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ENGINEERING HISTORY PAPER #58
"Engineering Then and Now"

by Andrew H. Wilson
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EIC HISTORY AND ARCHIVES
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Abstract

This paper was the basis of the talk given by the author to the Ottawa SAGE Kiwanis Group at Woodroffe United Church on 8 October 2014. Some of the themes included in the talk have since been expanded, although fewer illustrations have been used.

The thrust of the paper is to contrast engineering 60-to-100 years ago (then) with contemporary engineering (now). The representative themes include cooking and other household chores, sod huts and skyscrapers, boats and ships, bridges, canals and lift locks, automobiles, aeroplanes and spacecraft, and scientific research.

And, finally, a word or two about the future.

About the 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, the 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 almost 30 years ago. He has 'done' engineering history since 1975.

By way of introduction...

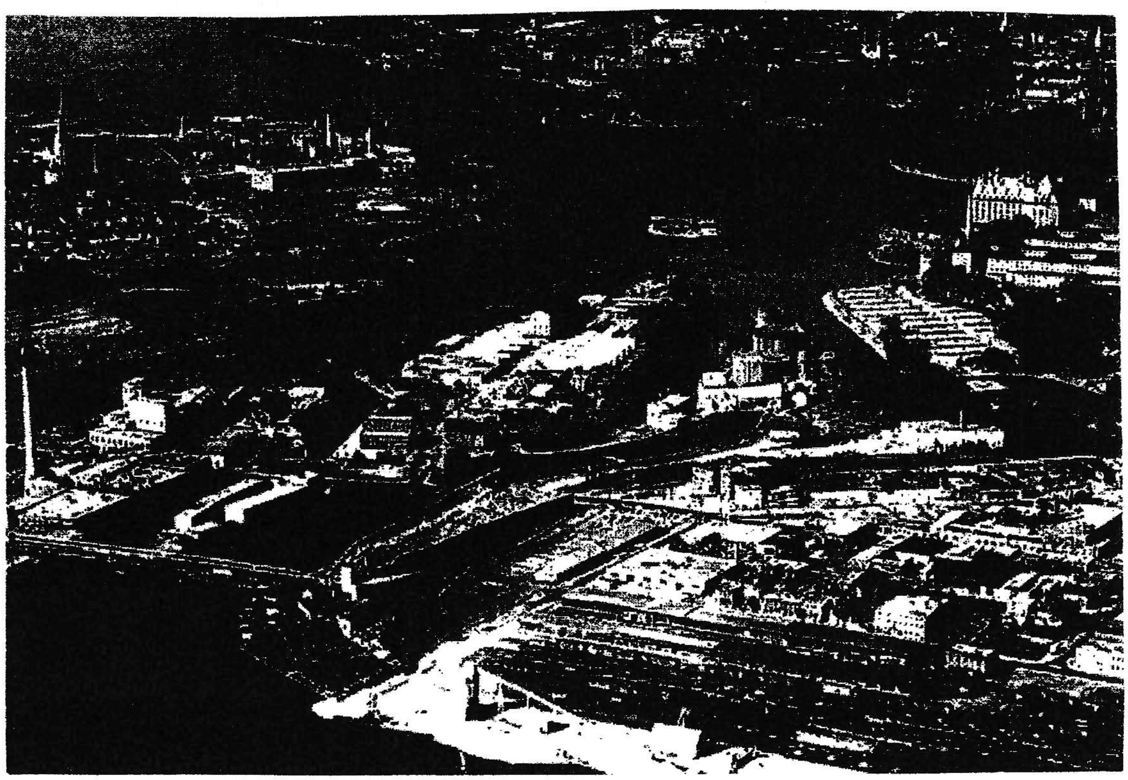
On the two occasions I have already spoken to you, my themes have been linked to the history of engineering. This time will be no exception.

This time, I would like to mention a number of contemporary engineering achievements that had their origins some years ago - then as opposed to now or recently - to help illustrate just how much things have changed - or not changed - and especially during the last 60 to 100-or-so years. I will also say a word or two about the future.

A hundred years ago, Canada's population was roughly 7.5 million. You might say that the country was just coming alive. Alberta and Saskatchewan had only recently become provinces and immigration to settle the West was in full swing. Manufacturing, metal mining and hydropower were growing in importance in Québec and Ontario. Railways could take you long distances, and short ones too. The automobile revolution was underway, but highways were still mostly unpaved. If you owned a motor car, chances were that flat tires bothered you a lot. So did mud in the spring. The average weekly food budget for a family was in the region of $8, but a dozen fresh eggs cost 34 cents. Wilfred Laurier was prime minister.

Many, if not most of you, will have seen the movie musical *Oklahoma.* It was set in 1906. One of the characters is Will Parker, who sings a song with the message that *Everything's Up-to-date in Kansas City.* There were gas buggies going by themselves. If you picked up a Bell telephone and listened you would hear a strange lady talking to you. You could see a skyscraper seven storeys high - about as high as a building ought to go, Parker says. Actually, there was already one in KC in 1906 that was 12 storeys high and another of 17 storeys under construction.

100 years ago, the area of the Ottawa River around the Chaudière Falls looked like this...



Sixty-or-so years ago, in the late 1940s and early 1950s, Canada was busy adjusting, with some success, to post-World War II circumstances. The Depression and the War were largely, but not entirely, forgotten. The Canadian population had doubled to around 15 million, thanks to the increased birth rate and high levels of immigration. Manufacturing had begun to prosper. Significant new oil and gas resources had been discovered. Automation was starting to revolutionize life and lifestyles. Airline and highway transportation systems were expanding. Social services and benefits were also expanding. Newfoundland joined the Canadian Confederation in 1949. Louis St. Laurent was the prime minister. These were, however, pre-computer days and engineers were still using slide rules!

The thing is that, even although something was engineered 100 years ago, or 60 years ago, it may still be standing and in use today. So, let us look back to then from now from a number of engineering perspectives.

Cooking...and Other Household Chores...

Around a century ago, in the United States, John Harvey Kellogg developed processes for the mass-manufacture of breakfast cereals, the *Cordon Bleu* cooking school in Paris was becoming world-famous, and the tea-bag and the ice cream cone were invented.

When I graduated in engineering 65 years ago, the president of the university preached my class a sermon on our duty as engineers to provide housewives with better tools and machines so that they could keep house more efficiently.

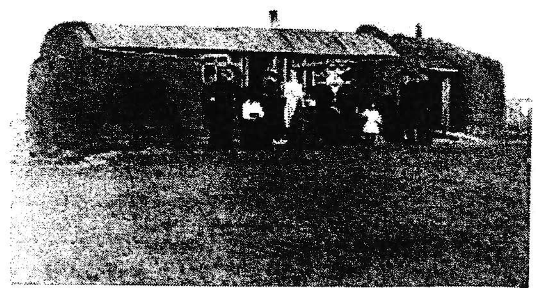
Looking at the record since then, we - or our colleagues elsewhere - have done just that. We have provided electric refrigerators and stoves, washing machines and dryers, microwaves, vacuum and cyclone carpet sweepers. Home heating systems use different fuels and are more efficient. Baby buggies, these days, look more like vehicles than simple boxes on wheels for transporting infants. A whole range of mechanized utensils are available, as are new cleaning materials. Furniture design is now more sophisticated and synthetic materials are extensively used. What we eat has changed over the years. There are many more processed and packaged foods, to say nothing about the equipment the big hotels need to operate and the food-producing companies use to make their products.

Sod Huts...and Skyscrapers...

Those of you who have visited the L'Anse aux Meadows historical site have seen the reconstruction of Norse sod-constructed buildings on that site. They were also used by the Inuit. With the arrival in Eastern Canada of the Europeans in the 1600s and 1700s, the building of low-rise wooden, stone and brick structures began, although early settlers also built houses of earth sods.

Those who have lived in the almost treeless Prairies know about them. 100 years ago they were often used as the first, temporary homes of settling immigrants. Today, their number has dropped almost to zero. But near Kindersley, Saskatchewan, the Addison sod house still stands, although wrapped in vinyl sheathing to protect it. In addition to being called 'the last of the soddies,' it was designated as a site of 'national historic significance' in 2004.

The best soddies, apparently, were built from deeply and thickly-rooted prairie grass to minimize damage from freezing. The walls could be 32 inches (two courses) thick and the grass-side-down rectangular sod 'bricks' overlapped, to a height of eight feet. The average house measured 18 feet by 24 feet. The inner walls could be covered with cloth or plastered with a clay mixture and whitewashed. A weak spot was the roof, often made from sods carried by long wooden poles. After rain showers, it would leak until such times as it could be covered or replaced by a waterproof material. Basic non-sod materials included wood for windows and doors, window glass and iron door hinges, although wooden boards could be used, initially or later, for the roof. Sod houses were generally warmer in winter and cooler in summer.



A pair of Prairie soddies

100 years ago there were already skyscrapers, as Will Parker noted.

Historically, the building of what might be called 'skyscrapers' began in the Middle Ages, with tall, spired cathedrals and Islamic minarets, as well as the turrets of fortresses, and individual towers. These spires and towers were usually uninhabited and climbing inside them required flights of stairs.

Modern generations of skyscrapers date from the 1880s. They were made possible by two major technical advances: the development of safe elevating devices (notably by the Otis Company), and steel (later, reinforced concrete) lattice structures that could be more heavily loaded than stone or brick walls. Also, there was often an economic advantage in building upwards instead of outwards and using less expensive space on the ground. In the engineering and architecture of skyscrapers, the cities of Chicago and New York deserve special mention, for it was there that engineers and architects began building them...and Europe and the rest of the world followed.

In recent years, the terms 'high-rise' or 'tower' and 'apartment block' or 'flat-iron building' have been used as well as 'skyscraper' - which is, incidentally, more likely to be an office building, while the others are living accommodations. Also, a skyscraper is usually taller than the others, and nowadays can have interesting irregular or tapered shapes, as well as being squared or rectangular.

The early 1930s, in spite of the Depression, saw the completion of several important New York skyscrapers, for example - the Chrysler Building in 1930 and the Empire State, the Waldorf Astoria, General Electric and RCA Buildings in 1931. The only notable one to go up between then and 1940 was the Rockefeller Center.

Since World War II, skyscrapers in New York have gone higher and higher - for example, the United Nations Center (1947), the PANAM Building (1963), the twin World Trade Towers (1973), which were levelled in the terrorist attack on September 11, 2001, the Trump Tower (1983), and the new World Trade Center (2013). Elsewhere in the United States and around the world there have been, for example, the Sears Tower in Chicago, Bank of America Center in Houston, the U.S. Bank Tower in Los Angeles, Tokyo City Hall, the Pertonas Towers at Kuala Lumpur, the 'Gherkin' in London, the Shanghai World Financial Center, the Chicago Spire, and several in Dubai, in the United Arab Republic.

Canada's first skyscrapers were relatively modest buildings in Montréal, Toronto and Quebec City, such as the Sun Life Building, the Royal York Hotel and the Bank of Commerce Building, and the Chateau Frontenac. Nowadays, there are groups of skyscrapers in the downtown cores of all Canada's major cities.

If we think of 'straight' towers, rather than 'buildings called towers', among the most spectacular have been the Eiffel Tower in Paris, the Washington Monument in D.C., and our own CN Tower, plus the Ostankino Tower in Moscow, the Milad Tower in Tehran, the Tokyo Skytree, the Cantor Tower in Guangzhou, China, and Centerpoint in Sydney, Australia.

