Does Technology Drive History?

The Dilemma of Technological Determinism

edited by Merritt Roe Smith and Leo Marx

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To the memory of Dr. Bern Dibner and with thanks to David and Frances Dibner for all they have done to encourage and support the study of the history of science and technology.

Contents

Introduction

Leo Marx and Merritt Roe Smith

If "determinism" sounds "cold and mathematical," as William James once noted,[1] then "technological determinism" surely sounds even more forbidding. Yet our subject is not nearly as esoteric as that arcane name suggests. By now, most people in modernized societies have become habituated to the seeming power of advancing technology (and its products) to change the way they live. For them, indeed, the steady growth of that power is just another self-evident feature of modern life, an obvious fact that calls for no more comment than the human penchant for breathing. As an explicit idea "technological determinism" may mean nothing to them, but the phenomenon it ostensibly represents is an omnipresent aspect of their awareness.

A sense of technology's power as a crucial agent of change has a prominent place in the culture of modernity. It belongs to the body of widely shared tacit knowledge that is more likely to be acquired by direct experience than by the transmittal of explicit ideas. Anyone who has witnessed the advent of the computer, for example, knows a great deal about how new technology can alter the very texture of daily life, and has gained this understanding as more than a bystander. Even those who do not use computers have had to accommodate their ways to some of its requirements in supermarkets, post offices, banks, libraries, schools, airlines, hospitals, or the military services—few departments of contemporary life remain unaffected by the new information technology. But of course the computer is only one of the radically new science-based technologies—along with television, jet aircraft, nuclear weaponry, antibiotics, the contraceptive

1. "The Dilemma of Determinism," in *Essays in Pragmatism* (Hafner, 1951), p. 40.

pill, organ transplants, and biogenetic engineering—whose transformative power has been experienced by millions alive today. For some three centuries, direct firsthand experience of that power has been a well-nigh universal feature of life in developed and developing countries.

The collective memory of Western culture is well stocked with lore on this theme. The role of the mechanic arts as the initiating agent of change pervades the received popular version of modern history. It is embodied in a series of exemplary episodes, or mini-fables, with a simple yet highly plausible before-and-after narrative structure. Before the fifteenth century, for example, Europeans are said to have known little or nothing about the western hemisphere; after the compass and other navigational instruments became available, however, Columbus and his fellow explorers were able to cross the Atlantic, and the colonization of the New World quickly followed. Newly invented navigational equipment is thus made to seem a necessary precondition, or "cause," of—as if it had made possible—Europe's colonization of much of the world.

Similarly, the printing press is depicted as a virtual cause of the Reformation. Before it was invented, few people other than the clergy owned copies of the Bible; after Gutenberg, however, many individual communicants were able to gain direct, personal access to the word of God, on which the Reformation thrived. As a final example, take the story, favored by writers of American history textbooks, about the alleged link between the cotton gin and the Civil War. In the late eighteenth century, slavery was becoming unprofitable in the American states; but after Eli Whitney's clever invention, the use of African slaves to harvest cotton became lucrative, the reinvigorated slavery system expanded, and the eventual result was a bloody civil war.

The structure of such popular narratives conveys a vivid sense of the efficacy of technology as a driving force of history: a technical innovation suddenly appears and causes important things to happen. It is noteworthy that these mini-fables direct attention to the consequences rather than the genesis of inventions. Whether the new device seems to come out of nowhere, like some *deus ex machina,* or from the brain of a genius like Gutenberg or Whitney, the usual emphasis is on the material artifact and the changes it presumably effects. In these episodes, indeed, technology is conceived in almost exclusively artifactual terms, and its materiality serves to reinforce a

tangible sense of its decisive role in history. Unlike other, more abstract forces to which historians often assign determinative power (for example, socio-economic, political, cultural, and ideological formations), the thingness or tangibility of mechanical devices—their accessibility via sense perception—helps to create a sense of causal efficacy made visible. Taken together, these before-and-after narratives give credence to the idea of "technology" as an independent entity, a virtually autonomous agent of change.

