Samuel Ruben: Inventor, Scholar, and Benefactor

by Kathryn R. Bullock

Electrochemistry and solid-state technologies have both been greatly enriched by the creative work of Samuel Ruben (1900-1988), Acheson Medalist (1970), and Honorary Member of ECS (1983).[1] Ruben Laboratories, which "Sam" founded in New York in the early 1920s, yielded more than 300 patents, and millions of dollars in royalties. Of the over 100 independent patents that were issued to him personally, he chose the most important as "the dry electrolytic aluminum capacitor, the solid-state magnesium/cupric sulfide rectifier (Fig. 1), the vacuum tube relay, the quick heater vacuum tube, and the concept of a balanced-cell mercury battery."[2]

Sam Ruben's achievements are remarkable when you realize that he never earned a college degree. He started experimenting with electricity and chemistry at age 11, became licensed as a ham radio operator and built radio sets with spare parts. He attended an experimental high school in New York City and completed only a handful of college night classes.[3] He got his first job as a researcher with the Electrochemical Products Company, a small company in New York City that was trying to produce nitrous oxide from the air by high-frequency, high-density capacity discharges. Ruben said he got the job "because I had some background and knowledge with high-frequency radio techniques from my amateur radio hobby...."[2]

Ruben met Professor Bergen Davis of Columbia University, who had worked with J. J. Thompson circa 1900, when Davis became a consultant for Electrochemical Products Co. Professor Davis arranged for Ruben to sit in on colloquia and formal courses at Columbia. He tutored him in the evening and made sure that he did his assignments.[2]

Ruben continued to attend evening and noncredit college-level lectures over the years. For his many accomplishments, he received a Doctor of Science from Butler University, Indianapolis. Polytechnic Institute of Brooklyn honored him with a Doctor of Engineering, *honoris causa*, and made him an Honorary Professor and a Fellow. Columbia University, where he was Senior Staff Associate in the Department of Chemical Engineering and Applied Science, made him a member of their Engineering Council and gave him a Doctor of Science, *honoris causa*. In 1965 he received the Medal and Certificate of Inventor of the Year from George Washington University. In 1982, Columbia University established the Samuel Ruben-Peter Viele Chair in Electrochemistry. In 1985 he became an adjunct professor at Reed College.[2] Ruben's belief in the importance of teaching is evidenced by his gift of $10,000 in support of the ECS Henry B. Linford Award for Distinguished Teaching.[1]

Duracell traces its history "to the early 1920s with an inventive scientist named Samuel Ruben and an eager manufacturer of tungsten filament wire named Phillip Rogers Mallory. Ruben came to the P. R. Mallory Company seeking a piece of equipment he needed for an experiment. But Ruben and Mallory saw an opportunity: uniting the one's inventive genius with the other's manufacturing muscle. Their partnership, which would last until 1975 when Mallory died, was the bedrock of Duracell International."[4] Duracell is celebrating 50 years as a corporate member of ECS and is receiving the Diamond Leadership Circle Award this year.

Ruben developed the mercury button cell in 1942 to overcome problems with zinc carbon batteries in harsh climates during World War II. P. R. Mallory manufactured millions of these mercury cells and founded the Mallory Battery Company shortly after that. In the 1950s Ruben went on to improve the alkaline manganese battery. Mallory made the cell in a new AAA size to operate a built-in flash unit that Eastman Kodak introduced. Duracell is still a leading producer of high-performance alkaline batteries.[4]

The development of the first implantable cardiac pacemaker was made possible by the mercury/zinc oxide (Ruben-Mallory) cell that Ruben patented in 1947 (Figs. 2 and 3).[7,8] Earl Bakken, founder of Medtronic, Inc., invented a wearable, transistorized heart pacemaker in 1957. An implantable version, developed by Wilson Greatbatch and William Chardack in 1958, was powered by Ruben's mercury oxide cell.[2] The mercury/zinc oxide cell was later replaced by the lithium iodine cell in pacemakers. Other batteries were developed to replace mercury cells as concern for the environmental issues of mercury grew.

Ruben developed the mercury cell based on his work earlier on the hermetically sealed C-bias voltaic cell and on the dry electrolytic capacitor that he patented in 1925.[1,5] The C-bias cell had a cadmium container as the anode separated by a grommet from, and crimped to, a sintered disc cathode made of vanadium pentoxide. The gel electrolyte which filled the container was ammonium glycoborate. The first sealed alkaline cell had a wound structure similar to the Ruben Capacitor structure. The aluminum anode and cathode were closely spaced to reduce the series resistance. The 0.25 millimeter thick separator was made of paper impregnated with ammonium glycoborate and sealed in an aluminum container.[5]

Replacing leaky wet capacitors, the dry electrolytic capacitor became a crucial component of nearly all electronic systems. Derivatives of that invention are now being used in implanted and external defibrillators to deliver the high voltage electrical pulses that save lives. Dr. Emanuel Piore, Vice-President of IBM, said, "I have mentioned a number of startling inventions: the steam