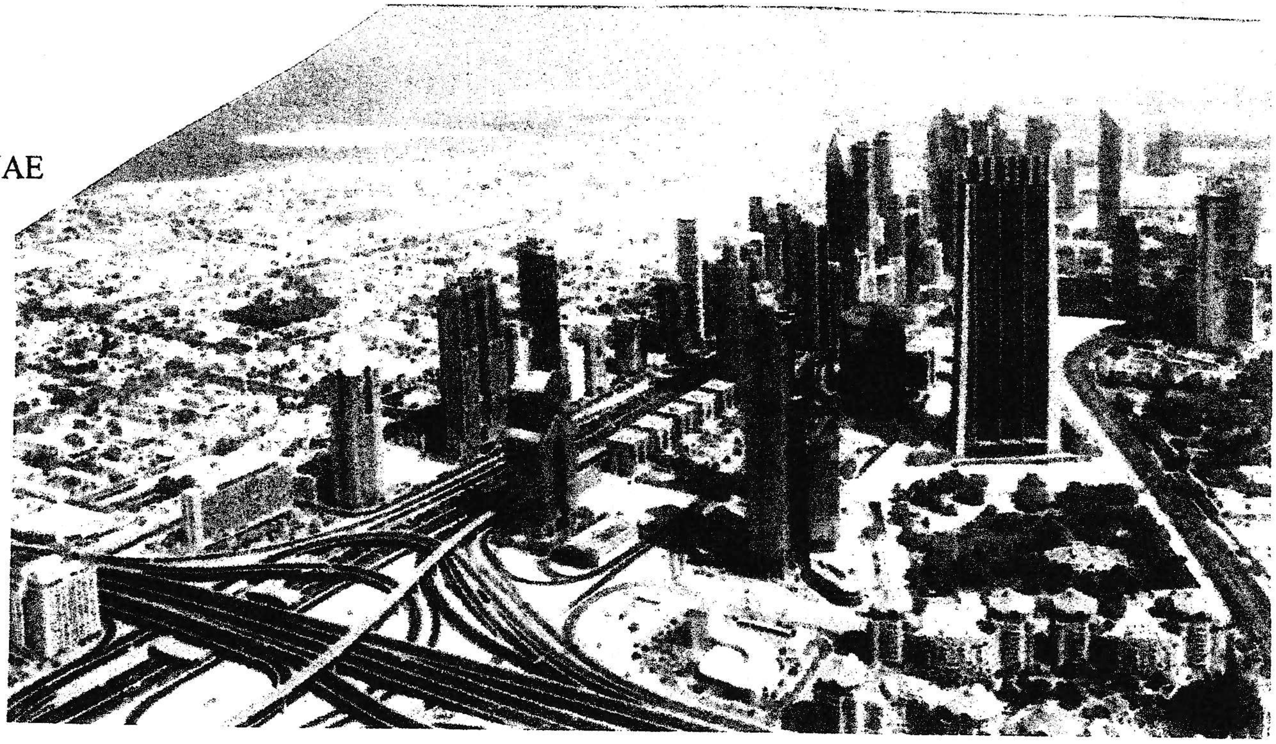
The first skyscraper...

10 storeys, Chicago

insurance building

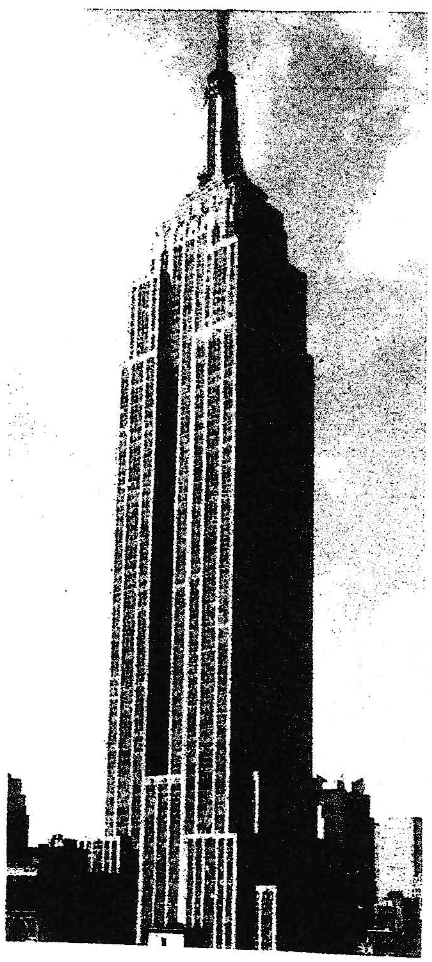
1883

Dubai, UAE



Empire State

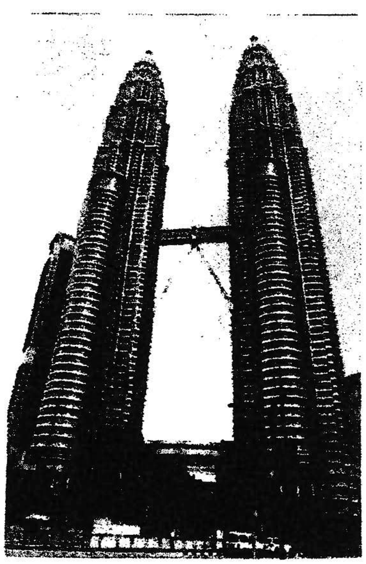
Building, NYC



Petronas Towers,

Kuala Lumpur

Kuala Lumpur



The Gherkin,

London

Canoes, kayaks, coracles...and cruise ships...

A hundred years ago, coracles were in use in the British Isles and kayaks and canoes in North America. Developed long before then, their purpose then and now is was to convey a single person or just a few people across lakes, up and down rivers and, to a limited extent, out to sea, using paddles or short oars.

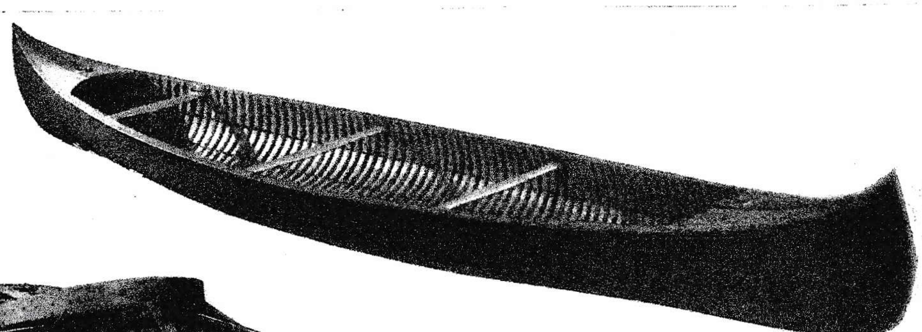
During the Age of Exploration in the 15th and 16th centuries the sail-power of the ships had increased, but they were not much longer. The famous *Mary Rose*, for example, had a length of 105 feet and a beam of 38 feet. Nelson's *Victory*, was commissioned in 1778. Its hull was 200 feet long, and its beam 50 feet. It had three masts and was square rigged. It carried 100 guns and a complement of 850 men.

Then, around 200 years ago steam began to supplement and eventually to replace sail, the *Claremont*, *Charlotte Dundas* and *Accommodation* being among the first to use it. Some years later, the *Royal William,* wooden hulled, steam and sail propelled, built at Québec, was the first to have watertight iron bulkheads. The first steamships were paddle-driven, either from the side or, for river travel, from the rear.

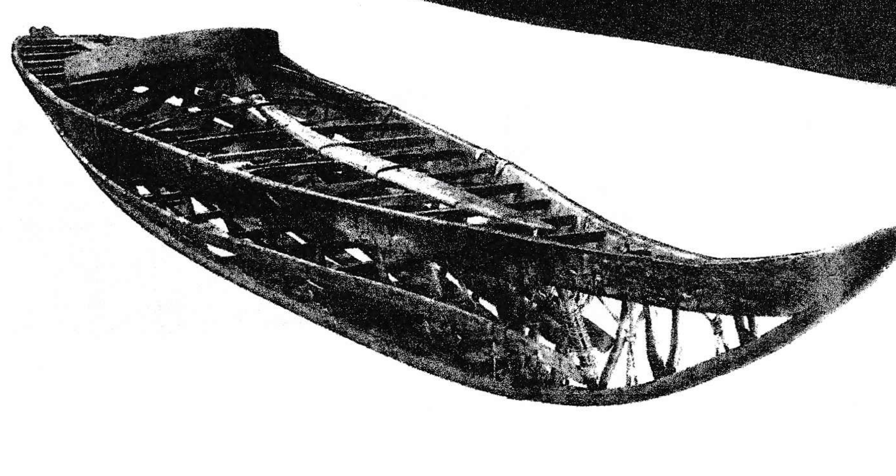
By the mid-19th century, iron and steel hulls had begun to replace wooden ones. Perhaps the most famous ship designer and builder of the mid-19th century was the Englishman, Isambard Kingdom Brunel, who designed and built the *Great Western, Great Britain* and *Great Eastern.* The *Great Western* had a wooden hull, the *Great Britain* had an iron one and was the first deep sea ship to have a screw propeller. *The Great Eastern,* in 1868, was the record-breaker of its day, at almost 700 feet in length, with a double hull and 10 watertight bulkheads.

A hundred years ago, the designs and materials used for coracles, kayaks and canoes had changed relatively little, although some canoes were much bigger. But by then, and thanks to steam and steel, some very much larger marine craft had been built in a tremendous variety of sizes. They were used to carry many more people and a great deal more cargo across oceans, seas and lakes and up and down rivers. At the end of the 19th century, the steam turbine was beginning to replace the reciprocating engine. The diesel was not too far into the future.

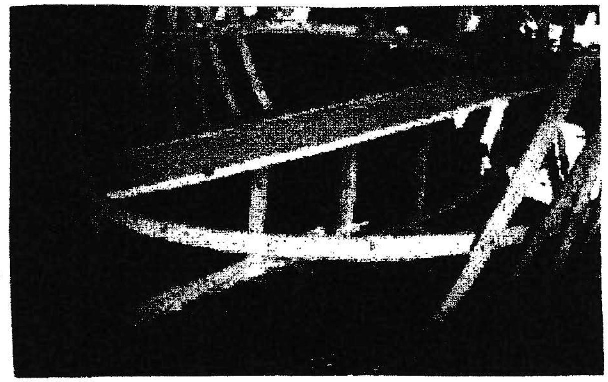
The canoe,



the kayak...



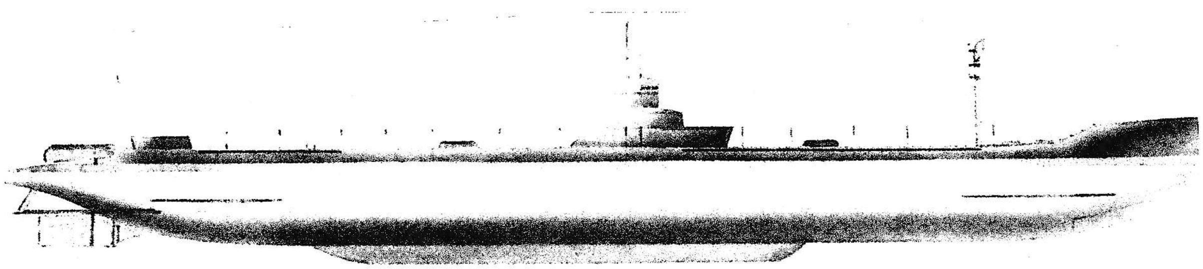
...and the coracle



Wars, and the threat of them, contributed significantly to the development of ships of all shapes and sizes. At the turn of the 20th century, for example, British admiral, Jackie Fisher, saw to it that his *Dreadnought* battleships and cruisers were built. World War I gave birth to the U-Boat and to the aircraft carrier. World War II contributed to the death of the battleship. The Cold War gave birth to the nuclear submarine, spearheaded by Admiral Rickover and the United States' *Nautilus*, and to the anti-submarine surface ships, such as the Russian *Kirov*.

But even a hundred years ago, there were some very large passenger ships, many plying the Atlantic between Europe and the United States - for example, the *Oceanic, Carpathia, Aquitania, Berengaria,* the unfortunate *Titanic* and her sister-ships, the *Olympic* and the *Britannic,* as well as the *Empress of Ireland*, which sank in the St. Lawrence, and the *Lusitania,* sunk during World War I, some of them reaching almost 900 feet in length, 50,000 gross (capacity) tons and speeds over 20 knots.

