Electric Boats and Ships

A HISTORY

Kevin Desmond

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On the cover *clockwise from top*: The solar-powered hydrofoil of (TU Delft); the *Eoseas*, a 305-meter five-hulled pentamaran cruise ship concept (Stirling Design International); Gustav Trouvé tests *Le Téléphone* (from Georges Barral, *L'Histoire d'un inventeur*, 1891)

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ALSO BY KEVIN DESMOND

Innovators in Battery Technology: Profiles of 95 Influential Electrochemists (McFarland, 2016)

Gustave Trouvé: French Electrical Genius (1839–1902) (McFarland, 2015)

To
Ἠλέκτρα (Elektra),
τοῦ Ἥλιος (Hēlios)
and to Ποσειδῶν (Poseidon)

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Foreword
by Christoph Ballin

This is the first international history of the birth and rebirth of the electric boat and ship from 1835 to the present day. It celebrates the Golden Era of electric launches, 1880–1910. It narrates how, despite the arrival of the internal combustion engine, electric propulsion continued its progress with the turbo-electric ship. It shows how sustainable and hybrid technologies, pioneered in small river craft towards the end of the 20th century, have recently been scaled up to oceangoing ships. The threads running through have always been fourfold: how silent in running, how far, how fast, and how long to replenish the energy. Kevin Desmond is neither an electrical engineer nor a boat builder, but rather a journalist with a passion for historical research. Understanding the key role of history for the future, he appreciates the importance of chronicling the present so that history can repeat itself, but better than before.

Kevin Desmond's chronicle of electric boats and ships provides the background of an important development of our time. In November 2016, the Paris Climate Agreement was ratified by over 100 countries at the COP22 in Marrakech; also at this meeting, the Climate Vulnerable Forum announced that the 47 member countries, the poorest nations in the world, including Bangladesh, Ethiopia and Yemen, were moving towards 100 percent green energy between 2030 and 2050. As part of this goal, it is obvious that electric boats will be playing a key part.

Driven by such political and technological developments in environmental protection and among others in battery technology, we are about to enter a new golden era in electric mobility. Electric mobility on the water is likely to capture a larger share than ever before. At the dawn of this development, Kevin Desmond's book comes at exactly the right moment.

Christoph Ballin is cofounder of Torqeedo GmbH, marine electric motor manufacturers. Since 2006, Torqeedo has made and sold more than 75,000 units.

Preface

In 1977, I was researching for a book about the history of motorboating in the library of the Science Museum, South Kensington, London: a somewhat challenging task. But the Scottish librarian was proving very helpful.

"Would motorboating history include electric boats?" he asked.

"Yes," I replied. "But I don't exactly know what electric boats are."

"Then you'd better take a look at this," he suggested. It was a slim beige folder, marked "electric boats." Turning through its pages, fragile old news cuttings, I learned about battery-powered launches in the early 1900s—on the River Thames, on the Austrian lakes, in the USA, and in France. Two of the articles mentioned a French engineer called Trouvé. It was the beginning of a long-term quest which would not only lead me to my recent biographies of Gustave Trouvé, but also into joining a crusade to revive silently running electric boats, which is, as you read through these pages, still ongoing some forty years later. The extraordinary thing is that nearly everything we have been doing since the 1980s had already been achieved almost one hundred years before.

In writing this book, I have found myself with three roles, that of an historian, then a biographer, and then a news reporter. As I completed writing this book in 2016, the penultimate chapter is devoted to the most recent developments in electric boating for inland and coastal waterways over the past twenty or so months, which may also point the way to the next decade … 2027, for which, apart from accidents, I as a historian hope to be around, if not longer!

ONE

Origins (1837–1889)

The origins of electric boating are found in the early part of the 19th century.

