as entanglement and complementarity) in new forms of information processing and communication. I wish the author had gone deeper in pursuit of these logical outgrowths of his core themes, instead of scampering to touch all bases.

For seekers of the third culture, I'd still recommend Richard Feynman as the best guide. Try *The Character of Physical Law* (MIT Press, 1967), the early chapters in each volume of *The Feynman Lectures on Physics* and, for the ambitious, *QED: The Strange Theory of Light and Matter* (Princeton University Press, 1986). ■

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Taming the world?

Our Own Devices: The Past and Future of Body Technology

by Edward Tenner

Knopf, 2003. 336 pp. \$26.

Howard P. Segal

The unintended effects of technological developments may be more harmful than beneficial. This was the message — familiar to scholars but not to the general public — that Edward Tenner discussed in original and amusing ways in his previous book *Why Things Bite Back: Technology and the Revenge Effect* (see my review in *Nature* 382, 504–505; 1996). In his latest book, *Our Own Devices*, Tenner examines the ceaseless interplay between technological devices and technique, or our ability to use them.

Most students of technology, he observes, concentrate on the devices themselves; their applications are usually harder to analyse. Yet Tenner also rejects the influential arguments of social critic Jacques Ellul that technique, broadly defined, has steadily shaped modern “technological society” and that its influence is inescapable. (The original French title of Ellul's most influential book, *The Technological Society*, was *La Technique*.)

Tenner focuses on several “body technologies” used in everyday life, and moves literally from toe to head: sandals, training shoes, chairs for office and home, musical keyboards, text keyboards, babies' bottles, glasses and helmets. Overall, these technologies have provided us with a more comfortable, efficient and protected existence as we have

modified the natural world — which is how the earliest technologies began. Invariably, though, there are those “revenge effects”. But *Our Own Devices* goes further than the first book in demonstrating how far body technologies have defined us as human beings.

Babies' bottles are usually the first technology that most of us encounter, but the technique of nursing must still be mastered by most children and mothers who seek to utilize both bottles and breasts. Regular use of rubber bottle nipples often diminishes infants' use of jaws and tongues to breastfeed. And too much baby formula may increase the prospects for certain adult ailments.

To take another example, most of us remain indebted to Roman sandals for the basic model of walking comfort in warmer climates. But comfort is not always a necessity, as the world's billion barefoot inhabitants could attest. For the rest of us, though, sandals — and shoes — make our feet too sensitive to manage without them. Yet cultural differences may dictate our particular choices, so Japanese men wearing geta (raised clogs) walk differently from their Western counterparts.

The role of literacy is critical to Tenner's analysis of glasses, chairs and keyboards, all of which affect us both physically and intellectually. Not surprisingly, glasses go hand-in-hand with mass literacy — but so does myopia. Ironically, glasses may cause children's eyes to grow differently, and so increase myopia as much as correct it. Meanwhile, a few straight-backed chairs for monks and clerks existed before ordinary people learned to read and write, but only with mass literacy did such chairs — and later reclining chairs — become fundamental to those enterprises. Reclining chairs, however, often weaken our back muscles, causing us to recline still more to be comfortable.

Initially, keyboards were used to spread musical literacy but later became critical for putting words on paper with typewriters. Yet many children's writing skills fail to develop properly because they spend ever more time on the computer keyboards that eventually followed.

Helmets provide one of Tenner's most intriguing examples. They were invented in classical times, but their success prompted the development of more powerful weapons and, Tenner claims, started the arms race. Adapted for sports, stronger, and presumably safer, helmets have ironically led to ever more violent contact and greater injuries.

However old in origin, all of Tenner's examples in their current forms reflect the sea change in conceptions about technology, in the West at least, over recent decades. We seem ever more concerned with technology providing small-scale fulfilment of individual needs and desires than with providing large-scale solutions to widely acknowledged social problems — from insufficient energy, communications and transportation systems to excessive poverty and population. Body technologies, rather than space programmes or nuclear power plants, have become our primary association with technology and technique. Tenner is not concerned with this trend, and seems happy to instruct and entertain in a non-ideological, often wry manner.

Tenner then briefly discusses the proliferation of mobile phones and palm pilots. Despite the dominance of the index finger, which represents ‘authority’, Tenner predicts the rise of the thumb: “when extended in the almost lost art of hitchhiking, the thumb shows the right attitude toward the future,

Alex Rodriguez of the Texas Rangers finds that helmets don't always offer enough protection.

K. WILLENS/AP PHOTO

open and cooperative but with a firm sense of direction."

Our Own Devices is even more insightful and provocative than Tenner's earlier book in illuminating how contemporary technology changes us as much as we change it. Tenner has become a worthy successor to such luminaries as business philosopher Peter Drucker, social critic Lewis Mumford and historian Lynn White in connecting technology's past, present and future. ■

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The spark of Enlightenment

Volta: Science and Culture in the Age of Enlightenment

by Giuliano Pancaldi

Princeton University Press: 2003. 384 pp. \$35, £24.95

Lucio Fregonese

Alessandro Volta (1745–1827) was a leading natural philosopher who made significant contributions to fields as diverse as electricity, chemistry and pneumatics. His famous electrical battery contributed decisively to the rise of modernity.

