became the world's first practical electric wheelchair, specifically designed for quadriplegics - a project that had been inspired by a disabled veteran of the Dieppe Raid of 1942, the initiative for which came from the Department of Veterans' Affairs. In

1947 he was asked by the RCMP to suggest improvements to the heavy dog-sleds - based on Inuit designs - used by the Force in the North to make then lighter and faster. In this case, his main conclusion was that there was little that could be improved upon!

During his career, Klein participated in many other projects - for example, the design and development of proximity fuses, the microsurgical staple gun, the *Hedgehog* antisubmarine system, and a wide range of gearing systems. Latterly, he became involved in the design and development of equipment for satellites and space, such as the *STEM* antenna and the *Canadarm*. In addition to his major projects, Klein produced hundreds of useful devices, many in support of the experiments being carried out by colleagues throughout NRC. Indeed, he became the 'man to go to' for colleagues in mechanical trouble. What he did on any one day was usually dependent on the problems brought through his office door. Interestingly, and unusually, he was not interested in patenting his devices. Klein retired from NRC in 1969, at age 65 and after 40 years service to NRC - about the time two men first set foot on the moon. But he remained active, consulting in regard to the *Canadarm* and the space shuttle.

During his lifetime. Klein received a number of awards in recognition of his work. After World War II, he was made a Member of the Order of the British Empire for his wartime work. In 1969, he was appointed an Officer of the Order of Canada. He was awarded fellowships of the American Society of Mechanical Engineers and the Britain's Royal Aeronautical Society. He received honorary degrees from Wilfred Laurier and Carleton Universities. In 1996, Carleton inaugurated the George J. Klein Medal for national competition in industrial design among high school students in Canada.

George Klein died in early November 1992 at the age of 88. He was inducted into the CMST Hall by NRC.

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Hugh Norman Le Caine was born at Port Arthur in May 1914, the first child of Hubert and Susan Le Caine. At the time, his father was a stationary engineer at the Current River Power Plant. His mother had taught school before he was born. He had a younger sister, Jeanne, and an adopted sister, Alison, with whom he shared his early years. He was home-schooled by his mother until he was nine. At an early age, he developed an interest in - and talent for - music, as well as the ability to memorize it easily. He learned to play the piano and several stringed instruments. His voice had absolute pitch and he sang in choirs. Also, his father's technical abilities 'rubbed off' on him, and he developed an interest in radios and electronics which, in turn, stimulated an interest in physics. He was class valedictorian when he finished high school. He also became a 'night-hawk.'

Influenced by the Great Depression, Le Caine chose to enter the Faculty of Applied Science, intending to study electrical engineering, rather than pure physics, or music, when he went to Queen's University in the fall of 1934. But he spent part of his first summer vacation in 1935 at the

Toronto Conservatory of Music, studying piano. In his second year at Queen's, Le Caine chose engineering physics as his major. His laboratory work that year caught the attention of Dr. J.A. Gray, who became his mentor and in whose lab he found a summer job at the end of his third year. After he graduated, Gray supervised his work for a master's degree in nuclear physics. It was while in Kingston, in a church, that he first came across the Hammond organ, which he described as "a superb engineering job." He also heard a demonstration of J.D. Robb's electronic organ - the first to be invented and made in Canada. In 1937, he was working to design and build one of his own, meantime developing a vibrating reed electrometer - the subject of a paper published in 1941.

In 1939 World War II began. Armed with an MSc degree in engineering physics, Le Caine took up an NRC Studentship to work at Queen's under the supervision of Dr. Gray, at the end of which he applied for a position at NRC in Ottawa on the basis of the electrical measuring instruments he had built and tested. He joined the Council in March 1940 and was assigned to work on the development of radar systems at a field station southeast of Ottawa. The microwave sets he worked on during the war supported the armed services in the field. He also wrote a number of papers describing the devices he had designed and built during these years. When not at work, he continued his interest in music and began to develop as a serious photographer.

By the middle of 1945, with the end of the war in sight, Le Caine had decided he wanted to work on electronic music. This proved to be more difficult to achieve in practice. He was not willing to accept the commercial objectives for his work that a company would require. So, for the next three years, he remained at NRC working on measuring and other devices in the lab during the day and on electronic music independently in his spare time. As Gayle Young has written:

> Le Caine developed a reputation as an agile problem solver, and he seldom discouraged others from coming to him for advice. This often made it difficult for him to work uninterruptedly on his own projects. He was temperamentally suited to late night work and developed the habit of working after most of the others had gone home. Although this ensured his privacy, the late night schedule made his social life difficult.

In addition, he planned his work in accordance with the theory that, in any eight-hour day, a person was more efficient during the first four hours than the second four.