Today a similar idea informs the popular discourse of technological determinism. It is typified by sentences in which "technology," or a surrogate like "the machine," is made the subject of an active predicate: "The automobile created suburbia." "The atomic bomb divested Congress of its power to declare war." "The mechanical cotton-picker set off the migration of southern black farm workers to northern cities." "The robots put the riveters out of work." "The Pill produced a sexual revolution." In each case, a complex event is made to seem the inescapable yet strikingly plausible result of a technological innovation. Many of these statements carry the further implication that the social consequences of our technical ingenuity are far-reaching, cumulative, mutually reinforcing, and irreversible.

An invention, once introduced into society, is thus depicted as taking on a life of its own. For example, the continuing improvement of the computer has followed a kind of internal logic (a logic embedded in its constituent material components and its design), so that each "generation" of enhanced computational sophistication has led, in a seemingly predetermined sequence, to the next. As the use of the computer spreads, more and more institutions have to reconfigure their operations to comport with the new capacities and constraints it creates. In the process, society as a whole becomes increasingly dependent on large, intricately interrelated technical systems. The whole network—a system of systems, or a megasystem—becomes the indispensable technological armature of the economy. Its continued functioning is a precondition for the reproduction of the entire social order.

Such a deterministic view of technology is a pervasive theme of the mass media nowadays. Take, for example, "The Machine That Changed the World," a 1993 documentary television series about the coming of the computer. The narrative structure is based on the stock before-and-after model, and the title neatly captures the idea—evidently appealing to large audiences—that advancing technology

has a steadily growing, well-nigh irresistible power to determine the course of events. This version of the idea is what James calls "hard determinism."[2]

As the essays in this volume suggest, the idea of technological determinism takes several forms, which can be described as occupying places along a spectrum between "hard" and "soft" extremes. At the "hard" end of the spectrum, agency (the power to effect change) is imputed to technology itself, or to some of its intrinsic attributes; thus the advance of technology leads to a situation of inescapable necessity. In the hard determinists' vision of the future, we will have technologized our ways to the point where, for better or worse, our technologies permit few alternatives to their inherent dictates. To optimists, such a future is the outcome of many free choices and the realization of the dream of progress; to pessimists, it is a product of necessity's iron hand, and it points to a totalitarian nightmare.

Critics of "hard" determinism question the plausibility of imputing agency to "technology." After all, they argue, the word is merely a modern abstract noun for a certain category of the arts—what used to be called "the mechanic arts." There are hundreds of technologies, and few assertions about "technology" apply with equal validity to all of them. In spite of the existence of an engineering profession, technology is not an organized institution; it has no members or stated policies, nor does it initiate actions. How can we reasonably think of this abstract, disembodied, quasi-metaphysical entity, or of one of its artifactual stand-ins (e.g., the computer), as the initiator of actions capable of controlling human destiny? To note the reified character of this presumed agent is to recall that—until now, at least—no technology, no matter how ingenious and powerful, ever has initiated an action not preprogrammed by human beings.[3]

2. Ibid.

3. The proviso "until now" is included in deference to the claims often made nowadays on behalf of the imminent capacity of scientists and engineers, with the help of artificial intelligence, robotics, biogenetic technology, and artificial-life theory (or some combination thereof), to create a suprahumanly intelligent, self-directing, self-replicating agent, or "mind child," whose existence will in effect render obsolete the traditional boundaries between the mechanical and the organic, between art and nature. This claim may be seen, in fact, as the current terminus of one popular tradition of technological determinism.

At the other end of the spectrum, the "soft" determinists begin by reminding us that the history of technology is a history of human actions. To understand the origin of a particular kind of technological power, we must first learn about the actors. Who were they? What were their circumstances? This approach leads willy-nilly to the more exacting and productive questions in the historian's tool kit. Why was the innovation made by these people and not others? Why was it possible at this time and this place rather than another time or place? Who benefited, and who suffered? In lieu of a "hard" monocausal explanation for the genesis of the presumed determinative power of a technical innovation, these questions suggest the greater plausibility of a "soft," less specific, multivalent explanation. Instead of treating "technology" *per se* as the locus of historical agency, the soft determinists locate it in a far more various and complex social, economic, political, and cultural matrix.