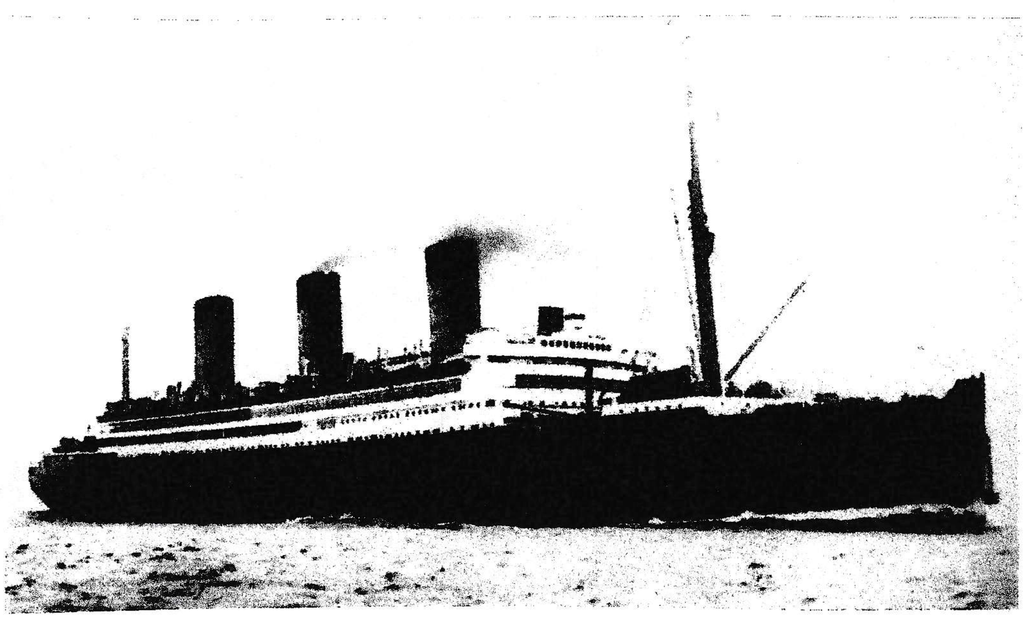
U-Boat



German SS *Imperator*,

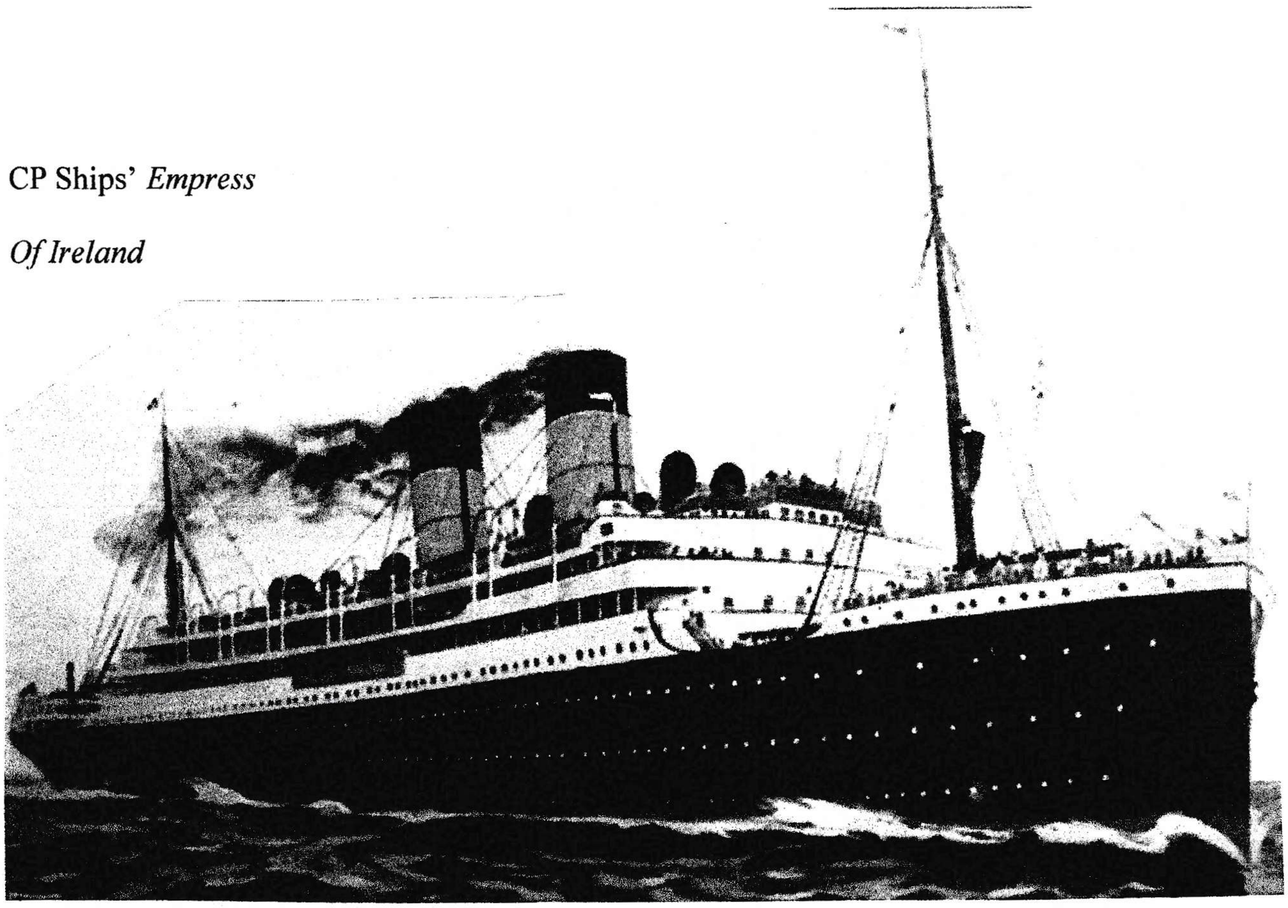
later British

RMS *Berengaria*



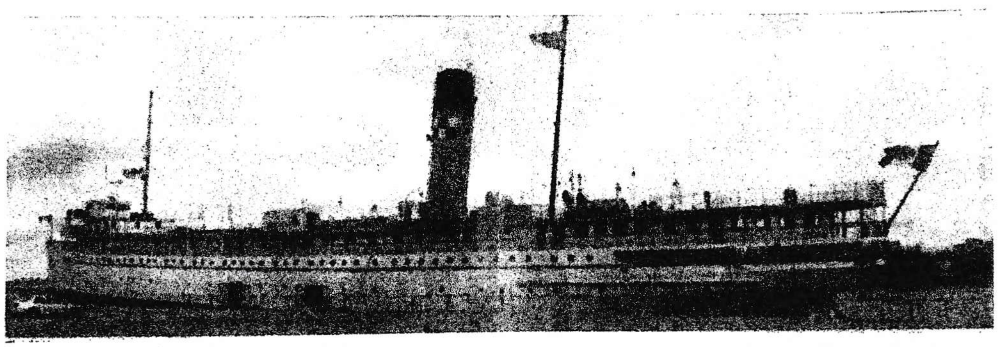
CP Ships' *Empress*

Of Ireland



Lake ships could be quite big, too. The Canadian Pacific steamship *Keewatin,* for example, was launched in 1907. The 4,000 ton vessel was over 300 feet long, with a beam of over 40 feet. It carried 300 passengers and a crew of 86. For 50 years it ferried passengers and freight across the Great Lakes. Decommissioned in 1965, it operated as a floating museum at Kalamazoo, Michigan, where it celebrated its centenary. Shortly thereafter, it was towed back to Georgian Bay, to become a tourist attraction.

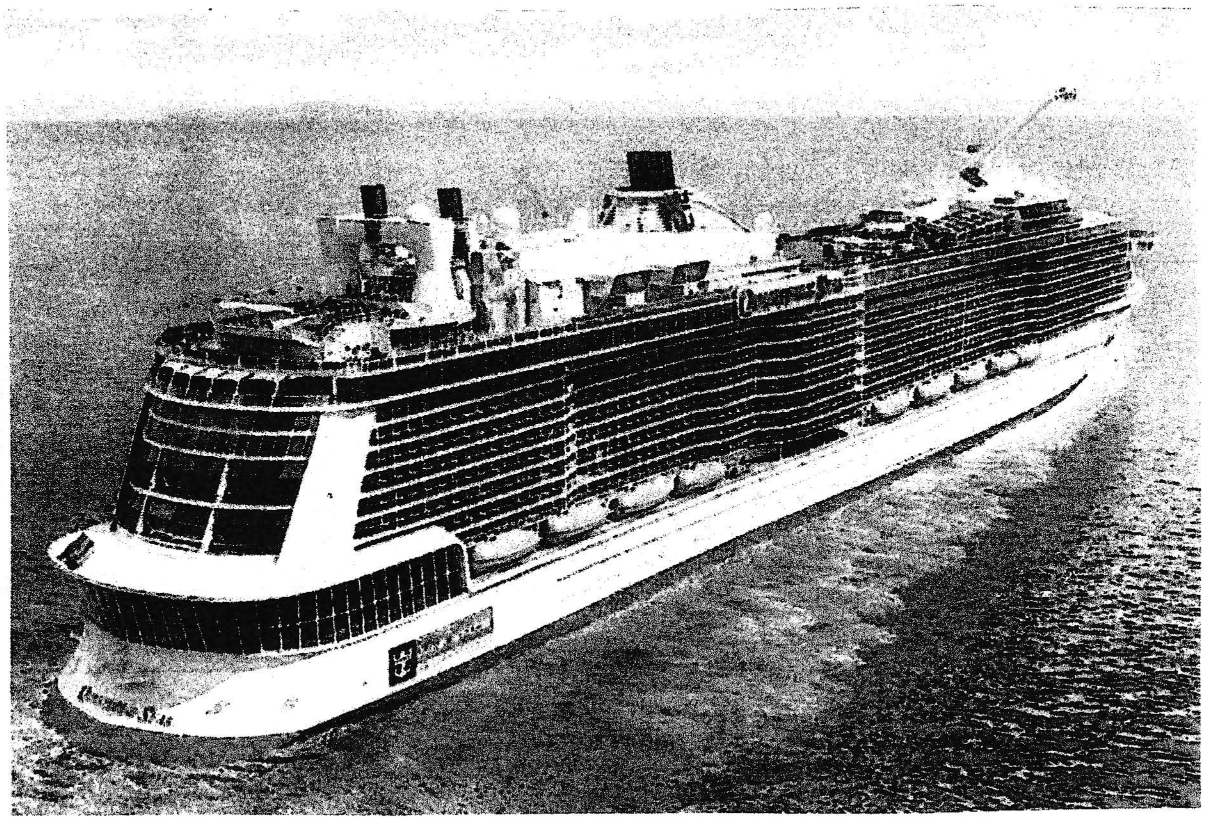
SS *Keewatin*

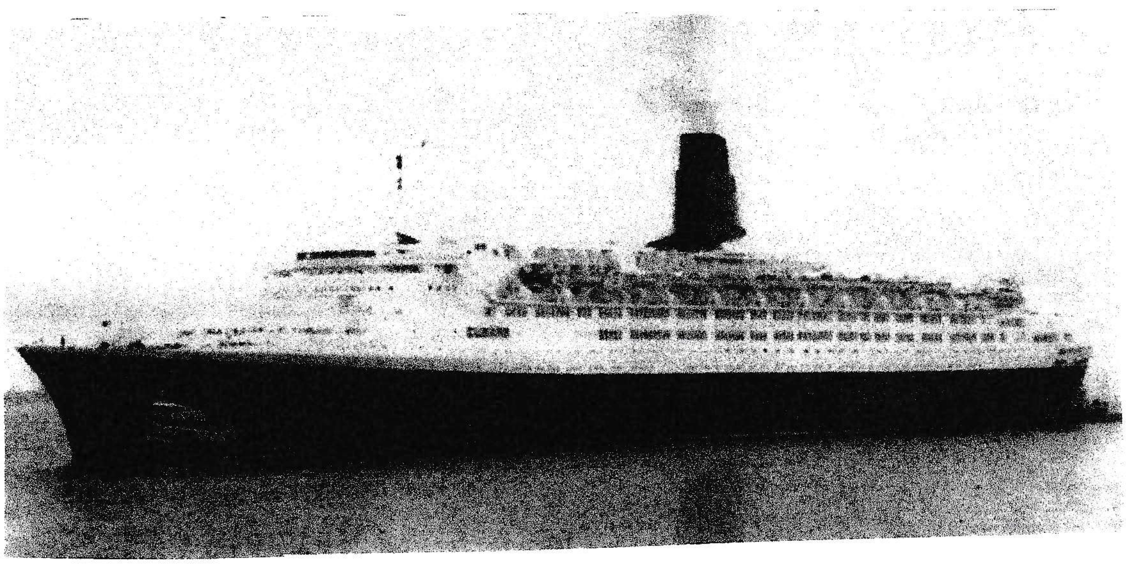


The 1930s, 1940s and 1950s brought the building of the British *Queens*, at 80,000 tons gross, as well as the *Empress of Britain,* the *Normandie,* the *Rex,* and the *America.* Then aircraft became the vessel-of-choice for transatlantic and other overseas passengers and the big ships were turned into cruise ships. Today's cruise ships are bigger still. For example, the Royal Caribbean's *Quantum of the Seas*, which is due for launching late in 2014 at the Meyer Werft Shipyard in

Germany, will have a capacity of 167,000 gross tons, a length of over 1100 feet and a beam of 136 feet. She will cruise at 22 knots, carry several thousand passengers and crew and see service mainly in Asian waters.