Pancaldi's book is a scientific biography of Volta within the context of Enlightenment culture. The author examines central aspects of Volta's biography, including his education and religious attitudes, and traces a lively picture of the social and scientific networks, both local and international, in which he operated. The sources used include Volta's correspondence, the main Italian scientific journals and the surviving information on the many journeys he made to meet and talk with other scholars.

The focus is mainly on Volta's work on static electricity (1765–1787) and the advanced stages (1796–1799) of the long path that took him to the invention of the battery. Ideally, these two achievements should be considered alongside his work in other scientific fields, but the partial state of our knowledge justifies this selective approach.

Pancaldi's interpretation of Volta's static electricity rests on a sharp polarization, which gives prominence to "experiment and apparatus over theory, instrumentalism over deep philosophical commitment, efficacy and public recognition over private achievement". Not all historians or philosophers of science will agree with such radical epistemological and historiographic assumptions.

In discussing the portrait of Volta in old age shown here, Pancaldi singles out three of the elements — theory, experiment and apparatus, and public recognition — that

appear in his pairs of polar opposites. The book in Volta's hand represents theory; the battery and the *condensatore* (the first version of the modern capacitance electroscope) in the foreground represent his electrical instruments; and the ribbon of the *Legion d'Honneur* on his jacket collar represents public recognition.

Pancaldi interprets Volta's invention in 1775 of the electrophorus (a new electrostatic generator that uses what we now call electrostatic induction instead of friction) as having been inspired not by theory but by the desire for an improved and effective apparatus, aimed at gaining social and scientific recognition. He claims that Volta simply imitated and improved on a similar device described years earlier by the German physicist Franz Aepinus. In about 1778, Volta is presented as having finally managed to define a sound theoretical framework, which was however "midrange", because it built on concepts (capacity, tension and actuation) that, according to Pancaldi, "stemmed directly from laboratory practice". Aepinus and two other important physicists working with electricity, Henry Cavendish and Giambattista Beccaria, are indicated as likely sources of inspiration. Volta's invention (1780) and conceptualization (1782) of the *condensatore* are rooted in his newly defined handling of electricity. Volta's later extensive efforts to quantify various electrical quantities, especially tension, are connected to the general "quantifying spirit" of the Enlightenment.

Pancaldi provides important insights into Volta's path to the battery. He shows that Volta's detection of contact electricity emerged in the context of the more general "hunt for weak electricity" pursued at the time. He also argues convincingly that Volta's creation of the battery was probably catalysed by a paper in which the English chemist William Nicholson had described an apparatus suggested to work like the electrical organ of the torpedo fish. The battery is accordingly presented as a largely "unintended consequence" of a process of "competitive imitation" with Nicholson to reproduce the functioning of the animal's organ. The relative merits of theory and practice are evaluated just as for Volta's static electricity. Experiment, laboratory-based conceptualization and instrumentalism are placed at the core of Volta's enterprise. His deep theoretical commitments are correspondingly given less weight.

Pancaldi offers new results on the way in which Volta presented the battery on various occasions and on how it was received in different contexts (the English and French press) and by various scholars (Nicholson, Etienne-Gaspard Robertson, Johann Wilhelm Ritter, Hans Christian Ørsted and Jean-Baptiste Biot). The battery found many heterogeneous uses and interpretations, which Pancaldi sees as further evidence of "unintended

Fulfilling his potential: Alessandro Volta valued theory, experiments and public recognition.

consequences". Another chapter focuses on the celebration of Volta, including iconography and the centennial commemoration of his death in fascist Italy.

Pancaldi's final image of Volta is of an instrumentalist with manipulative and eclectic tendencies, characteristics that Volta certainly had. But Volta's natural philosophy seems to require further clarification. Volta himself denied that Aepinus' device was the inspiration for his electrophorus, claiming instead that he produced it with the highly theoretical goal of confirming his own conceptualization of a very complex area called "vindicating electricity". As Pancaldi points out, Volta continued to allude to his deep theoretical views as a prime mover of basically all his electrical achievements, including his controversial hypothesis (1792) of contact electricity. As evidence of this, Volta repeatedly referred to his very first electrical paper (1769), a difficult work that remains the only systematic theoretical exposition he ever produced in this field.

From the portrait reproduced here, Volta seems indeed to reassert a deep theoretical commitment, with his natural philosophy as a whole (the book) indicated as the origin of his electrical instruments. Conversely, he can be seen as claiming that the instruments speak in favour of his own natural philosophy. It seems that further enquiry and reassessment are needed for both Volta's natural philosophy and its links with the instruments he produced. ■

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