The soft determinists' viewpoint may be illustrated by the way they might explain the growing credence given to the idea of technological determinism itself. An obvious historical starting point for this tendency is the marked acceleration in the rate of technical innovation that occurred, according to a broad current consensus of knowledgeable historians, in the West in the seventeenth and eighteenth centuries. But why did a propensity to innovate come to the fore at that time in the British Isles, in the North American colonies, and in Western Europe? Historians have proposed a great variety of well-documented, well-reasoned answers. Some focus on the particular efficacy of certain material, geographic, demographic, and socioeconomic preconditions: access to raw materials or markets; the existence of a mercantile capitalist economy; the operation of the profit motive; the accumulation of capital; the availability of a needy, teachable, exploitable labor force. Others attribute causal primacy to intellectual, cultural, or ideological factors: the extent of secular learning; the existence of a reservoir of entrepreneurial or financial skills; the presence of scientific rationalism, Christianity, the Protestant work ethic, or an artisanal ethos. Indeed, almost every identifiable attribute of early modern Western societies has been proposed as the putatively critical factor. Although it seems probable that the answer is to be found in some distinctive combination of these factors, the truth is that no one can say exactly what accounts for the special propensity to innovate that *initially* developed in the West in the early modern

era.[4] Thus agency, as conceived by "soft" technological determinists, is deeply embedded in the larger social structure and culture—so deeply, indeed, as to divest technology of its presumed power as an independent agent initiating change.

And yet we need only look at the world of the 1990s to revivify the intuitively compelling idea that technological innovation is a major driving force of contemporary history, if not the primary driving force. Even if the critique of hard determinism is valid, it may only lead us to alter the status of technology to that of a second-order agent of history. Its power to effect change may be derived from certain specific socio-economic and cultural situations, but to say that is only to relocate the *origin* of that power. Once it has been developed, its determinative efficacy may then become sufficient to direct the course of events. In that case "technological determinism" has been redefined; it now refers to the human tendency to create the kind of society that invests technologies with enough power to drive history. If any particular form of human power now has an outstanding claim to that distinction, it probably is technological power. Indeed, one of our chief reasons for collecting these essays is our sense of the increasingly strong hold of that claim on the public imagination. People seem all too willing to believe that innovations in technology embody humanity's choice of its future. Whether that choice is an expression of freedom or an expression of necessity is the dilemma these essays are intended to elucidate.

Many of these essays were first delivered at a two-day workshop held at MIT in December 1989. In addition to the contributors to this volume, the participants included James Bartholomew, Nicholas Bloembergen, Alfred D. Chandler, Jr., I. Bernard Cohen, Jill K. Conway, Colleen Dunlavy, Gerald Holton, Robert Howard, Carl Kaysen, Kenneth Keniston, Philip Khoury, Bruce Mazlish, and William H. McNeill. Their contributions and interventions proved essential in helping us establish the topical and thematic outlines of the book.

4. The word "initially" requires special emphasis here because the recent development of technological sophistication in Japan, South Korea, Taiwan, and Singapore undermines any notion of an inherently or permanently distinctive affinity between the West and technological innovation.

As the project moved from the workshop to the compositional stage, we received advice and assistance from a number of people. Kenneth Keniston and Bronwyn Mellquist offered valuable commentary on several drafts of the introduction and the first essay. Pamela Laird, James H. Nottage, George O'Har, and Paul Vermouth provided much needed assistance with the selection and preparation of illustrations. An anonymous referee offered many helpful recommendations. We also wish to acknowledge the expert editorial assistance of Laurence Cohen and Paul Bethge of The MIT Press, whose close readings of the manuscript helped to improve our prose and clarify our ideas at many points. Finally, we wish to thank the Dibner Institute for the History of Science and Technology, particularly Executive Director Evelyn Simha and her staff, for sponsoring the workshop and helping to organize it. Our debt to the Dibner Institute is considerable, and the dedication on page v is meant to thank those who made it possible.

