Book Reviews

A Wizard of Arcanery

Steinmetz. Engineer and Socialist. RONALD R. KLINE. Johns Hopkins University Press, Baltimore, MD, 1992. xii, 401 pp., illus. $39.95. Studies in the History of Technology, 13.

When, almost a decade ago, the U.S. Postal Service decided to honor four American electrical inventors on its stamps, it chose Nicola Tesla, Howard Armstrong, Philo Farnsworth, and Charles Steinmetz. For the first three, who had been the subject of some persistent and noisy lobbying, the stamp designers chose to depict specific objects the honorees had invented (an induction motor, a radio receiver, a television camera), but next to Steinmetz's face the possibly perplexed stamp makers simply put a graph of a sine wave. And with this neat little bit of symbolism, the Post Office managed to capture the essential problem of interpreting the man's place, not so much in the development of electrical technology as in the pantheon of hero-inventors that, even in the 20th century, most of the world uses to mark the stages of technological progress. Despite almost 200 patents, and useful devices and equipment that materially aided the expansion of electric power systems in the first decades of the century, Steinmetz's central contributions were intellectual, mathematical, tools for manipulating the electrical world. These are not easy to depict or to describe.

This is the first of the challenges that confronts Steinmetz's latest biographer. The second, suggested in Kline's title, is that Steinmetz, more than perhaps any other famous American inventor, was as readily identified by his non-technical, political, concerns as by his engineering. As Kline himself admits, it is the perplexing figure of the mathematical wizard closely identified with one of America's giant corporations, General Electric, who was also one of the country's most famous socialist politicians and writers, that often first catches the eye of the modern observer. Making sense of this apparently strange combination is something that previous Steinmetz accounts, largely by journalists, have failed to do. They have, in general, left the impression that Steinmetz's socialism was simply a quirk, the kind of eccentricity that one must put up with in great minds. One of Kline's great services is to dispel this fundamentally silly notion.

At the center of Steinmetz's life was his approach to engineering, more specifically to the complex problems of generating, transmitting, and using electric power. Initially trained as a mathematician in his native Germany, Steinmetz found it necessary for both economic and political reasons to immigrate to the United States in 1889. There he had little difficulty in finding employment in Rudolf Eickemeyer's small but progressive electrical shop in Yonkers, New York. There Steinmetz, who had already begun to tackle some of the mathematical problems posed by alternating current circuits, managed in four years to establish himself as one of the most creative mathematical minds in the American electrical engineering community. His rapid success was due in part, as is often the case, simply to being the right person in the right place at the right time. By the 1890s, it was already evident to many that the advantages of alternating current over direct current were compelling in many circumstances, especially when transmission over any distance was involved. But certain specific problems in devising appropriate devices for ac, particularly motors, and the greater complexity of calculating the behavior of ac circuits and installations stood in the way of its wider application. Such a situation was uniquely suited to the talents of a mathematician like Steinmetz.

Charles Steinmetz about 1890. [From *Steinmetz: Engineer and Socialist*; Hall of History Foundation, Schenectady, NY]

Certainly Steinmetz had to overcome substantial obstacles in his rise to professional prominence. His lack of English upon arriving in America, his short stature and physical deformity (his hunched back was inherited from his father), and his lack of familiarity with the practices of the American electrical community posed problems not easily brushed aside. But with the help of Eickemeyer and through a supreme confidence in his intellectual abilities and a personality that was accustomed to the extra effort needed to make itself heard and be taken seriously, Steinmetz was able to use the rapidly changing technical environment and the evolving professional scene to his advantage. By the time Eickemeyer's firm was purchased by General Electric in 1892, Steinmetz's reputation among his peers was already substantial enough to make him, as well as Eickemeyer's patents, a desirable acquisition for the new corporation.

All of this is easy enough to understand, at least in the most general terms. But to explain the specific nature of Steinmetz's contributions to engineering, to come to grips with both the intellectual and the practical substance of his work, requires the explication of mathematical and electrical concepts that are unfamiliar to all but engineers themselves. Kline adopts the felicitous phrase of one of Steinmetz's contemporaries to characterize the essence of his contributions: the generating of "electricity from the square root of minus one." Following in the footsteps of such great mathematician-physicists as James Clerk Maxwell and Hermann von Helmholtz and alongside contemporaries like Oliver Heaviside, Arthur Kennelly, and Michael Pupin, Steinmetz elaborated and promoted methods of using complex numbers to simplify the equations that engineers needed to solve to predict the behavior of the devices and systems they designed. It is easy enough to understand that this was extremely important to the advancement of the field in these key years, but to go beyond this, to understand just what Steinmetz actually created in these years and just why, a century later, electrical engineering students still learn and use his methods, poses difficulties for the non-specialist reader.