At the time, a small fleet of steam-engined paddleboats were braving the oceans, although cautiously still rigged with masts and sails. The only way for narrowboats to travel around the growing network of Britain's canals was to be towed by shire horses. There was only one inter-city steam locomotive route in operation, the Liverpool and Manchester Railway. All those who had visited London's Royal Institute to marvel at the late Sir Humphry Davy's unique electrical Great Battery had arrived by foot or horse-drawn carriages. The teenage Princess Victoria was yet to inherit the throne from her uncle King George III. Andrew Jackson was President of the USA.

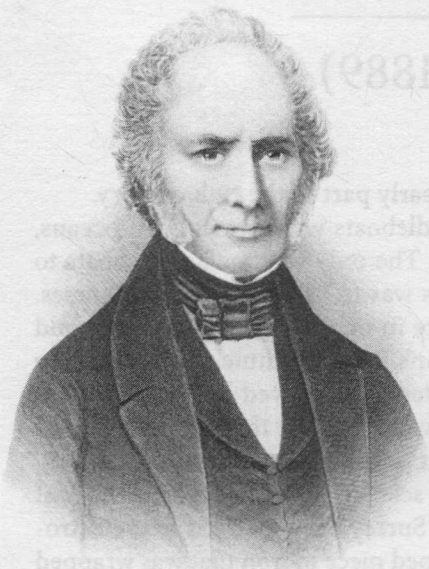
In 1825 William Sturgeon, 42-year-old lecturer in science and philosophy at the East India Company's Military Seminary at Addiscombe, Surrey, exhibited his first electro-magnet on a wooden stand. This was a horseshoe-shaped piece of iron that was wrapped with about 18 turns of bare copper wire. The iron was varnished to insulate it from the windings. When a current was passed through the coil, the iron became magnetized and attracted other pieces of iron; when the current was stopped, the iron lost magnetization.

Eleven years later, Sturgeon was working at the experimental laboratory of the Royal Victoria Gallery for the Encouragement of Practical Science in Manchester, England, when he started up a journal, *The Annals of Electricity, Magnetism and Chemistry*.[1] In its April 1837 edition, on page 250, in the column "Miscellaneous Articles," Sturgeon reports: "In the first number of these 'Annals' I have described an Electro-magnetic Engine, by means of which, pieces of machinery are put in motion. I have now to announce that I have *succeeded in propelling a boat*, and also a locomotive carriage, by the power of Electro-magnetism. The particulars of their construction will be communicated as soon as their present rude state is sufficiently corrected for their appearance in public. W.S." Unfortunately, no further information about Sturgeon's electric boat has come to light, although it is likely that the boat trial was on the local Manchester Ship Canal. His personal papers were destroyed in a bombing raid during the Second World War.

A more important (even if unsuccessful) trial took place in St. Petersburg, Russia. It was just before midday on September 13, 1838. From the Peter and Paul Fortress (Petropavlovsk), a paddleboat was rowed out into the midstream of the River Neva. At the given signal, the oars were shipped, the paddles began to turn and the boat started to move up against the current. Above the water, unlike what would be expected of a steamboat, there was no smoke, nor was there any puffing or clattering engine noise, the paddle turning noiselessly, moved by the "magnetic engine." The boat reached a speed

of 1.5 knots. She was the *Elektrokhod*, the world's first ever passenger-carrying electromagnetic boat.[2]

Four years before, in April 1834, in the town of Königsburg (present-day Kalinsgrad), a German engineer called Moritz Hermann Jacobi had presented a model of "a magnetic apparatus," as he called it. Its horizontal motion was provoked by the layout of magnets and a disc covered with annealed copper wire. The force of the apparatus reached 0.002 hp.



Top: **In 1837, William Sturgeon of Manchester, England, succeeded in propelling a boat on the Manchester Ship Canal by the power of electro-magnetism (courtesy Institution of Engineering and Technology Archives).** ***Bottom:*** **Boris Semonovitch Iakobi (1801–1847), Russian pioneer of electric boats (Musée EDF Electropolis, Mulhouse).**

Jacobi wrote about this apparatus to the Academies of Science in Paris and St. Petersburg. On December 3, his work was published by the Academy of Sciences in Paris. Jacobi's "magnetic apparatus" was based on work on electromagnetic induction, carried out several years before by an English blacksmith's son called Michael Faraday.