Does Technology

Technological Determinism in American Culture

Merritt Roe Smith

In this essay, Merritt Roe Smith provides a brief history of technological determinism and shows how deeply such thought is embedded in American culture. He maintains that, as early as the 1780s, public servants like Tench Coxe began to attribute agency to the new mechanical technologies associated with the rise of the factory system. He reveals, moreover, that the technocratic spirit Coxe represented grew by leaps and bounds during the nineteenth century as the United States experienced rapid industrial expansion and gained status as a world power. Smith also shows how artists, advertisers, and professional historians contributed to the emergence of a widespread popular belief in technology as the driving force in society. He even detects elements of technological determinism in the writings of the scholars who became the most outspoken critics of modern technological society.

The belief in technology as a key governing force in society dates back at least to the early stages of the Industrial Revolution. Referred to as "technological determinism" by twentieth-century scholars, this belief affirms that changes in technology exert a greater influence on societies and their processes than any other factor. Indeed, one contemporary writer who refers to himself as a technocentrist maintains that "technology broadly conceived, along with its lesser sibling Science, is the central force in the modern world, more important to defining the patterns and problems of twentieth-century life than international conflict, national politics, the maldistribution of wealth, and differences of class and gender, because it is in some sense prior to all of these."[1] Within this genre of thought and expression one can discern two versions of technological determinism: a "soft view," which holds that technological change drives social change but at the same time responds discriminatingly to social pressures, and a "hard view," which perceives technological development as an autonomous force, completely independent of social constraints.[2]

The intellectual heritage of technological determinism can be traced to the enthusiasm and faith in technology as a liberating force expressed by leaders of the eighteenth-century Enlightenment. Within this tradition at least two streams of thought—one enthusiastic, the other critical—contributed to the formulation of the determinist position. Both viewpoints hold technology and science to be powerful agents of social change. This is noteworthy because deterministic thinking took root when people began to attribute agency to technology as a historical force. One sees such thought in the celebration of the new science by Voltaire, James Ferguson, and J. T. Desaguliers, in the memorable verses of Alexander Pope, in Diderot's *Encyclopedie,* in James Watt's ingenious feedback mechanisms, in the popular eighteenth-century metaphor of a clockwork universe, and

1. Memo from Wade Roush to the author, March 31, 1992 (in the author's possession).

2. Although he does not adopt the adjectives "soft" and "hard," Thomas J. Misa distinguishes between the various versions of technological determinism in "How Machines Make History, and How Historians (and Others) Help Them to Do So" (*Science, Technology, and Human Values* 13 (1988): 308–331) (see esp. p. 309). For a criticism and a denial of the distinction between hard and soft determinism, see Bruce Bimber's essay in this volume. Also see Alex Roland, "Theories and Models of Technological Change: Semantics and Substance," *Science, Technology, and Human Values* 17 (1992): 90–92.

even in the critical perspectives of such later essayists as Thomas Carlyle. Above all, deterministic thinking can be seen in the conception and popular acceptance during the eighteenth century of the idea of progress.[3]

While technological determinism initially sprouted in Europe, it found even more fertile ground in the newly independent United States—primarily because Americans were so taken with the idea of progress. Benjamin Franklin and Thomas Jefferson, foremost among the new nation's prophets of progress, were true believers in humankind's steady moral and material improvement. As avid proponents of the cause of liberty, they looked to the new mechanical technologies of the era as means of achieving the virtuous and prosperous republican society that they associated with the goals of the American Revolution. For them, progress meant the pursuit of technology and science in the interest of human betterment (intellectual, moral, spiritual) and material prosperity. Both men emphasized that prosperity meant little without betterment; a proper balance between them had to be maintained. Indeed, Jefferson's oft-repeated reservations about large-scale manufacturing reflected his concern about the fragility of liberty, power, and virtue in society and his sense of how easily a republic could be corrupted. If carried to extremes, Jefferson worried, the civilizing process of large-scale technology and industrialization might easily be corrupted and bring down the moral and political economy he and his contemporaries had worked so hard to erect. As much as Jefferson esteemed discovery and invention, he considered them *means* to achieving a larger social end. For his part, Benjamin Franklin refused to patent his inventions, for, as he put it, "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." An exemplar of the Enlightenment, the author of Poor Richard's memorable aphorisms considered his inventions not a source of private wealth but a benefit for all members of society.[4]

