Canadian Engineering History:

A Thumbnail Sketch

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Preamble

Engineering can be, and has been, defined in a variety of ways. A very early definition was that it is "the art of directing the great source of power in Nature for the use and convenience of people." Nowadays, it has to be considered as an informed *activity* performed by purpose-trained practitioners in regard to the design, production and maintenance of machinery, constructions, processes and devices that is being augmented constantly by experience, research, and information that extends beyond science and technology and requires some understanding of economics and business, the law, the social sciences, and politics, as well as an appreciation of the past as well as the future.

This paper has been written especially for students of engineering, to introduce them to some of the past events and achievements in engineering activity in Canada. The text is relatively short and makes use of information that has already appeared in other, longer stories of Canadian engineering. For the purposes of this paper, however, some of Newfoundland and Labrador's engineering achievements prior to 1949 have been included. The illustrations are also few in number, but a bibliography has been appended to encourage further reading.

To provide some background to the events and achievements, some economic, social and political information has been included. To help accommodate its 'thumbnail' description, this paper omits specific references to Canadian achievements abroad, to engineering in the Armed Forces, and to some of the companies with obvious engineering connections. And while it mentions 'final' events and achievements, it usually omits the earlier details.

Estimates have been given throughout the paper of the numbers of engineers in professional practice in Canada. These numbers are simply 'ballpark' figures since formal counts in years past have had problems. For example, at the time of Confederation, not all who professed to practice professionally were sufficiently qualified and experienced. Later, not all who professed engineering in the national censuses were qualified to do so and some, who were, simply chose the occupations in which they were actually engaged. Some others thought of themselves as scientists. Also, not all university engineering graduates actually in practice join the provincial associations or the Canadian learned societies, which are the main non-government 'counting' agencies.

In the beginning…

As Canadian mythology has it, the first engineers in this country were beavers, who built dams, weirs and lodges in watery surroundings. Centuries later, their successors are still doing these things.

When their turns came, the First Nations, Métis and Inuit were concerned with survival in the country's often harsh climate and with transportation over land and water throughout the year, imperatives that have been in place ever since. Their contributions included kayaks and canoes, igloos, teepees, longhouses, palisades, snowshoes, moccasins, dogsleds, toboggans, Red River carts, bone and metal tools and weapons, and weirs, dams and other devices for trapping fish and animals.

The early French, and later the British, adventurers and settlers in Eastern Canada made use of what the indigenous people had engineered. They also learned to adapt European engineering practices to Canadian needs and conditions and to devise new ones to suit their new needs, particularly in regard to stone fortifications, port facilities, and deeper waterways for their larger boats and ships. In support of agriculture, for example, they drained maritime marshes using tide gates (*aboiteaux*).

By the early 19th century, a rag-based paper industry had been established. Not long after, paper was being made from woodpulp, and kerosene had been made and manufactured. The building of sailboats was well established on the Atlantic coast and St Lawrence estuary. Steamboats were providing services on the major rivers and lakes, most of them locally built, as were some of their engines. One of them, the *Prince William,* crossed the Atlantic. The first canals, including those on the Rideau, Ottawa and St. Lawrence Rivers, had been built, as had railways and telegraph lines, all of them helping to stimulate settlement and primary industries, including the manufacture of agricultural machinery. Saw, flour and grist mills were everywhere. So were blacksmiths' shops. The export of squared timber was in full swing on the Ottawa and St. Lawrence Rivers, involving the development and construction of rafts, timber slides and fish ladders.

Around mid-century, Newfoundland was connected to the British Isles by submarine telegraph cable. In Ontario, the Canadian Northwest and British Columbia, settlers' trails, including the Fraser Valley's Cariboo Road, had been built. On the west coast, steamboats were arriving, as well as the first of the gold rushes. The first Canadian locomotive was built in Toronto, followed by the first North American railway tunnel, at Brockville. What was then the Ontario Foundry in Kingston (and later the Canadian Locomotive Company) had built its first locomotives for the Grand Trunk Railway (GTR). Around this time, also, the GTR purchased land in Montréal for a rail yard and its (later extensive) Point Saint Charles Shops. By the late 1850s, some of the rails laid in Canada were being made here. Also, Roebling's (American) suspension bridge had been opened at Niagara Falls, and in 1860 the Prince of Wales opened the original, tubular Victoria Bridge across the St. Lawrence at Montréal, as well as the new Parliament Building at Ottawa. Soon, the first city-wide water, sewer and fire protection systems were in operation in cities such as Montréal, Ottawa, Toronto and Hamilton. Gold had been mined in B.C., coal in Cape Breton, iron in Southern Ontario and silver in Northern Ontario. As noted already, steam engines were manufactured domestically and ships were being built. The establishment of the Geological Survey of Canada in 1863 expedited the search for minerals across the country and helped the further development of the mining industry.

Formal engineering education began in Canada at what is now the University of New Brunswick in 1854, but it was another two decades before engineering degrees were awarded by degree-granting academic institutions. Up until then, *engineering* had been principally a military occupation. But an engineer's employment in civil life was often dependent on his political views and connections. The earliest consulting engineering firms in Canada were usually associated with British or American principals.

The body of this paper has been divided into three post-Confederation time periods, each with three sections: economic and other events having engineering implications and consequences; specific engineering events and achievements; and some notes on the development of the profession.

Also, the historical material ends with Canada's Sesquicentennial in 2017.

From Confederation until the First World War…

Economic/Social/Political

By July I, 1867, the new Dominion of Canada had a population of around 3.5 million, many of them living in Montréal, although the capital city was Ottawa.

The House of Commons was 'home' to 181 MP's. The size of the Dominion public service in Ottawa and elsewhere was relatively small, some 2,600 people. The American Civil War had ended and trade and political and economic relations had resumed with the United States. However, for a variety of reasons, the early post-1867 years were disappointing economically and the major engineering project, the railway to the west coast, was mired in financial and political problems.

During this first period, Canada as we now know it became more recognizable. The provinces of PEI, Manitoba, Saskatchewan, Alberta and British Columbia were formed, as were the Yukon and Northwest Territories. Canadian sovereignty in the High Arctic was established in the 1880s, as was a uniform Canadian dollar. At first, the Canadian West remained largely unsettled, with unrest in Manitoba and across the prairies. Settlers on farms there and everywhere else were also learning to cope with cold winters and bug-infested summers and, with land still available, settlement in the U.S. was still attractive. However, the pre-Confederation 'staples' economy of fur, fish and timber was coming to an end. Manufacturing in Ontario was dominated at first by mostly small, agricultural machinery producers, of whom the Massey, Harris and Cockshutt companies were examples. Two-thirds of Canada's coal production was coming from 21 collieries in Nova Scotia.

The first Patent Act passed in 1869. A Canadian Manufacturers' Association was founded in 1871, and a Bank Act passed through Parliament. The Canadian dollar was stabilized. Also in 1871, the negotiation of First Nations Treaties began. A year later, the Dominion Lands Act was passed to encourage settlement of the West, and a Dominion Militia Act established the Canadian Army. The North-West Mounted Police was formed in 1873. Education in farming became available when the Guelph Agricultural College opened a year later. The Supreme Court 'arrived' in 1875.

The Bell Telephone Company was chartered in 1880. In the early 1880s the Dominion Bridge Company opened its first plant at Lachine, Québec, as did a locomotive works at Montréal, the Polson Iron Works at Toronto, and a shipyard at Collingwood, Ontario. Nickel-copper deposits were discovered in the Sudbury Basin. Some years later, iron ore was discovered in the Labrador Trough.

The first two Canadian prime ministers were Macdonald and Mackenzie, but it was only during the second Macdonald administration, after 1878, that a national policy favouring manufacturing took effect and the promised Canadian Pacific Railway (CPR) to British Columbia was finished, in 1885. This coincided with the Northwest Rebellion, during which the new railway helped get troops to the prairies, and river steamboats built in Canada were involved in the Battle of Batoche in Saskatchewan. Back in 1879, Sandford Fleming

had made his ‘standard time’ proposals, which were adopted worldwide in 1884.The economy and politics remained remarkably stable through the Laurier and Borden administrations and into the First World War.

By the late 1880s, the growing attractiveness of electric power and its many uses were becoming evident. The General Electric Company of Canada was established at Peterborough in 1892 and, a year later, the Canadian Electrical Association was formed. In 1885 the Northern Electric and Manufacturing Company was established in Montréal and, shortly thereafter, the Westinghouse Company of Pittsburgh opened a plant at Hamilton.

Around this time, also, a number of Nova Scotia coal companies merged to form the Dominion Coal Company while, out West, the Crow’s Nest Pass Agreement on freight rates for grain took effect. The CPR also gained access to mining and smelting activities in south eastern B.C.. In the east, the Davie Shipbuilding Company began operating at Lauzon, Québec and, before the end of the century, the Shawinigan Water and Power Company was founded to develop the hydro-electric and other potentials of the St. Maurice River, and the exploitation of the power of Ontario’s Niagara Falls had begun. The late 1890s also brought the Klondike Gold Rush, Canadian military participation in the Second Boer War in South Africa, and the settlement of the prairies, where sod houses were being used as dwellings. There were around a half-million farms in the whole of Canada. The country’s population was now over 5 million.

The Canadian Patent Office began operating in 1900. The International Nickel Company was established by merger in 1901. The Northern Aluminum Company was founded at Shawinigan in 1902, and later became Alcan. In 1903, while building the Temiscaming & Northern Ontario Railway, silver deposits were discovered at Cobalt, and the Northern Ontario mining boom had begun. It lasted for 30 years. In 1904 the Regiment of Royal Canadian Engineers was founded. In 1906, the CPR purchased the smelter at Trail, B.C., and renamed the company that eventually became Cominco Ltd..