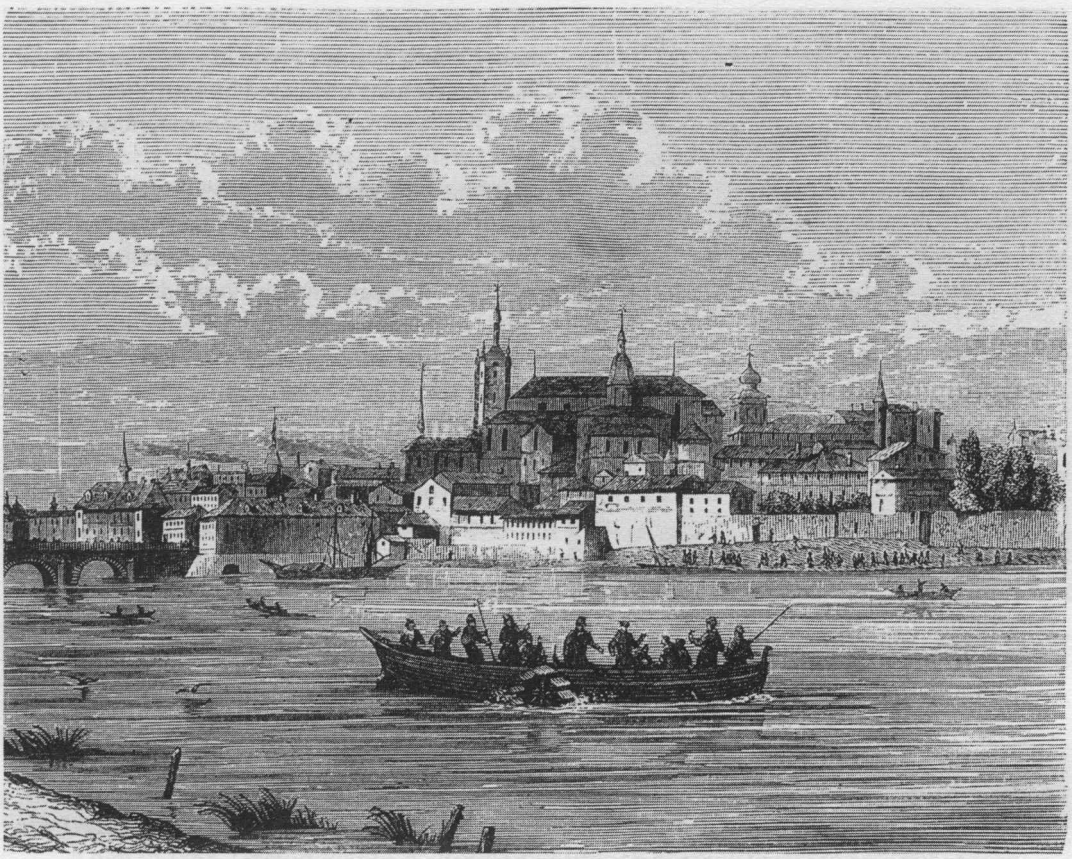
It was in 1831 that as thirty-year-old Fullerian Professor of Chemistry at the Royal Institution, London, Faraday had published an article in *Philosophical Transactions* titled "Induced Electricity," backing this up by successfully demonstrating a model. Jacobi was among those who read the article.

In 1835 Jacobi was invited to Russia by Count Kankrine, finance minister at the time. He would spend the rest of his life there. In 1842 he was elected a member of the Academy of Sciences of St. Petersburg. He married and they had four children. Acquiring Russian citizenship, he would become known as Boris Semonovitch Iakobi.

In 1837 Iakobi wrote to the president of the St. Petersburg Academy and to Culture Minister Count Ouvapov, explaining his invention to them. He was keen that "his new homeland" take full advantage of electric motors.