3. For an introduction to the literature on technology and the idea of progress, see Merritt Roe Smith, "Technology, Industrialization, and the Idea of Progress in America," in *Responsible Science: The Impact of Technology on Society,* ed. K. B. Byrne (Harper & Row, 1986), and Leo Marx, "Does Improved Technology Mean Progress?" *Technology Review* (January 1987): 33–41, 71.

4. Smith, "Technology, Industrialization, and the Idea of Progress in Amer-

However, just when Franklin and Jefferson were espousing a new republican technology sensitive to human perfection, a more technocratic vision of progress was beginning to emerge. Evident in the speeches and writings of Alexander Hamilton and his associate at the U.S. Treasury Department, Tench Coxe, this new viewpoint openly attributed agency and value to the age's impressive mechanical technologies and began to project them as an independent force in society. Although Hamilton is remembered as the country's leading exponent of mechanized manufacturing during the 1790s, Coxe (1755–1824) was its most eloquent and persistent advocate. Like many of his contemporaries, Coxe believed that America's political independence hinged on the establishment of economic independence. Given the country's dependent economic status, he emphasized the need for machine-based manufactures as the prime solution to its political problems. Indeed, he told an audience of sympathetic listeners in the summer of 1787 that manufacturing under the factory system represented "the means of our POLITICAL SALVATION." "It will," he noted, "consume our native productions . . . it will improve our agriculture . . . it will accelerate the improvement of our internal navigation . . . it will lead us once more into the paths of virtue by restoring frugality and industry, those potent antidotes to the vices of mankind and will give us real independence by rescuing us from the tyranny of foreign fashions, and the destructive torrent of luxury."[5] Whereas Jefferson had emphasized technological development in the interest of the spiritual needs of individual citizens, Coxe shifted the emphasis away from human betterment and toward more impersonal societal ends, particularly the establishment of law and order in an unstable political economy. From the start,

ica," pp. 2–4; Marx, "Does Improved Technology Mean Progress?" pp. 35–37 (Franklin quote: p. 36).

5. Tench Coxe, *An Address to an Assembly of the Friends of American Manufactures, Convened for the Purpose of Establishing a Society for the Encouragement of Manufactures and the Useful Arts, Read in the University of Pennsylvania, on Thursday the 9th of August 1787,* reprinted in *The Philosophy of Manufactures: Early Debates Over Industrialization in the United States,* ed. M. B. Folsom and S. D. Lubar (MIT Press, 1982) (quotes from pp. 61–62). For perceptive treatments of Coxe's writings see John F. Kasson, *Civilizing the Machine* (Grossman, 1976), and Leo Marx, *The Machine in the Garden* (Oxford University Press, 1964), pp. 150–169.

technological determinism proved highly compatible with the search for political order.

