The Ether-Drift Experiment

The Michelson Era in American Science, 1870–1930. STANLEY GOLDBERG and ROGER H. STUEWER, Eds. American Institute of Physics, New York, 1988. x, 300 pp., illus. $54. AIP Conference Proceedings, vol. 179. Based on a conference, Cleveland, OH, Oct. 1987.

The Michelson-Morley experiment of 1887, in which light was found to have the same velocity whether moving in the direction of the earth's rotation or perpendicular to it, is still occasionally cited as having both disproved the existence of a luminiferous ether and inspired Einstein to formulate his theory of special relativity. Historians have long been skeptical of such claims. Many leading physicists, Albert Michelson included, continued to believe in the ether decades after the famous experiment was performed. Einstein, most evidence suggests, gave the experiment little serious consideration before publishing his theory of special relativity. And when Michelson, in 1907, became the first American to win a Nobel Prize, the award committee chose to ignore the ether-drift experiment and instead celebrated the accuracy of his interferometer and its value in metrological investigations. Their judgment of Michelson's achievement, it more and more seems, accurately reflected contemporary opinion.

If the history of science were only about landmarks in theory, there would be little purpose in commemorating the Michelson-Morley experiment with the lavish centennial jubilee that led to the volume under review (and to a companion collection of lectures by prominent physicists: *Modern Physics in America*, Fickinger and L. Kowalski, Eds., also published by the American Institute of Physics). Other than stimulating H. A. Lorentz to suggest that matter may contract in the direction of its motion just enough to conceal the ether drift sought by Michelson and Morley, the 1887 experiment had few direct effects on theoretical physics.

But science is much more than theory, and when understood in a broader sense the Michelson-Morley experiment does offer historians opportunities to illuminate important aspects of the culture of *fin de siècle* science. The experiment was, among other things, a triumph of precision measurement in an age when exactitude had been elevated to a religion among scientists. It depended upon an exquisitely tooled instrument at a time when science more and more was becoming dependent upon technology, and it, in turn, led to new interferometer-based tools at a time when technology more and more was becoming dependent on science. The experiment also offers testimony to the growing competence of American scientists in a world in which Europe still enjoyed a scientific preeminence as secure as its political and economic power.

In all these ways the Michelson-Morley experiment exemplifies an era, and this volume, to the credit of its editors and 23 contributors, enlarges our understanding of each of these facets of its subject. Scientific instruments, too often taken for granted by historians, receive their due in the opening contributions by Chris J. Evans and Deborah Jean Warner, Darwin H. Stapleton, and Edwin T. Layton, Jr. Their papers not only provide us with a much fuller understanding of the genesis of the famous Michelson interferometer but also explore its large and important effects on engineering disciplines in the 20th century, where, in modified form, it became an indispensable tool for the exact measurement of lengths, the calibration of micrometric standards, and the study of variations in the index of refraction in gases and liquids.

Michelson's career in science, which spanned the decades during which America moved toward a rough parity with European scientific powers, is ably discussed in several papers—most notably by Kathryn Olesko, who expertly analyzes the relevance of Michelson's pedagogical duties at the Naval Academy to his development as a physicist, by Albert Moyer, who adds much to our knowledge of Michelson's life during the year of the experiment itself, and by John L. Michel, who offers fresh insights into the relationship between Michelson and his junior colleague at the University of Chicago, Robert A. Millikan. Jed Buchwald and Nancy Nersessian explore the place of Michelson's work in the physics of the late 19th century and debate its role in the thought of Lorentz. Robert Marc Friedman, in a contribution based upon the recently opened Nobel archives, shows us that Michelson's award, and those of other laureates, depended far more upon the internal politics of the Swedish scientific community than historians have hitherto supposed.

This is a heterogeneous collection of essays, but it is one that mirrors the diversity and richness of Michelson's life, associations, and science. He would be pleased.

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Erwin Schrödinger

Schrödinger. Life and Thought. WALTER MOORE. Cambridge University Press, New York, 1989. xii, 513 pp., illus. $39.50.