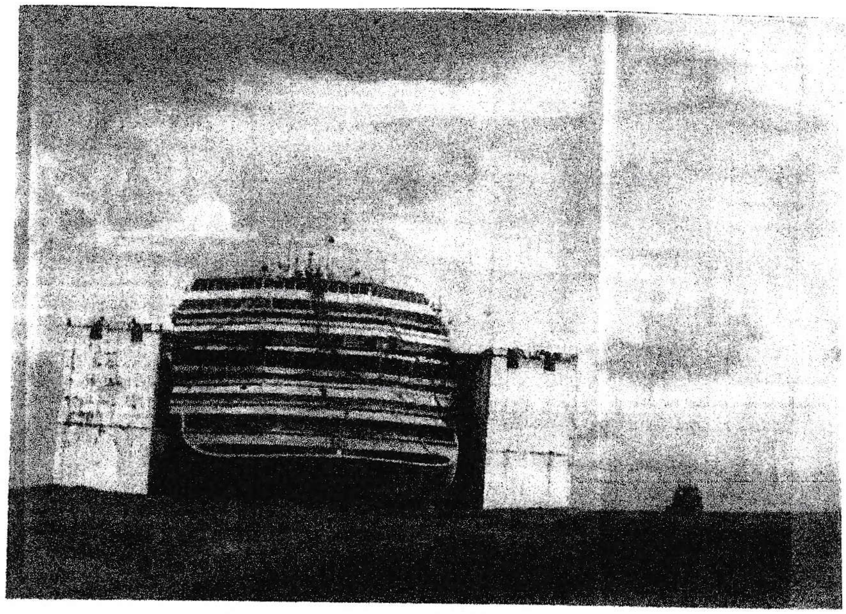
MS *Quantum of the Seas*





MS *Queen Elizabeth 2*

And speaking of cruise ships, quite recently the *Costa Concordia*, which had run aground on an Italian island early in 2012, was spectacularly salvaged and towed for breakup at Genoa.



Cruise ship *Costa Concordia* nearing end of refloating operations

Post-WorldWar II, freighters were still quite small, but this changed with the arrival of container ships, which were first developed from surplus tankers in the early 1950s. These ships now carry around 90 per cent of the world's dry, non-bulk, cargoes. The very largest of them measures 1200 feet in length, with a beam of 160 feet, and has a carrying capacity equivalent to something like 15 pre-WW II freighters. But tankers got bigger too. Even lakers now are over 700 feet long and just fit into the locks of the Welland Canal. Speaking of canals, the Panama is currently being enlarged to take most of the largest ships, both container and cruise.

Maersk Line container ship

I have always considered ocean-going ships to be the most useful practical training grounds for mechanical and electrical engineers, and even more so today.

Bridges...

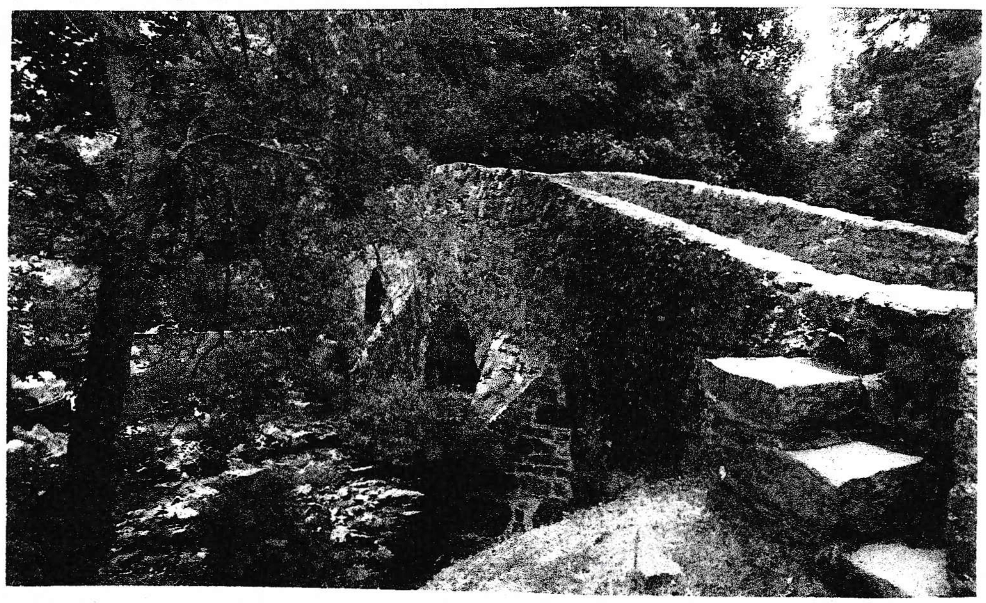
Getting from one place to another, across impediments to travel such as gorges, ravines, streams and rivers has often been made much easier by the building of bridges.

The very first bridges - in prehistoric times - were provided by nature in the form of a series of convenient stones in the bed of a stream or of downed trees dragged into position by the people who used them. Bridges grew marginally more sophisticated when several pieces of wood were lashed together and were strong enough to bear the weight of an animal-pulled cart. The Romans around the time of Julius Caesar were great arch bridge and aqueduct builders. In the mountains of Bhutan, the bridges were suspended by chains of metal links.

During my travels last year on the Isle of Man, in the middle of the Irish Sea, I came across a stone bridge over a small river that had been built originally in the year 1132 AD by Cistercian monks from the nearby abbey. I took its photograph...

Isle of Man bridge,

12th century

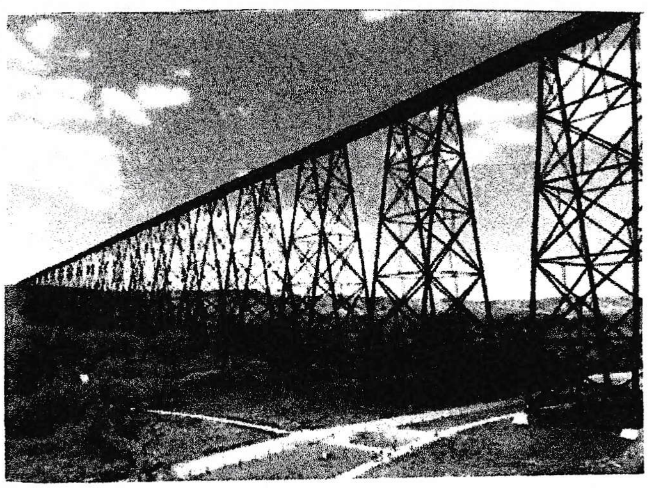


In more recent times, the first cast iron bridge in the world was built at Coalbrookdale in Shropshire, England, over the River Severn, in 1779. But neither cast nor wrought iron had sufficient strength to take heavy loads of locomotives and whatever they were pulling. So the next iteration of bridge-building technology had to wait for the arrival of steel as the preferred construction material.

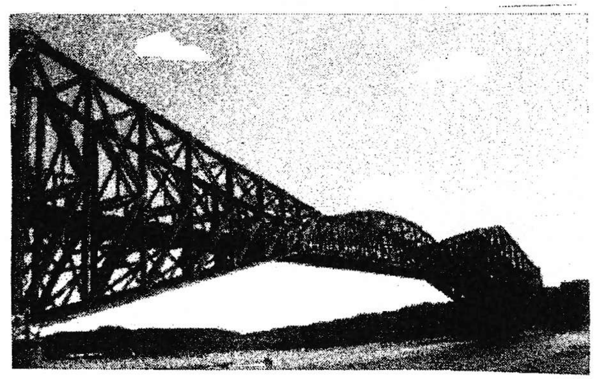
Over the last hundred years, the principal bridge-design types have been beam, truss, arch, cantilever, suspension, and cable-stayed. Some bridges, such as the bascules, have moveable parts. Others have swung or lifted. Some modern bridges are quite spectacular, and especially for the slenderness of their structures. But the Tacoma Narrows Bridge was too slender. It collapsed spectacularly in the 1940s.

Interestingly, of the world's longest bridges at the present time, most are in China, with the United States a distant second.

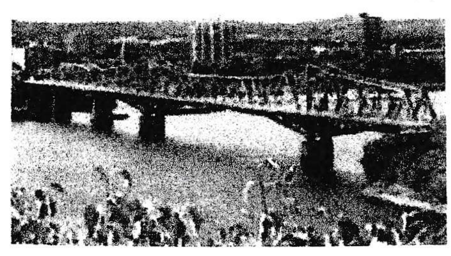
The world is now full of spectacular bridges. From 100-odd years ago there is the Lethbridge Viaduct, in Southern Alberta, the Québec Bridge, with its tragic construction history, and the Alexandra (Interprovincial) Bridge across the Ottawa River. Sixty-odd years ago, there was the Sydney Harbour Bridge in Australia and the Lion's Gate Bridge in Vancouver. In the 1960s, the Verrazano-Narrows Bridge at the entrance to New York harbour. Contemporary bridges include the eight-mile long, 62 pier arch-type Confederation Bridge between Prince Edward Island and New Brunswick, across the Northumberland Strait, that was opened in May 1997. The British-designed Millau Viaduct in southern France was completed in 2004. It is cable-stayed and has the highest piers in the world, some higher than the Eiffel Tower. In 2011, the Chinese opened the world's longest sea-bridge - a six-lane, 27-mile long, Y-shaped structure, that stands on 5,200 pillars. It connects the port city of Qingdao with an airport and the industrial suburb of Huangdao. It took four years to build.