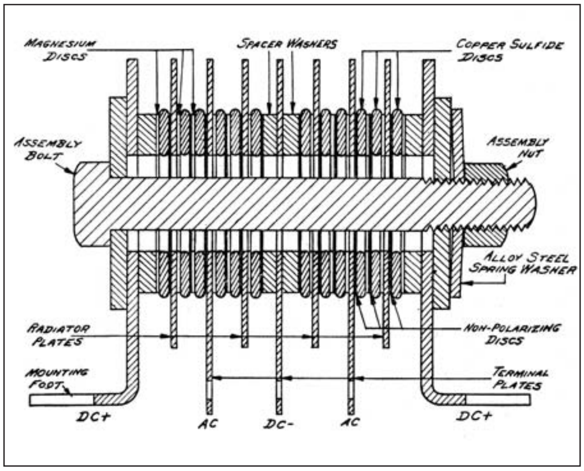

Fig. 1. Practical magnesium-copper sulfide rectifier unit.[7]

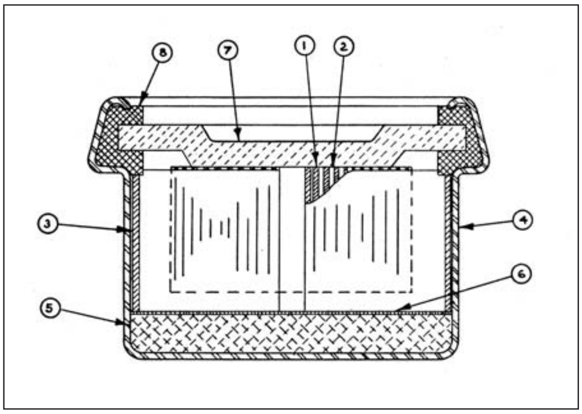

Fig. 2. Cross-section of the "roll anode" Ruben cell: (1) amalgamated anode strip, (2) electrolyte absorbent, (3) anode insulator, (4) cell container, (5) depolarizer, (6) barrier, (7) cell top, and (8) insulating and sealing grommet.[8]

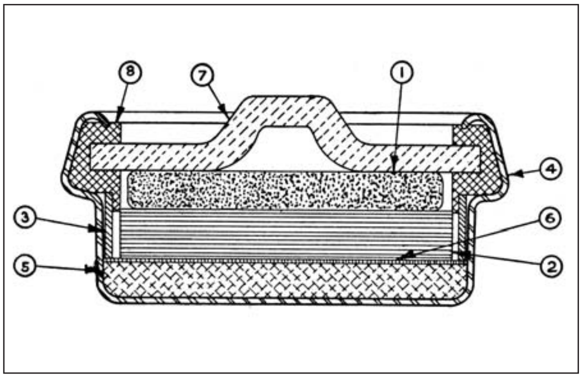

Fig. 3. Cross-section of the "pressed powder anode" Ruben cell: (1) powdered zinc anode, (2) electrolyte absorbent, (3) anode insulator, (4) cell container, (5) depolarizer, (6) barrier, (7) cell top, and (8) insulating and sealing grommet.[8]

mentioned a number of startling inventions: the steam engine, the telephone, the aeroplane. Dr. Ruben's inventions are of comparable importa nce to o ur civilization yet are not known to the public at large. The reason for this is that his inventions, which always made certain things possible as practical devices, are buried in the black boxes. One can almost say that the radio as we know it today would not have been possible without this invention [the dry electrolytic capacitor]."[3,6]

Ruben's explanation of his guiding philosophy toward technical innovation was paraphrased by Salkind, "The process of translation of the imaginative concept in today's technology requires understanding it in relation to the existing science and technology. This is materially facilitated by the accumulation of as broad mental tool storage of the facts of technology as possible, by continuous study and experience. The most important mental tool I have worked with was the result of a very early recognition of the value of the science of materials, or more specifically, the periodic classification of the elements and their relative properties, with particular reference to the electronic construction of matter so that the difference between physics and chemistry becomes an energy relation. That this is not a hindsight observation may be noted in my rectifier patents of 1925, in which I classify the suitable materials in relation to their valence position in the periodic table of elements."[2]

Sam Ruben's philosophy and the inventions that he created encompass and enable the breadth of electrochemical and solid-state science and technology included in the activities of ECS. His strength was in understanding the importance of the relationships between physics and chemistry, between materials and electronics, between "wet" and "dry" technologies. There is a message in that for all of us as we work together to create a better future for our world. ■

Acknowledgments

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References

1. F. A. Trumbore and D. R. Turner, *The Electrochemical Society 1902-2002: A Centennial History*, The Electrochemical Society, Pennington, NJ (2002).
2. Interview with Dr. Samuel Ruben by A. J. Salkind, Palm Springs, California, January 23, 1983, reported in *Batteries for Implantable Biomedical Devices*, p. 38, Boone B. Owens, Editor, Plenum Press, New York, (1986).
3. E. S. Hintz, *Chemical Heritage*, **24** (1), 30 (2006).
4. www.duracell.com/us/company/history
5. S. Ruben, *The Evolution of Electric Batteries in Response to Industrial Needs*, p. 1, Dorrance and Co., Philadelphia, PA (1978).
6. Henry B. Linford, "Samuel Ruben—Acheson Medalist," *J. Electrochem. Soc.*, **118**, 11c (1971).
7. S. Rubin, *Trans. Electrochem. Soc.*, **87**, 282 (1945).
8. M. Friedman and C. E. McCauley, *Trans. Electrochem. Soc.*, **92**, 198 (1947).

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