Claims to be the first are always open to question. Unknown to Iakobi and his Russian colleagues, in Paris in 1832, Hippolyte Pixii, a 24-year-old scientific instrument maker, had already operated a small electric motor with power drawn from batteries, while three years later in 1835, Thomas Davenport, a Vermont blacksmith, had already exhibited a model electric railway.

At this time, with the goal of modernizing Russia, Tsar Nikolas I decided to organize the transport system. Having created the first railway line from St. Petersburg to Pavlovsk, he summoned Iakobi, who had just installed an electric telegraph around the capital.



In 1838, the *Elektrokhod* on trials on the Neva (Musée EDF Electropolis, Mulhouse).

The Tsar became particularly interested in Iakobi's machine and envisaged it replacing steam engines. Iakobi's salary was increased from 2,500 rubles per year to 12,000 rubles. He settled in St. Petersburg and began working on a considerably larger scale. He wrote: "The invention of a new way of locomotion must not be seen as a curiosity but as a world event."[3]

During 1838, Iakobi assembled a motor intended for paddleboat propulsion with transformation of the rotary motion into horizontal motion. It was installed in a standard eight-oar naval sloop dispatched from the Baltic Fleet. It measured 7.5 meters (24 feet) long, 2.3 meters (7 feet) in beam, and with a draft of 0.65 meters (2 feet). Energy came from a cell developed by London chemist John Daniell. This was battery of 320 couples, containing plates of zinc and copper, 36 square inches each, and excited by a charge of sulfuric acid and sulfate of copper.

On September 13, 1838, trials of the *Elektrokhod* took place on the Neva, both against and with the current. But the battery gave out nitrous fumes in as big a quantity as smoke from a steam locomotive. Iakobi and his volunteer passengers, choked and asphyxiated by these sickening and suffocating fumes, were obliged to temporarily halt their observations.

But as Iakobi wrote to Faraday: "Although we journeyed during entire days, and usually with ten or twelve persons on board, I was not well satisfied with this first trial; for there were so many faults of construction and want of insulation for machines and

batteries, which could not be repaired on the spot, that I was terribly annoyed. All these repairs and important changes being accomplished, the experiments will shortly be recommenced. If Heaven preserve my health, which is a little affected by continual labors, I hope that within a year from this time I shall have equipped an electro-magnetic vessel of from forty to fifty horse power."[4]

These new experiments were carried out with slightly larger boat in 1839. It measured 8 meters (26 feet) in length, 3 meters (10 feet) in beam, with a 75 cm (3 feet) draft. It was equipped with a battery of sixty-four cells on the system recently developed by 28-year-old Welsh scientist William Grove of Swansea. The Russian minister of finance supplied 16 kg of platinum made up into 64 pairs of plates, measuring 230 cm^2 (36 $inches^2$) each. This battery was one-fifth the size of the one used the previous year and was charged with concentrated nitric and sulfuric acids. But the power of this motor reached only 0.75 hp and the boat, with fourteen passengers on board, reached a disappointing speed of 3 mph (4.8 kph).

Studying these experiments, Admiral Adam von Krusenstern estimated that these were laboratory studies and one could not hope that the *Elektrokhod* could arrive at results on a par with those regularly achieved by steam-engined boats. In 1841, an even more powerful battery was installed in the boat, but the experiments only gave disappointing results.

In 1840, chemistry professor Sibrandus Stratingh of Gröningen in the Netherlands built a model electric boat which he launched on the canal near his farm.[5]

In August 1848, an electric boat was demonstrated on the private lake of John Dillwyn Llewelyn's Penllergaer estate near Swansea, Wales. Its electric galvanic motor was designed and built by an eccentric, long-haired inventor called Benjamin Hill of Clydach, and its energy came from a cell developed by "local boy" William Grove. Grove later invented the gas battery, forerunner of the fuel cell.