Lethbridge Viaduct

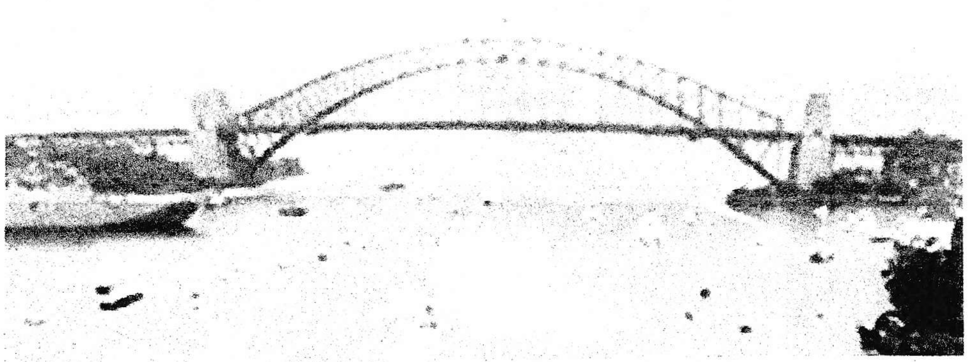


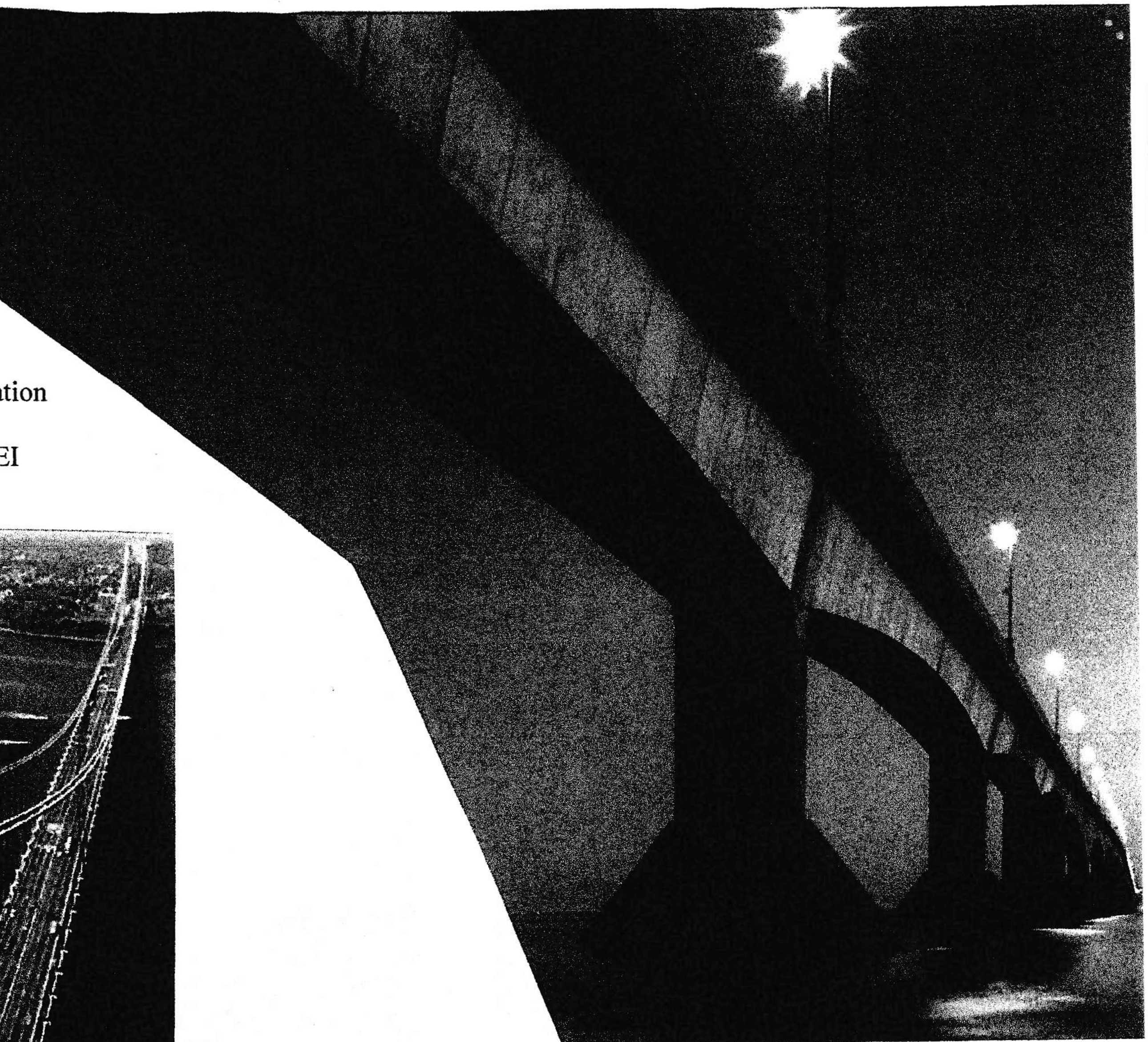
Québec Bridge



Alexandra Bridge

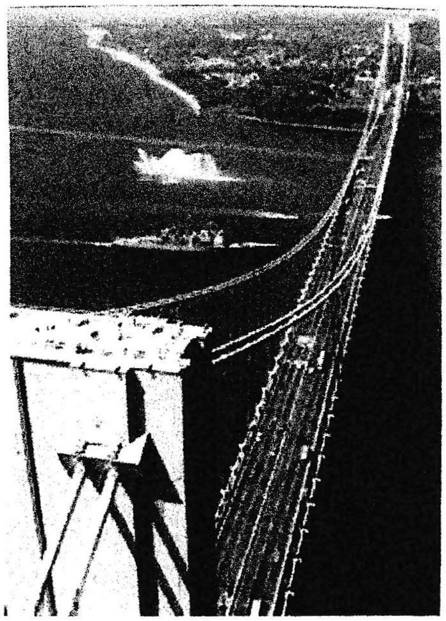
Sydney Harbour Bridge





Confederation

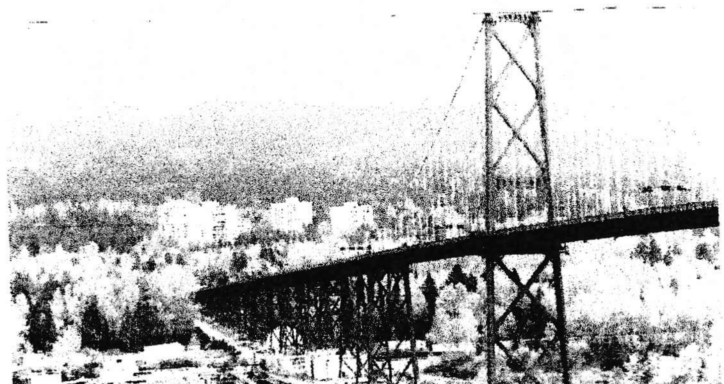
Bridge, PEI



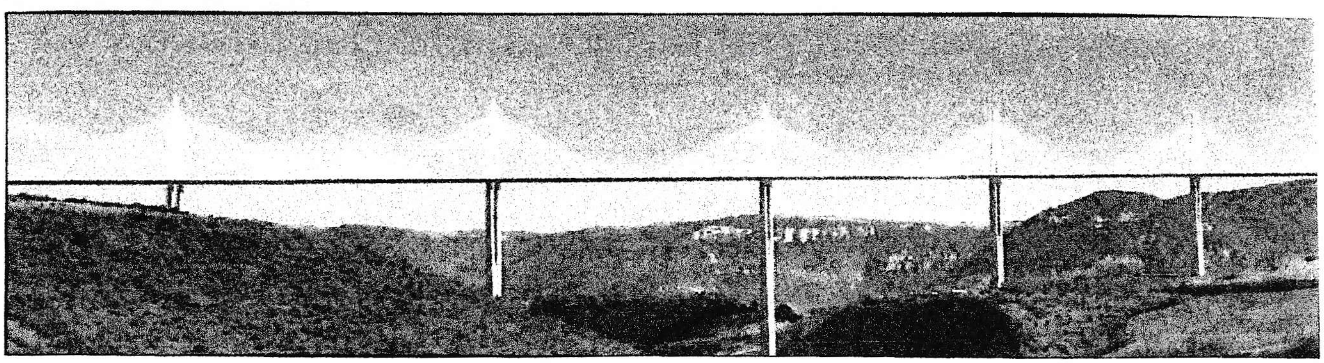
Verrazano-Narrows

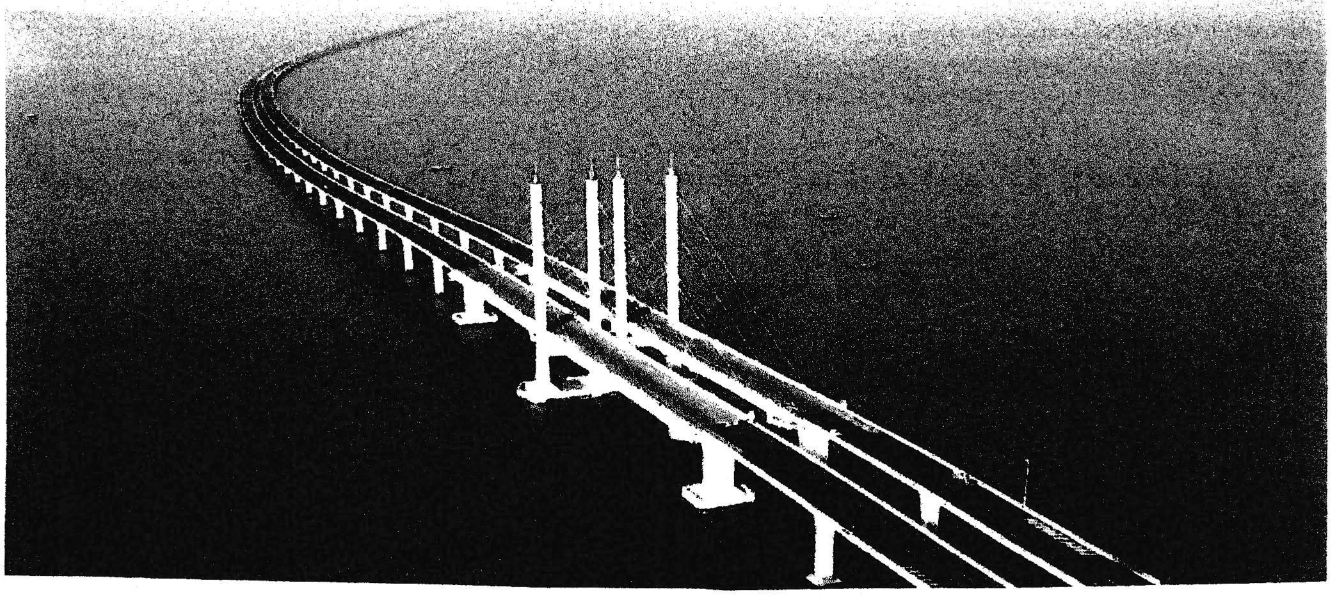
Bridge

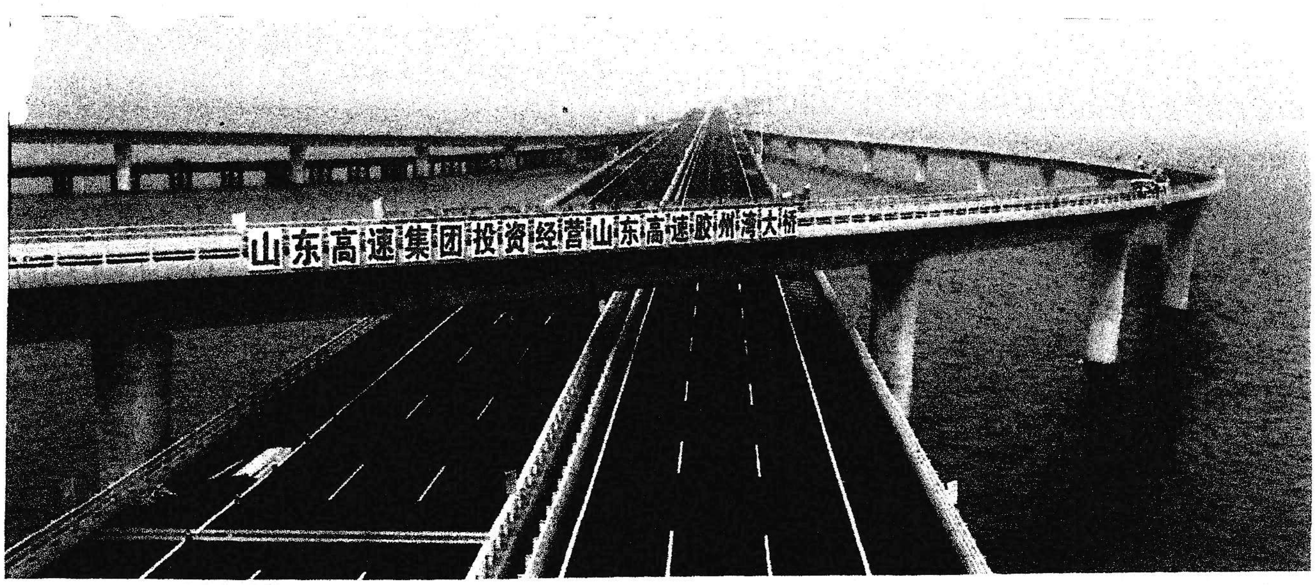
Lion's Gate Bridge

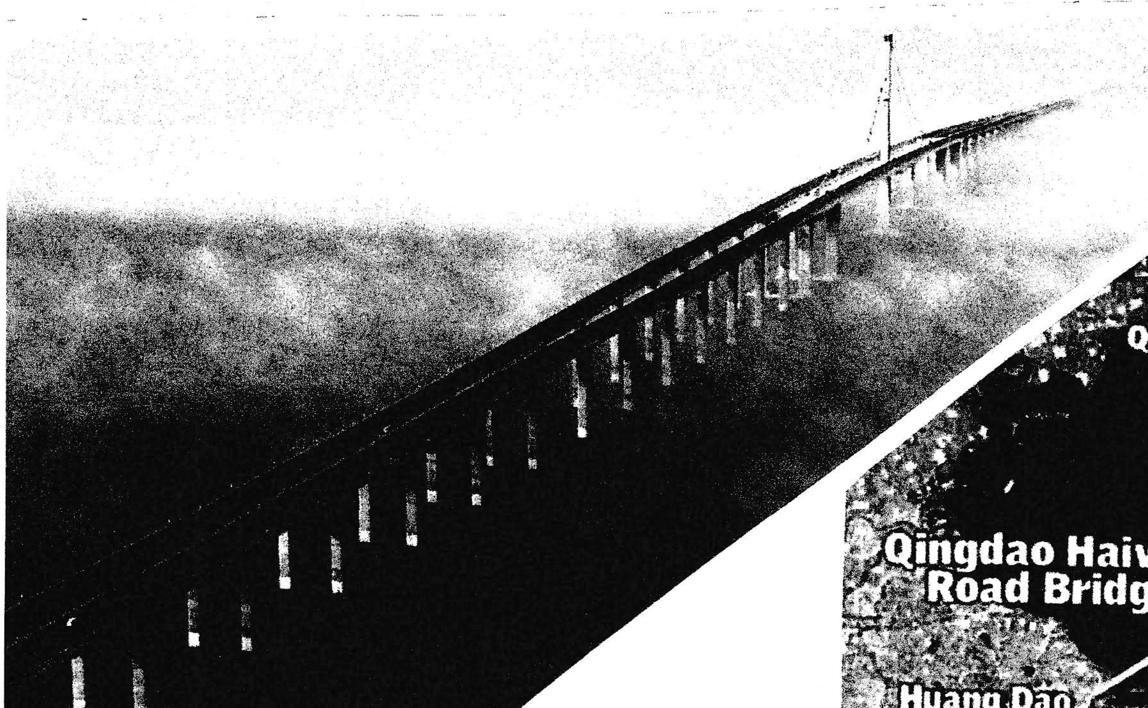


Millau Viaduct






山东高速集团投资经营山东高速胶州湾大桥

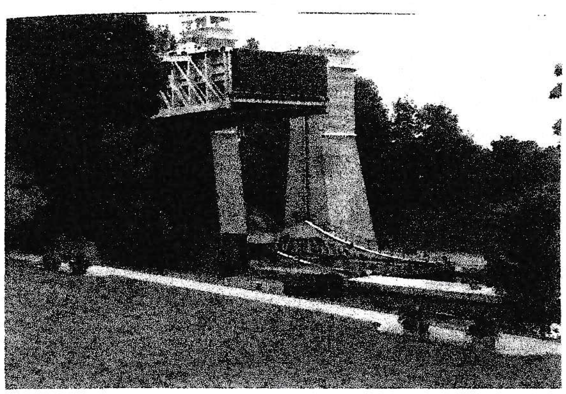


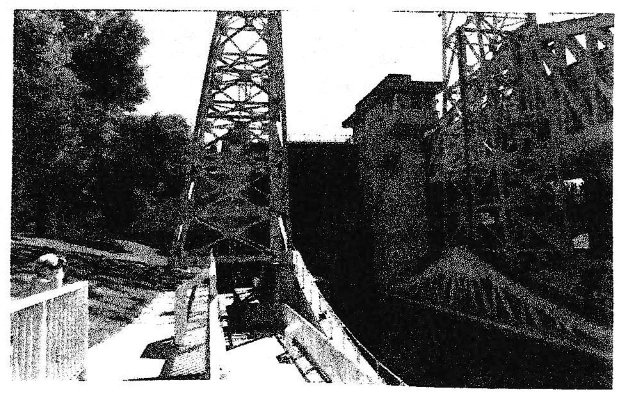

Quigdao Island
for airport
Qingdao Haiwan
Road Bridge
Qingdao
Huang Dao

Canals...

There were bridges before there were gas buggies, and there were canals before there were railroads. The canals were of two main kinds: the inland ones, usually narrower, like the Rideau and the Trent-Severn in Canada and those in the Norfolk area of England; and the larger ones that were built across isthmuses to take ocean-going ships from one ocean, sea or lake to another, like the ones at Kiel, Suez, Panama, all now over 100 years old, and the Welland, whose first, narrow version was completed in 1829.

In 1920, almost a century later, Canada's relatively narrow Trent-Severn Waterway was finally completed, although much of its construction occupied the years 100-odd years ago. There had been a variety of problems involved, some technical, but many political and economic. One of the technical problems - differences in the levels of water throughout the canal - was solved with the building of locks as well as three unusual structures. One was at the Big Chute marine railway near the western end. It was essentially a wheeled, boat-carrying carriage that ran on rails and took its cargo of boats up or down to the next level of water. The other two were lift locks - essentially very large tanks into which boats were steered and parked. Then the tanks were lowered or raised to the next water levels. One of them was built a Peterborough and the other at Kirkfield, and it is with the former that most of us are familiar.



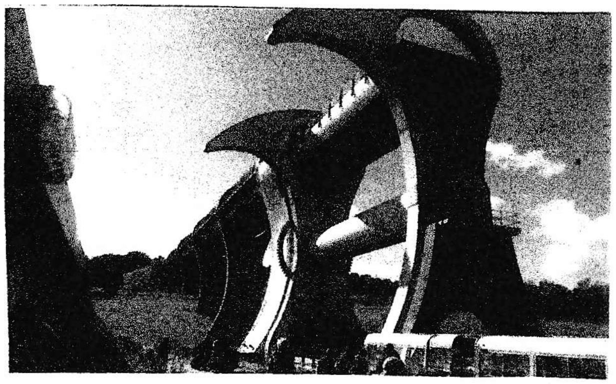
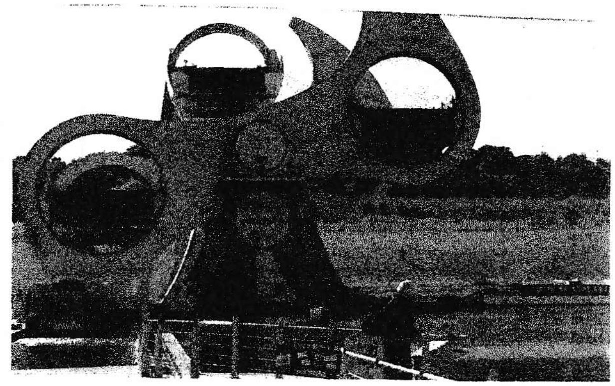


Peterborough and Kirkfield Lift Locks

But there was another canal system in another country on another continent that had the same two-level problem. The original canal between the Clyde and Forth Rivers in Scotland went from estuary to estuary. While the city of Glasgow was included in this route, the city of Edinburgh was not. So the Union Canal was built to join Edinburgh to the main canal near the town of Falkirk. All this happened before 1790, when the Forth-Clyde system was opened. Interestingly, William Symington's small steam-driven boats, culminating with the *Charlotte Dundas,* were tested on the Canal.

Originally, a series of locks took the boats from one canal to the other, from one level to the other. That was a long time ago. As time passed, the usefulness, usage and maintenance of the Forth, Clyde and Union Canals deteriorated, due in large part to the increase in size of steam sea-going vessels, to the coming of the railways and, later, the highways. It became a small-boat thoroughfare. Parts of it were filled in. It was effectively closed by 1963.

With the approach of the Year 2000, however, it was decided to revive travel on the two canals. This time, the difference in levels between them would be accomplished using a *lift lock.* But there was a twist. It would also be a tourist attraction. So the Falkirk Wheel was designed and built. Technically, its function is essentially the same as the ones at Peterborough (opened 1904) and Kirkfield (opened 1907), but its operation is quite different. The tanks, instead of going straight up and down, trace a circular path.

The Falkirk Wheel

Gas buggies...

Seen from today's perspective, the first motor cars were primitive machines, and the roads they used were usually not much more than unpaved tracks rutted by the passage of horse-drawn wagons and stagecoaches. But even before the advent of the motor car, there was a technology of road building. A Wikipedia item on *How Roads Were Built* describes the process in North America around 1800.