In 1906, Adam Beck organized the Hydro-Electric Power Commission of Ontario. The Boundary Waters Treaty between Canada and the United States was signed in 1909 and established the six-member International Joint Commission with jurisdiction over shared waters, from the St Lawrence to the Pacific, and issues such as water quality and flows and the placement of dams. In 1910, the Steel Company of Canada was formed by merger, at Hamilton. In 1911, the Royal Canadian Navy was formed, with two old British warships. In 1912 the Sherman family founded the steel company that later became known as Dofasco. In 1914, Canada went off the gold standard, and the Dominion Coal Company was producing 40% of Canada’s coal. There were 50,000 registered motor cars across the country. And a Department of Highways was established in Québec, two years later in Ontario.

The First World War began for Canada in August 1914. The first Canadian contingent reached England in October. The Army fought in Europe for four years. The Navy spent much of the War on convoy duty in the North Atlantic. Canadian airmen served with British units. At home, deprived of what they had previously imported, Canadian entrepreneurs started to make the goods themselves, in addition to building warships, planes and munitions for the war effort. The country also became the ‘breadbasket’ for the Allies.

Canadian Government Railways (CGR) was established in 1915 to manage several lines that were in financial trouble, and to guide their wartime contributions. These included the Intercolonial Railway, the second Transcontinental, and the PEI Railway. In 1915, also, Teck-Hughes Gold Mines Ltd. opened at Kirkland Lake, Ontario. The National Research Council of Canada (NRC) was established in 1916 on the British and U.S. models to provide support for scientific research, with particular reference to industry, but without laboratories of its own. Also in 1916, the Palliser Triangle in southern Alberta and Saskatchewan was plagued by drought and the loss of much farming investment, and the first Dominion income tax was introduced. The Canadian Engineering Standards Association (CESA, now simply the CSA) was founded by Sir John Kennedy and others in 1917. The McLaughlin and Chevrolet companies amalgamated to form General Motors of Canada, and Daylight Saving Time was first used.

Engineering

H.S. Taylor built Canada's first 'horseless' carriage in 1868. Steel was first produced in Nova Scotia in 1870, about the same time that rock drilling was first used in the mining industry. The Ottawa River canals were enlarged to accommodate the larger vessels then in use. Elijah McCoy developed the lubricating cup for steam engines. Charles Barnes invented a rotary vane pump. In 1875-76, Alexander Graham Bell carried out telephone experiments at Brantford, Ontario. In 1878 the first telephone exchange was opened at Hamilton.

Also in the 1870s, the first electric arc lamps were made, and Evans and Woodward invented and patented an incandescent electric light bulb, and later sold their patent to Edison. The development of electric lighting for city streets began in Montréal in the late 1870s and, over the next decade, spread to other cities and to large towns. By 1882, the first demonstration of electric streetcars had taken place in Toronto, Thomas Ahearn had cooked the first meal by electricity, in Ottawa. Ahearn and his partner Soper had also introduced the city to the electric streetcar, and to electric heating for it.

By 1875 there were over 5,000 miles of railroad track and 1,000 working locomotives in Canada, and a standard railway track gauge. By 1876 the Intercolonial Railway linking Central Canada with the Maritimes had been completed. At Sandford Fleming's insistence, the bridges for it were made of iron rather than wood. Two years later, the Canadian Pacific Railway (CPR) began progressing the first transcontinental railway westwards toward B.C.. The line to Vancouver was completed in 1885, its passage through the mountains of British Columbia representing a considerable engineering achievement, with the often-spectacular wooden trestle bridges attracting considerable international attention. By then, the first grain elevators were being built at the Lakehead and across the prairies, of wood but later of concrete.

Mining and smelting had begun in southern British Columbia, and there was a mining boom in Northern Ontario. Industrial textile production had begun when the Dominion Cotton Mills Company was formed from a half-dozen smaller companies. By 1884, O. Jull, at Orangeville, Ontario, had built the first self-powered, locomotive-driven snow removal machine and J.G. Cockshutt of Brantford had invented (and manufactured) the sulky plow. By 1885, the Reversing Falls Bridge was opened at Saint John, New Brunswick, a municipal water pumping station had been built at Fredericton, and the first sulphite pulpmill in Canada began production at Sheet Harbour, Nova Scotia. In 1886, the first electric power was generated

on Prince Edward Island, using a steam generator. In 1889, the first steel-hulled, propeller-driven Canadian ship (the SS *Manitoba*) was built at Owen Sound by the Polson Company, and a new suspension bridge was built at Niagara Falls to replace the one destroyed in a violent wind storm. In 1891, Hobson's St. Clair railway tunnel was opened between Sarnia, Ontario, and Port Huron, Michigan.

In the early 1880s, the Bell Telephone Company, the Dominion Bridge Company, the Collingwood Shipyard and the Montreal Locomotive Works were established and mining began in the Sudbury Basin. By 1887 the first graving dock had been built at Esquimalt, B.C.. In the 1890s, the Massey and Harris agricultural implement companies merged. The General Electric Company of Canada began operations at Peterborough, including building large electrical dynamos and motors, as did the Canadian Westinghouse Company at Hamilton. The Northern Electric and Manufacturing Company (which much later became Nortel) was established at Montréal to make telephone equipment, followed by the Davie Shipbuilding Company at Lauzon, Québec and the Wallace Shipbuilding Company in Vancouver. The first framed, self-supporting 'skyscraper' in Canada - the Robert Simpson six-storey department store in downtown Toronto - was built, with elevators. The first three-phase alternating current plant was installed at St. Hyacinthe, Québec.

By the 1890s, the steam tractor had become the workhorse of the prairie farmlands. The first a.c. motors were driving mine hoists in British Columbia. Speaking of B.C., two steamships (SS *Moyie* and *Minto*) were built in Toronto, dismantled and sent west by rail, where they were reassembled for service on the Arrow and Kootenay Lakes. Thomas Willson used an electric furnace to make calcium carbide from coke and lime and set up a manufacturing plant for it at Niagara Falls. The hydraulic plant at De Cew Falls, Ontario, using transformers, began transmitting a.c. power 32 miles to Hamilton. And by the end of the century, concrete had become a major construction material.

In 1898 the Yukon Territory was in the midst of its Gold Rush, but the White Pass and Yukon Railway, intended originally to serve this rush, was not completed until 1900. In 1899, extensive irrigation work was taking place in Southern Alberta. On the other side of the continent, the 900-mile-long, narrow gauge Newfoundland Railway had been completed by contractor Robert G. Reid, and mining had begun on Bell Island.

In the early 1900s, a chemical production industry that included aluminum as well as calcium carbide began at Shawinigan, Québec, to take advantage of the recently-harnessed hydro-electric potential of the St. Maurice River, some of which was 'exported' to the city of Montréal. The construction of hydro-electric generating plants grew, in the Niagara Gorge. Increasingly, electric power was replacing steam.

Just after the turn of the century, the first Ford Motor Company plant in Canada began building vehicles and engines at Windsor, Ontario. The mining boom that began in Northern Ontario in the early 1900s was helped by the building of the Temiscaming & Northern Ontario Railway. The newsprint industry in Eastern Canada and British Columbia expanded significantly and continued to do so for the next 20 years. On the Trent-Severn Waterway in Ontario, many years in the building, lift locks were completed at Peterborough in 1904 and at Kirkfield three years later. By then, the CPR's spiral tunnels were in place in British Columbia, as was the mile-long railway viaduct at Lethbridge, Alberta. By 1907, the new Québec Bridge

had experienced collapse when under construction. In 1910, the Polson Iron Works in Toronto built the SS *Bigwin* and the SS *Trillium,* both of which were still in service over 100 years later. In 1912, the second transcontinental railway across Canada was completed. In 1913, the newly-built Transcona grain elevator at Winnipeg experienced foundation failure and partially collapsed. It was later re-founded successfully.

Aviation - world-wide - got its heavier-than-air start with the Wright Brothers machine at Kittyhawk in the United States in 1903. Not long after that, in Canada, Alexander Graham Bell and the Aerial Experimental Association began their aircraft development work at Baddeck, Nova Scotia. Their first successful machine, the *Silver Dart,* flew at Baddeck in February 1909.

Faced with the disappearance of off-shore supplies of certain engineered products during the First World War, manufacturing industries in Canada, including chemicals and pharmaceuticals, expanded their activities. This activity was supplemented by contracts let through the Canadian branch of the Imperial Munitions Board. At home, the building of ships and aircraft expanded, and the Canadian Army in France developed a reputation for its work in railways, tunnelling, artillery and signals.

By 1914, the western part of the third transcontinental railway had been completed (the eastern part in 1917). In support of irrigation, the Brooks Aqueduct was completed in Southern Alberta. The Kettle Valley Railway across southern British Columbia was finished in 1916. Again, its spectacular trestle bridges attracted international attention. That same year, the CPR completed the Connaught Tunnel in British Columbia. In 1918, the Mount Royal Tunnel was opened at Montréal.

Profession/ Education

In 1867 there were approximately 200 engineers in professional practice in Canada.

Degree-level engineering education began in the 1870s at McGill University and École Polytechnique in Montréal, Queen's College and the Royal Military College in Kingston, and the University of Toronto. By the end of this first post-Confederation period, professional education in engineering could also be obtained at the Nova Scotia Technical College and UNB in the Maritimes, and the Universities of Manitoba, Saskatchewan, Alberta, and British Columbia. Research, however, was not then a major preoccupation of the professors.