Between 1945 and 1947, Le Caine was involved, formally, with a project to develop a small electron accelerator (microtron), from theory to actual operation, in a group led by Dr. W.J. Henderson. He was also increasingly active, informally, in electronic music, in accommodation he rented from the Council. One of its rooms served as an electronic laboratory-cum-studio, which doubled as a bedroom, and another was a 'performance' room which housed his own piano, organ and other instruments. As Young has noted:

> In 1945 Le Caine began to build a new electronic musical instrument to demonstrate his ideas. At first the instrument was built inside drawers of a desk, with all the electronic parts hidden from view, but it was soon moved out and became a keyboard instrument

> with its own stand. Le Caine named it the *Electronic Sackbut* after the medieval wind instrument that was the precursor of the trombone. The name was probably chosen because one of the Saskbut's features was a sliding pitch device.....
>
> In essence, the sackbut was the first synthesizer......
>
> Le Caine built the sackbut himself at his home studio using methods similar to those he employed at the NRC lab......
>
> By the summer of 1946 the sackbut had progressed to the point where it was being played as a keyboard instrument, not only by Le Caine, but by many of his friends. There were regular jam sessions at Le Caine's home, and some were recorded on acetate discs.

In 1946, Le Caine took his first motorcycle ride and, in 1947, bought himself a large one. From then until the end of his life, he would be a devoted rider of motorbikes.

In 1948, based on his work on the microtron, Le Caine was awarded a doctoral scholarship in nuclear physics by NRC to work in England at the University of Birmingham, where the world's first, large proton accelerator was being built. Le Caine was to assist with the design. However, over the next three years, he became somewhat disillusioned with his part of the work, which was limited to building electronic equipment, with no opportunity to pursue his own work on electronic music. In October 1951, he returned to Canada and, with help from his sister Jeanne, finished up his thesis. Birmingham awarded him his doctorate in the summer of 1952.

At this stage in his career, he could have joined the research staff at the Chalk River Laboratories to pursue the nuclear part of his experience, but he chose to remain in Ottawa at NRC. It was during this time that the Council's research activities were being expanded under its new president, E.W.R. Steacie. For his first year back, Le Caine was more technical trouble-shooter than researcher. As Young has written:

> Le Caine's interests tended increasingly to be related to electronic music instruments. His method was not that of the pure research scientist, but more related to engineering and the practical application of electronic techniques to the process of sound production. Few people were designing (such) instruments and Le Caine possibly recognized an opportunity to make a contribution. He was also motivated by his intense curiosity.

In December 1951, he moved his studio to another house nearby, and began to spend more and more time working on electronic music, including several keyboards. However, around two years later, NRC formed a new division, for radio and electrical engineering (REED), of which he became a member. He moved again, to a house he built nearer the location of the new division that provided both home and studio. In the spring of 1954, also a result of the formation of REED, his duties within the Council were changed to allow him to pursue his electronic music interests formally in an NRC laboratory, and his home studio equipment was moved there. He was also allowed to work the hours of the day he preferred - after his colleagues had gone home.

Le Caine also began to lecture outside the Council on electronic music and to demonstrate the musical abilities of the sackbut. Formally, his objective was to develop instruments for possible manufacture by Canadian industry. His technician worked 'normal' days and met with him for briefings and discussions at the end of each day. This arrangement applied, with some variations, until Le Caine retired from NRC in December 1974.

Young has listed Le Caine's principal electronic music projects for the 20-year period he worked at NRC in this field, among which were the following: the sackbut: 1954-60 and 1969-73; the touch-sensitive electric organ: 1953-57; the multi-track tape recorder: 1955-64; the oscillator bank: 1957-59; the spectrogram: 1959-62; printed circuit keys: 1962-69; the serial sound structure generator: 1965-70; the sonde (to simplify the work of the composer): 1968-70; the polyphonic synthesizer: 1970, and the paramus: 1972-74 - an instrument that combined computer control with analog sound generation. Transistors, which became commercially available around 1957 made a significant difference to Le Caine's work. He also did some composing of electronic music, particularly in his earlier years. In Young's book, he is quoted as saying, of his best-known piece:

> By the end of 1955 I had produced *Dripsody* on my variable speed multiple tape recorder. I had been working for months on a composition using three sound objects: the breaking of a pane of glass with a hammer, the sound of a ping-pong ball hitting the bat, and the sound of the fall of a single drop of water. I had tried many approaches but none proved viable. One night, about 2:45 am, I thought: why not try the drop of water alone? The composition *Dripsody* was an experiment in the use of variable playback speed on the sound of the fall of one single drop of water recorded on a very short length of tape.

In 1970 and 1971, Le Caine and his technical people modernized the sackbut with a view to having it manufactured commercially. However, this process was lengthy and ended unsuccessfully. In 1971, he had heart surgery, followed by a successful convalescence. In the years prior to his retirement, he worked on the paramus and other instruments and was in demand as a lecturer on electronic music. His instruments were taken on a nation-wide tour by the Science and Technology Museum, but Le Caine did not participate. At the same time, his situation within NRC was becoming increasingly less secure as the objectives and personnel of REED changed. He was told that his work would not be continued once he retired. He did so in 1974.

Le Caine was also deeply involved in the establishment and programs of the electronic music studios at the University of Toronto, from 1959, and McGill, from 1964. He married later in life - but retained most of the working habits he had developed as a bachelor, although he never brought work home from the lab. In recognition of his contributions to electronic music, he was awarded honorary degrees by McGill, the University of Toronto - and Queen's, in 1974, when the new music building was also named the Harrison Le Caine Hall, after the noted musicologist and teacher, Dr. Frank Harrison, and himself.

