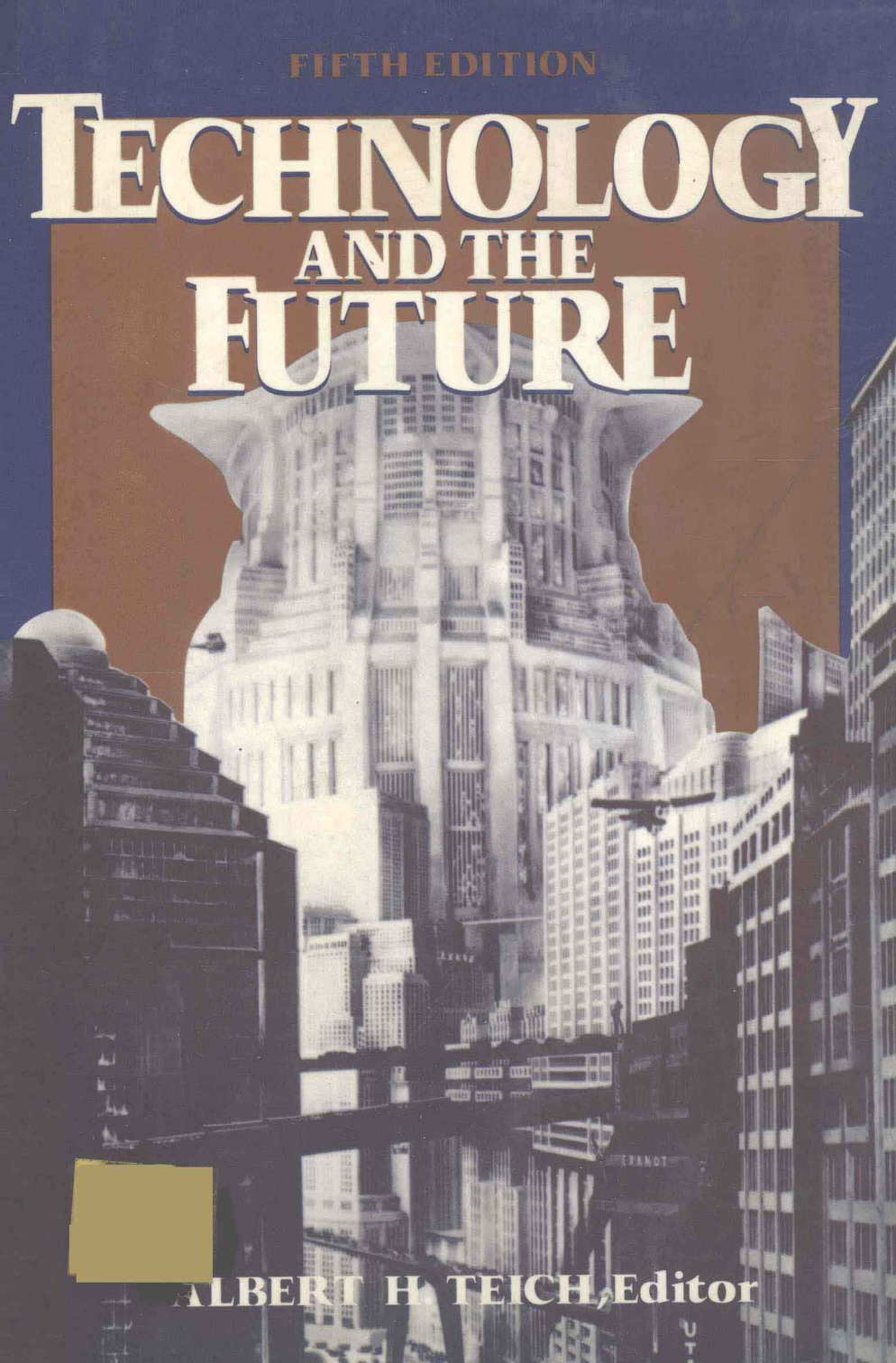
FIFTH EDITION

TECHNOLOGY AND THE FUTURE



ALBERT H. TEICH, Editor

TECHNOLOGY AND THE FUTURE

FIFTH EDITION

Albert H. Teich, Editor
American Association for the Advancement of Science

St. Martin's Press
New York

To the memory of my parents,
Ina and Maurice Teich

Senior editor: Don Reisman
Project management: Publications Services
Cover design: Celine Brandes
Cover photo: Photofest