The profession of engineering was formalized in 1887, when the Canadian Society of Civil Engineers (CSCE), as distinct from military ones, was established. Not surprisingly, most of those who became its first members and leaders were associated with railways and canals. Their discipline was principally civil, with some mechanicals and miners, and some were serving in the Dominion and provincial governments as well as in the private sector. However, in 1896, a separate Canadian Institute of Mining (CIM) was formed from provincial mining societies, although the CSCE for many years retained an interest in mining. Attempts were made at the turn of the century, unsuccessfully as it happened, to regulate the profession by provincial statutes. Around then, also, a rival to the CSCE, the Dominion Society of Amalgamated Engineering (DSAE), operated for a few years. But by the time of First World War, the growth in numbers of mechanical and electrical engineers prompted the CSCE to examine itself. Among the changes made,

in April 1918, was one of name - the CSCE became the Engineering Institute of Canada (EIC). Another was to establish the monthly *Engineering Journal* (which was continuously published until 1987).

Among the consulting firms established during this first period were Reid, Crowther in Calgary, J.T. Donald & Company and Proctor & Redfern in Toronto, and Montréal Engineering (which later became Monenco) and the Surveyor Company (which later became SNC) in Montréal.

Engineers whose activities drew particular attention during this period included Thomas and Samuel Keefer, Sandford Fleming, Casimir Gzowski, John Kennedy, Walter and Frank Shanly, John Galbraith, Percy Girouard, Collingwood Schreiber, W.P. Anderson, Thomas Ahearn, F.N. Gisborne, Henry Cambie, Robert Reid, William and Franklin Polson, J.M.R Fairbairn and George Duggan.

In summary…during this first post-Confederation period, Canada moved from having a rural economy in the east and empty spaces in the west to having one more dependent on the uneven growth and distribution of secondary industries and population, along with larger cities and more towns and villages, plus developing transportation, water and sewage systems, and a settled, mainly agricultural, West. From a slow start after 1867, and its base in railways and canals, engineering contributed significantly to the country's evolution. From the energy point of view, at the turn of the century, steam was being replaced by hydro-generated electricity, and the new disciplines of electrical, chemical and aeronautical engineering were emerging. The use of concrete and steel increased significantly during the final years of the 19th century. Canada's efforts during the First World War earned it a place in international diplomacy, in part because of its military engineering expertise. Engineering was helping make the country 'work.'

Post First World War to the Second World War…

Economic/Social/Political

By 1919 Canada had a population of around 8 million. Montréal was still the largest city.

The early postwar years were unsettled for a variety of reasons: for example, the difficult transition from service to civilian life for many war veterans, labour unrest and the Winnipeg Strike, and the widespread effects of the 'Spanish flu' pandemic. The rest of the 1920s were more favourable economically, until the Great Depression began in 1929 and lasted more or less until the beginning of the Second World War. During this war, the Canadian economy (and engineering) boomed.

On the railway front, the Dominion government established Canadian National Railways (CNR) in 1919 to take over from the earlier-established Canadian Government Railways (CGR) the further consolidation and management of the lines that were in financial trouble, and now included the Grand Trunk system. Also that year, the government created the Historic Sites and Monuments Board of Canada to recognize sites, events and people deemed to be of national historic significance, including those related to Canadian events and achievements. The Canadian Air Force was formed in 1920 and received its 'Royal' designation four years later. Regular radio broadcasting began in 1921 and, within two years, there were 34 radio stations. Throughout the 1920s the mining and hydro-electric sectors were the most active from

the engineering point of view, followed by pulp, paper and newsprint. Electrification throughout Canada was assisted by the individual provinces through their Rural Electrification legislation. Exports centred around wheat, lumber and minerals. Secondary manufacturing played a supporting role. Manufactured imports came principally from the United States but, with the Great Depression, came the Smoot-Hawley Act and Canadian retaliation to interfere with cross-border trade.

The 1920s saw the establishment of the first Canadian industry-supported research institute - the Pulp and Paper Research Institute of Canada (PPRIC), later PAPRICAN, and now part of FP Innovations - by the pulp and paper industry, which has made contributions over the years to the improvement of the industry's engineering activities.

By the early Great Depression years Canada's population had reached just over 10 million, but both birth rates and immigration had begun to fall. Emigration rates had not. The Prairie Provinces suffered more hardship than the rest of the country, having to deal with drought as well as market disappearance. But by then the British Empire was gaining through politics as well as trade. The Balfour Declaration of 1928 was followed by the Statute of Westminster in 1931, which granted full legal freedom to Canada and the other Dominions, and to the Ottawa Agreements, which encouraged trade within the Empire. However, Canada had no 'New Deal' like the United States, to help alleviate the distress many suffered during the depression. But there were still a number of helpful engineering-related Dominion government initiatives. For example, the CBC and the Trans-Canada Telephone Network were founded in 1932, the Prairie Farm Rehabilitation Administration, which had engineering as well as economic responsibilities, and Trans-Canada Airlines in 1937, as a CNR subsidiary. In 1938 the Niagara Falls Bridge Commission became responsible for the maintenance of the International bridges across the river.

Recovery from the depression began slowly in the mid-1930s but needed the Second World War to be completed and for severe unemployment to disappear. After September 1939, membership of the Armed Forces increased significantly, as did employment associated with war production, and particularly in regard to the building of ships and aircraft. More women entered the labour force to do production jobs. Again, Canada became the Allies' 'breadbasket' and the manufacturing sector reacted to the disappearance of supplies from foreign sources.

Engineering

Between the early postwar years and the beginning of the Great Depression, the Esquimalt drydock - then the second largest in the world - was built at Victoria. A series of studies was carried out on the development and use of alkali-resistant concrete in Western Canada. Dr. Karl Clark received a patent for a method of extracting oil from the Alberta tar sands and (later) the first experimental oil sands extraction plant was built at Bitumount. The Hudson Bay Railway was completed from The Pas to Churchill, Manitoba, over peat and permafrost. The first ice roads were built in the Northwest Territories. So called 'bush flying' was pursued by former First World War pilots and others to open up Canada's North and to support mining, forestry and other northern activities. The 160 km Shoal Lake Aqueduct was built to carry water from Northern Ontario to Winnipeg. The first Great Lakes self-unloading vessel was built. The Queenston-Chippewa Generating Station (later renamed Sir Adam Beck I) was completed at Niagara Falls.

Edward Rogers developed the battery-less radio, The International Nickel Company began aggressively to engineer new uses for nickel. The Trent-Severn Waterway was (finally) completed across Ontario. Courtaulds built the first synthetic fabric plant at Cornwall, Ontario, Arthur Sicard developed his snowblower, and Armand Bombardier the first of his snowmobiles. The CN Railway put the first diesel locomotive in Canada to work. The Shawinigan area, and the St. Maurice River, remained the key chemical manufacturing industry centre in Canada. Also in Québec, Alcan's aluminum refining and Noranda's copper mining and refining activities began and have continued ever since. The Île Maligne hydro-electric generating plant, then one of the world's largest, was completed on the Saguenay River to provide power for Alcan's smelter at Arvida. Aerial photography, which was developed during the First World War, was further developed for the mapping of Canada.

Rupert Turnbull built and used Canada's first wind tunnel and began the development of the variable-pitch propeller. A pulp mill was opened at Bathurst, New Brunswick, to clarify green liquor by a process developed by John Bates to improve the manufacture of kraft paper. The Saint John drydock was completed. Alexander Graham Bell died and F.W. (Casey) Baldwin took over management of the work at Baddeck. By then its focus had shifted from aircraft to hydrofoils. The Bell-Baldwin HD-4 broke the world water speed record and held on to it till the 1930s.

As noted above, some significant engineering projects were completed or carried out during the depression years. One of them was the first hydro plant in Saskatchewan, at Island Falls. In Saskatoon, the specially-designed and built (for Depression times) Broadway Bridge was opened. The Ghost hydro-electric plant was completed on the Bow River in Alberta, and the Seven Sisters plant on the Winnipeg River, the Chats Falls generating station on the Ottawa River, and the Beauharnois station in Québec. The facilities at the Hudson's Bay port of Churchill were opened. Some impressive buildings were completed, included the Maple Leaf Gardens Stadium and the Bank of Commerce Building in Toronto, and the Sun Life Building in Montréal. By 1931, Toronto had a 720-mile-long sewer system that could also clear storm waters. The fourth Welland Canal (the Ship) was built, with features such as the spectacular flight locks, but without disrupting traffic operations along the Third Canal. The Jacques Cartier and Mercier Bridges were opened at Montréal, the Ambassador Bridge between Detroit and Windsor, and the Lion's Gate and Burrard Bridges at Vancouver.

A rugged 'bush' plane, the Noorduyn *Norseman,* was designed and built in Montréal without the help of a wind tunnel. It went on to be one of the most reliable, long-serving planes in Canada's north and around the world. A self-propelled combine harvester was developed for the Massey-Harris Company by Thomas Carroll. Donald Hings created a hand-held, two-way portable radio or *walkie-talkie* for use by the mining industry in British Columbia. The first commercial electron microscope was designed and built at the University of Toronto. The Queen Elizabeth Way between Toronto and Hamilton was opened by H.M. The Queen during the 1939 Royal Visit to Canada. In 1941 British Columbia completed a major southern highway, from Hope to the Alberta Border.