John Llewelyn's father kept a diary in which he wrote: "January 9, 1841. Drove in the afternoon to meet John at Lewis's laboratory to try a small electric galvanic apparatus, as invented by Mr. Hill, for propelling boats instead of steam. It worked beautifully and John is constructing a larger machine for an experiment with his boat on the lake at Penllergaer."[6] A report about this Welsh electric boat appeared in the *Cambrian Supplement* of August 18, 1848. It was titled "The Nautical Application of the Grove Cell":

> [T]he boat, which was impelled by electric current, was, however, the principal object of attraction. It was constructed for the purpose, but the boat was ordinarily used for pleasure purposes, capable of conveying about six persons.... [B]y the action of the rotating magnet on a screw propeller, by means of a cog wheel attaching to the axle of the rotating magnet and another wheel on the axle of the screw propeller, the boat was put into motion. This is capable of carrying seven persons, but on this occasion not more than five were in it, at one time. With the cargo the speed at which it was propelled was 3½ miles an hour—a speed some of our readers think not too great, but it must be recollected that the boat was not constructed for fast sailing. The large body of visitors who witnessed this ingenious contrivance expressed the greatest satisfaction at the result of this trial of electro-motive power.[7]

In the year 1848, at a meeting of the British Association at Swansea, Hill was asked by some gentlemen connected with the copper trade to make some experiments on the electrical propulsion of vessels. They stated that, although electricity might cost thirty times as much as the power obtained from coal, it would nevertheless be sufficiently economical to induce its employment for the auxiliary screw ships employed in the copper trade with South America. Mr. Robert Hunt, in the discussion of his paper on

electromagnetism before the Institution of Civil Engineers in 1858, mentioned that he had carried on an extended series of experiments at Falmouth, and at the instigation of Benkhausen, Russian Consul-General, he communicated with Jacobi upon the subject.[8]

In a letter sent to the author in November 1990, Professor R.M. Barker commented:

"The demonstration was successful enough to impress Faraday, Wheatstone and Grove but there must surely have been trouble with the fumes from the Grove cells. Also, Hill's motor had a wooden frame, so there was no magnetic circuit, its efficiency would be poor."

In 1856 an electric boat was constructed by Searle & Sons of Stangate, Lambeth on the Thames, London, for eccentric electricity enthusiast George Edward Dering of Lockleys Manor in Hertfordshire. It was worked by a motor in which rotation was effected by magnets arranged within coils, like galvanometer needles, and acted on successively by currents from a battery.[9]

William Grove, inventor of the battery which powered Llewelyn's boat in 1848 (author's collection).

In France, in 1855, while electric devices abounded at the Palace of Industry, scarcely any were to be found at the Champs de Mars Exhibition in 1857.

Then in 1858, Gaston Planté, a 24-year-old French physicist working at the Conservatoire des Arts et Métiers in Paris, invented the lead-acid battery. His first model contained two sheets of lead, separated by rubber strips, rolled into a spiral, and immersed in a solution containing about 10 percent sulfuric acid. A year later, Planté developed a battery consisting of nine of the elements, housed in a protective box with the terminal connected in parallel.

Although from a Venetian patrician family, in his youth, Count Antoine de Molin had fought valiantly for the French Emperor Napoleon I. He had then become interested in astronomy, physics, agriculture and oceanography, but above all he was passionate about developing an efficient electric motor. Ignorant of Planté's battery, de Molin chose to use the galvanic battery developed some years before by Robert Bunsen, professor of chemistry at Marburg University, even though he knew that when in operation Bunsen cells emitted noxious fumes of nitrogen dioxide. With energy from the Bunsen cells, de Molin installed his "electro moteur" in a boat. The vessel chosen was an iron-hulled flat-bottomed keelless electric paddleboat, and the water space selected was the Lac Inférieur, one of the two lakes in the Bois de Boulogne, Paris. Weighed down by several thousand kilograms of battery and 14 passengers, with its chain-driven bronze paddles doing their best, the de Molin prototype slowly started to head out from the chalet and down the lake against the wind, disappearing behind the island that forms the center of the lake—but did not reappear. Had its battery fumes, like those of Iakobi's boat, asphyxiated its passengers? We shall never know. The aged Comte de Molin dying in August of that year, and the experiments were not resumed.[10]