Library of Congress Catalog Card Number: 88-63076

Manufactured in the United States of America.
43210
fedcba

For information, write:

St. Martin's Press, Inc.
175 Fifth Avenue
New York, NY 10010

ISBN: 0-312-01885-1

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Preface

The year 2000 is rapidly approaching, but the future is already here. One expert reports that if you regard every microprocessor chip as a computer, there are now more computers in the world than people. Teenagers in Hong Kong stroll the streets of Kowloon chatting with their friends on cellular phones—devices not much bigger than Maxwell Smart's famous shoe phone and considerably more practical. Just 20 years after humans first walked on the moon, the Voyager space probe is expected to send back the first close-up television pictures of the planet Neptune, more than 2.5 billion miles from Earth. Fax machines send letters around the world in seconds; optical storage devices make it possible to put an entire encyclopedia on a compact disk. Recombinant DNA technology allows the creation of bacteria capable of producing human insulin and growth hormone.

One of the major differences between modern and traditional societies is that in modern societies we expect change. The future *will* be different from the past. Technology is key to that change—both as a manifestation and as a cause. And an understanding of how technology relates to society and society relates to technology is vital if we want that change to lead to an improvement in the human condition.

Technology is "in" today. Despite a string of disasters—from Bhopal to Challenger to Chernobyl—the public mood (to the extent it is possible to judge such a thing) seems strongly enthusiastic about technology. The "high-tech" style is maintaining its hold on the popular fancy in everything from automobiles to furniture, home appliances, and exercise equipment. There is growing interest in high-technology industry as a route toward economic development. Virtually every state in the Union, from Pennsylvania to Arkansas, has established an agency to subsidize the growth of technology-based firms through tax incentives, "incubator" facilities adjacent to university campuses, cooperative applied research centers, and research grants. Even popular music reflects the interest in technology. A newsletter published by engineering students recently listed its "High Tech Hot 50" songs, including *Radio Waves* (Roger Waters), *99 Luft Balloons* (Nena), *I, Robot* (The Alan Parsons Project), *Weird Science* (Oingo Boingo), and *The Future's So Bright (I gotta wear shades)* (Timbuk 3).

This is the fifth edition of *Technology and the Future* (originally *Technology and Man's Future*). When I prepared the original version

of the book in 1971–72, the public mood regarding technology seemed very different. A large and vocal segment of society viewed technology as a threat, a Frankenstein monster out of control, carrying humanity headlong toward destruction. Romantic, idealistic visions of society were in vogue and led many observers and social critics to question the direction of mainstream technology and call for more social control over it.

My purpose in assembling the book was to present a balanced set of readings on technology and society—to give students from both technical and nontechnical backgrounds an opportunity to explore the nuances and subtleties of the many differing views on this subject. At the same time, I sought to relate these views to policy perspectives, suggesting avenues of public action that might influence the future in positive ways. Subsequent editions, including the present one, though larger in size and broader in scope, have held to this original concept.

In all its editions, *Technology and the Future* has reflected my own search for purpose in the development of technological society. This search and questioning of the direction of technological development are as relevant today as they were nearly two decades ago, when they were more fashionable.

I introduced the first edition with some personal reflections on the visions of the future with which I had grown up: World's Fair-style images characterized by neatness and order, miles upon miles of gleaming chrome, millions of buttons to push, endless gadgets to do all the work, automated highways on which to travel effortlessly, once-a-day nourishment pills to save one the trouble of eating three meals a day. This type of future (captured vividly by Joseph J. Corn and Brian Horrigan in a Smithsonian traveling exhibition and a book entitled *Yesterday's Tomorrows* [Summit Books, 1984]) seemed inevitable to me in my childhood, but as I grew older I began to wonder about whether the type of *technological* progress I had envisioned was also *human* progress. My hope in publishing this book, then as now, was not to provide definitive answers to questions such as this, but rather to stimulate students to think about them constructively, and to provide some help in structuring that intellectual exploration.

