by Massimo Guarnieri

When Cars Went Electric, Part 1

In recent years, increasing attention to environmental pollution and concern about the depletion of oil reserves have boosted an interest in electric and hybrid cars as viable alternatives to gasoline-powered automobiles. R&D programs copiously supported in many countries are notably aimed at developing advanced management systems, high-efficiency motors, and innovative batteries with high energy densities, both of the rechargeable and fuel-cell types. When we think of electric vehicles in this framework, they appear to us as future technologies in comparison with conventional internal combustion engines (ICEs). However, we may be surprised to learn that, a century ago, electric cars were far in advance of gasoline cars.

Mankind has always been intrigued by speed, and our first attempts to move even faster than a galloping horse date back to the past, long before motors were built, possibly to ancient Egypt, where sails were first used to harness the power of the wind. Wind-propelled sail chariots, capable of high speeds over land, were reported in China in the sixth century A.D. One millennium later, a similar vehicle was made in Europe by the Flemish mathematician and military engineer Simon Stevin (ca. 1548–1620) for racing along the sandy Dutch beaches (Figure 1).

More complex, self-propelled cars were conceived in the Middle Ages. In 1331, Guido da Vigevano (ca. 1280–ca.1349) designed a windmill-powered battle car for a crusade planned, but never carried out, by King Philip VI of France, but later gave up. This was actually the first idea in Europe for a vehicle not reliant on muscle power. Around 1478, Leonardo da Vinci (1452–1519) designed and most likely built his own car, the first internally propelled vehicle, well ahead of its time. Recent comprehensive studies of his sketchbook have highlighted that it was powered by large coiled springs located in cylindrical drumlike casings. The first steam-powered toy car was designed in China around 1672 by the Flemish Jesuit missionary Ferdinand Verbiest (1623–1688), who resorted to the Italian engineer Giovanni Branca's steam-turbine idea (1624).

FIGURE 1 – Stevin's wind car, early 17th century. (Photo courtesy of Wikipedia Commons.)

As a matter of fact, as soon as technological progress made motors for generating mechanical power available, inventors began to imagine how to exploit them for powering vehicles. This was the case of Nicolas-Joseph Cugnot (1725–1804), a French army engineer officer who, around 1770, first built a real car (a tricycle 7.25 m long traveling at 4 km/h) propelled by a steam engine intended for transporting cannons. Apart from its inadequate breaking system and stability problems, the car suffered from high inefficiency and a poor power-to-weight ratio of its steam engine, when compared with the standards of the day (Watt's engine had not yet been developed). More success smiled on British inventor Richard Trevithick (1771–1833) and American inventor Oliver Evans (1755–1819) when they built high-pressure steam locomotives around 1800.

In 1807, the Swiss inventor François Isaac de Rivaz (1752–1828) constructed the first successful albeit crude ICE, fed with a mixture of hydrogen and oxygen, and, the following year, used it to power the forerunner of ICE automobiles. However, it remained unique for decades.

In a similar way, early attempts at building electric-propelled cars appeared just a few short years after the possibility of electromagnetically obtaining mechanical actions emerged in 1820, when the Danish physicist and chemist Hans Christian Ørsted (1777–1851) discovered electromagnetism by observing the deflection of a compass needle in proximity to an electrical current. As early as 1822, English mathematician and physicist Peter Barlow (1776–1862) obtained the continuous rotation of a disk by the interaction of a magnetic field and an electric current, but the crude setup was not suitable for developing useful mechanical actions. Soon, other devices able to produce stronger electrodynamic forces were built, notably the electromagnetic multiplier (the first coil) of the German physicist Johann Schweigger (1820) and the

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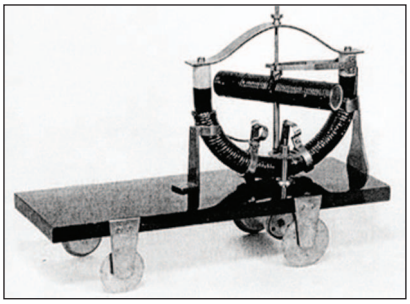

FIGURE 2 – Jedelik's toy electric car (1828). (Photo courtesy of Museum of Electrical Engineering.)

iron-cored electromagnet of an English physicist and inventor William Sturgeon (1825).

Based on these achievements, early rudimentary electric motors were constructed with the aim of moving cars. In 1828, Slovak-Hungarian priest Ányos Jedelik (1800–1895) built a tiny car powered by the first crude but viable electric motor (Figure 2). This was soon followed in Scotland by Robert Anderson with a primitive electric carriage (1832–1839), and in the Netherlands, by Sibrandus Stratingh (1785–1841) with a small scale electric car (Figure 3) in 1835.

