quite thought-provoking. Historical writings on the Radiation Laboratory are sparse. These reflections from someone who not only had an inside view but also recognizes the implications of what was done there for comprehending the nature of effective scientific leadership and scientific cooperation are a valuable addition.

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The Storage Battery

Bottled Energy. Electrical Engineering and the Evolution of Chemical Energy Storage. RICHARD H. SCHALLENBERG. American Philosophical Society, Philadelphia, 1982. xvi, 420 pp., illus. Paper, $20. Memoirs Series, vol. 148.

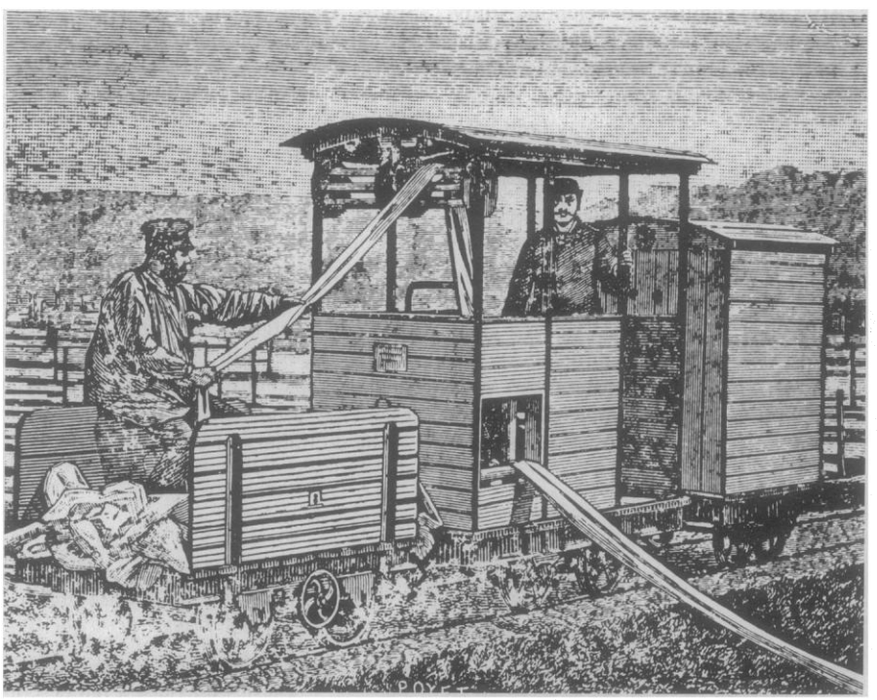
This posthumously published monograph examines the history of the electric storage battery and its applications from the early 19th century to around 1970. The book deals with the interaction of science, technology, and the marketplace. It offers considerable insight into both internal and exogenous factors that influence the process of technological change. With an undergraduate degree in chemical engineering and a doctorate in the history of science, Schallenberg was well equipped to deal with the details of chemical reactions in batteries and to use the development of the battery to illuminate important issues in the history of science, engineering, and invention. An impressive array of patent documents, manuscript sources, and published books and articles are cited, and numerous drawings are included that are very helpful in understanding design changes. Since the account covers a long time span and involves a variety of cultural and economic environments, Schallenberg chose to use biological evolution as an analytical framework, regarding the storage battery as a kind of technological species that survived by adapting to changing environments.

According to Schallenberg, the battery went through a three-phase process of evolution. During the first phase, which lasted from the invention of the battery until the early 1850's, the battery was the object primarily of scientific investigation. Johann Ritter, who is credited with creating the prototype storage battery, was influenced by German nature philosophy in his research, and the battery became the "technological incarnation" of the scientific concept of energy conservation (p. 1). In the second phase, which lasted until the early 1880's, the battery became a tool for members of a scientific tradition of electric meteorology and was used commercially in the telegraph industry. Gaston Planté, a French chemist, developed the lead-acid battery during this period and used it in laboratory simulations of meteorological, solar, and galactic phenomena. He also patented a device known as "Saturn's Tinder Box" that used his battery to operate a combination door bell and cigar or lamp lighter (p. 33).

