after the war the term "solid state" helped define a set of problems in physics, it did not for long correspond to a social community in which members had strong ties to each other, except in periods when they had to struggle against other interest groups in physics.

The book as such is an example of what might be called "big history of science," stemming as it does from an international collaboration and guided by advisory committees that "consisted largely of senior physicists but also included historians and sociologists of science." Readers are assured of its scientific credentials by the *imprimatur* given in a short foreword by E. Mollwo and two founding fathers of the field, Nevill Mott and Frederick Seitz.

As for the overall emphasis of the treatment, "the choice or elimination of the various topics was," according to the editors, "endorsed by our scientific advisors." Though choices are always to some extent arbitrary, I think the way they have been made is far from satisfying from the point of view of the professional historian of science. Whereas recent historiographical concerns have centered on instruments or on industrial or military influence on the direction of research, the main criteria used to select topics for inclusion here were "fundamental scientific significance" and "role played in technological innovations." The role of the military in some of these developments—which cannot have been negligible—is given short shrift. Given the intended audience for the book one could hardly have expected a truly social history of the specialty, and fortunately for the social historian research schools and the institutional structure of the field are discussed in some chapters, particularly Weart's. But in truth this book, like earlier collective works in the history of particle physics, fills for the scientific community a social function that was well summarized by Leon Lederman in his preface to one of those works, where he wrote that the immediate benefit of that volume would be for those working in the field, for it would "help them raise their consciousness about the fact that the field in which they work in has a culture and a history, to which they contribute in their everyday work."

The editors are conscious of the limitations of their work and express the hope that its "very inadequacies . . . will work as a stimulus to further research into the history of this grand field of knowledge." In order to facilitate such research the Center for the History of Physics of the American Institute of Physics has published a *Guide to Sources for History of Solid State Physics*, compiled by Joan Warnow-Blewett and Jürgen Teichmann. Let us hope that historians of science will use it—alongside the present book—but this time to frame their questions in the terms of their own discipline rather than according to the preoccupations of the scientists, which are perfectly legitimate but nonetheless distinct from those of historians.

Yves Gingras
Département d'Histoire,
Université de Québec à Montréal,
Montréal, Québec, Canada H3C 3P8

■

Technological Winners

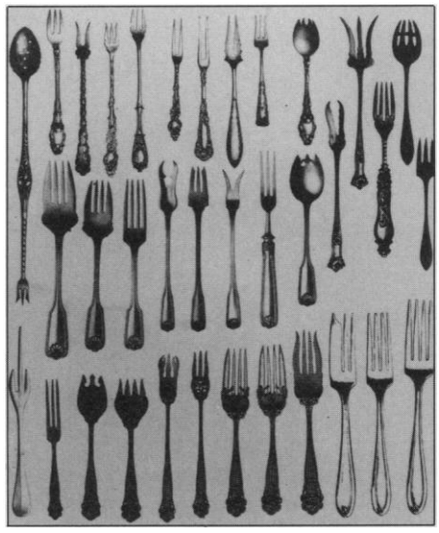
The Evolution of Useful Things. HENRY PETROSKI. Knopf, New York, 1992. xii, 289 pp., illus. $24.

In his *Just-So Stories*, Rudyard Kipling tells tall tales about what might be called, loosely speaking, the "evolution" of animals. How did the camel get its hump? How did the leopard get its spots? Henry Petroski's *The Evolution of Useful Things* is a collection of "just so" stories about technology. It's a series of historical vignettes intended to explain, as the dust jacket of the book has it, "how everyday artifacts—from forks and pins to paper clips and zippers—came to be as they are."

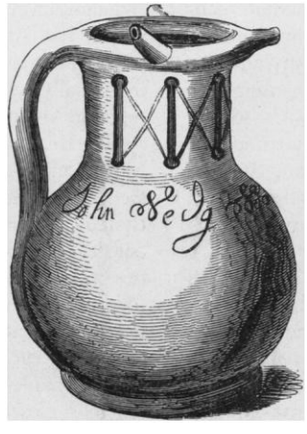
Petroski's theory is a simple one. He reduces the development of all technologies to a simple rule: "form follows failure." By this he means that new technologies replace old because the old ones fail their users in some way. The fork evolved because the knife wouldn't hold a piece of meat for cutting—and then evolved into a baroque variety of forks because a simple standard fork failed at specialized tasks, like picking up fish or oysters. The motorcycle comes about because the bicycle failed to go under its own power—and then evolved further as inventors searched for the least undesirable arrangement of components. The zipper emerges because buttons didn't do a good job of fastening shoes.