At that time, experimental electrical rail cars were moving too. An American blacksmith and inventor Thomas Davenport (1802–1851) built a toy model in 1835, Scottish inventor Robert Davidson (1804–1894) created a real-size model in 1838–1842, and American electrical experimenter Charles Grafton Page (1812–1868) made

FIGURE 3 – Stratingh's small electric car (1835). (Photo courtesy of University Museum Groningen.)

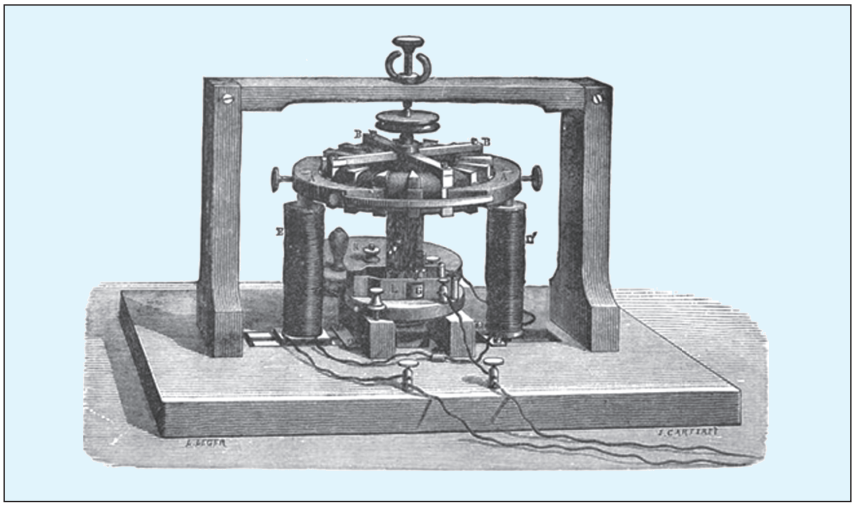

FIGURE 4 – Pacinotti's advanced commutator (1860). (Photo courtesy of Wikipedia Commons.)

a locomotive powered by his reciprocating electrical engine in 1851. Accordingly, the use of rails as conductors was patented in 1840 in the United Kingdom, and in 1847 in the United States.

Nevertheless, those electrical carriages were too rudimentary and unsuitable for practical development. Their motors, basically consisting of combined electromagnets automatically operated in sequence by primitive commutators, were poor in efficiency and power. Moreover, the only available generators were early electrochemical cells of the types developed by French scientist Antoine-César Becquerel (depolarized cell, 1829) and Welsh lawyer and chemist William Grove (zinc–platinum cell, 1830). Even with the improvements introduced by the English chemist and physicist John Daniell (1790–1845) (double-electrolyte depolarized cell, 1836), those primary batteries, which included noble metal electrodes and had to be disposed of once exhausted, remained expensive energy sources. Nonetheless, even with their deficient engines and batteries, those cars could run, and their development was markedly ahead of ICE vehicles, which made a lonely and uncertain appearance in 1826 with an unfortunate car from American inventor Samuel Morey. ICE vehicles would take a substantial step forward only in 1863 with the motors developed by the Belgian engineer Étienne Lenoir.

Practical rechargeable batteries were lacking in the mid-19th century. Actually, they would have been useless, because they would only be recharged by primary cells, resulting in a costly and inefficient operation. Viable dynamos appeared in the 1860s, thanks to a series of developments culminating with the advancements by Werner Siemens (1856 and 1867), Antonio Pacinotti (1860) (Figure 4), and Zénobe Gramme (1869). These electromechanical generators, which were typically powered by steam engines, could produce virtually unlimited electric energy at very low costs when compared with primary electrochemical cells, and they paved the way for the spread of electricity in many different fields. When such generators became available, the first practical rechargeable cell appeared, namely, the lead-acid accumulator by Gaston Planté (1859). The improved model by Camille Alphonse Faure (1881) achieved great success in the electric cars of the following decades. DC electric motors were developed at around the same time as generators, still before the reversibility principle was annunciated (Siemens, 1867) and demonstrated (Pacinotti, 1869; Gramme, 1873). They became practicable, thanks mainly to the same men. With these advancements, dc electric motors approached maturity, and together with rechargeable batteries, they were ready to provide a major boost to electric vehicles.