At the same time, the book reflected—and continues to reflect—my ambivalence and that of our society as a whole toward technology. Introducing the second edition in 1977, I was struck by the contrast between the technological achievement of the Apollo moon landing in 1969 and the technological failure of the energy crisis that arose only four years later. I suggested that this contrast reflected an ambiva-

lence characterized (as many authors have described it) by admiration of what technology can achieve on the one hand, and concerns about the problems it creates on the other. In the third edition (published in 1981), I suggested that a similar ambivalence could be seen in the unproven but not implausible speculation that many of the protestors who took part in the famous demonstration against construction of a nuclear reactor at Seabrook, New Hampshire, were also admirers of the intensely technological fantasy film, *Star Wars*.

Despite today's technological bandwagon, ambivalence toward technology is still very much apparent. Those who employ technology most effectively are often most critical of its social dimension. Pope John Paul II, for example, as adept as any world leader in using the most up-to-date transportation and communications technology to carry out his mission, warned steelworkers in Venezuela in early 1985 that they must not become "slave[s] of the machine." The Pope, who worked in a chemical factory before becoming a priest, spoke of the "ideology of technology," declaring that it must not be allowed to impose "the primacy . . . of the technical over the moral."[1]

Finally, the continuity of this version of *Technology and the Future* with prior editions can be seen in the book's attention to policy. In the first edition, the major policy theme was technology assessment. The topic of world models was introduced in the second edition, and the third edition brought in notions of alternative or "appropriate" technology. The fourth edition added risk assessment and promotion of technological innovation. The present edition retains elements of all of these, while adding a women's perspective and expanding the discussion of using technology.

The book is divided into four major sections. "Thinking about Technology," the first section, brings together several different perspectives on the relationship of technology to society. It represents my own sampling of the many writers and schools of thought on this vast subject. The selections are intended to stimulate readers to question their own ways of thinking about technology. What exactly is the phenomenon under discussion? Everyone seems to know, more or less, what technology is—that is, until they start trying to define it.

The articles in the first section will enable the reader to understand how differing concepts of technology influence various authors' perspectives on the relationship of technology to society.

[1] E. J. Dionne, Jr. , "Pope Says Workers Must Not Be 'Slave of Machine,' " *The New York Times*, January 30, 1985, p. A3.

The second section "Forecasting, Assessing, and Controlling Technology," is policy oriented. Most of the articles focus on the need for concerted public action in matters relating to technology. One selection deals with trends in indicators of the Earth's "health." Others are devoted to assessing the impact of new types of technology in the framework of the policy process (including a retrospective assessment of what was expected of computers when they were first developed) and to assessment of technological risks. Finally, the last paper in the section examines the role of technical controversies in democratic policymaking.

In Section 3, "Reshaping Technology," six writers question the assumptions underlying mainstream industrial technology and examine alternatives to it. These writers share a belief that simply guiding the development of conventional technologies may not be enough. The time has come, they feel, to ask fundamental questions about the very direction of technological change and to consider ways in which that direction might be altered. The first four articles center on the concepts of alternative or "appropriate" technology. The last two consider the impact of technology on women, with particular emphasis on labor force and career issues.

"Using Technology," the fourth section, was introduced in the fourth edition, but has been completely revised in the fifth. On the whole, it reflects the current enthusiasm for using advanced technology to promote economic growth and industrial competitiveness. In this regard, individual chapters focus on superconductivity, biotechnology, and artificial intelligence. At the same time, however, the section includes a piece on biomedical technology that highlights the moral dilemmas posed by advances in that area. These articles, a bit different from those found elsewhere in this volume, are intended to stimulate thought and discussion about the future of technological society in terms of specific, tangible technologies, not just abstractions.

In a departure from prior editions, I have added a brief "headnote" before each selection in order to put the selections in context and provide background about their authors. To avoid duplication, I have shortened the section introductions and eliminated the "About the Authors" section.