The projected route had first to be surveyed for distance, direction and elevation. Then the area to be used as the road had to be cleared of boulders, stumps, brush and trees, and this was usually done by hand or with the help of horses. Once the stump-puller had been invented, it was estimated that seven men and a team of horses could pull 40 stumps a day although, in forested areas, this could still add up to slow progress. After clearing, the road surface was levelled and graded, often using hand-held rakes and hoes, but sometimes with horse-drawn scrapers. Elevation changes had to be closely monitored since there was a limit to the ability of horses to pull loads uphill and control their wagons or whatever on the downslope.

Although the new roads could take their wagon and stagecoach loads, they were still unable to escape the erosion and rutting of use and the flooding of bad weather. Drainage ditches were needed on both sides and, on the working surface, stones had to be laid in two layers and hammered into place, with the smaller stones on top. Hard clay mixed with gravel was then spread to cover the stones and the gaps between them. However, each two months or so, repairs to the surface would be needed.

Today, there are still thousands of miles of unpaved roads in North America, without stone layers on top. Those that are to be paved, be they of two lanes or many, are still surveyed to begin with. But instead of men and horses, use is made of a variety of powered mechanical equipment that includes rock drills, diggers, spreaders, graders, pavers, compactors, and so on. And the final surfaces of asphalt or concrete do not need short-term maintenance. They should last for years. And when they need to be replaced, the asphalt ones can be scraped and resurfaced - by machines.

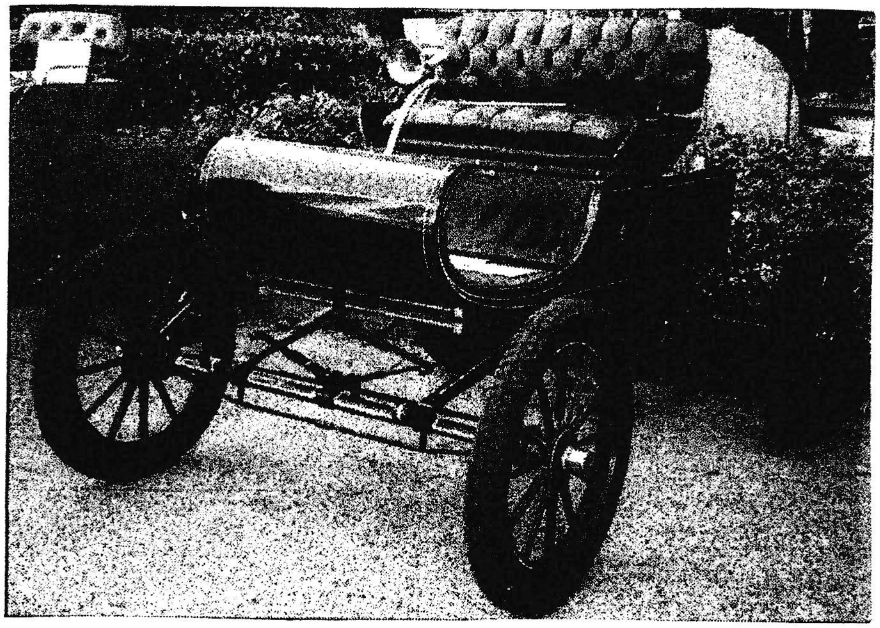
The development of the early motor cars was contemporaneous with the development of engines for them. The first cars were direct descendants of the bicycle as well as the various types of horse-drawn carriage. They usually carried one or two, and later four, people…and exposed them to the elements of weather. The late-19th century development of cars in Britain also suffered from the restrictions of the so-called 'Red Flag Law,' which required that a man carrying a red flag or a lantern precede a car to warn people of the vehicle's approach.

Originally, the steam-, electric- and gasoline-driven engines competed with one another. Gasoline finally won the completion, but not until around 1910.

Early U.S automobiles included the Curved Dash Oldsmobile, of which 425 were made in 1901, 5,500 in 1904. It had a 1.6 litre single-cylinder gasoline engine, made by Leland & Falconer of Detroit, which developed seven horse-power, and was positioned under the two-passenger seat. Steering was by tiller. It weighed 700 pounds and could reach a top speed of 40 km per hour.

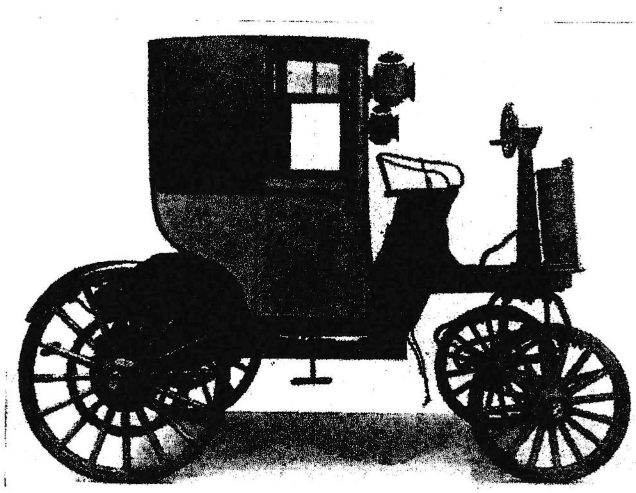
The 'Dash's' R.E. Olds was one of the automobile pioneers. Others included Benz, Daimler and Diesel in Germany, Lanchester, Rolls and Royce, Morris and Austin in Britain, Peugeot in France, the Duryea brothers, Kettering, Sloan, Hupp, Duesenberg and Ford in the United States. Much of the pioneering development of the automobile took place between 1890 and 1914. Henry Ford not only gave the world the Model T, he was a pioneer of the mass production of automobiles and engines (and other products). 15 million Model T's - or 'Tin Lizzies' - were built and sold between 1908 and 1927.

I still remember going on trips with my family in my father's 1920s car, a Sunbeam, and seeing him having to stop from time to time to adjust or clean some part of it, or to change a flat tire. Even when I first owned a car, I did quite a lot of the tuning-up and maintenance myself, and changed tires when necessary. Nowadays, I won't touch a thing!