Canadian engineering activities during the Second World War mirrored those of the earlier conflict, but were larger in scale and including merchant as well as naval ships, fighter, bomber and training aircraft, and munitions. Regarding training aircraft, aeronautical engineer Elsie MacGill designed and built one

which, unfortunately, was not adopted by Allied Air Forces. Canada also built a series of airfields across the country as part of the Commonwealth Air Training Plan and participated with the U.S Army Corps of Engineers in building the Alaska Highway. The Polymer Corporation's plant was built at Sarnia to manufacture synthetic rubber and was the forerunner of the large postwar chemical engineering plants that operated across the country, based on oil and gas reserves. The manufacture of aluminum at Arvida was stepped up and, to support it, the Shipshaw hydro-electric plant was built nearby on the Saguenay River. Elsewhere in Canada, notable wartime engineering projects included the magnesium plant at Haley Station, Ontario, which used the process developed by Dr. Lloyd Pigeon, the first Canadian nylon plant, opened by DuPont and, in Northern Ontario, INCO's Copper Cliff smelter complex and the Steep Rock Iron Mines. In 1944, the newly formed Hydro-Québec took over the Montréal Heat Light & Power Company.

The National Research Council's laboratories were opened in Ottawa in 1932. They played their part in national and international research projects during the Second World War, especially in regard to the Armed Forces and to participation in the Manhattan Project through the laboratory established first in Montréal and later transferred to Chalk River where, in September 1945, the *Zeep* reactor went critical, the first to do so outside the United States. In addition to giving the NRC additional research and development responsibilities, the Dominion government established a number of engineering-based companies to strengthen the war effort, such as Turbo Research, to do work related to aero-engines, Victory Aircraft, to build planes, and Research Enterprises, to produce electronic and optical devices and instruments. Within the Army, the Royal Canadian Electrical and Mechanical Engineers Regiment (RCEME) was formed.

By the end of this second post-Confederation period, the NRC was not the only Research Council in Canada. Three provinces had established them, with industry-related research and engineering assistance and local problem solutions as their priorities. The Alberta Research Council was established back in 1921 and, as happened with NRC initially, without laboratories (these were added in 1954). The Ontario Research Foundation dates from 1928, but it had laboratories from the beginning, as did the British Columbia Research Council when it was set up in 1944.

Profession/Education

By 1919, there were approximately 4,500 engineers in professional practice in Canada.

Before the First World War ended, attitude changes among the membership of the CSCE/EIC had revived the idea of regulating the practice of the profession. As a federally-chartered body, EIC could not undertake this function. Instead, it established a committee to recommend a draft model law for potential adoption by the provinces. In September 1919, the law found favour with the membership. Over the next two years, seven provinces enacted suitable legislation. Saskatchewan's was delayed until 1930, and the others until the third post-Confederation period.

Other changes that took place during the second post-Confederation period included the founding of a Canadian Institute for Chemistry (CIC) in 1921, which admitted chemical engineers as members. In 1944, after merging with the Canadian Region of the Society for the Chemical Industry, then CIC changed its name to the Chemical Institute of Canada (also CIC).

The Ritual of the Calling of the Engineer, better known as the Iron Ring Ceremony, has its origins in the suggestion of University of Toronto mining professor, Herbert Haultain, that Canadian engineers take an oath of service at the beginning of their careers, as medical doctors did. He discussed this formally with seven past presidents of the Engineering Institute in 1922. They supported him. At Haultain's request, Rudyard Kipling was asked to compose an appropriate text for 'The Ritual,' which he did, while Haultain himself arranged for the initial supply of iron rings, which would be worn by those completing The Ritual. The first six engineers to undergo it did so at the University Club of Montreal in April 1925, followed by 14 more in Camp 1 at the University of Toronto. Although administered by the individual University Camps, the ceremony has been supervised since then by the independent Corporation of Seven Wardens and not by the Institute or the Universities.

In 1925, frustrated by the low level of public and private engineering consulting contracts being awarded to Canadian consultants, and especially by the Dominion government, an Association of Consulting Engineers of Canada (ACEC) was established, in Ottawa, to be the voice of the consultants and to help improve their business situations.

Meanwhile, the Engineering Institute itself set about expanding its 'learned' activities and developing an active series of branches across the country, But as the 1920s wore on, the Institute became concerned that the existence of the provincial Associations could lead to fewer engineers joining it. By 1935, the EIC had set up a committee under Gordon Pitts to examine how it and the Associations might amalgamate. The committee deliberated for two years but, in the end, failed to gain the support of the Institute's membership. (The members of the Associations did not vote.) However, as a result of their participation in the process, the Associations decided in 1936 to establish a Dominion Council of Professional Engineers to undertake special activities on their joint behalf and to work with the government in Ottawa.

During the depression, the EIC's membership fell to a low point of 3800 in 1934 and included 700 who were unemployed. To help them, the Institute offered a free employment service. In any event, by 1939 membership numbers had climbed back by 1000.

The number of universities offering engineering education in Canada remained unchanged during this second period. The numbers of students varied with economic circumstances.

A relatively small number of engineering consulting firms were established between 1919 and 1945. The early ones included the Swan Wooster Engineering Company in British Columbia, H.G. Acres and H.H. Angus in Ontario. Lalonde et Valois (which later became Lavalin) and the Shawinigan Engineering Company in Québec. Ed Underwood and Roy McLellan bought the consulting partnership of McArthur and Murphy (set up in Saskatoon in 1911) and formed what became UMA Ltd..

Engineers whose activities drew particular attention to the profession during this second post-Confederation period would include: Rupert Turnbull, Julian C. Smith, Arthur Surveyer, C. D. Howe, A.G.L. McNaughton, C.J. Mackenzie, Philip L. Pratley, Robert W. Angus, Elsie Gregory MacGill, H.E.T. Haultain, John Bates, Armand Bombardier and Charles A. Magrath.

In summary… during this second post-Confederation period, in economic, social and political terms, the unspectacular but hopeful twenties were succeeded by the depressed thirties, and rescued by the busy forties and the Second World War. Engineering activity mirrored these movements, although there was more apparent strength in engineering than in the economy. Projects begun in the late 1920s were continued until completion or were revived in the 1930s, assisting the general economic recovery. The education of young engineers continued, but at times jobs became relatively scarce. The Second World War provided both full recovery and impressive challenges for the profession, and new skills, including research and development, were acquired. Canada emerged from the war with the fourth largest manufacturing sector among the Allies and the ability to take advantage of new technical skills for further development.

Post Second World War to 2017…

Economic/Social/Political

Immediately post-Second World War, Canada's population was around 12 million. The country was beginning its embrace of so-called 'high technology,' but the service sector - rather than primary and manufacturing industry - was beginning its domination of economic statistics. And long before the first 25 years of this third post-Confederation period was up, the term 'Dominion' that had been describing Canada was no longer being used and 'federal' referred to the activities of the government in Ottawa. We now had 'feds,' just like the Americans!

The first 25 years after the War were mostly 'boom' years for the economy, which became more fully integrated with the American one and especially after the passage of several pieces of trade-related legislation. These included the 1959 (Defence) Production Sharing Agreement, the Canada-U.S Auto Pact in 1965, the Free Trade Agreement with the U.S. in 1989, and three-party NAFTA Agreement with the U.S. and Mexico in 1994.

Internationally, the General Agreement on Tariffs and Trade came into force in 1947. (GATT was later re-named the World Trade Organization.) The so-called 'Cold War' also began in 1947 and lasted until 1991, when the Communist regimes of Eastern Europe came to an end. But well before then, in 1949, the Communist Party of China had begun its rule. The Korean War, in which Canada participated, lasted from 1950 to 1953. The Suez Canal Crisis happened in 1956. Since then, several other wars have occurred in Europe and the Near, Middle and Far Easts, some involving the Canadian Armed Forces. The Cuban Missile Crisis erupted in 1962. In July 1969, NASA's Apollo 11 Mission landed the first astronauts on the moon. The early 1990s saw the initiation of a long series of international conferences on the environment, notably at Kyoto in 1997, Montréal in 2005, and Paris in 2015. The United States was attacked by terrorists in 2001 on what is usually referred to as '9/11.' The year 2011 ended Canada's main participation in the decade-long war in Afghanistan and, briefly in 2015, the civil war in Syria. In 2016, the British voted narrowly to exit the European Union. Canada and the European Union concluded a Comprehensive and Economic Trade Agreement (CETA) in 2017. By then, China was challenging the United States for world

economic leadership. China was also sponsoring a new attempt at globalization that was reminiscent of the so-called 'Silk Road' of hundreds of years ago.

The recessions that have occurred in Canada from time to time since the Second World War have generally been relatively minor. Only three have been serious: in 1982, when unemployment reached over 13%; the so-called 'Dot-Com-Bubble' of 2000, which lasted about three years; and the 2008 sub-prime mortgage crisis that began in the United States, attracted countermeasures in both Canada and the U.S., and was over in Canada two years later. To these should be added the two oil supply crises of the 1970s and the serious inflationary trend that was also in play at that time. As well, the Canadian dollar hit an all-time low against the U.S. one in 1986.

In Canada, by the Citizen Act of 1946, Canadians were no longer British subjects. Saskatchewan became the first province to introduce Medicare, and the federal government followed. The province of Newfoundland and Labrador joined the Canadian Confederation in 1949. In 1957, the Gordon Royal Commission reported, favourably, on Canada's economic prospects. The 'Quiet Revolution' began in Québec in 1960. The Canadian Coast Guard was formed in 1962 as part of the federal Department of Transport, but was later transferred to the Department of Fisheries and Oceans. In 1963, the Government of Québec expanded Hydro-Québec by taking over 11 private power companies as well as most municipally-owned utilities. The international, and specially built, EXPO 67 at Montréal helped celebrate Canada's Centennial, and the theme of EXPO 86, held in Vancouver, was transportation and communications. Canada's three armed services were amalgamated in 1968. Twenty years later, the distinctive service uniforms were restored, but the CAF amalgamation remained. Canada repatriated its Constitution from Great Britain in 1982, but without the support of Québec. Attempts to remedy this were later made, unsuccessfully, through the Meech Lake and Charlottetown Accords. These developments were accompanied by the political rise of the *Péquistes.* In 1980 and 1995, unsuccessful referendums were held in Québec on the possible separation of the province from Canada. The third Territory, the Inuit homeland of Nunavut, was created in 2000 from the Northwest Territories.