The third phase of battery development began around 1880 with the advent of the electric light and power industry and saw the storage battery become an engineering tool with a variety of industrial and consumer applications. Schallenberg found that America lagged well behind European countries in battery technology prior to 1895, chiefly, he believes, as a result of "the prejudice of American electrical engineers against storage batteries" (p. 395). American engineers changed their attitude during the period of rapid growth of the electric streetcar industry when banks of batteries were installed in the power plants that furnished power to streetcars. The Electric Storage Battery Company of Philadelphia rose to dominance in the United States with sales of over four million dollars by 1903. The reasons for the failure of the battery-powered passenger car to achieve commercial success are discussed along with the spectacularly successful system invented by Charles Kettering in 1911 that used the battery as part of a starting, ignition, and lighting system for the gasoline-powered automobile. The scale of use of the automobile battery led to American leadership in the mechanization of battery manufacture.

A chapter is devoted to the history of the alkaline storage battery, a type that was pioneered by Thomas A. Edison and by the Swedish chemist Waldemar Jungner. The sintered-plate battery that was developed during the Second World War enabled miniaturization and manufacture in a variety of shapes. Batteries of this type have been used as rechargeable batteries in a wide range of consumer devices.

The interpretative concept of "technological buffering" proposed by Schallenberg should be of interest to historians of technology. Schallenberg defines a buffer technology as "a technique which is introduced for the purpose of adapting a



"In . . . 1882, Force et Lumiere conducted the first experiment with in-plant industrial use of battery transport. The large Duchesne-Fournet bleaching ground wanted to mechanize the laying and take-up of cloth, but the use of a small steam locomotive was precluded, because of the smoke and cinders. Therefore, Force et Lumiere built a small electric locomotive, weighing 2,500 pounds . . . and carrying 1,400 pounds of batteries in a small tender. The locomotive ran up and down the bleaching ground . . . and drew in the cloth by attaching the motor to a small winch. . . . The results heralded an unhappy pattern repeated frequently . . . during the next decade and a half. The batteries worked splendidly for a few runs . . . , but after a few charges, the electrodes . . . refused to receive further charging." [From *The Electrician* (London), 27 May 1882; reproduced in *Bottled Energy*]

new technology to established industrial processes of which it is a part, but into which it does not yet fit in the most efficient or comfortable way" (p. 393). For example, the storage battery was used as a buffer as the new electromechanical dynamo was first being introduced into engineering practice. Schallenberg suggests that a buffer technology often appears during a period of rapid technological change and later is abandoned as the newer technology matures.

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Botanical History

Botanical Exploration of Southern Africa. An Illustrated History of Early Botanical Literature on the Cape Flora. Biographical Accounts of the Leading Plant Collectors and Their Activities in Southern Africa from the Days of the East India Company until Modern Times. MARY GUNN and L. E. CODD. Published for the Botanical Research Institute by Balkema, Cape Town, 1981 (U.S. distributor, Merrimack Book Service, Salem, N.H.). xvi, 400 pp., illus. $56. Introductory volume to the *Flora of Southern Africa*.

After four centuries of scientific study of plants, the curtain is beginning to come down on the reconnaissance stages of botanical exploration, even though inventories are still under way (and with a great deal of urgency) in a number of remote tropical regions. Although Cook in the late 18th century inaugurated the age of the modern technical expedition with elaborate logistic support, botanical pioneers such as Clusius and Rauwolf were busy in the field two centuries earlier. The romantic chronicles of the adventures of Cook, Humboldt, Wallace, Spruce, and many others have now been in circulation for over a hundred years, and in addition to republication of original journals there are scholarly reviews on many botanical explorers, such as William Stearn's *Humboldt, Bonpland, Kunth and Tropical American Botany* (Cramer, 1968). However, we do not yet have a definitive worldwide review of the botanical expeditions of the 16th to 19th centuries. This lack may be due in part to the balkanization of the colonial endeavors that provided the great windfall of riches from abroad to the botanical centers of Europe, so that relevant documents are scattered in a number of languages and often hidden in governmental archives. Mary Gunn and L. E. Codd's volume on the botanical exploration of South Africa is of interest because it will make an important contribution to an eventual synthesis of the history of botanical exploration.