It is 22 years since the publication of William T. Scott's slim "Introduction" to Erwin Schrödinger's writings. That was very useful but deliberately restricted in its scope. Schrödinger had a many-sided life. Walter Moore paints on an altogether broader canvas, as is possible in some ways because the lapse of time has blunted sensibilities, and so comes somewhere near to capturing the whole of a modern Renaissance man. What everyone knows about Schrödinger is the invention of wave mechanics in 1925–26, and this gets full treatment. Moore gives careful descriptions of the discovery and of Schrödinger's correspondence at the time, and these descriptions can be read with profit by those with only an elementary knowledge of physics. But the correspondence shows also Schrödinger's thoughts about the difficult aspects of the theory that he was not able to resolve clearly; these are particularly apposite today when it has been more fully realized that we know only how to operate quantum mechanics, not how to understand it. Many of us are aware of one other branch of physics where Schrödinger was outstanding—we know his beautiful *Space-Time Structure*, written when he was in Dublin toward the end of his life. This gets the same treatment, and so again background to the finished book is provided, with a description suitable for nonspecialists.

What is more surprising is the number of other branches of physics that Schrödinger was interested in and in how many he made important progress. Color vision, statistical mechanics, and nonlinear electrodynamics were only a few. But Moore does not leave it at that. Schrödinger had many intellectual interests, worked hard at philosophy (though in an unfashionable way, leaning heavily to Indian philosophy), wrote some passable poetry in both German and English, and, indeed, had only one blind spot—he hated music. Without going into too much detail, Moore makes clear just how wide his interests were. But, as Schrödinger himself said, his life story cannot be anything like complete without including the many women who crossed his path. His views on women have a distinctly unmodern ring; they are seen as the help to the creative genius. Moore chronicles the various affairs with care and relates the lady in the ascendant at each time to the scientific work going on at that time; for it was only at times of great erotic excitement that Schrödinger was correspondingly productive in

physics. Moore is assisted in this aspect of his enterprise by a number of striking pictures of the women; but it is a little disappointing that the identity of the inspiration of wave mechanics is unknown and that the inspiration of the unified field theory is not named.

As if this were not enough to make a best-seller among scientific biographies, Moore also does justice to Schrödinger's exciting adventures. In this respect his early life was straightforward; his sojourn in the Austrian army in the First World War was uneventful. But when the Nazi threat erupted in 1933 Schrödinger had been in Berlin for seven years. As a good Aryan Catholic he could have made peace, but he chose to leave instead, having made no secret of his dislike of the regime. He exiled himself in Oxford, where he was far from happy and where the bohemian *ménage à trois* of the time was frowned upon. Then, despite advice from his friends, he accepted the chair in Graz; he had no idea of the possibility of the *Anschluss*. It was only two years before he was dismissed from the chair by the Nazis, but he was at first unable to leave the country. He finally got out via Italy, which was the only country then requiring no visa, and so to Oxford again. Meanwhile de Valera organized the Dublin Institute for Schrödinger to be head of the school of theoretical physics, but, while waiting to take up the appointment, Schrödinger gave some lectures in Ghent and was nearly trapped by the advancing German armies. Dublin was reached only through the United Kingdom, where he needed special treatment as an enemy alien. The story encapsulates the century we have lived through.

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Tales of Invention

My Life With the Printed Circuit. PAUL EISLER. Lehigh University Press, Bethlehem, PA, 1989 (distributor, Associated University Presses, Cranbury, NJ). 170 pp., illus. $29.50.