Back in the late 1940s, the Iron Ore Company of Canada was formed and began the development of its mineral rights in the Québec/Labrador region, including the building of a 560 km railway to the shipping port of Sept Îles. Canadian Aviation Electronics (later CAE) was established in Montréal in 1947 and went on to establish a world-wide reputation for the design and manufacture of flight simulators for the airlines. During the 1950s, the Teck Resources Corporation used airborne magnetic surveys to develop the high-grade copper ore reserves in the Temagami region of Ontario, the Newfoundland Electric Power Commission was established to help with rural electrification, and potash mining began in Saskatchewan. In 1971, the SEBJ was formed in Québec to oversee the construction of the James Bay hydro-electric projects. In 1974, the Hydro-Electric Power Commission of Ontario was renamed Ontario Hydro. In 1978, the International Joint Commission initiated the Great Lakes Water Quality Agreement. By 2014, Canada was the world's 8th largest iron ore producer, mainly from the Labrador trench. In the 2017 federal budget, $14.4 bn was committed to providing short-term funding the rehabilitation, repair and modification of existing transit and social infrastructure and for broadband access in remote communities. An Infrastructure Bank was created by the federal government to assist in this process.

The Canadian companies in the aircraft-building business that prospered during the postwar years have specialized in military, bush and STOL aircraft, and regional jets. But Avro Canada closed down not long after the 1959 cancellation of the *Arrow,* and de Havilland was bought first by Boeing and later by Bombardier, which had also acquired Canadair, the Learjet Company in the United States, and Short & Harland in Northern Ireland. Orenda Engines Ltd. was formed to build and repair the eponymous engine. Pratt & Whitney became famous for its series of small jet engines, beginning with the PT-6. The Noorduyn Company remained in the business until 1982. Since 1986, the Bell Helicopter Company has built aircraft in Canada.

In 1947 the federal government established the Defence Research Board (DRB) to take over responsibility from NRC for defence-related R&D. The Canadian Overseas Telecommunications Corporation was set up by the government in 1950, and was later renamed Teleglobe Canada. In 1951 it organized a Defence Research Telecommunications Establishment (DRTE) within DRB to lead Canadian research and engineering in this new electrical/electronic field. A decade later, Canada became the third country to enter the 'space race' in 1962, with the launch of its first satellite, *Alouette I.* NASA subsequently invited Canada to participate in its shuttle and astronaut programs. A company, SPAR Aerospace Ltd., was formed in 1967 from the Special Products Division of de Havilland Aircraft of Canada to specialize in the design and construction of space-related hardware. By 1969, DRTE had been renamed the Communications Research Centre. That same year, Telesat Canada was formed to provide domestic communications services across the country, and the company, MacDonald Detweiler & Associates, was established in Vancouver to make space hardware. The Canadian Space Agency was created in 1989 to coordinate the national, government-funded space program. In 1999 the robotics division of SPAR was sold to MDA. But in 2008, the federal government blocked the sale of MDA to a U.S. company. In 2017, Maxar Technologies of Colorado became MDA's holding company.

Back In 1971, Canada had adopted the metric system.

Canadian industry participated in the growth of production of electrical and electronic communication devices, including computer systems, telecommunications, electronic equipment and has done some of the needed R&D. In addition to the long-established Canadian General Electric and Westinghouse, the companies involved have included the RCA Victor (Canada) Company, Electrohome, Bell Canada plus Bell Northern Research and Nortel, Mitel, the Newbridge companies started by Terry Matthews, and a host of small companies, more than 1000 at any one time, and several new trade associations. Notably, Mike Lazaridis founded the company, Research in Motion, in 1984. It later became famous by designing, making and marketing the *Blackberry* wireless devices. However, by 2012, the company had ceded its market share to competitors.

While the Blackberry Company remains in business to produce software, many well-known Canadian companies that made their marks much earlier 'disappeared' in the years after the Second World War, mostly by changing ownership or closing down. By the late 1980s, these included the Cockshutt Plow Company, the Canadian Locomotive Company of Kingston, the Dominion Bridge Company, RCA Victor (Canada), the Foundation Company of Canada, and the Victoria Machinery Depot, which had built, among other things, ferries for service in B.C. waters. Later casualties have included Nortel. And by the early

2000s, Dofasco had been acquired by a Belgian company, Arcelor, INCO had agreed to be acquired by Vale of Brazil, Falconbridge/Noranda by Xstrata, Alcan by Rio Tinto, and Stelco by U.S. Steel. On the other hand, Petro-Canada was merged with Suncor, and Dome Petroleum acquired the Hudson Bay Oil & Gas Company in 1981, only to be taken over by Amoco Canada in 1988.

Since before Confederation, the forest, pulp, paper and newsprint industries have been making regular and significant contributions to the economy and to engineering. But since the beginning of the 21st century, this has changed, due in no small measure to the world-wide growth of the Internet. In 2004, for example, there were 50 mills in operation in Canada, employing over 300,000 people. Ten years later, the figures were 30 mills and under 200,000 people.

Another old, engineering-dependent industry that has seen a decline in its activity and competitiveness since the Second World War is shipbuilding, although work is still carried on at St. John's, Halifax, Saint John, the St Lawrence River, the Great Lakes and the West Coast, but the Collingwood Shipyard closed in 1986. Major drydocks have also disappeared. The industry is currently sustained by cyclical orders for the Canadian Navy and for inland, coastal and other small vessels, plus ship repairs and some oil rig work, notably at Bull Run in Eastern Newfoundland.

The NRC's postwar focus changed as steps were taken to broaden its support for research, development and engineering in industry. Since 1962, the Council has administered the Industrial Research Assistance Program in its various forms. It also played a role in the postwar development of research activities in Canadian engineering faculties. But in 1978, NRC ceded the administration of its university research support programs to the Natural Sciences and Engineering Research Council (NSERC).

The federal government established the Atomic Energy Control Board (AECB) in 1946. In 1952, the NRC-run Chalk River Laboratories became part of Atomic Energy of Canada Limited (AECL), which also established a Commercial Products Division in Ottawa to deal with sales of isotopes and equipment world-wide. In the early 1950s, in addition to running its laboratories, AECL began the development of its CANDU nuclear power reactor, along with such partners as Canadian General Electric and the Hydro-Electric Power Commission of Ontario. In 2000, the AECB became the Canadian Nuclear Safety Commission (CNSC).

The Sheridan Park Research Community was established at Mississauga, Ontario, in the early 1960s to encourage research and engineering activities in Canadian industry. It was Canada's first such campus-style park devoted to these activities. One of the early tenants was AECL, which had moved its CANDU reactor development and design activities there. Other similar parks have since been established elsewhere.

Canadian engineering activities in the Arctic were stimulated by military and sovereignty considerations in the 1950s and 1960s, and in the 1970s and 1980s by the search for oil, gas and minerals. The 1969 traverse of the Northwest Passage by the SS *Manhattan* (although not the first ship to do so) also played a role. Since the '80s, and for a variety of reasons, activity has been low key. At their height, these activities were served by a number of organizations: for example, the Arctic Institute of North America, the Centre for Cold Ocean Resources Engineering (C-CORE) at St. John's, Newfoundland, the Centre for Frontier

Energy Research (C-FER) at Edmonton, the Canadian Polar Commission and the NRC, plus companies such as Imperial Oil, Dome Petroleum and Gulf Canada Resources and a number of government departments and agencies.

By the turn of the 21st century, Toronto had become the largest Canadian city and the population of the Capital, Ottawa, was approaching 1 million. By 2017, the country's population exceeded 36 million - triple the 1946 figure - and the work force numbered 20 million The House of Commons had 338 members, and the federal public service numbered around 260,000. The service sector claimed 70% of the GDP, industry 27% and all other sectors 3%.

Engineering

Again for 'thumbnail' reasons, the format of this section is a little different from the two earlier ones.

During this third post-Confederation period, the United States has led the world in research and the engineering and manufacturing that resulted from it, with a half-dozen other countries providing competition. In 2017, the U.S. still had this lead, but the majority of the world's manufacturing was being done in China. By this time, also, a great deal of international attention was being devoted to climate change, the practical, non-political solutions to whose problems lie principally with engineering.

Up until the Second World War, much of the engineering done in Canada and by Canadians might best be described as 'conventional' or 'adaptive,' relying on the United States, in particular, for the introduction of many new products (such as automobiles and much farm equipment), designs and processes. To a significant extent, the country's wartime experience helped to change this. And to some extent, the postwar science- and engineering-related activities of individual federal and provincial departments, agencies and programs in Canada - plus the companies, the universities and colleges, and individual engineers - have also helped.

There have been three major areas of development in Canadian engineering during this period: the first, a significant increase in the numbers of engineers in professional practice (as well as in and non-practicing roles); the second, participation in 'high technology' areas of engineering, such as nuclear power, space, electronic devices, robotics, control systems and computers, STOL and other aircraft, tall structures, oil and gas recovery, pipelining and Arctic engineering; and the third, the growth of engineering-related research and development in federal and provincial departments and agencies and the universities. At the same time, activity has continued in long-recognized areas of Canadian engineering expertise, such as hydro-electric power generation, transportation, and the manufacture of products associated with cold weather.

