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“Engineering History: A Hard Sell?”

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Some weeks ago, I promised Nelson Ferguson that I would begin by reminding you that today, January 25, has its place in history. It is the birthday of Scotland's second patron saint: Robert Burns. All over the world this day, in celebration, Scotsmen and pretend-Scotsmen will be consuming haggis and whisky and speaking or listening to words that this man wrote. Amen!

Today's will be an old fashioned presentation. No power point for you to read along with me. No diagrams, tables of data or pretty slides to admire. Just talk!

Also, in spite of what you may have gathered from Arnold, it is about *Engineering History: A Hard Sell?* In other words, in spite of the effort that has gone into recording and preserving engineering history in Canada and elsewhere, not very many people appear to have been paying attention to the results or to how they came about. Engineering, it appears, is one of the endeavours that is very widely taken for granted.

Yet, almost everywhere, and almost all of the time, we come across examples of it - and especially of the civil kind. The older non-civil kinds are often to be encountered in museums, of which there are hundreds, even in Canada. All varieties are to be found in books, which are usually well illustrated. And there are even TV programs and Internet websites that include engineering history. Places like the Science and Technology Museum in Ottawa and the Science Centre in Toronto have attempted in major ways to bring the general public's attention to engineering achievements. Halls of Fame for engineers, as well as national recognition through honours and awards, have also contributed. To an extent, these have succeeded, but significant portions of our national leadership, as well as of the public generally, remain unaffected.

Again, it is fair to ask if any of the world's eminent historians, past or present, are known for their work on the history of engineering? Today, in Canada, I can count on the fingers of one hand the number of professional historians who embrace engineering as their principal interest. And there are not many more of the amateur variety. Two hands might be enough for them. Also, since the world has been run from time immemorial by politicians and military men of one kind or another, and by lawyers and accountants, is it fair to expect the professional historians, especially, to pay more attention to those who simply carried out the policies and the orders?

As I wrote earlier in another paper, the first evidence of human engineering activity was the evolution of primitive tools - the kind that gave people a better chance to survive. Then came the discovery of fire and its ability to change one type of material into another, to make new things - or to destroy the original ones. About 7000 years ago, in the Middle East, houses were first built on stone foundations. Around 5000 years ago the Egyptians began building their pyramids of stone, which they had learned to split from quarries. Kiln-fired brick was developed around 3500 years ago. Along the way the wedge, the lever and the wheel were developed. Measurement began when levers were used as balance beams for weighing. The Greeks were the inventors of the ancient world - the screw, the ratchet and the water wheel. The Romans were the builders - baths, aqueducts and roads. The Chinese were also active - the wheelbarrow and the rotary fan.

But engineering history examples can be found in out-of-the-way places, too - places such as Bhutan, for example. There, 600 years ago, a man called Thangtong Gyalpo is said to have developed, manufactured and used heavy iron chains for suspension bridges, a hundred or more of which were built in Bhutan and Tibet. Some of the original links can still be seen at the museum at Paro, in Bhutan.

The years from 500 to 1500 AD are known as the Dark Ages. Yet they were the years when war and religion contributed massively to engineering through, for example, the building of castles and other fortifications and huge and ornate places of worship. Also, moveable type for printing, mechanical clocks and spinning wheels date from this period. Then there was the Renaissance, dominated by engineer-inventor-visionaries like Leonardo da Vinci, when flywheels were first used and the connecting rod transformed reciprocating into rotary motion. Between 1500 and 1750 AD we have the development of iron bellows, water turbines, gear and screw-cutting machines, Guericke's air pump and the steam engines of Savery and Newcomen. The First Industrial Revolution, roughly from 1750 to 1850, was sparked by James Watt - another Scotsman, whose birthday is also in January, but is not celebrated officially - with haggis, whisky or anything else - and his more efficient steam engines. This Revolution also brought the engineer in closer contact with manufacturing. The Second Revolution, roughly from 1850 to 1950 was driven by advances in transportation, from the railroads to aircraft, by the availability of electric power on a large scale, by steel-making, by advances in the production of synthetic materials, and by two lengthy wars. The post-1950 Third Revolution - the electronics and space one - is presently in progress.