These are fascinating stories, but they remain only stories. Petroski's attempt to build a theory of technological change from them fails. His rule of "form follows failure" is a tautology. It has no explanatory power, but merely suggests that we arrived at the current state of technology because the old way failed and the new way was "better." His evolutionary theory includes neither a mechanism to explain novelty nor a mechanism to explain selection. It looks back at each decision from the viewpoint of the "right" answer, rather than looking at the full context of the situation where the variation and selection occurred. It's a map that shows only those forks in the road we decided to take.

The problem stems from Petroski's sources and from his narrow focus on invention. Petroski's sources tend to be historical retrospectives by the technological "winners." So the story of the zipper is taken from a publication by Talon, Inc., the story of the Post-It note from an official 3M company history. These sources tend to play up the "how'd we ever live without it?" side of the story. Petroski's treatment of industrial design, told exclusively from the memoirs of designers, shows a similar prob-



Victorian flatware. "This collection of forks shows the variations available in several silver patterns. *Top row, left to right:* oyster fork-spoon, oyster forks (four styles), berry forks (four styles), terrapin, lettuce and ramekin fork. *Middle row:* large salad, small salad, child's, lobster, oyster, oyster-cocktail, fruit, terrapin, lobster, fish, and oyster-cocktail fork. *Bottom row:* mango, berry, ice-cream, terrapin, lobster, oyster, pastry, salad, fish, pie, dessert, and dinner fork." [From *The Evolution of Useful Things*]



"Earthenware 'puzzle jugs,' such as [this one] were produced by the Wedgwood family in the late seventeenth century. These ale jugs were deliberately designed to be confusing to use and served as a basis for wagering in alehouses. The drinker would bet he could down the ale without spilling any, but to do so he had to cover up the right combination of holes and tubes, lest the jug behave more like a dribble glass. Had a unique form existed, the practice of wagering might not have been so popular." [From *The Evolution of Useful Things*]

lem. Industrial designers, eager to prove their worth, played up the problems of products before their redesign. Patents, another major source for Petroski, are also problematic. The American patent system requires an inventor to show how the new device is an improvement over earlier ones, that is, how the unimproved product fails. Petroski's use of patent claims as a source falls into the trap of telling the story, again, from the "winner's" point of view.

Not until the last few pages of his book does Petroski move from telling stories of failure and success to consider the larger systems within which technologies exist. These afterthoughts outline the problems with his simplistic formulation of technological change. For example, Petroski acknowledges that we have to "include not only things we can hold in our hands but also the organizations and systems that produce and distribute those things." He also begins to complicate his notion of failure. He suggests, for example, that different people—different players in the act of technological change—might have different criteria for failure. What might be an improvement to one person, he admits, might make things worse for another. There are many, often conflicting, notions of failure that drive technological change in different directions.

If Petroski had used this more complex theory in his discussions of forks, pins, and paper clips, his book would have been more interesting and more useful. But complexity undermines his model. For these last-second thoughts throw the whole notion of "evolution" of technology into question. Things don't evolve; they are pushed in different directions by the decisions of inventors, manufacturers, marketers, and users, people who have economic, social, and cultural as well as practical reasons to remake technological artifacts in ways that serve them best. For example, people managed just fine without the zipper. It took zipper manufacturers some 20 years of technological innovation and an additional 20 years of marketing to convince the public it needed zippers. Even then, the zipper was adopted not because of "need" or because button flies failed but because of cultural ideas about modernity and fashion. There are many players in technological change, not just inventors who see failure and ways to overcome it. Failure is in the eye of the beholder.