During this third period, civil engineering has still been the dominant discipline in Canada, with mechanical and especially electrical/electronics giving energetic chase as the country discovered semiconductors, hand-held electronic devices, and computers on a very large scale. The number of disciplines has also grown. For example, one of these is medical and biological engineering (MBE), whose practitioners work closely with medical professionals and chemists. They study, evaluate and design medical and biological systems involving, for example, prostheses, instrumentation, information systems, drug development and

production, and tissue engineering. The 'learned' society for this discipline was founded in 1965 by Jack Hopps, the acknowledged Canadian 'father' of MBE. At another level, one of the new engineering descriptors - *mechatronics* - originated in Japan and may be described as device-related, combining electrical and mechanical systems with robotics, computers, telecommunication, control systems and product engineering.

The National Research Council was responsible for defence-related research during the Second World War. In 1947 this assignment was given to the newly created Defence Research Board, which established a network of establishments across the country that developed research and engineering strengths in areas such as communications, including earth satellites and space systems, chemical, biological and other weapons systems, materials, operations research, and surveillance, The Board also operated the Churchill Research Rocket Range in Northern Manitoba,, from which the Canadian-developed *Black Brant* research rockets were launched to explore the upper atmosphere. In 1977, DRB became the Canadian Armed Forces' Defence Research and Development Branch and, in 2000, Defence Research and Development Canada. The NRC's own postwar 'domestic' focus and responsibilities changed over the years as steps were taken to broaden its support for research, product design and manufacture in industry. For example, a Division of Building Research was established in 1947 and given responsibility for the development of the National Building and Fire Codes, support for Central Mortgage & Housing Corporation and the construction industry in general. During this third period, many other federal departments and agencies have had research and engineering responsibilities. Some, like Public Works Canada, have had direct involvement with engineering work. Similarly, within provincial government departments and agencies.

At the end of the Second World War, Canada emerged with a place in the new discipline of nuclear engineering - and developed a world-class laboratory at Chalk River, which became home to two of the world's foremost research reactors, the NRX and NRU, which also produced isotopes for the world market. As noted above, in 1952 responsibility for Canada's nuclear energy program was transferred from NRC to Crown-owned Atomic Energy of Canada Ltd.. Subsequently, AECL's development work on the CANDU power reactor system was transferred from Chalk River to Sheridan Park. Its isotope marketing and sales was already in Ottawa. And part of AECL's reactor research program was re-assigned to a subsidiary laboratory at Pinawa, Manitoba. The first generation of electricity by nuclear power in Canada took place at the NPD reactor at Rolphton, Ontario, near Chalk River, in 1962. The later power reactors for Canadian service were designed and built with the cooperation of the HEPC of Ontario, Hydro-Québec and New Brunswick Power at Douglas Point, Bruce, Gentilly, Point Lepreau, Pickering and Darlington. Nuclear 'hiccups' in Canada have been rare, two of them occurring at the Chalk River reactors in the 1950s. The Canadian Nuclear Association was formed in 1960 as a trade association, later adding a 'learned' arm, the Canadian Nuclear Society. However, the Canadian power reactor program was undermined by the disasters at Three Mile Island in the U.S. in 1979, at Chernobyl in Russia in 1986, and at Fukushima in Japan in 2011, and by the public's perceived problems with nuclear waste disposal.

Canada became the third nation to fly a satellite in space, with the launching of the research satellite *Alouette I* in 1962. This project was led by John Chapman at the David Florida Laboratory of DRTE in Ottawa. A feature of its design was the use of STEM tubular antennas, whose basic design had been worked out by George Klein of the NRC ten years earlier. The *Alouette II, ISIS I and II* satellites followed,

between 1965 and 1970, with the participation of the RCA Victor Company in Montréal. Beginning in 1972, Canada launched the first of the *Anik* series of domestic communications satellites in geostationary orbit (the first in the world) and, over the next 40 years, launched over a dozen more. Most were, however, built by Hughes Aircraft in the U.S.. By 1978, MacDonald Detweiler & Associates of Vancouver (MDA) was involved in the design of synthetic aperture radar for NASA's *Seasat A* satellite. However, the world's space programs were interrupted by the NASA shuttle disasters to the *Challenger* and *Columbia* shuttles in 1986 and 2003. By 1981, the first robotic *Canadarm* for use in space had been built by SPAR Aerospace in Toronto. The arms were used throughout the U.S. space shuttle program. In 1995, Canada's first earth-observation satellite using synthetic aperture radar, *Radarsat I,* was launched. It was built by MDA. In 2001, *Canadarm II,* designed and built by MDA, which had taken over the Robotics Division of SPAR in 1999, became an integral part of the earth-orbiting International Space Station (ISS), whose construction began in 1998, and in whose operations Canada has been a participant. *Radarsat II* was launched in 2007. The Canadian-built - also by MDA - *Dextre* telemanipulator was installed on the ISS in 2008 as part of Canada's contribution to the Station. In 2013, Canadian engineer Chris Hadfield commanded the ISS for three months.

In aviation, the de Havilland Company designed and built - among others - the *Chipmunk* trainer in 1947 and, later, the ubiquitous *Beaver, Otter and Twin Otter, Dash 7* and *8,* while Avro Canada was the first in the world to build and fly a passenger jet aircraft, the *Jetliner,* which never went into production. And it designed and built the military *Arrow,* whose production was famously cancelled in February 1959. Canadair designed and built aircraft such as the passenger-carrying *Northstar* in 1948, the CL-215 water bombers in 1969 that are now used worldwide to fight forest fires, and an experimental propeller-driven V/STOL aircraft, before moving more recently into executive and regional jets. In the 1950s, Avro Canada produced three notably powerful gas turbine engines: the *Chinook,* the *Iroquois,* and the *Orenda.*

As noted already, one area in which Canadian engineering expertise is known worldwide is the construction and operation of large hydro-electric plants to serve the growing international market. During this third post-Confederation period, construction and operation of these plants has continued on many of the country's major rivers - for example: the Columbia and the Peace in British Columbia, the South Saskatchewan, the Nelson in Manitoba, the Ottawa in Ontario/Québec, plus the James Bay rivers, the Saguenay and the Outardes in Québec, and the Churchill in Labrador. Hydro-Québec became the first utility in the world to operate 735 kV power lines, bringing electrical power from remote generating plants to markets. And Manitoba Hydro built the HVDC power lines (the bipole lines) to bring Nelson River power to the south.

As well, many other large engineering projects and plants were completed during the period after the Second World War: the Trans-Canada Highway from coast to coast, beginning in 1949 and completed in 1970; the Kitimat-Kemano aluminum project in British Columbia completed in 1954, the year that steelmaker Dofasco, of Hamilton, was the first Canadian plant to introduce the basic oxygen process, and the Sherritt-Gordon Nickel Refinery was established at Fort Saskatchewan to use a Canadian-developed nickel refining process; the St. Lawrence Seaway in Ontario and Quebec in 1959; the various oil-sands extraction plants in Alberta, from 1967; major port installations on the East Coast, the St. Lawrence, the Great Lakes, and the West Coast including facilities for container ships; thousands of miles of oil and gas

pipelines across the country and into the United States; petrochemical plants in Alberta, Ontario and Québec, agricultural chemicals in Saskatchewan, pharmaceuticals in Central Canada, and oil refining in the Atlantic Provinces.

Research involving engineering began in Canada in the 1920s but it was not done on any scale until the Second World War. Since then, there has been constant criticism of the adequacy of Canadian industry's level of effort, by 'international standards.' However, in the 1960s, the federal government established four special programs to provide assistance for industrial R&D. Only one - NRC's IRAP - has survived, although several others, including tax incentives, have been introduced. The provinces now have their own Research Councils and industrial support programs, and a number of research and engineering organizations have been set up within the non-profit sector. As a group, over the years, these organizations have made substantial and significant contributions to Canadian industry's engineering. The Universities were slower to contribute to the solution of industry-related problems, but with encouragement from NRC, and later NSERC, have recently been more responsive to this need. The lack of private venture capital to take new products and processes to market has also attracted negative reactions although, in recent years, this situation has apparently been improving.

Disasters having consequences for engineering have been relatively rare in Canada. These have concerned mostly with burning buildings, in-mine explosions and major surface floodings. One of the latter, caused by spring floodings of the environs of Winnipeg by the Red River was largely mitigated by the completion in 1968 of a floodway round the city. Also, the oil rig *Ocean Ranger* was lost in a storm off Newfoundland in 1982. There was the massively disruptive ice storm in Eastern Canada in 1998. In August 2003 there was a power outage that affected eight northeastern United States and Central and Eastern Canada. More recently, there have been railway and pipeline and chemical spills and fires - for example the massive chemical fire at Lac Mégantic, Québec - and serious spring flooding in Southern Alberta in 2013. (One potential disaster that did *not* happen was computer-related 'Y2K' at the very beginning of the year 2000!)

Museums have long been part of the Canadian landscape, serving to enlighten citizens with regard to their heritage and development, and most of those that include engineering artifacts in their exhibitions date from the third post-Confederation period. For example, the first national aeronautical collection, at Rockcliffe Park, Ottawa, was begun in 1964. The National Museum of Science and Technology (NMST) was opened in Ottawa in 1967 as a Centennial project. The NMST later became the *Canadian* Science and Technology Museum (CSTM). In 1991, in partnership with NRC, the Museum established a Science and Engineering Hall of Fame. By 2014, when the Hall was discontinued, there had been 60 inductees, most of them scientific researchers. Even among the engineers, the majority were honoured for their research, few for doing what most practicing engineers do: designing, making, building, operating and managing. There are also Science Centres at Toronto, Montréal, North Bay, Regina and Calgary. Again, unfortunately, museums tend to credit *science* with the design and production of their *engineering* exhibits.