Part of the problem - and the first element in the 'hard sell' - lies in the fact that, until about 250 years or so ago, the people who masterminded the engineered works, machines and other such things were not called 'engineers.' Some were builders or master builders of various kinds, constructors of fortifications and the engines of war, artisans, machinists, millwrights, shipwrights, and so on. Most were known as craftsmen, rather than professionals.

The second element of the 'hard sell' - the lack of an agreed definition of *engineering* - is still with us, although we are certainly not without variations on the theme, so to speak. For example, Philip Lapp, whom some of you will know, was fond of saying that "engineering is what engineers do." He was right, of course, but not helpful! In 1828, the U.K. Institution of Civil Engineers said that it was "the art of directing the great sources of power in nature for the use and convenience of Man." Later definitions have attempted to extend this more precisely, with debatable or far too complex results. Since my audience today has spent its working life 'doing' engineering of one kind or another, I don't propose to belabour this point, but will say simply that, in my view, engineering is an *activity*, in contrast with science, which is a body of knowledge concerned with *know why*, and technology, which is another such body, concerned with *know how*. Engineering, in its practice, makes use of both. And it is *not*, in this practice, captured by the term *applied science*.

The third element of the 'hard sell' is the question: Why should we study the history of engineering in the first place?

My colleague, Don Lawson, the chair of the CSSE History Committee, wrote in an e-mail recently:

My own immediate interest in engineering history is to understand how we got to this point, and probably equally to make sure I learn lessons so as not to repeat (the mistakes). In other words, to use it as a process to build up knowledge. The latter appears so basic and obvious to me, although I have over the years met many who don't agree. Their argument is generally along the lines of 'we know best, we are thorough and don't make mistakes, therefore there is nothing we can learn from people who make mistakes - we think positive!'

Personally, I follow Don's reasoning - and I have read enough of the American engineering historian Henry Petroski's writing to realize that it is also valid for him. More on Henry in a moment. In my case, I also had family members who were 'into' history in a serious way and who provided me with much of the stimulus to study it. Engineering history took on its importance gradually, with

experience over the years, and as opportunities to contribute to it developed.

But this element has another important aspect. One of Canada's best-known politicized historians, Dr. Jack Granatstein, wrote a few years ago:

History is important, I believe, because it is the way a nation, a people, and an individual learn who they are, where they came from, and how and why their world has turned out as it has. We simply do not exist in a contemporary world. We have a past, if only we would try to grapple with it. History teaches us a sense of change over time. History is memory, inspiration and commonality - and a nation without memory is every bit as adrift as an amnesiac wandering the streets. History matters, and we forget this truth at our peril.

In his book, *Who Killed Canadian History?* (Harper Collins, 1998) - in which, incidentally, this quotation can be found - Granatstein went on to make another point that should be applied to engineering. He was speaking principally about the *national* history of Canada, about how it is no longer part of the curricula in many schools, and is not even healthy at the university level. He went on to say that those courses that do exist are principally concerned with sub-areas of national history - for example, the regional, gender, aboriginal, immigrant, labour and other sections of Canadian society. While all of them have strong reasons to be studied, hardly anyone nowadays seems willing or interested in putting them together into a national history, and to teach the subject from this perspective.

Engineering, then, is one of the several sub-areas of the national history of this or any other country. For this reason, it deserves study for itself. But, taking Granatstein's point, it also deserves to be integrated into a *national* story so that a much more rounded economic/political/social picture may emerge, that the links between them may be established, and that the various 'multiplier effects' of engineering can be properly identified and measured.

I would suggest, however, that engineering practitioners are usually better placed than scholarly historians to deal with the purely technical developments within engineering history, just as the scholars are usually better at building engineering into the national history picture. But a few of the scholars can, indeed, deal with technical matters - as Canadians Robert Passfield and Norman Ball have done - just as some engineers are capable of dealing with engineering in economic, political and social contexts.

