Book Reviews

Unassuaged Alarms

Understanding Technology. CHARLES SUSSKIND. Johns Hopkins University Press, Baltimore, 1973. xii, 164 pp. $6.95.

Susskind, a professor of electrical engineering at Berkeley, has written this book to reduce the widespread ignorance of technology that he sees among those who have a "liberal" education.

In an easily read book of 150 pages, including rather copious end notes, Susskind reviews the rise of technology since the Industrial Revolution, explains simply and clearly computers and electronic control devices, encapsulates the ideologies of several critics of technology, considers ethical problems and challenges in various applications of technology in the recent past and in the future, and proposes a Hippocratic oath for engineers, in order that they may more fully assume moral as well as technical leadership. All of this is based upon very wide reading and a familiarity with much that goes on outside the United States.

In 1946, when the future of government support of science was much in doubt, James B. Conant published his little book *On Understanding Science*. He thought that "some understanding" of science was needed by "those in positions of authority and responsibility as well as those who shape opinion." He reasoned that if such people understood what science—which by implication included technology—could and could not do, then they might be receptive to the "Endless Horizons" of Vannevar Bush while avoiding the excesses of enthusiasts and charlatans.

A quarter of a century and perhaps 30 billion dollars of support for "basic" research later (that represents 3 million man-years), a sort of sequel to Conant's book is provided in Susskind's *Understanding Technology*. Much research has in fact been converted to technology, and the results have alarmed many people. Susskind reflects an opinion rather widely held among engineers that the chief reason for alarm is an absence of appreciation and understanding of technology. Don't "blame technology (and by implication, the technologist)," he writes, "for society's shortcomings. Perhaps society itself should be held principally responsible."

Perhaps, but a reader not already persuaded that current technology is wholly benign and that any difficulties of the moment will be removed in the near future by new and improved technology will not be reassured by this book. A great deal of essentially hostile criticism is acknowledged by Susskind, and in his chapter "Ideologies of technology" he reviews at some length the diverse views of Bellamy, Veblen, Orwell, Galbraith, Ellul, Marx, and others. He acknowledges also the standard objections to the various current technologies—invasion of privacy by computers, refusal of discarded plastics to rot away, radiation hazards and the need for "careful storage" of wastes from nuclear power plants, and so forth. Yet the merits of such objections are not analyzed or even examined. It is as though the advantages of computers, plastics, and nuclear power plants were so obvious as to preclude any need to take seriously the "opposition." It is not enough to be told, even in jest (for there is no other reassurance), that computers can never "take over" because "you can always pull out the plug!"

"An Engineer's Hippocratic Oath" is proposed to deal with difficult moral problems, which Susskind illustrates through the dilemmas faced by engineers who worked on the Jew-exterminators of the Nazis. It is a commendable statement, quite similar to the "Creed of an Engineer" adopted in 1950 by Verein Deutscher Ingenieure and certainly better than the uncertain codes of ethics of American engineering societies. One can only wonder whether the present generation of German engineers is, through adoption of the creed, more responsive than American engineers to moral issues.

Despite the extensive knowledge that it reflects, the book nevertheless misreads important aspects of the criticisms of technology that are being made by those whom Susskind would instruct. As noted above, Susskind assumes that the reason for negative criticism is ignorance of the nature and promise of technology. I contend, on the contrary, that while public knowledge of the substance of technology is indeed slight and unsubstantial, public *understanding* of its potentialities and limitations is at least as clear and firm as that of the engineering community. By pleasant or bitter personal experience, the public knows at first hand what technology can do. The public likes its automobiles and television sets and the endless gadgets that the economy soaks up. They (the public) take to all these things as a smoker to his cigarettes; but they know also that machines get out of order frequently; they know that the engineer's promise of a future in which everything works is simply a constantly receding mirage. The general public was much less surprised, for example, by the explosion of the oxygen tank on Apollo 13 than were the engineers of NASA (see H. S. F. Cooper, Jr., *Thirteen: The Flight that Failed*, Dial, 1973). Safety features of nuclear power plants are still based upon the "maximum credible accident," yet it requires only a few years of reading newspapers to realize that many of the most serious accidents of complex technical systems are the incredible ones, which statistically should never have happened.

Susskind writes that "all segments of society should participate in deciding how technology might be used to solve contemporary problems." Yet it is clear that he expects acquiescence not participation. The pattern thus far, which has made the public wary of "participation," has been to seek public approval of projects that are already and irrevocably under way. Citizen groups have found that the technical community will listen to them only in a courtroom. When engineers show themselves willing to discuss matters with the public rather than lecture the public about its technical ignorance, and when the technical promoter is willing to take "no" for an answer when he asks the public for its judgment, I believe the public will respond by becoming interested in the engineer's problems and dilemmas as well as its own.