We may sympathize with Kline's problem in directing his story to as general an audience as possible while dealing with topics as arcane as "complex impedance,"

Steinmetz in his "office" at Camp Mohawk, about 1920. [From *Steinmetz: Engineer and Socialist*; Hall of History Foundation, Schenectady, NY]

"synchronous reactance," and "primary admittance." His solution will not please everyone. By reducing his explanations of Steinmetz's work to the most general descriptions, relegating all equations and functions to the endnotes, and defining most concepts in only the briefest terms, Kline will leave many readers (including, at times, this one) frustrated. Arguably, however, the only alternatives were either a book that could be understood only by specialists or a miniature course in alternating current theory and methods. As historians come more and more to grapple with interpreting modern technology, they will confront Kline's dilemma and will probably have to resign themselves to not satisfying everyone.

Kline's task in interpreting Steinmetz's socialism is only marginally easier, for here too it is important to approach the subject with an understanding of its context, both in terms of American political thought and practice and in terms of the engineer's place in the corporation. Almost half of this carefully researched and well-written book is devoted to exploring the sources of Steinmetz's socialism, the paths that it took in America, and how it was consistent both with intellectual currents of the early 20th century and with Steinmetz's perception of the place of engineers and corporations in society. Seen in these terms, there was nothing paradoxical in the man's promotion of "corporate socialism." The apparent contradictions, Kline makes clear, were more the product of the various uses that such disparate interests as General Electric, the Socialist party, and the electrical engineering profession made of Steinmetz and his reputation.

That the peculiar-looking genius, with his occasional forays into spectacular experiments with high-voltage lightning generators and his unconventional (but essentially non-threatening) politics, should be the object of publicists and myth-makers should come as no surprise. Well informed by recent studies of similar mythologizing, Kline explains both the rise and the decline of Steinmetz's popular reputation. In the end we are left with a figure distinctive, complex, and sometimes puzzling, but, thanks to this biography, fundamentally human.

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Models of Vision

Computational Models of Visual Processing. MICHAEL S. LANDY and J. ANTHONY MOVSHON, Eds. MIT Press, Cambridge, MA, 1991. xii, 394 pp., illus. $55. A Bradford Book. From a workshop, Cold Spring Harbor, NY, June 1989.

This volume arose from an unusual meeting that brought together visual psychophysicists, physiologists, and engineers. The participants demonstrated their computational models of visual processing on the spot with computer programs that they brought with them in addition to the usual slides. In a sense, the computational models presented in this collection of essays were at the meeting too, contributing to the discussion. This volume presents an accessible view of visual processing from a computational viewpoint that successfully updates David Marr's *Vision* (Freeman, 1981).

The focus of the book is on the early stages of visual processing, starting with a bundle of light rays entering the eye and projecting onto the array of photoreceptors in the retina. In the opening chapter, Adelson and Bergen coin the term "plenoptic" to describe the geometric structure of this bundle throughout space, a concept first introduced by Leonardo da Vinci. The plenoptic function elegantly unifies many traditional spatiotemporal filter models of early visual processing, the goal of which is to concentrate information regarding the shape, motion, texture, color, and depth of objects in an image. Each of these characteristics is discussed separately in later chapters.

Models simulated on digital computers run the risk of being too accurate. For example, the array of pixels in a digital image is perfectly ordered, but in the retina individual photoreceptors form an irregular lattice. How is this irregularity compensated so that humans can judge alignment with an acuity that is 5% of the width of a photoreceptor? Ahumada shows how learning can be used to calibrate the positions of the photoreceptors by taking advantage of correlations that are inherent in projections from the retina. This solution is consistent with evidence for correlational mechanisms that act during the development of visual maps in the brain. This is an exciting area of research, since unsupervised learning algorithms may also prove useful in extracting properties of objects that might be difficult to describe analytically. In a related chapter on noise as a limiting factor in visual detection, Pelli argues that the rate-limiting step may occur as early as the photoreceptors.

The pioneering studies of David Hubel and Torsten Wiesel in primary visual cortex laid the groundwork for models of the spatial (Hawken and Parker) and spatiotemporal (Shapley, Reid, and Soodak) properties of cortical cells. Rectifying nonlinearities are found already in simple cells, and complex cells are even more nonlinear (Heeger). Bergen and Landy show how the nonlinear responses of neurons may be used to perform texture segregation, and Graham points out that nonlinear cortical gain-control mechanisms are also important for understanding visual processing that takes place well above thresholds of detection. In the visual perception of occlusion, a distant feature can profoundly influence the inter-