The autobiography of Paul Eisler, an Austrian electrical engineer who settled in Britain in 1936, is a personal account of one of the many technical and scientific careers of refugees from the Continent who strengthened the Allied side during World War II. The author describes the obstacles placed in his way by the lack of any sort of entrée to major manufacturers in prewar Britain and by his status as an "enemy alien," which meant temporary internment once the war broke out in 1939. By then he had gained a narrow foothold in a chain of movie houses and had introduced several innovations in them. After his release he returned to an idea he had first thought of in 1936, of replacing the wiring in radio receivers by metal strips attached to bakelite sheets. In 1941 he went to work for a music printer with offices in London's theatrical district, in the hope of finding a way of depositing the strips by printing techniques. By 1943 he had advanced far enough to apply for three patents (which were not issued until 1950) on the technology and manufacture of printed wiring and to build some demonstration models that were shown to potential users, including some Allied military personnel—without success. "Not a single industrial firm or Government department in [Britain] could be found who would give the invention even a trial," writes Eisler. "However, during the demonstrations in Shaftesbury Avenue the Americans had—unknown to me—picked up the idea and their National Bureau of Standards developed a proximity fuse using a printed circuit."

On the basis of this unlikely and wholly undocumented scenario, the author assumes credit for initiating a development that he avers led to the use of proximity fuzes containing printed circuits in 1944, in particular in the shells used to bring down the V-1 flying bombs (the pilotless aircraft launched from the Continent against London and other targets). In actual fact, the only printed circuit used in proximity fuzes in World War II was a part of the fuzes of trench-mortar shells; and this circuit was fabricated by a long-established technique, silk-screen deposition on a ceramic substrate (followed by heating), not by Eisler's foil technique. Not only that, Eisler asserts that the printed circuit's "principles of design have given birth to the transistor, the integrated circuit, the 'chip', and the microprocessor." On the contrary: it was the invention of the transistor that first made printed circuits interesting to manufacturers of electronics equipment; in the older vacuum-tube devices, wiring costs were a negligible part of the total production cost.

The book is further marred by an apparent lack of editoral attention, as evidenced by the misleading title (less than a third of the book concerns printed circuits) and such errors as "Philip's laboratory" for the Dutch research organization, "ordinance" for ordnance, "principle" for principal, "neurolgia," and "Pittsburg." British and U.S. patents are listed separately and not cross-referenced. The author has provided next to no bibliographical apparatus, and the bibliography and notes that were supplied by Mari Williams, a researcher from the London School of Economics, range far afield in the general literature of technology and innovation.

The book's real interest lies in the account of a hapless inventor's tribulations in postwar Britain under the wronghead sponsorship of the National Research and Development Corporation (which is here made to look like the Office of Circumlocution that Dickens described in *Little Dorrit* in 1857). Eisler recounts how he finally extricated himself from its clutches and achieved commercial success, without government sponsorship, with another invention, the use of metal foils attached to insulating sheets for heating elements. Possible applications ranged from heating prepared foods to defrosting car windows and keeping entire rooms comfortable by radiant heating from walls and ceilings, but the first returns came from a licensee in California—a manufacturer of waterbed heaters! That is a story well worth recounting and full of insights for budding inventors.

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Shore Life

Shore Ecology of the Gulf of Mexico. JOSEPH C. BRITTON and BRIAN MORTON. University of Texas Press, Austin, 1989. viii, 387 pp., illus. $49.95; paper, $22.50.

Viewed from space, or vicariously via a Landsat photo or geologic map, the Gulf of Mexico coastline is dominated by beaches, some of them strikingly set off as slender barrier islands guarding lagoons along the Texas and Mexico coasts. Upon closer view, the shifting sands are seen to present a harsh environment where few species of plants and animals cope successfully, forming biotic communities of limited complexity. Britton and Morton turn this potential liability for their book into an asset. It allows them space to explore other shore environments, to introduce the biology of major groups of organisms, and to recount the known biological features of most species present. Their goal was to provide a guide to these organisms and their ecological relationships.

Shore Ecology of the Gulf of Mexico takes its topical and organizational cues from the second author's *Sea Shore Ecology of Hong Kong* (with J. E. Morton, 1983). As in that book the writing is felicitous, and the authors achieve their goal. This aim is, however, more modest than the title suggests, with respect to both geography and substance. Britton and Morton treat only the western half of the Gulf, from the Mississippi delta through Texas and Mexico to the Yucatan.