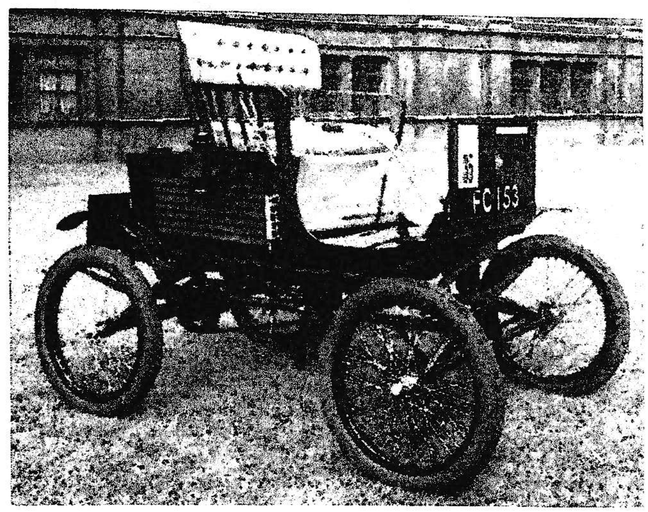


Curved Dash Olds

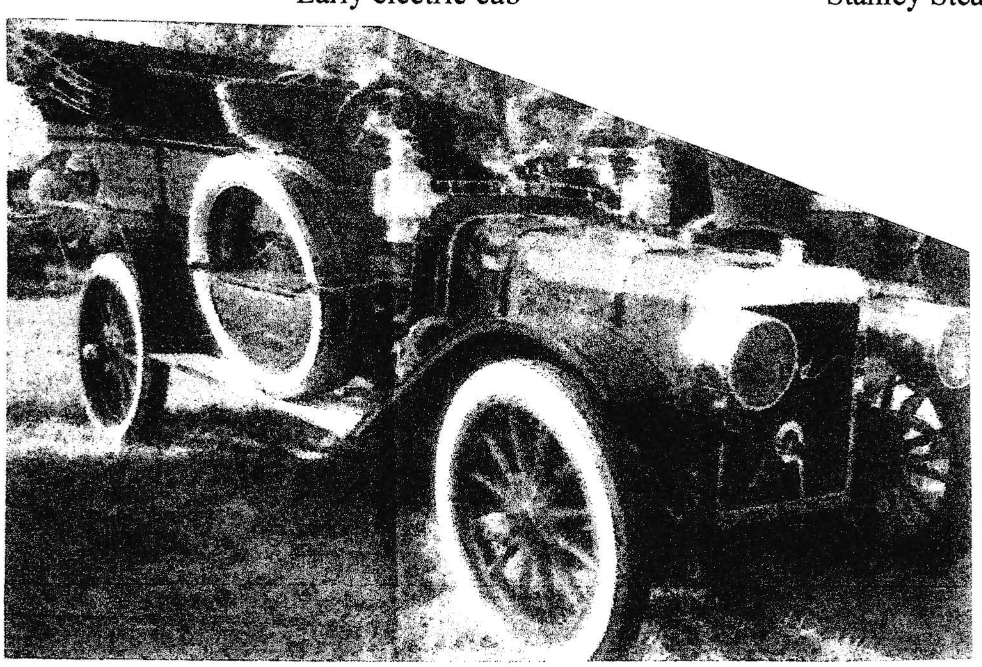
1901



Early electric cab



Stanley Steamer

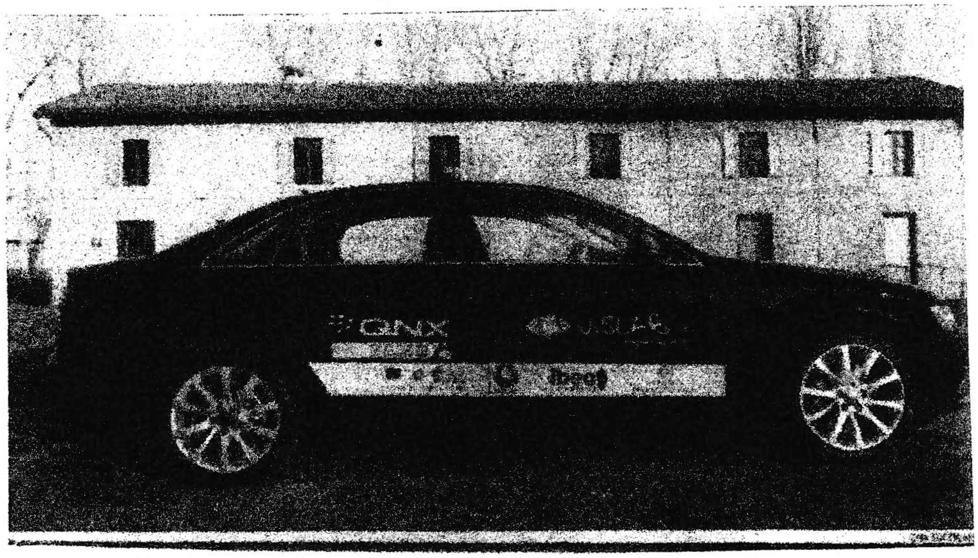


Ford Model K

touring car

1906

Nowadays, also, not all automobiles are larger than they were 100 years ago, as they were in the post-WW II decades. Pollution problems have had an effect on both car and engine designs. They have also succumbed to the electronic revolution and to system complexity rather than simplicity. They can go much faster when limits permit. Gasoline or hybrid engines now power them. Many have GPS systems to read the maps. In future, they might be driverless.



Driverless car, joint project of QNX Software Systems and the University of Parma, Italy

Aeroplanes...and Spacecraft...

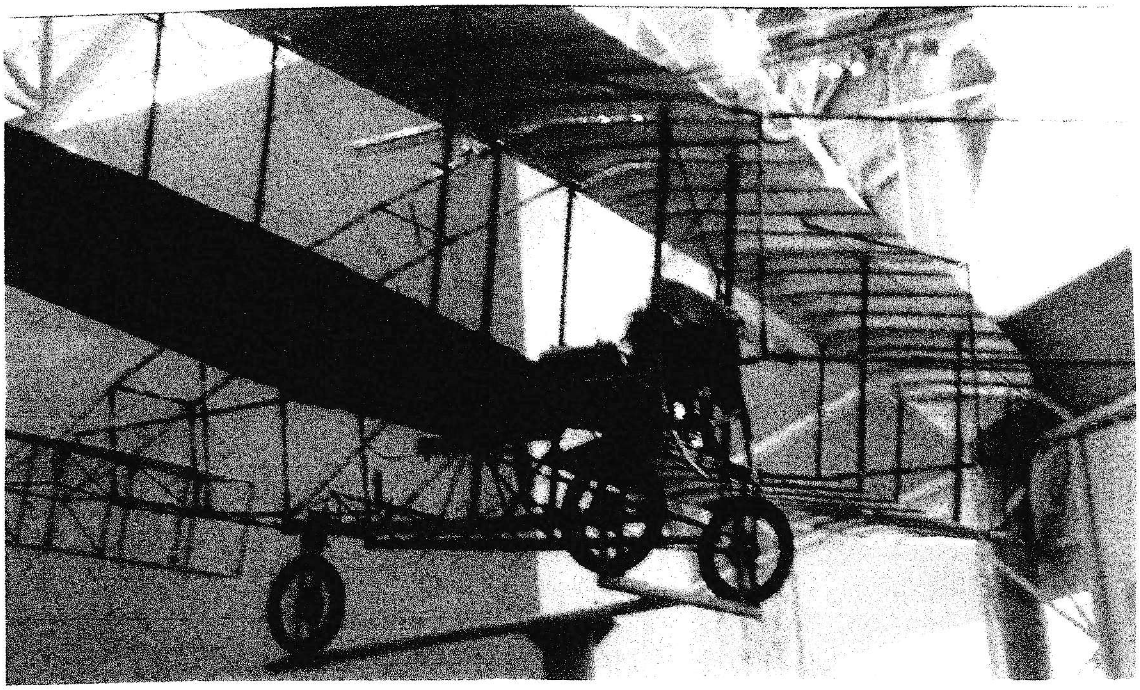
The development of the aeroplane goes back over 100 years, to the balloons, kites and other constructions of the 19th century, when people like the Montgolfier brothers, Otto Lillienthal, Hiram Maxim, Percy Pilcher and Alexander Graham Bell tried to build flying machines that would carry people. It was not until 1903 that the Wright brothers did this successfully, although it is possible that a New Zealand farmer, Richard Pearse, who built his own plane and engine, may have flown some months before the Wrights. Among those who followed was J.A.D McCurdy in the Bell *Silver Dart* in Canada in 1909. These early planes carried only one person.

World War I brought improvements to aircraft performance and increases in size. It was the growth of commercial aviation and the development of more powerful engines that helped to increase their carrying capacities, beginning in the 1920s, together with the exploits of pilots such as Charles Lindberg, Amelia Earhart and Jim and Amy Mollison, not forgetting the contributions of Canada's bush pilots in the far North. In the 1930s, led by Germany's Count Zeppelin, experiments in airship travel were undertaken. Britain's R-100, for example, crossed the Atlantic and spent some time in Eastern Canada before making the return journey. Its sister-ship, the R-101 was less successful and crashed on its maiden flight to India, putting an end to the airship program in Britain. The first trans-Canada flight in a passenger aircraft was pioneered by C.D. Howe, as Minister of Transport in 1937.

The single-passenger

Silver Dart

1909



The 23-32 passenger Douglas DC3 *Dakota*, the 'workhorse' aircraft for decades, from the 1930s

The Airbus A380

'Super Jumbo' can carry

850 one-class passengers

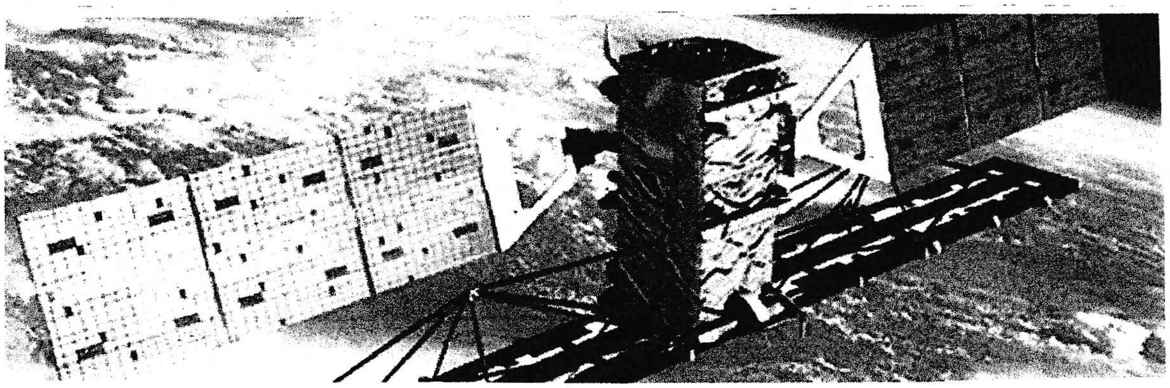
2014

World War II advanced the design and construction of aircraft significantly, from the British *Spitfire* and *Lancaster*, and the American *Flying Fortress* and *Mustang*, to the German *Vi* and *V2* rockets.

Today's military transport and civilian passenger planes look heavy and lumbering but are able to carry heavy and bulky freight loads, as well as hundreds of passengers, at speeds the early pioneers could only envy. However, we should take note of the technical success, but failure so far, of commercial *supersonic* aircraft.

The world of a hundred years ago imagined space travel, but considered it unlikely to happen. The era in fact began almost 60 years ago, in 1957, with the flight of the first unmanned earth satellite - *Sputnik 1.* This was followed by the moon landings of the 1960s and 1970s, communications and other functional satellites, the late lamented space shuttle missions, and with the building of the permanently-manned International Space Station.

An example of a contemporary satellite is the *Radarsat-2,* a Canadian-designed and -built satellite capable of marine surveillance, ice monitoring and mapping. It was launched in December 2007.



Radarsat-2

But one must not forget the drones of various shapes and sizes that are being flown nowadays by remote control, sometimes from very long distances away, often with spying or destructive objectives in mind.