I continue to be gratified by the growing interest in the study of technology and society in U.S. colleges and universities and by the remarkably wide range of disciplines and courses in which *Technology and the Future* is used. I am grateful to many people who have con-

tributed to the success of the book. My deepest appreciation goes to the authors and publishers of the selections included here for allowing me to reprint their work. In many cases, the selection that appears here represents only a brief introduction to a rich body of thought and writing. I hope that the exposure to these authors in *Technology and the Future* serves to stimulate readers either to seek out the complete work from which the excerpt is taken or to look for other writings by these authors.

I also want to express my thanks to the users of the book for their interest and helpful feedback; to a number of friends and colleagues for their comments and suggestions on the outline of this new edition; and to my editors at St. Martin's Press for their foresight, interest, and support. The following individuals also provided suggestions through reviews or responses to questionnaires: Paul Chambers, Broome Community College; Michael Feuer, Drexel University; Devendra P. Garg, Duke University; Patrick W. Hamlett, University of Missouri-Rolla; Ronald Hoy, California University of Pennsylvania; Ralph G. Lewis, Florida International University; Peter Limper, Christian Brothers College; Timothy John Lomperis, Duke University; Daniel Pound, University of Alabama at Tuscaloosa; Mareleyn Schneider, Fordham University; Eugene Selk, Creighton University; Carl Swenson, Seattle University; John Visvader, College of the Atlantic. Special thanks are reserved for my sons, Mitch and Ken, and my wife, Jill, for their patience and for giving me inspiration, assistance, encouragement, and much more.

Contents

1. Thinking About Technology

INTRODUCTION

Technology is more than just machines. It is a pervasive, complex system whose cultural, social, political, and intellectual elements are manifest in virtually every aspect of our lives. Small wonder, then, that it has attracted the attention of such a large and diverse group of writers and commentators. A small sampling of the range of writings on the social dimensions of technology is contained in this first section of **Technology and the Future**. All of the writers represented here are attempting to understand—from one perspective or another—these social dimensions of technology. Little else ties them together. Their points of view are vastly different. Their common object is not so much to prescribe particular courses of action as it is to explore the conceptual, metaphysical issues underlying technology-society relations.

Historian Leo Marx explores the development of the American notion of progress and looks at its connections with technological advance. Robert Morison, a physician and philosopher, seeks to understand the values we serve through our technology by questioning our national obsession with physical health. Alvin Weinberg (a physicist) suggests that we can find shortcuts to the solution of social problems by transforming them into technological ones—since technological problems are much easier to solve. By addressing a much more mundane sort of problem—how to keep a motorcycle running smoothly—Robert Pirsig explores both the scientific method and the mystique that keeps many people from feeling comfortable with machines.

In *The Control Revolution*, social scientist James Beniger develops a powerful new theory of the ways in which technology, particularly information technology, shapes social institutions. Emmanuel Mesthene and John McDermott engage in a classic debate on the politics of technology—Mesthene coolly describing its moral neutrality and McDermott bitterly criticizing what he

sees as the right-wing bias of contemporary technology. Finally, Samuel Florman, an engineer and humanist, proposes an alternative approach, a "tragic" view that recognizes the role of technology in human life, including its limits.

The reader looking for unequivocal answers to the problems posed by technology will not find them here. On the whole, the articles in this section, like those in the remainder of the book, raise many more questions than they answer.

Does Improved Technology Mean Progress?

LEO MARX

The concepts of technology *and* progress *have been firmly linked in the minds of most Americans for the past 150 years. Only in the past two decades has the question that Leo Marx asks in his article "Does Improved Technology Mean Progress?" begun to receive serious attention in our culture. This question is the perfect starting point for* **Technology and the Future**. *Deceptive in its simplicity, it underlies most of what follows in this book.*

Marx, who holds the William R. Kenan Professorship of American Cultural History at MIT, is the author of The Machine in the Garden: Technology and the Pastoral Ideal in America *(1964) and* The Pilot and the Passenger: Essays on Literature, Technology and Culture in the United States *(1988). He holds a Ph.D. in history from Harvard and has taught at that institution and at the University of Minnesota and Amherst College. He has twice been a Guggenheim Fellow and was a Rockefeller Humanities Fellow in 1983–84. Marx was born in New York City in 1919.*