We engineers should also recognize that scepticism exists among today's historians - and members of the general public - with regard to the importance of our profession alongside that of the economic, political and social objectives of the nation. As well, there are some who dislike engineering - for two main reasons: they don't care for the ways in which it appears to aggravate environmental and other problems that are now being experienced; and they don't care for the products of engineering that are destructive, warlike or downright nasty. As well, let's face it, there has been some bad engineering done from time to time - some of which Henry Petroski has recorded in his writing.

As an aside: I recognize that the *general public* - to use a common phrase - is not a homogeneous entity. There are in fact multiple 'publics,' each of which requires a different approach to the provision of historical information and a different priority for this provision.

The fourth element in the 'hard sell' has two distinct, but related, manifestations. The first is that, in the minds of many members of the public and, it seems, most of our political leaders, it is *science* and not

engineering that 'drives the bus.' All that is good in the world, they believe, can be derived from, and through, science. But if anything goes wrong - a bridge or a building falls down, or there is a major air or space-related disaster - it is engineering's fault! To a considerable extent, the media are to blame for this, as they are the ones who report the disasters, as well as the discoveries, to the public. Of course there are times that engineering should indeed be fingered as the culprit. But it should also be given credit when it does creditable things. Scientists did not build the CN Tower. Engineers did.

The second manifestation is what might be called 'the R&D syndrome.' For decades now, we have been hearing how Canada's national research and development expenditures consistently fall behind those of other leading G8, G20 or OECD countries - and this in spite of continual and significant increases in public and private spending in this country. To some extent, this view is the result of the 'science' manifestation just mentioned, namely, that it is only through research that more 'good' stuff is added to it, regardless of its relevance for engineering, or the contributions of engineering experience. This manifestation is a result of the lack of understanding of the role of engineering in the design, production, operation and maintenance of both goods and services, exports and imports, and so on, and particularly in regard to that most desirable of activities - market-successful technological innovation.

Another aside: I recognize that research, and particularly development, is done to provide what engineers need by way of new information. Unlike research for science, which is primarily *curiosity*-oriented, R&D for engineering is *use*-oriented.

Part of the responsibility for these misinterpretations can be traced to the former Economic Council of Canada, whose early studies in the mid-1960s engendered hope that Canada's economic growth would be stimulated by science and technology. The Council did, indeed, agree that research and development, technological innovation, technical information transfer, and highly qualified manpower could be important for economic growth. But its research into these linkages was not in sufficient depth, nor was it sustained over the longer haul. Engineering was never mentioned, and the Council's recommendations were not accepted by its political masters. In a way this was strange since the Economic Council inherited, among its terms-of-reference, some that had been in place for its predecessor agency, the National Productivity Council, which had dealt with its mandate in very practical engineering terms. But perhaps this should not be so surprising since economists and industry people tend to define 'productivity' in different ways.

Another federal advisory agency of the 1960s and 1970s, the Science Council of Canada - whose members always included a proportion of engineers and industry people as well as of 'pure' scientists - did deeper, more sustained, research. But even with its emphasis on technological innovation, it failed to rid itself of the emphasis on R&D expenditure levels and on *science* policy, or *policies* for science, and failed to ascribe to engineering its full and proper role in the innovation process and in *technology* policy. In my view, a study by this Council of the history of engineering would have helped to eliminate this failure.

Finally, the fifth element in the 'hard sell' I propose to mention is the lack of interest taken in the history of engineering by engineers themselves, not only in Canada, but throughout the world. I say this in spite of the publications in this field that have been brought out by engineering institutes, associations and societies in many different jurisdictions, as well as by individuals. But if you look more closely, you find that many of these were published to help celebrate a centennial or some other anniversary and - again - publication has not been sustained over time.