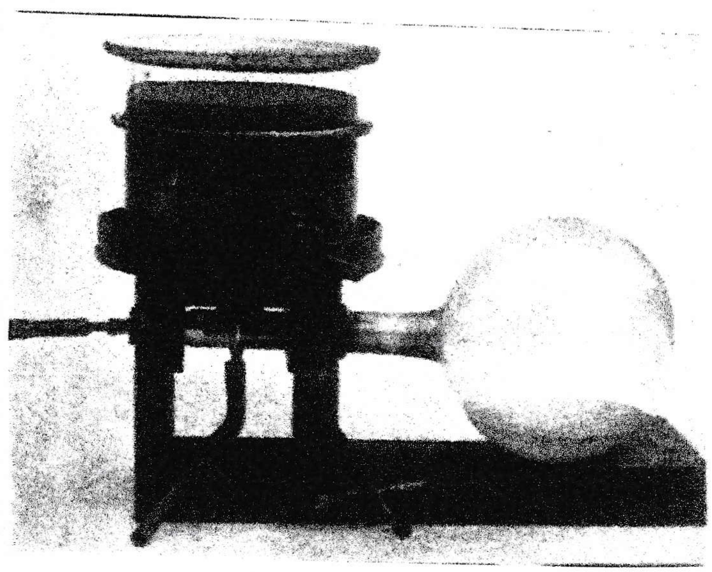
Scientific research...

Scientific research has been discussed extensively in some circles in recent years. One of the contemporary features of some of it has been the greatly increased technical sophistication and huge expense involved in doing it, especially in physics.

Back around the turn of the 20th century, a British physicist, C.T.R. Wilson, engineered in the

Cavendish Laboratory at Cambridge University what he called a 'cloud chamber' to study "condensation phenomena in pure gases" - in other words, to study the structure and behaviour of particles that make up matter. He began developing this apparatus around 1895, but had to put it aside for some years for other work. It was not until 1911 that he devised a model suitable for his experiments. In the illustration, the original chamber appears to be quite small - which it was. Its development and construction costs are not known. They were most likely buried in the miscellaneous expenses of running the workshop of the Cavendish Laboratories at Cambridge. Modern cloud chambers are not much bigger.

C.T.R. Wilson

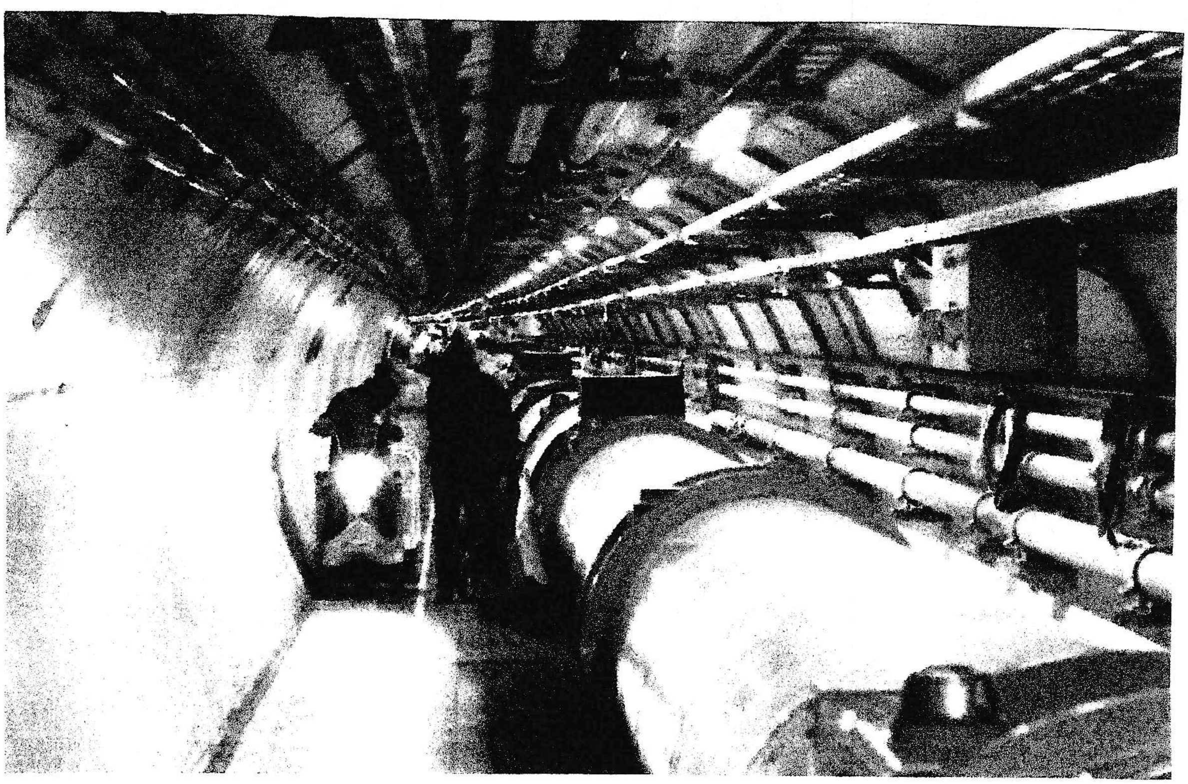


An early cloud chamber

The particle hunt continues...

However, the kind of experimental machines needed to study the structure of matter nowadays has become very much larger, and none is larger than Large Hadron Collider (LHC), at the huge CERN Laboratory on the French-Swiss border. This machine fires particle beams at selected targets, at speeds close to that of light. The set-up involves thousands of huge, cooled magnets, and a beam circuit that is 27-kilometres in circumference. It took ten years to build, and started up in 2008. One of its objectives has been to identify the particle known as the 'Higgs boson' whose existence had been predicted by Peter Higgs. The LHC has now apparently done so. Thousands of people have been involved in designing, building and running the Collider and its initial cost was $2.4 billion. Recently, the LHC has been made even more powerful, again at significant cost.

Peter Higgs



Part of the tunnel of the Large Hadron Collider

C.T.R. Wilson shared the Nobel Physics Prize in 1927 for his cloud chamber and some of the work it did. Peter Higgs shared the 2013 Nobel Physics Prize for his work on the theory of the existence of his boson.

A word about the future...

Some years ago I borrowed an idea of Tolstoy's and wrote an article with the title *It is the Business of the Future to be Dangerous*. It still is, not necessarily because of what engineers may do, but because of the use that may be made of some of it, and over which people generally may not have much control. Forecasting the future is also a dangerous business. It could be quite wrong, or it could be misleading.

Leaving aside the negative aspect of the future, let me *speulate* about it for a minute or two.

Electronic devices will likely get faster, and even smaller. A computer on your wrist? In any event, it would seem that the electronic world will continue to produce new ways of transferring information, faster. This will not necessarily be a bad thing, but it could be.

The digitizing of records, instead of keeping them on paper, is likely to become the rule and not the exception. While this saves space and makes the records more easily accessible to more people, the technology of the process, like that for electronic devices generally, will change constantly and records will need to be re-recorded. But will we be able to access information in Chinese, Russian or Japanese, and even in French, German and Spanish directly? Electronic translation?

We will hear more about mechatronics, which combines electrical, mechanical, electronic and software engineering. It will continue to be applied in robotics, where it started, and to include the design and manufacture of quite new, small devices and systems. We will also hear more about nanotechnology - the direct use of atoms and molecules - to extend the capabilities of existing devices and systems and to create new ones for medical, energetic and other purposes.

While tomorrow's commercial aeroplanes may get even bigger than they are today, they are unlikely to go any faster. Humans may go back to the moon, and may even venture to Mars...or they may not. Whatever happens, Sir Richard Branson and his Virgin Airlines will soon be taking people for rides into space in their special airplanes.

New disruptive innovations and the accompanying engineering are already giving us driver-less automobiles. Three-dimensional printing may also become commonplace.

Generally speaking, the weapons of war are likely to become even more accurate and destructive. You may even find there is a drone following you.

We will have to wait and see the full extent to which our climates will change. Likely, the new weather patterns will involve warmer times and colder times than they tend to deliver nowadays. Remember that, in practice, and over very long periods of time, climates have changed all by themselves. There was an Ice Age on our planet not too many thousand years ago.

But there will be two overriding problems to be solved as we go into the future. First, will the engineering that is done lead to negative changes in employment patterns and to real income reductions? Second, can the present rates of economic growth be sustained? Economists seem to think so. They also seem to think that technological innovations will bring about the necessary adjustments in the supply of scarce commodities and in the mechanics of the marketplace. But will they?

Finally, a bit of history to remind us again of the 'distance' engineering has come since around the time of the Canadian Confederation…

As part of my research, I have collected books, articles, speeches and other sources of information. One of the speeches was given in January 1928 by Charles Camsell, then deputy minister of Mines and Resources, to the Ottawa Branch of the Engineering Institute of Canada. It is called *Transportation in Northern Canada* and has much to do with Camsell's own trips across that part of the country. However, he describes a trip his father took in 1858, with these words:

> (In the 1850s) the gold discovered in the gravels of the Fraser River and British Columbia woke up and began to attract the attention of the world. About the same time considerable trouble with Indians was developing in Minnesota and the Dakotas, which was thought might spread across the boundary line into Canada. In order to preserve law and order and protect the interests of the Crown, a small detachment of the Royal Canadian Rifles, of which my father was an officer, left Kingston on June 20th, 1858, and travelling by vessel by way of Hudson Straits and Hudson Bay landed at York Factory. From there, the detachment travelled by York boat up the Hayes and Nelson Rivers, across Lake Winnipeg, and up the Red River to Fort Garry, arriving at that point on October 15th. In other words,…it took four months to get from Kingston to Winnipeg, a journey that we (in 1928) now make in less than two days.

In 2014, this same trip would take under two hours once the traveller had reached Ottawa or Toronto airports!

Camsell goes on to say that, in 1870, his father had occasion to make a trip from Fort Simpson, on the Mackenzie River, to England in winter time. The nearest railroad point to Simpson was a station on the Great Northern Railway in Minnesota, about 2,500 miles away. It was considered to be fast travelling in winter when the same team of four dogs could take him all the way through. If he (Camsell) had asked the Air Force in 1928 how long it would take them to make that journey, their answer would probably be two days, certainly not any more. Today (in 2014), the Air Force's answer would be a matter of hours.

*****

Acknowledgements

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Sources

Canada Yearbook, 1867-1967

Judith Dupré, *Skyscrapers,* Black Dog & Leventhal, New York, 1990

John Jennings, *The Canoe,* Firefly Books, Toronto, 2002

(Ed. Gibbons), *Encyclopaedia of Ships,* Silverdale Books, England, 2001

Henry Thurston, *Building the Bridge to PEI,* Nimbus Publications, Halifax, 1998

Canadian Space Agency, *Radarsat II*

British Waterways Scotland, *The Falkirk Wheel,* 2011

C.T.R. Wilson, *Reminiscences,* Royal Society, London, 1960

Automatics did save Mom, Ottawa Citizen, June 17, 1999

Buildings: How high can they go, Globe & Mail, March 6, 2014

Costa Concordia, Ottawa Citizen, July 14, 2014

SS Keewatin is coming home, Globe & Mail, October 14, 2011

From Chariots to Motor Cars, Chartered Mechanical Engineer, February 1967

The Curved Dash Olds, Ottawa Citizen, ay 24, 2001

Mercedes-Benz 100 Years, Financial Post, February 1, 1986

MacDonald Dettwiler looks to the stars, Globe & Mail, March 4, 2014

Who cares about mechatronics, Mechanical Engineering, June 2008

Life after privacy, Globe & Mail, March 2, 2014

Wikipedia: cooking; sod houses and 'the last of the soddies'; skyscrapers; coracles; large ships and liners; container ships; Forth & Clyde Canal; the Falkirk Wheel; the Coalbrookdale bridge; the world's longest bridges; the 'Red Flag' rules; Qingdao-Haiwan road bridge; history of the automobile; Airbus A38; nanotechnology engineering;

Movie: *Oklahoma*

Sources identifiable in the text, not included

Photo Credits

Ottawa Citizen, March 3, 2001: Chaudière Falls

Globe & Mail, August 20, 2014: Maersk container ship

Globe & Mail, July 20, 2014: *Costa Concordia*

Globe & Mail, unknown: DC3

Ottawa Citizen, July 31, 2009: Model K Ford

Ottawa Citizen, April 8, 2014: driverless car

Wikipedia: sod houses; the first skyscraper; the Empire State Building; Dubai;the Petronas Towers; the Gherkin; *Empress of Ireland; Quantum of the Seas; Queen Elizabeth II;* the Verrazano Narrows Bridge, Alexandra, Millau, Sydney Harbour, Lion's Gate and Qingdao-Haiwan Bridges; Airbus A380; Professor Higgs; Large Hadran Collider

Sources above: canoe, kayak and coracle; U-boat; *Berengaria; Keewatin;* Confederation Bridge; Curved Dash Olds; early electric and Stanley Steamer vehicles; *Radarsat II;*

The author: 12th century bridge; Lethbridge Viaduct; Peterborough and Kirkfield Lift Locks and the Falkirk Wheel; the *Silver Dart;*

Family archives: CTR Wilson and the cloud chamber