Looking back for the "failure" that leads to invention and defining present-day technology as the end process of successfully overcoming those failures doesn't tell us much. Too much is missing from the theory. What's left out is economics, culture, social structure, belief—almost everything that might serve to explain, rather than ratify, the direction of technological change. Building a useful theory of technological change from the stories Petroski gives in *The Evolution of Useful Things* is about as likely as coming up with the Darwinian theory of evolution from the evidence presented in Kipling's *Just-So Stories*. To understand the direction of technological change, the historian must look at the bigger picture—not the view from one side of a fork in the road, looking back, but an aerial view that shows the path we took and the path we didn't take, as well as what we saw when we made the choice.

Steven Lubar
National Museum of American History, Washington, DC 20560

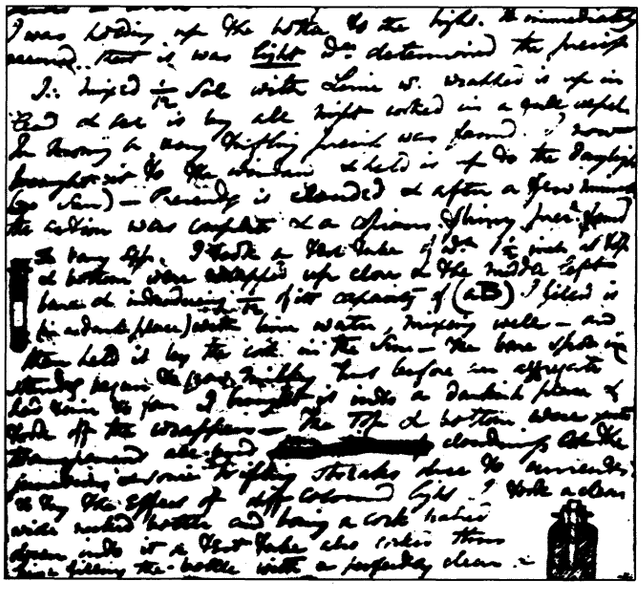
■

Fixing Images

Out of the Shadows. Herschel, Talbot, and the Invention of Photography. LARRY J. SCHAAF. Yale University Press, New Haven, CT, 1992. xii, 188 pp., illus. $50.

Early in January 1839, François Arago announced to the French Academy of Science that Louis Jacques Mandé Daguerre had discovered a method for making permanent the image formed within a camera obscura and that shortly the exact nature of this process would be revealed to the public. There was an excited response to Arago's announcement that was immediate and far-reaching. In England, William Henry Fox Talbot was taken aback. In 1835 he had devised a process like the one described by Arago but had never publicized his discovery. The French announcement pushed Talbot to make a counterclaim for priority and apparently dealt him a personal blow from which he never recovered. Although Talbot and Daguerre were not the only people to disclose photographic discoveries in 1839, Talbot's photogenic drawing and Daguerre's daguerreotype were the most important and influential processes announced that year. The introduction of photography brought about a technological revolution then as profound as the introduction of the computer in recent times. There is a great deal of tradition and myth surrounding the history of early photography, and only in the last ten or so years has there been a reevaluation of that history using original sources. The story is complicated and has often been cast as a nationalistic rivalry between the English and the French. However, the importance of photography and the greatness of the principals involved in early photography are diminished when looked at from such a simplistic point of view.

Out of the Shadows by Larry J. Schaaf is an account of Talbot's role as discoverer of photography. Schaaf uses many primary sources not previously available to scholars, including Talbot's diaries, notebooks, and correspondence with his friend Sir John Herschel. Schaaf briefly describes the state of early-19th-century British science and through short biographical portraits of Talbot and Herschel shows how they fit into the scientific community. He then provides a résumé of the prehistory of photography and some of the work that led to its discovery, including Talbot's first work with photogenic drawings, which began in 1834. The majority of the book describes Talbot's and Herschel's experiments, discussions, and public presentations of photogenic drawing and the development of the more successful calotype process. Herschel is revealed to be a strong supporter of Talbot both as an interested friend and as an active scientific colleague. We also see the interests of the two friends diverge as Talbot becomes more involved in the art of producing images and the commercialization of the process while



John Herschel's research notes. "In March and April of 1831, Herschel conducted a series of experiments on the action of light on platinum salts. In addition to using flower juices as color filters, he used light to make rudimentary patterns on the surface of a solution. These experiments were demonstrated to Henry Talbot at the time." [From *Out of the Shadows*; Science Museum Library, London]