In this essay (first published in Technology Review *in 1987), he examines how the concept of progress has itself evolved since the early days of the Republic and what that evolution means for understanding the technological choices that confront us today. Improved technology* could *mean progress, Marx concludes, but "only if we are willing and able to answer the next question: progress toward what?"*

Does improved technology mean progress? If some variant of this question had been addressed to a reliable sample of Americans at any time since the early nineteenth century, the answer of a majority almost certainly would have been an unequivocal "yes." The idea that technological improvements are a primary basis for—and an accurate gauge of—progress has long been a fundamental belief in the United States. In the last half-century, however, that belief has lost some of its credibility. A growing minority of Americans has adopted a

skeptical, even negative, view of technological innovation as an index of social progress.

The extent of this change in American attitudes was brought home to me when I spent October 1984 in China. At that time the announced goal of the People's Republic was to carry out (in the popular slogan) "Four Modernizations"—agriculture, science and technology, industry, and the military. What particularly struck our group of Americans was the seemingly unbounded, largely uncritical ardor with which the Chinese were conducting their love affair with Western-style modernization—individualistic, entrepreneurial, or "capitalist," as well as scientific and technological. Like early nineteenth-century visitors to the United States, we were witnessing a society in a veritable transport of improvement: long pent-up, innovative energies were being released, everyone seemed to be in motion, everything was eligible for change. It was assumed that any such change almost certainly would be for the better.

Most of the Chinese we came to know best—teachers and students of American studies—explicitly associated the kind of progress represented by the four modernizations with the United States. This respect for American wealth and power was flattering but disconcerting, for we often found ourselves reminding the Chinese of serious shortcomings, even some terrible dangers, inherent in the Western mode of industrial development. Like the Americans whom European travelers met 150 years ago, many of the Chinese seemed to be extravagantly, almost blindly, credulous and optimistic.

Our reaction revealed, among other things, a change in our own culture and, in some cases, in our own personal attitudes. We came face to face with the gulf that separates the outlook of many contemporary Americans from the old national faith in the advance of technology as the basis of social progress.

The standard explanation for this change includes that familiar litany of death and destruction that distinguishes the recent history of the West: two barbaric world wars, the Nazi holocaust, the Stalinist terror, and the nuclear arms race. It is striking to note how many of the fearful events of our time involve the destructive use or misuse, the unforeseen consequences, or the disastrous malfunction of modern technologies: Hiroshima and the nuclear threat; the damage inflicted upon the environment by advanced industrial societies; and spectacular accidents like Three Mile Island.

Conspicuous disasters have helped to undermine the public's faith in progress, but there also has been a longer-term change in our thinking. It is less obvious, less dramatic and tangible than the record of catastrophe that distinguishes our twentieth-century history, but I believe it is more fundamental. Our very conception—our chief criterion—of progress has undergone a subtle but decisive change since the founding of the Republic, and that change is at once a cause and a reflection of our current disenchantment with technology. To chart this change in attitude, we need to go back at least as far as the first Industrial Revolution.

THE ENLIGHTENMENT BELIEF IN PROGRESS

The development of radically improved machinery (based on mechanized motive power) used in the new factory system of the late eighteenth century coincided with the formulation and diffusion of the modern Enlightenment idea of history as a record of progress. This conception became the fulcrum of the dominant American worldview. It assumes that history, or at least modern history, is driven by the steady, cumulative, and inevitable expansion of human knowledge of and power over nature. The new scientific knowledge and technological power was expected to make possible a comprehensive improvement in all the conditions of life—social, political, moral, and intellectual as well as material.