One of the drawbacks is that there are apparently few engineering heroes about whom life stories might be written. In the Canadian context, Alexander Graham Bell - whom we share with Scotland and the United States - has been biographed quite often, most recently by

historian/biographer Charlotte Gray. Our other 19th century 'heroes' or 'notables' - Gzowski, Fleming and Thomas Keefer - have also been biographed. But who are the notables of the 20th century?

As it happens, the Canadian Museum of Science and Technology and the Historic Sites and Monuments Board of Canada have the means to recognize engineers and engineering achievements through the Museum's Hall of Fame and through designation by the Board as being of national historic importance. After induction, the Hall people at least have permanent panels in the Museum devoted to their achievements, but those recognized by the Board receive no additional recognition beyond small permanent plaques, not always erected where they attract the public's attention.

In Canada, we have few engineers who have researched and written to any extent in the engineering history field, and there are only a few in those countries with more extensive engineering achievements. In Canada, there was Robert F. Legget. The United States, for example, can claim several, such as Eugene Ferguson, John Lienhard and Henry Petroski. In Britain, there is L.T.C. (Tom) Rolt - an engineer who gave up his professional activities to write history. In not a few cases, the historical publications of the societies and institutes I mentioned earlier were written by professional writers, although with 'real' engineers looking over their shoulders.

The Engineering Institute of Canada, as a corporate entity, has taken some interest in the history of engineering from time to time. For example, there was Committee on Biographies in the late 1920s. In the 1970s, the EIC joined with the federal Department of Indian Affairs and Northern Development in a project called the Canadian Engineering Heritage Record, which was intended to identify and record historical works, buildings and artifacts across the country. In the early 1980s, the Institute - with a very strong assist from the Life Members' Organization - established a History Committee. It came to an early end, but not before it had spun off a branch in Montreal and one in Toronto, both of which lasted for quite a few years. In 1991, the Institute appointed a Secretary for History and Archives, who subsequently undertook, with the help of representatives from the Societies and from outside the Institute, to nominate engineering achievements and Institute members for recognition by the Historic Sites and Monuments Board and the Hall of Fame of the Canadian Museum of Science and Technology. In 1999, the Secretary's duties and the work of nomination were combined, extended and assigned to a representative Standing Committee for History and Archives, which is still in operation. Meanwhile, the CSCE and CSME societies had established their own History Committees and activities, with the Canadian Geotechnical Society establishing one later, as did CSSE, after it was formed from the LMO.

In the world of engineering history, Henry Petroski is *my* hero. An American, he is the only person I know to hold, simultaneously, the titles of professor of civil engineering and professor of history - both at Duke University, North Carolina. Henry has now published 15 books on a remarkable variety of subjects in the field, beginning with *To Engineer is Human: The Role of Failure in Successful Design*, and including *Engineers of Dreams: Great Bridge Builders and the Spanning of America* - which includes a section on the Québec Bridge, *Pushing the Limits: New Adventures in Engineering* and, his latest, *The Essential Engineer*. Henry is also the author of a regular column in the *American Scientist* magazine and a frequent contributor to engineering history conferences. He has been widely honoured for his work.

Finally, to combat the 'hard sell' - what can be done? A list of things can be compiled easily:

Make sure that more people understand what engineering is and what engineers do, and how they do it; this will not be done simply by devising a better definition;

Encourage greater activity in the field by both amateur and professional historians; produce material that better attracts the attention of leadership people and members of the various

general publics; and

Popularize more notables and achievements by such agencies as the CSTM Hall of Fame and the Historic Sites and Monuments Board; sponsor more TV and radio programs and websites; and write more articles, books and pamphlets. Speaking of the CSTM, its title should include 'Engineering.'

'Getting it done' will be the real problem, along with attracting enough enthusiasts and money for it. One might hope that this could be as easily done as said. After all, historian Elizabeth Abbott wrote in the December 10 issue of the *Ottawa Citizen* that "history is a practical discipline." So, too, is engineering!

Thank you for your attention.