The Second World War (and the American Military) stimulated postwar research into permafrost, muskeg and other Arctic- and North-related engineering problems. Postwar Canadian engineering construction in the Arctic and the North was particularly active until the 1980s (and again in the 2000s), and has included the development of ice islands and caissons in the Beaufort Sea for oil and gas recovery, pipelines for

both, Arctic and northern mining in places such as Baffin and Little Cornwallis Islands and in the Territories, iceberg towing off Newfoundland, port facilities, and the development of winter ice roads in the Territories. The Mackenzie Highway originally from Grimshaw, Alberta, to Hay River, NWT, opened in 1948, the Dempster Highway connecting the Klondike with Inuvik in 1979, and the highway from Inuvik to Tuktoyaktuk in 2017. The Consolidated Gold Mine opened at Yellowknife in 1938 (and closed in 2012), the Giant Mine, also at Yellowknife, began producing gold in 1948 (closed 2014). In the 1950s, the Beaverlodge-area uranium mines in Northern Saskatchewan made Canada the world's largest producer of uranium. Between 1952 and 1960 the Eldorado Uranium Mine was in operation at Port Radium in the Northwest Territories. The Voisey Mine was opened in 2005 in Labrador. In more recent years, the Diavik and Ekati diamond mines began operations in the NWT. In 2012 the Deh Cho Bridge over the Mackenzie River, on the Yellowknife Highway, was opened to traffic. The first freighters carrying mined iron ore left Mary River, Baffinland, Nunavut, in 2015.

Among the notable bridges built during this third post-Confederation period were: the Angus L. Macdonald, at Halifax, 1955; the Burlington Skyway, Hamilton, 1958 and 1985; the Princess Margaret Bridge at Fredericton, the Hippolite-Lafontaine Bridge/Tunnel across the St. Lawrence at Montréal, and the Laviolette Bridge downstream at Trois-Rivières, 1967; the A. Murray Mackay Bridge at Halifax, 1970; the Annacis Bridge at Delta, B.C., 1986; the Confederation Bridge between PEI and New Brunswick, 1997; and the Port Mann (replacement) Bridge, Coquitlam, B.C., 2012.

Among the notable buildings were: the 'Diefenbunker' at Carp, Ontario, built by the Foundation Company of Canada in 1961 as a nuclear fall-out shelter for the federal government; the Place Ville-Marie multi-purpose cruciform office tower, Montréal, 1962; the TD Centre, Toronto, 1966; the rebuilding of the Montréal Central Station as Place Bonaventure, 1967; the Husky Tower, Calgary, 1968; the West Coast Transmission Building, Vancouver, 1969; the National Arts Centre, Ottawa, 1969; the CN Tower, Toronto, 1976; the West Edmonton Mall, 1981; the Roy Thomson Hall, Toronto, 1982; the Calgary Saddledome, 1983; the multi-purpose B.C. Place Stadium, with its air-supported roof, Vancouver, 1983; and the Skydome (later the Rogers Centre), Toronto, 1988.

The following individual engineering events and achievements should also be noted:

> Eric W. leaver, the co-founder of Electronic Associates Ltd., patented a robotic machine tool system in 1947
>
> The Tea Hill Microwave Station was established on PEI to replace underwater cable to Nova Scotia in 1948
>
> The University of Toronto Electronic Computer, Mark 1, was being built in 1949, the first in Canada
>
> An aluminum bridge was opened across the Saguenay River near Arvida, Québec, and Hopps, Bigelow and Callahan developed the first external heart pacemaker in 1951

Ontario began building the 400-series of superhighways in 1952; the following year British Columbia opened four major highways

The building of the Pinetree Line of air defence stations across Canada began in 1954; it was followed by the Mid-Canada and DEW Lines

The Toronto subway started operating in 1954, the Montréal Subway in 1966; the Edmonton and Calgary LRTs opened 1978 and 1981, Vancouver in 1985, and the first line at Ottawa in 2001

In 1955, Bruce Nodwell developed the double-sprocket, wide-tracked vehicle for use in the Alberta oilfields, in Northern Canada and Alaska

The final link in the Trans-Canada Microwave Network was completed in 1958

Harry Stevenson, at NRC, designed a crash position indicator that was subsequently manufactured in Canada and became mandatory equipment for aircraft; the first Bombardier *Ski-Doo* went on the market, in 1959

By 1960, the conversion of railway locomotives from steam to diesel had been completed

The laker, MV *Saguenay,* the first bulker to use diesel main engines and bow thrusters, was launched in 1964

The Boundary Layer Wind Tunnel began operations at Western University; and de Havilland began production of the *Twin Otter*, in 1965

Toronto's GO Transit system went into operation in 1967

The Canadian Armed Forces commissioned an experimental ocean-going hydrofoil, the *Bras d'Or,* in 1968, which was put on extensive trials but was later withdrawn from service

An experimental turbo-train entered service in 1968, but was withdrawn in 1981

A team of aeronautical engineers from the University of Toronto helped Apollo 13 get home in 1972, after its 'Houston, we have a problem' call on the way to the moon

The energy crisis of 1973 persuaded many home-owners to upgrade the insulation of their homes and buildings; the R-2000 program was launched by Ottawa in 1982

The DMS-100 digital telephone switching system that could service 100,000 lines, developed by Nortel in 1975

The Tri-University Meson Facility (TRIUMF) - a 520 MeV cyclotron - was built on the campus of the University of British Columbia and officially commissioned in 1976

In the late 1970s, the Canadian Government Communications Research Centre developed the Telidon videotext/teletext system, which was overtaken in the marketplace by the Internet

The first permanent IMAX format film installation - developed by four Canadians - opened at Ontario Place, Toronto in 1978

Canadian-designed and -built, the first of 200 of Toronto's new CLRV (and ALRV) streetcar fleet went into service in 1979

In 1980, distance education began by satellite in B.C., Manitoba and Québec; and Canadair began marketing its *Challenger* executive jet

Video games were first developed in Canada in 1983; by 2017, the industry was the third largest in the world, after the U.S. and Japan

The first of 12 Halifax Class guided missile frigates, built at Saint John and Lauzon, was commissioned by the Royal Canadian Navy in 1987

There were 16.3 million motor vehicles in Canada by 1988

Ballard Power Systems, of Burnaby, B.C., developed the first PEM fuel cell technology in 1989

Ottawa's *Freenet* system went into operation in 1992

A second tunnel under the St. Clair River replaced the original Hobson Tunnel in 1993

D-Wave Systems Inc., also of Burnaby, B.C., established quantum computing in 1999

The early 2000s coincided with the introduction of cloud computing in Canada

In 2004, the Welland Canal was deepened to increase its carrying capacity; and the Canadian Light Source (CLS), a third-generation synchrotron facility, was opened at Saskatoon

Asbestos production ended in Québec in 2012, having been mined there since 1878

It has been estimated that, by 2017, 84% of Canadian households had home computers; by then, also, Canada was thought to be operating 2% of the world's earth-orbiting satellites (36)

Profession/Education

In 1946, at the beginning of this third post-Confederation period, there were around 6,000 engineers in professional practice in Canada.

A notable feature of university education in engineering in this country at that time was the arrival of so many veterans as undergraduates in the university institutions that had existed prewar. After graduation, and when the many immigrant engineers who had come to Canada were added, these new engineers

helped increase the country's technical competence and worked to the advantage of the economy as a whole. To spread the teaching load, new schools were established. And with time, increasing emphasis was placed on research activities in the academic environment and on the numbers of graduate students that could be accepted (and supported, initially by NRC and, later, by NSERC). Subsequently, the universities were encouraged to establish activities devoted to the solution of specific industrial problems. Since 2000, there has been additional pressure on academic engineering institutions to participate more actively in marketplace innovation - and in the engineering of climate change.

And after about 20 postwar years, the engineering students' once ever-present slide rules were replaced by electronic calculators and later by computers and other devices!

As noted, the number of new schools established to teach engineering increased. in the Atlantic Provinces, these included the Memorial University of Newfoundland, which first offered engineering degree courses in 1967, and Université de Moncton, which did so when given university status in 1963. The Technical University of Nova Scotia became part of Dalhousie University in 1993. Université Laval in Québec, although it was founded in the mid-19th century, did not offer engineering degrees until 1947. Université de Sherbrooke began its degree courses in 1951. By the late 1960s, engineering degrees were being offered at the several campuses of the new Université du Québec. Loyola College and Sir George Williams Universities both had engineering degree courses when they joined forces to form Concordia University in 1974. The University of Ottawa and Carleton University offered degrees in 1956 and 1957. In Toronto, Ryerson Polytechnic Institute, has been able to award degrees since 1971, and was given full university status in 1993. An established university, McMaster, at Hamilton, has offered engineering since 1956. Engineering at the University of Waterloo began in 1957, at first in association with the University of Western Ontario. The first class to graduate from the University of Windsor did so in 1961. Lakehead University has had degree courses since 1972. In Saskatchewan, the Regina Campus of the University of Saskatchewan achieved university status in 1975 and awarded its first engineering degrees in 1981. The Calgary school was originally part of the University of Alberta, and gave its first degrees in 1969. The school at the University of Victoria was established in 1983.

At recent count, there were more than 45 institutions in Canada offering Engineers Canada-accredited engineering programs, including in addition to the above, UOIT at Oshawa (now Ontario Technical University), and Simon Fraser University at Burnaby, B.C.. There were even more that offered the technologist/technician/drafting training that supports engineers in professional practice.