As industrial capitalism gained a firmer grip on the American economy during the early decades of the nineteenth century, Coxe's technocratic perspective became increasingly dominant among other segments of the population.[6] While evidence of tension and discontent could be found among the new class of industrial workers and in the works of certain artists and intellectuals, by and large journalists, popular orators, and politicians hailed "the progress of the age," reassuring their audiences that technological innovation not only exemplified but actually guaranteed progress. The evidence for progress seemed incontrovertible. Decade by decade the pace of technological change quickened—railroads, steamships, machine tools, telegraphy, structures of iron and steel, electricity—and with each decade the popular enthusiasm for "men of progress" and for their inventions grew. Ralph Waldo Emerson, often a critic of the new mechanical age, exclaimed "Life seems made over new." "Are not our inventors," asked another enthusiastic writer, "absolutely ushering in the very dawn of the millennium?" It certainly seemed so to Horace Greeley, the editor of the *New York Tribune.* Upon visiting New York's Crystal Palace Exhibition in 1853, he pronounced: "We have universalized all the beautiful and glorious results of industry and skill. We have made them a common possession of the people. . . . We have democratized the means and appliances of a higher life." A writer in the prominent *North American Review* asserted that the benefits of machinery "are seen every where, felt every where, and must abide forever."[7]

What began as a trickle of enthusiasm for technology in the late eighteenth century became a rivulet by the Civil War and continued

6. Leo Marx provides an insightful discussion of the origins of the technocratic spirit in his contribution to this volume.

7. "Works and Days," in *Emerson's Works,* vol. 7, *Society and Solitude* (Houghton, Mifflin, 1870), p. 158; Douglas T. Miller, *The Birth of Modern America, 1820–1850* (Pegasus, 1970), p. 32; Horace Greeley, ed., *Art and Industry at the Crystal Palace* (Redfield, 1853), pp. 52–53; "Effects of Machinery," *North American Review* (Boston) 34 (January 1832): 226–227. For further documentation see Hugo A. Meier, "Technology and Democracy, 1800–1860," *Mississippi Valley Historical Review* 43 (1957): 618–640, and Russell B. Nye, *Society and Culture in America, 1830–1860* (Harper & Row, 1974), pp. 3–31, 258.