South Africa happens to be one of the most interesting theaters of botanical exploration, because of its extremely rich flora and its location astride the sea routes to the Orient that were used in the 16th to 18th centuries. In this book, Gunn and Codd have organized the subject matter into two separate parts: a history of systematic botany as it relates to South Africa up to the time of Linnaeus (about 1750), and a dictionary of all the plant collectors who have worked in South Africa, from Justus Heurnius in 1624 to botanists still active today.

The section on pre-Linnaean botany brings together in a coherent account the history of the interaction between the plant collectors—many of them Dutch or with Dutch connections—in South Africa, colonial administrators, and the professional botanists back in Europe. This section is extensively illustrated with figures of South African plants and titlepages or frontispieces of historically important books. It is unfortunate that many of these illustrations are printed in a flat gray tone.

The dictionary of botanists provides a great wealth of biographical information and should prove of permanent value as a resource for historians of science. For example, over three pages are devoted to J. F. Drège, including a portrait, a handwriting specimen, a detailed itinerary of his botanical travels, and a discussion of the disposition of his specimens. Similarly critical and meticulously documented essays are offered for other leading figures such as Harry Bolus, W. J. Burchell, William Harvey, C. P. Thunberg, and C. L. P. Zeyher. A considerable number of the photographic portraits are published for the first time. For the botanists of German or French extraction, the entries in this book may be the first modern accounts available in English.

Much of the interest of this work resides in the account of the hitherto little-publicized history of the early botanical explorers. The termination of the narrative with Linnaeus seems particularly unfortunate, since it was one of Linnaeus's students, Thunberg, who proved to be the "father" of South African botany with his intrepid plant explorations of 1772–1774 and publication of his classic *Flora Capensis* (1807–1820), the basis for all further botanical work in South Africa. The early cut-off date is partly compensated for by the biographical sketches, but the post-Linnaean botanists are not placed in historical context as was done for their predecessors. The authors have provided a chronological list of collectors up to 1850, so the reader can to some extent construct a chronicle of botanical exploration between 1750 and 1850 by reading the individual dictionary entries, but for a comprehensive view one must still consult other works. Hutchinson (*A Botanist in South Africa*, 1946) provides a useful survey of pertinent literature to 1944, and also an essay on plant collectors that treats Thunberg and Burchell (as well as Hutchinson's own travels) in considerable detail. Lighton (*Cape Floral Kingdom*, 1973), who curiously is not cited by Gunn and Codd, gives a popular account with information on a number of botanists of the 19th and 20th centuries. A very readable account of 20th-century systematic botany in South Africa is provided by Dyer (in A. C. Brown, Ed., *A History of Scientific Endeavour in South Africa*, 1977).

Within the limitations noted above, Gunn and Codd have presented an outstanding documentation of botanical history; indeed, the cyclopedia of Malaysian plant collectors by Van Steenis-Kruseman (*Flora Malesiana*, 1950–1974) is the only other reference work of comparable breadth and degree of documen-

Illustration of a dried inflorescence of *Protea neriifolia* from *Exoticorum libri decem* by Charles de l'Ecluse (Clusius). "Clusius provided a full description of the specimen, which he referred to as 'an elegant thistle'. . . . It has the distinction of being the first known botanical object to have reached Europe from South Africa." [From *Botanical Exploration of Southern Africa*]