THE CEDARGROVE SERIES OF

DISCOURSES, MEMOIRS AND ESSAYS

#20/2012

# ENGINEERING HISTORY: RECOGNIZE IT?

by Andrew H. Wilson

April 2012

**Abstract**

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

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

**About this Series**

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

**About the Author**

He is a graduate in mechanical engineering and the liberal arts and has held technical, administrative, research and management positions in industry in the United Kingdom and the public service of Canada, from which he retired over 25 years ago.

He became actively interested in the history of engineering on his appointment to chair the first history committee of the Canadian Society for Mechanical Engineering in 1975 and served both CSME and the Engineering Institute of Canada in this capacity for varying periods of time until 2003. He has researched, written and edited historical material for both organizations, and is a past president of both.

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

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

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

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

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

Before 3000 BC, the Sumerians had drained the marshes along the lower Euphrates and irrigated drier land, and the Egyptians had begun to build their pyramids. Around 1400 BC the latter were cutting stones from quarries to make obelisks, principally for the decoration of temples. Some of these great stones wound up many centuries later being transported across the sea, to be re-erected in cities such as Rome, Paris, London and New York. Around 530 BC, Eupalinus built an aqueduct and water system, with a tunnel, for the city of Megara in Greece. Around 350 BC the Romans built the *Via Appia* and brought the first water to Rome by aqueduct from springs 16 km away. Sometime later the Greek, Archimedes, developed his

screw pump and the Chinese invented cast iron. Around 260 BC they began to build their *Great Wall* and about a century later made the first paper. Around 100 BC the Romans discovered that possolana volcanic ash made excellent concrete that could even be used under water. During the first century BC they built the aqueduct and high bridge at Nimes, in France. During this century, also, Vitruvius - another Roman - wrote what is believed to be the earliest surviving book on engineering. In the first century AD, Emperor Vespasian ordered the construction of the Colosseum in Rome. The earliest known windmills were built in Persia around 600 AD.

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

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

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

When the Europeans began to arrive in Newfoundland and Eastern Canada in the 16th and 17th centuries they brought their own technologies with them. But the inland regions, especially,

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

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

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

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

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

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

In Britain, where practical training through the apprenticeship or pupil routes were held to be preferable, the first Regius Chair of Engineering was not established until 1845, at the University of Glasgow. Both the French and British systems influenced early American engineering training and education, and particularly at the first school - at West Point - in the

early 19th century and at the first public institution to offer it - Rensselaer Polytechnic. Canada's early professional engineers were mostly trained in France, Britain or the United States. At first, and for most of the 19th century, those trained in Canada took the apprenticeship-pupilage routes. University-level education began very slowly and very modestly at the University of New Brunswick and McGill University in the 1850s.

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

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

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

The first is the design and construction of a waterworks at Hamilton Ontario. In the 1850s, cholera outbreaks were common. One of the cities seriously affected was Hamilton. To improve citizens' health, provide pure drinking water as well as water for fighting fires, the city fathers