The Dominion Council of Professional Engineers was enlarged in 1952 when the Association in Newfoundland and Labrador joined it, followed by the PEI Association in 1955, and by the Yukon, the Northwest Territories and Nunavut Associations in 1956, 1969 and 2008. In 1955 the Dominion Council changed its name to the Canadian Council of Professional Engineers (CCPE) and, in 2007, became Engineers Canada (EC). In recent years, many of the Associations have expanded their membership to include geoscientists. One of the recurring tasks performed by CCPE/EC has been the assessment of courses of engineering instruction in Canadian schools and of the qualifications of engineers for practice. It was also the sponsor of the Canadian Engineering Manpower Board, which later became the Human Resources Board.

The Engineering Institute prospered during the first two postwar decades, its total membership reaching over 22,000 in the early 1960s, with as many as 60 branches across the country. However, by 1968 this upward trend had been reversed, influenced by the growth of specialized 'learned' societies in Canada and the United States, by its inability to provide adequate technical coverage for the burgeoning number of disciplines, and by declining advertising revenues from the *Engineering Journal*. So it established a committee (chaired by Clifford Downing) to examine the situation. As a result, in 1970 the Institute formed its first semi-autonomous Constituent Society - for mechanical engineering. This was followed by three more, for civil, electrical, and geotechnical engineering. For the relatively large number of Institute members who declined to join these societies, a General Members' Group was formed. But further administrative difficulties led, in 1986, to the EIC becoming a *federation* of fully autonomous Member Societies, with limited residual responsibilities of its own, the societies having acquired full responsibility for the customary 'learned' activities. The federation also began to admit to membership societies that had not originally been part of the Institute - for example the Canadian Society for Chemical Engineering (which had been formed within the Chemical Institute of Canada in 1966) and the Canadian Nuclear Society (which had been formed within the Canadian Nuclear Association). As well, the General Members Group joined as the Society for Engineering Management and the Institute's Life Members' Organization as the Canadian Society of Senior Engineers. The Electrical Engineering Society first added 'and Computer' to its title and later joined with Region 7 of the IEEE to form IEEE Canada. The *Engineering Journal* ceased publication in 1987. As at 2017, the Institute had a dozen Member Societies. Its principal interests have been in supporting the activities of its members, in the continuing education of engineers, and in honouring individual engineers' achievements.

A second attempt was made, beginning in the mid-1950s, to amalgamate/confederate the 'learned' Institute and the 'licencing' Associations. This time, both parties, both Councils and many committee meetings were involved over the next several years. But once again the initiative failed to gain the necessary approval. The two prominent areas of disagreement involved the differing objectives of the Institute and the Associations, and federal-provincial responsibilities as defined in the British North America Act.

Early during this third post-Confederation period, provincial and territorial associations of consulting engineers were established. They are now member organizations of ACEC. Although the Association has recently participated in national and international technical conferences, and annually honours engineering achievements, its interests remain associated with the *business* of consulting. In 2009, the name of this over 400-member body was changed to the Association of Consulting Engineering Companies (still ACEC!).

The majority of the consulting engineering firms that currently operate in Canada were established during this third post-Confederation period. Among the early ones were Wright Engineers in Vancouver in 1946, Associated Engineering Services in Western Canada in 1948, James F. McLaren & Associates in 1950 in Toronto and Beauchemin-Beaton-Lapointe in Montréal in 1954. Two of the older, larger firms, SNC and Lavalin, merged in 1991.

Also during this third period, several other 'learned' societies of engineers have appeared. These include, in 1954, the Canadian Aeronautics Institute, which was formed by merging the Aeronautics Division of EIC with several other Canadian aeronautical organizations. After further mergers in 1962, the CAI became the Canadian Aeronautics and Space Institute. A Canadian Agricultural Engineering Society was founded in 1958, becoming the CSAE two years later. It affiliated with the American Society in 1987, but became the Canadian Society for Bioengineering in 2004. The Canadian Medical and Biological Engineering Society was founded in 1965. In 1989 a Canadian Dam Safety Association was formed, and in 1997 was renamed the Canadian Dam Association after merging with the Canadian Conference for Large Dams. In 1990, 'and Petroleum' was added to the title of the Canadian Institute of Mining and Metallurgy. The origins of the Canadian Society for Chemical Engineering and the Canadian Nuclear Society have already been noted. With the exceptions of CASI, CIMM, all of these societies joined the EIC federation as Members sometime after 1986.

The profession of engineering in Canada (and elsewhere) has, historically, been populated by men. There were no women engineers during the first post-Confederation period, and only a very few during the second. They began to trickle into engineering classrooms in the 1960s, and more prominently since the 1970s. The numbers most frequently quoted are percentages of graduating classes, of newly licensed engineers, or of university department staffs, those currently in professional practice being less certain. In 2009, for example, around 11% of engineering faculty in the universities were women. In 2017, 22% of the undergraduate engineering students were women. Also, a number of engineering stakeholders, led by Engineers Canada, have established a 'Champions Network' to seek ways to ensure that, by 2030, the percentage of women in graduating classes has reached 30. Meanwhile, the recent attention being paid to STEM education and opportunities has been helping bring engineering career information to girls as well as boys in high schools.

In 1967, to help celebrate Canada's Centennial, the 'learned' societies in engineering in Canada organized an International Congress in Montréal in conjunction with EXPO 67 to draw attention to the profession's past and potential future contributions to the country's development. Also, to honour the profession itself, part of this exhibition's space was designated as *The Engineers' Plaza*, whose centrepiece was a sculpture by Gerald Gladstone representing engineering as a whole. A second such Congress was held in Montréal in 1987 to celebrate the Centennial of Engineering as a Profession in Canada.

By 1980, several other countries had established Academies of Engineering (or their equivalent), but Canada had not. At the initiative of the Engineering Institute, activities leading to the founding of a Canadian one were undertaken, and the Canadian Academy of Engineering held its inaugural meeting in Montréal during the Engineering Centennial Congress in 1987. There were 44 founding members, and the founding president was Robert Legget.

Tragedy struck at École Polytechnique in Montreal on December 6, 1989, when a gunman shot and killed 14 women, most of them engineering students. This event has been commemorated in various ways since 1989. One of them has been the establishment of the Canadian Engineering Memorial Foundation, one of whose objectives is attracting women to the engineering profession.

Engineers whose activities have (so far) drawn particular attention to the activities of the profession during this third post-Confederation period would include: Robert Shaw, Elsie Gregory MacGill (again), George Klein, Josef Kates, Robert Legget, Camille Dagenais, Bernard Lamarre, John Chapman, Philip Lapp, Howard Rapson, Alan Davenport, Jack Mollard, Jack Hopps, Martha Salcudean and John MacDonald plus several who are still active… Micheline Bouchard, Mike Lazaridis, Terrence Matthews, Keith Rowe, Indira Samarasekera, Gerald Heffernan, Marc Garneau, Chris Hadfield, Elizabeth Cannon, Ishwar Puri, and Molly Shoichet…and Engineer the Rt. Hon. Julie Payette, who is the current Governor General of Canada. She was also the first Canadian astronaut to visit the International Space Station.

By 2017, there were around a quarter of a million engineers in professional practice in Canada.

In summary… whereas the first post-Confederation period was dominated from the engineering point of view by steel and electricity, and the second by the Great Depression and the Second World War, the third one was dominated by engineered developments in nuclear power, space travel and electronic communications. During this period, and taking advantage of its Second World War experience, Canada moved with countries such as the United States, Japan, South Korea, the European Common Market countries, and most recently China, into an intensely engineering-dominated period in world history. While only a few of the technical advances during this period were made initially in Canada, the country has been able to take advantage of developments elsewhere and to play a relatively large part in the world's research and development. On the other hand, some of the companies that had notably served Canadian engineering in years past either changed ownership or disappeared altogether. The challenge has been, and still is, to maintain Canada's standing internationally and to maintain competence those fields of engineering that are germane to Canada's needs and aspirations.

Three final points. First, in the various political arenas around the country, the numbers of professional engineers participating in the political process has been miniscule and has hardly increased over earlier periods. At any one time, for example, only a half-dozen (out of over 350 or more) sit as M.P.'s in the House of Commons, and even fewer hold Cabinet posts. Second, no one knows how much is spent annually on engineering in Canada, or in any other country for that matter, or whether the funds have been well spent, and so no time series or other comparisons can be made. R&D *expenditures*, on the other hand, has been minutely analysed in some countries, but again without specific reference to engineering, and especially by the OECD. But these international comparisons have said nothing about the *uses* to which the money spent was put or about its *effectiveness.* Third, the profession of engineering is made up of a variety of related disciplines but is far from homogeneous. And the engineering 'cultures' in the three principal sectors of the economy - private, public and academic - are different. But the iron ring holds Canadian engineers together.

To end with a very short quotation, from a paper delivered in 1932 by A.W.F McQueen of the H.G.Acres Company:

> Engineering is not an end in itself; it is the means of accommodating certain desired results for the progress and welfare of society.

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Much relevant information has been included in the papers listed in the History Section of the Engineering Institute of Canada's (EIC's) website. These 90-odd papers can be accessed through https://eic-ici.ca/engineering-history-papers-collection/. The titles of the most relevant papers included in this list will not be repeated in what follows…but see especially #92.

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Engineers Canada (and earlier, the Dominion/Canadian Council of Professional Engineers)

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…and, of course, the Internet and Wikipedia.

The author also had the use of the analysis of Engineering Institute of Canada membership prepared by Huet Massue in 1948, copies of which are no longer available from the Institute.

The above were also the principal sources for the material discussed in this paper.

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