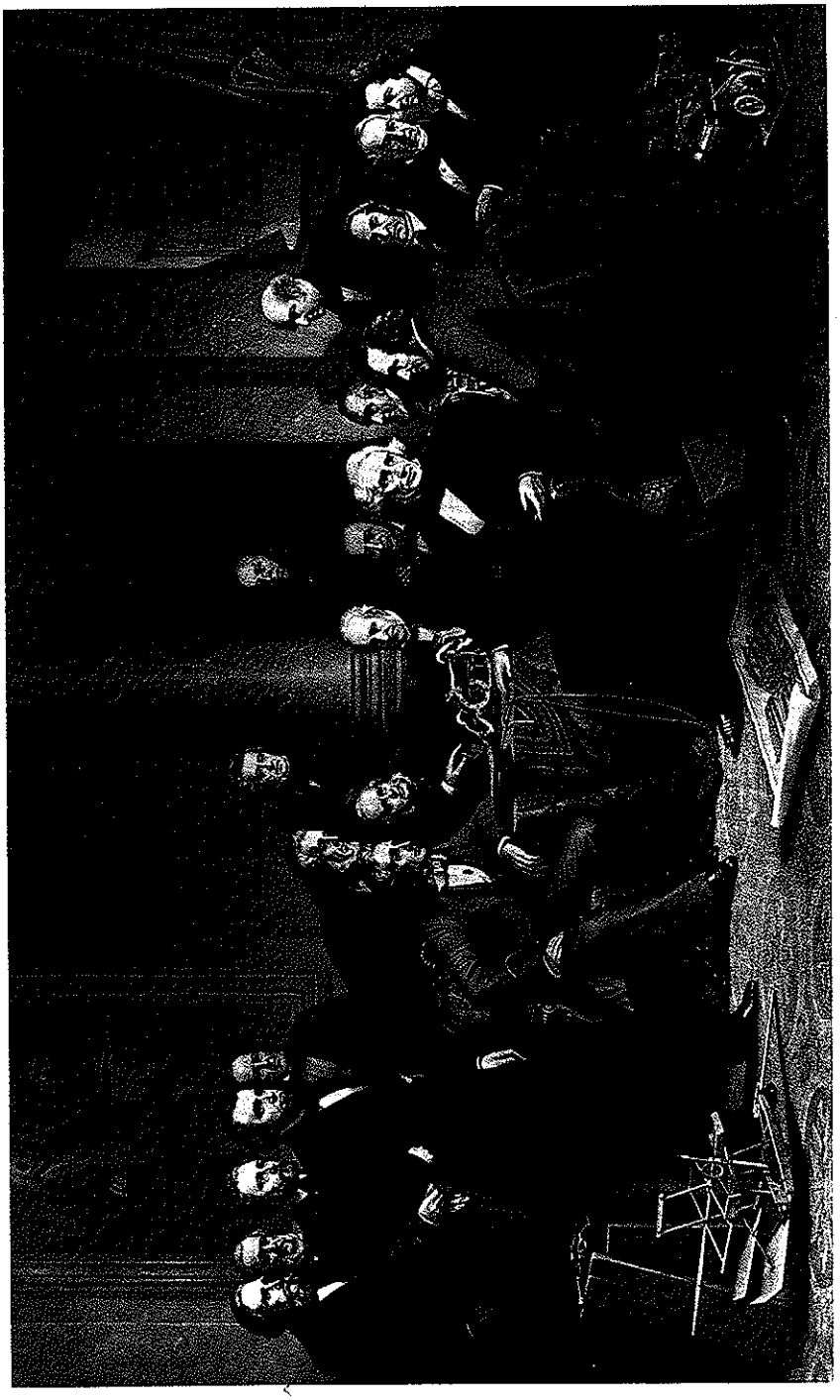

Figure 1
Christian Schussele's portrait "Men of Progress" (1863) celebrated the role of inventors in American society and sought to place them in the pantheon of national heroes. Among those portrayed are Samuel Colt (inventor of the revolving pistol bearing his name, third from left), Cyrus McCormick (fourth from left, standing beside a model of his reaper), Charles Goodyear (seventh from left, with a pair of rubber boots beneath his chair), and Elias Howe (extreme right, sitting behind his patented sewing machine). Samuel F. B. Morse (seventh from right) occupies the most prominent position in the portrait. He is seated at the table, demonstrating his telegraphic apparatus to the group, and has turned to converse with Robert Hoe (fifth from right), whose rotary printing press is represented by the drawing on the floor at Morse's feet. At upper left hangs a portrait of Benjamin Franklin, considered by many to be the symbol of American inventive genius and, appropriately in this instance, an important precursor of Morse in electrical experimentation. For further information, see Brooke Hindle and Steven Lubar, *Engines of Change* (Smithsonian Institution Press, 1986), pp. 75–77. Photograph courtesy of Dibner Institute for History of Science and Technology.

to surge thereafter. Between the 1860s and the early 1900s, many popular books, articles, paintings, and lithographs celebrating the new technology found their way into America's parlors and sitting rooms. A sampling of books from the period reveals such titles as *Eighty Years of Progress, Men of Progress, Triumphs and Wonders of the 19th Century, The Progressive Ages or Triumphs of Science, The Marvels of Modern Mechanism, Our Wonderful Progress, The Wonder Book of Knowledge,* and *Modern Wonder Workers.* The belief that in some fundamental sense technological developments determine the course of human events had become dogma by the end of the century. Writing in 1899, James P. Boyd confidently asserted that "the nineteenth century stands out in sublime and encouraging contrast with any that has preceded it." "As the legatee of all prior centuries," he continued, "it has enlarged and ennobled its bequest to an extent unparalleled in history." "Indeed," he concluded, "it may be said that along many of the lines of invention and progress which have most intimately affected the life and civilization of the world, the nineteenth century has achieved triumphs and accomplished wonders equal, if not superior, to all other centuries combined."[8]

8. James P. Boyd, *Triumphs and Wonders of the 19th Century* (C. W. Stanton, 1899), p. i. Also see, for example, *Eighty Years' Progress of the United States* (L. Stebbins, 1864); James H. Parton et al., *Sketches of Men of Progress* (New York and Hartford Publishing Co., 1870); Benson J. Lossing, *The American*