The modern idea of progress, as developed by its radical French, English, and American adherents, emerged in an era of political revolution. It was a revolutionary doctrine, bonded to the radical struggle for freedom from feudal forms of domination. To ardent republicans like the French philosopher Condorcet, the English chemist Priestley, and Benjamin Franklin, a necessary criterion of progress was the achievement of political and social liberation. They regarded the new sciences and technologies not as ends in themselves, but as instruments for carrying out a comprehensive transformation of society. The new knowledge and power would provide the basis for alternatives to the deeply entrenched authoritarian, hierarchical institutions of *l'ancien régime*: monarchical, aristocratic, and ecclesiastical. Thus in 1813 Thomas Jefferson wrote to John Adams describing the combined effect of the new science and the American revolution on the minds of Europeans:

> Science had liberated the ideas of those who read and reflect, and the American example had kindled feelings of right in the people. An insurrection has consequently begun, of science, talents, and courage, against rank and birth, which have fallen into contempt. . . . Science is progressive.

Admittedly, the idea of history as endless progress did encourage extravagantly optimistic expectations, and in its most extreme form, it fostered some wildly improbable dreams of the "perfectability of Man" and of humanity's absolute mastery of nature. Yet the political beliefs of the radical republicans of the eighteenth century, such as the principle of making the authority of government dependent upon the consent of the governed, often had the effect of limiting those aspirations to omnipotence.

The constraining effect of such ultimate, long-term political goals makes itself felt, for example, in Jefferson's initial reaction to the prospect of introducing the new manufacturing system to America. "Let our work-shops remain in Europe," he wrote in 1785.

Although a committed believer in the benefits of science and technology, Jefferson rejected the idea of developing an American factory system on the ground that the emergence of an urban proletariat, which he then regarded as an inescapable consequence of the European factory system, would be too high a price to pay for any potential improvement in the American material standard of living. He regarded the existence of manufacturing cities and an industrial working class as incompatible with republican government and the happiness of the people. He argued that it was preferable, even if more costly in strictly economic terms, to ship raw materials to Europe and import manufactured goods. "The loss by the transportation of commodities across the Atlantic will be made up in happiness and permanence of government." In weighing political, moral, and aesthetic costs against economic benefits, he anticipated the viewpoint of the environmentalists and others of our time for whom the test of a technological innovation is its effect on the overall quality of life.

Another instance of the constraining effect of republican political ideals is Benjamin Franklin's refusal to exploit his inventions for private profit. Thus Franklin's reaction when the governor of Pennsylvania urged him to accept a patent for his successful design of the "Franklin stove:"

> Governor Thomas was so pleased with the construction of this stove as described in . . . [the pamphlet] that . . . he offered to give

> me a patent for the sole vending of them for a term of years; but I declined it from a principle which has ever weighed with me on such occasions, namely; viz., *that as we enjoy great advantages from the inventions of others, we should be glad of an opportunity to serve others by any invention of ours, and this we should do freely and generously* [emphasis in original].

What makes the example of Franklin particularly interesting is the fact that he later came to be regarded as the archetypal self-made American and the embodiment of the Protestant work ethic. When Max Weber sought out of all the world *the* exemplar of that mentality for his seminal study, *The Protestant Ethic and the Spirit of Capitalism*, whom did he choose but our own Ben? But Franklin's was a principled and limited self-interest. In his *Autobiography*, he told the story of his rise in the world not to exemplify a merely personal success, but rather to illustrate the achievements of a "rising people." He belonged to that heroic revolutionary phase in the history of the bourgeoisie when that class saw itself as the vanguard of humanity and its principles as universal. He thought of his inventions as designed not for his private benefit but for the benefit of all.

THE TECHNOCRATIC CONCEPT OF PROGRESS

With the further development of industrial capitalism, a quite different conception of technological progress gradually came to the fore in the United States. Americans celebrated the advance of science and technology with increasing fervor, but they began to detach the idea from the goal of social and political liberation. Many regarded the eventual attainment of that goal as having been assured by the victorious American Revolution and the founding of the Republic.

The difference between this later view of progress and that of Jefferson's and Franklin's generation can be heard in the rhetoric of Daniel Webster. He and Edward Everett were perhaps the leading public communicators of this new version of the progressive ideology. When Webster decided to become a senator from Massachusetts instead of New Hampshire, the change was widely interpreted to mean that he had become the quasi-official spokesman for the new industrial manufacturing interests. Thus Webster, who was generally considered the nation's foremost orator, was an obvious choice as the speaker at the dedication of new railroads. Here is a characteristic peroration of one such performance in 1847: