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Ulf Bossel

Fuel Cells

From Birth to Maturity

Springer

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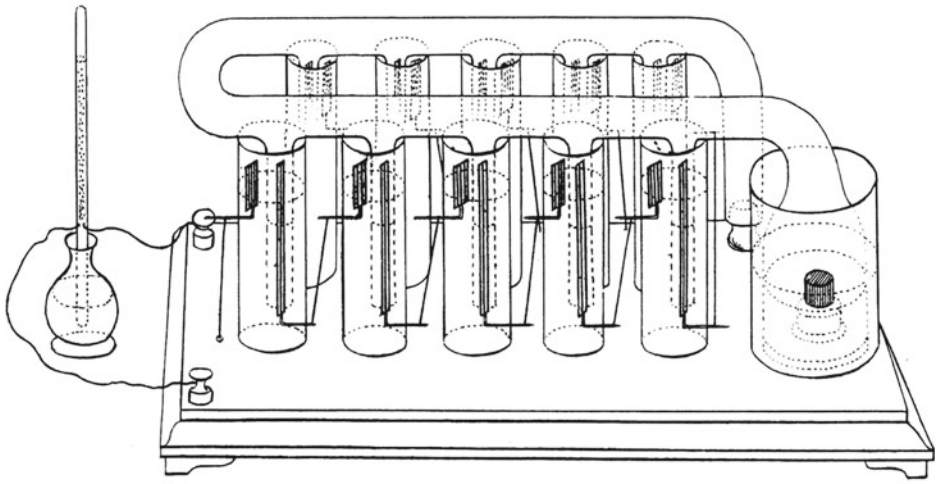

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Including the first publication of the complete correspondence between **Christian Friedrich Schoenbein** and **William Robert Grove** 1839–1868

In due respect dedicated to
Christian Friedrich Schoenbein
by his great-great-grandson

Preface I

Even before Schoenbein, other scientists had seen a voltage arising when working with hydrogen and oxygen under electrochemical conditions, but neither one of these early pioneers clearly identified the effect, established the experimental conditions, or provided a hypothesis for its occurrence. To appreciate the ingenuity of the fuel cell pioneers, the availability and simplicity of scientific instruments of that time should be considered as well as the rudimentary understanding of physics and chemistry in the years between 1835 and 1845.

This book is therefore devoted to the all "fathers" of the fuel cell. It will hopefully help shed some light on questions concerning the birth of the fuel cell: Who did what and when? As it turned out, some models and analyses propagated in text books do not pass an updated critical review. With completed equations and corrected physical models, an excellent agreement is obtained between the corrected theory and experimental evidence. The book is not meant to be the final word. It is intended to contribute information and evidence about the path from early beginnings of science and engineering to the fuel cell technology of today.

For the first time, the complete correspondence between Schoenbein and Grove is presented in this book as well as related illustrations bringing personal items and the early half of the nineteenth century to recognition. The fuel cell is not only an accomplishment of science, but also the product of European history and culture. Both are reflected in the personal exchange between the two outstanding representatives of the early days of science, Christian Friedrich Schoenbein and William Robert Grove.

As is often the case, when attempting to examine a situation too closely, unanswerable questions emerge. That is okay. Let there always be a degree of uncertainty and even mystery associated with breakthroughs in science. It makes science somehow more amenable and acceptable.

Finally, I would like to thank Dr. Peter Nolte for the transcription of the letters exchanged between Schoenbein and Grove and Dr. Frank James of the Royal Institution for applying his familiarity with Schoenbein's and Grove's handwriting to the transcription process.

Oberrohrdorf, Switzerland Ulf Bossel

Preface II

The Fuel Cell Effect was discovered in 1838 by Christian Friedrich Schoenbein who published his results in the January 1839 issue of the Philosophical Magazine. Grove followed in the February issue with a short note on the same subject, but then continued the development of his "gaseous batteries" in the following years. His intensive research led to the first useful fuel cell in 1846 combining 10 cells to a stack. With this technical achievement he is certainly the inventor of fuel cells. But shortly after Siemens invented the generator in 1866, power production with fuel cells was reduced to a foot note in the history book of science. In fact, the word "fuel cell" cannot be found on any of the 3600 pages of the 1963 Student Edition of the Handbook of Chemistry and Physics. Fuel cells appeared again as space technology. They are now recognized as promising power sources for a clean and carbon-free future.

Chapter 1 is devoted to the birth of the fuel cell technology. The reader is guided into the early days of science when the development of instrument made discoveries possible and discoveries suggested new experimental procedures. Only a few laboratories had platinum at their disposal and were thus privileged to engage in fuel cell studies.

Chapter 2 presents the correspondence (one letter missing) between Christian Friedrich Schoenbein and William Robert Grove. This is the first publication of the exchange between two outstanding scientist and close friends. The letters were found in the archives of the libraries of the University of Basel and the Royal Institution in London. The letters reflect not only science, but also personal appreciations and lifestyle of that time.

Chapter 3 deals with the fuel cell puzzle. How can we obtain an OCV of 1.23 V or where can we find four electrons? The text book analysis of the fuel cell effect is based on an incomplete equilibrium equation advance (by Faraday?) in the 40s of the nineteenth century. Also, two electrochemical processes have to be considered, not just one. Theory and experiment can be brought to a convincing agreement when some corrections are applied to the fundamental fuel cell analysis.

Oberrohrdorf, Switzerland — Ulf Bossel

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Birth of the Fuel Cell

1

1.1 January 1839

> "… we are entitled to assert that the current in question is caused by the combination of hydrogen with (the) oxygen (contained dissolved in water) and not by contact".

This is the first written positive identification of the fuel cell effect. It is the final conclusion of the paper "*On the Voltaic Polarization of certain Solid and Fluid Substances*" [1] by Christian Friedrich Schoenbein (spelled "Schönbein" in German), Professor of Physics and Chemistry at the University of Basel in Switzerland. The account appeared on page 43 of the January 1839 issue of "The London, Edinburgh, and Dublin Philosophical Magazine", in short, "Philosophical Magazine" or "Phil. Mag.".

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