After retiring, Le Caine continued to work at home, undisturbed, and for a time at a small office at NRC. He wrote, mostly, studied Swahili, took film courses, shot films......and rode his motorcycle. On one afternoon in July 1976 he had a very serious accident on the road to Montréal. He died of a stroke suffered almost one year to the day later.

He was inducted into the Hall by NRC.

***

Her full name was **Elizabeth Muriel Gregory MacGill**, but she was better known as Elsie Gregory MacGill or, simply, Elsie MacGill. She was born in Vancouver in 1905, and had two half-brothers from her mother's first marriage, and an older sister from her second, to lawyer James MacGill. She achieved a number of firsts - following in the footsteps of her mother, Helen Emma Gregory MacGill, who was the first woman graduate in the British Empire to receive a university degree in music (from the University of Toronto), the first woman to be appointed a judge in British Columbia (and the third in Canada), and one of the earliest Canadian feminists.

As Elsie herself wrote in the text that accompanies her entry in the Hall of Fame website:

> I was the first woman to receive an electrical engineering degree in Canada, as well as the first woman in North America to hold a degree in aeronautical engineering. Although I held many important positions in the aeronautics industry, I am perhaps best known for my work during World War II. As chief engineer for the Canadian Car and Foundry Company, I oversaw the production of the Hawker *Hurricane* in Canada, and I designed a series of modifications to equip the *Hurricane* for cold weather flying.
>
> I was also the first woman aircraft designer in the world. My *Maple Leaf* trainer may still be the only plane ever to be completely designed by a woman. Although I never learned to fly myself, I accompanied the pilots on all test flights - even the dangerous first flight - of any aircraft I worked on. It was the best way to assess the aircraft's performance.....

She did not, however, fly in a *Hurricane* since it only had a seat for the pilot!

Elsie's graduated from the University of Toronto in May 1927. Disenchanted with her first employment, at a small engineering company in Pontiac, Michigan, and attracted by the University of Michigan's activities in aeronautical engineering at Ann Arbor, she was offered a fellowship and enrolled in a master's program there the following November. She received her degree in 1929. However, just before this happened, she contracted polio and wrote her final exams in her hospital bed. For the following three years, while she recovered, she was confined to a wheelchair, after which - and almost to the end of her life, she was dependent on canes to get around.

In 1932, she resumed her career, enrolling as a doctoral student in aeronautical engineering at MIT, but dropped out late in 1934 to join the Fairchild Aircraft Ltd. at Longueuil, Québec as an assistant aeronautical engineer. Between then and May 1938, when she left Fairchild, she participated in design work related to a number of the Company's aircraft, none of which, in spite of good engineering, were commercial successes. She made contact with researchers in aeronautics at the National Research Council in Ottawa that would serve her throughout her career, as well as participating in the wind tunnel work that was carried out there. It was at Fairchild that she first met manager E.J. (Bill) Soulsby and his wife, who would figure prominently throughout her life. She was also an enthusiastic participant in the test flights of the aircraft. As Bourgeois-Doyle has written about the first of these flights:

> Elsie's legs were still too weak for her to consider piloting the plane, but on this day, she began a convention that would earn the respect of many pilots and earn recognition as a true aviation pioneer: to always accompany the pilots in any of the planes she had helped design as the 'participating observer' on all test flights....

Doyle also commented that she shared many minor achievements at Fairchild and that the special knowledge, skill and hard experience she acquired there turned her into a more capable engineer through learning what did not work as well as what did.

In 1937, the Soulsbys moved to Fort William where Bill took up a managerial appointment with the Canadian Car and Foundry Company, which was in the process of developing a place for itself in the Canadian aviation industry. When the position of chief aeronautical engineer became vacant, Bill encouraged Elsie to apply for it - which she did, successfully, moving to the Fort William in the summer of 1938. For the first while, she worked on the production of U.S.-designed Grumman *G-23* planes, most of which were sold abroad since they did not appeal to Canadian buyers. Her next project involved more design and stress analysis - for the all-metal Gregor *Fighter*, which Can-Car was developing on its own and which flew for the first time in December 1938. But the company could find no market for it.

In January 1939, Elsie received a new assignment - to prepare the complete design for the first all-Canadian biplane, which Can-Car hoped would appeal to the Canadian Armed Forces as a primary trainer, to be called the *Maple Leaf II*. (The *Maple Leaf I* trainer had been a failure, but the Company decided to continue the name.) This was quite a challenge since, among other features, the trainer had to incorporate aerobatic capabilities and be suitable for flying under Canadian conditions. The Company also expected there would soon be a war in which Canadian pilots would participate.

Maple Leaf II took its first test flight on October 31, 1939, with Elsie on board. With its safe landing, she became 'the first woman to have designed an aircraft.' As Bourgeois-Doyle commented:

> There are undoubtedly other women of achievement in the early years of aeronautical engineering. Yet the fact that Gardner, Lunn, Lotz and the other women most often cited as pioneers in aeronautical engineering acquired their qualifications at least a few years