A constant reader of the technical press finds a set of assertions, repeated frequently and without support because so obvious to the writers, that forms a litany of faith in technical solutions of problems both technical and social. I

find in Susskind's book many of these assertions. For example, "opponents of technological advance" would not be so bold "if they realized that it would mean a return to, say, outdoor privies" (p. 69). Engineers should listen to warnings regarding hazards of "nuclear weapons, electronic computers [etc.]" only if the warnings are "logically derived from facts and visible trends" (p. 88). "Blaming engineers for the shortcomings of technological society makes about as much sense as blaming the failure of a new play on the stage hands" (p. 118). "Technology, the source of the problem, will once again prove to contain within itself the germs of a solution compatible with the betterment of man's lot and dignity" (p. 132). The list could be easily doubled in length. Such assertions simply provoke counterassertions, which effectively stifle discussion.

Finally, Susskind the engineering professor deals with dissenting and protesting students. He observes that there was little problem among students of medicine, engineering, or the other professions. The "true believers" in student movements were "more likely to be students of the humanities and social sciences." The reason? They were "demoralized by the devastating thought that they, who should be the future leaders if there was any justice, might turn out to be unwanted and unnecessary," made obsolete by technologists. My counterassertion: the suggestion that this is what the student movement was all about is simply fatuous.

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Atmospheric Physics

Earth's Magnetospheric Processes. Proceedings of a symposium, Cortina, Italy, Aug. 1971. B. M. McCORMAC, Ed. Reidel, Boston, 1972. viii, 420 pp., illus. $37.50. Astrophysics and Space Science Library, vol. 32.

Every two years, B. M. McCormac organizes a two-week international conference on magnetospheric physics. The conferences are always well attended, because McCormac carefully promotes interaction between participants. Every two years, a well-edited conference proceedings appears. I have found these to be the best summaries of the current status of this sprawling field. These proceedings will provide the future historian of science with a series of snapshots of the development of magnetospheric physics. Our future historian may well conclude that the 1971 Cortina conference symbolically marked a turning point. It certainly was for McCormac's conferences themselves. Originally conceived in part to educate a fledgling European space science community, they now, by the number of high-quality European papers in the 1971 volume, announce the growing size and sophistication of the European program. More important, 1971 found a fundamental change in magnetospheric physics. No longer would simple discovery suffice, the physics had to be addressed. With the geometry of the magnetosphere settled, its time dependences had to be understood. These concerns permeate the volume.

Earth's Magnetospheric Processes contains over 30 papers by acknowledged experts grouped under the headings Magnetospheric Structure and Processes, Magnetospheric Particles, Magnetic Fields and Currents, Electric Fields and Plasma Convection, Acceleration and Diffusion (of particles), and Magnetospheric Substorms. The papers in their diversity illustrate the many different physical processes—and the different measurements they require—we need to synthesize into a working model of the time-dependent magnetosphere. The very fact that they are collected in one volume, rather than dispersed throughout the journal literature, clarifies the task ahead. Of the many papers presented, I would like to single out two whose topics seem to have stimulated incessant discussion afterward. It now appears that whenever the solar wind magnetic field changes direction the magnetosphere adjusts by changing its internal plasma flow, creating a characteristic sequence of events in the auroral zone, called a substorm by its discoverer, S. I. Akasofu. The controversy provoked at Cortina by M. P. Aubry's tart review of substorms continues to this day. V. M. Vasyliunas's theoretical paper on the interrelation of magnetospheric processes, published only in these proceedings, became a foundation of future work in magnetospheric convection theory. Vasyliunas wrote down and used the full set of equations describing the coupling of the magnetosphere to the highly conducting ionosphere to produce calculations of the flow for the special case of a magnetosphere loaded with energetic protons during magnetic storms. Although definitive results are still to be obtained from the research program so initiated, there seems to be general agreement that this is the way all time-dependent magnetospheric flow problems should be solved.

All in all, *Earth's Magnetospheric Processes* is indispensable for libraries and serious magnetospheric physicists. Since some papers are tutorial in nature, it is also useful for students, though its price is a drawback.

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Widespread Mineral

Apatite. Its Crystal Chemistry, Mineralogy, Utilization, and Geologic and Biologic Occurrences. D. MCCONNELL. Springer-Verlag, New York, 1973. xvi, 112 pp., illus. $17.40. Applied Mineralogy, vol. 5.

Apatite is a mineral which is widely distributed in nature. It is the major constituent of the hard tissue of vertebrates, forms the tests of some invertebrates, and is ubiquitous in rocks. It is also the major raw material used by the chemical industry for the production of phosphorus and its compounds.

McConnell's studies of the mineralogy, crystallography, and crystal chemistry of apatite extend over more than 35 years and have been paramount in the advancement of the field. It therefore is fitting that he should prepare this volume on apatite. McConnell stresses the crystallography and crystal chemistry of the compound. This emphasis is found even in the chapters entitled "Phosphorites," "Geology: igneous and metamorphic occurrences," and "Biological apatites." Since the size of the book—11 chapters are included in little over 100 pages—precludes complete coverage of the many and diverse topics related to apatite, it is fortunate that this common denominator is stressed.

The author's style of writing, blunt statements, and critical comments will be amusing to some readers, serve as admonitions to others, and be irritating to still others. Regardless of one's disposition toward this style, it does serve to identify and alert the reader to controversial matters and important reservations concerning apatite studies. In the final chapter, a critique, the author gives a cautionary review of some practices and techniques in the