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Author(s): LEO MARX
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Technology: The Emergence of a Hazardous Concept*

BY LEO MARX

"... the essence of technology is by no means anything technological."
—Heidegger[1]

New Concepts as Historical Markers

THE history of technology is one of those subjects that most of us know more about than we realize. Long before the universities recognized it as a specialized field of scholarly inquiry, American public schools were routinely disseminating a sketchy outline of that history to a large segment of the population. They taught us about James Watt and the steam engine, Eli Whitney and the cotton gin, and about other great inventors and their inventions, but more important, they led us to believe that technological innovation is a—probably *the*—major driving force of human history. The theme was omnipresent in my childhood experience. I met it in the graphic charts and illustrations in my copy of *The Book of Knowledge*, a children's encyclopedia, and in the alluring dioramas of early Man in the New York Museum of Natural History. These

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exhibits displayed the linear advance of humanity as a series of transformations, chiefly represented by particular inventions—from primitive tools to complex machines—by means of which Homo sapiens acquired its unique power over nature. This comforting theme remains popular today, and it insinuates itself into every kind of historical narrative. Here, for example, is a passage from a recent anthropological study of apes and the origins of human violence:

> Our own ancestors from this line [of woodland apes] began shaping stone tools and relying much more consistently on meat around 2 million years ago. They tamed fire perhaps 1.5 million years ago. They developed human language at some unknown later time, perhaps 150,000 years ago. They invented agriculture 10,000 years ago. They made gunpowder around 1,000 years ago, and motor vehicles a century ago (Wrangham and Peterson, 1996, p. 61).

This capsule history of human development from stone tools to Ford cars illustrates the shared "scientific" understanding, circa 1997, of the history of technology. But one arresting if infrequently noted aspect of this familiar account is the belated emergence of the word used to name the very rubric—the kind of thing—that allegedly drives our history: *technology*. The fact is that during all but the very last few seconds, as it were, of the ten millennia of recorded human history encapsulated in this passage, the concept of *technology*—in our sense of its meaning—did not exist. The word, based on the Greek root, *techne* (meaning, or pertaining to, art, craft) originally came into English in the seventeenth century, but it then referred to a kind of learning, discourse, or treatise, concerned with the mechanic arts. At the time of the Industrial Revolution, and through most of the nineteenth century, the word *technology* primarily referred to a kind of book; except for a few lexical pioneers, it was not until the turn of this century that sophisticated writers like Thorstein Veblen began to use the word to mean the mechanic arts collectively. But that sense of the word did not gain wide currency until after

World War I.[2] (It is curious that many humanist scholars—I include myself—have so casually projected the idea back into the past, and into cultures, in which it was unknown.) The fact is that this key word—designator of a pivotal concept in contemporary discourse—is itself a surprisingly recent innovation.

Why does that matter? From a cultural historian's viewpoint, the emergence of such a crucial term—whether a newly coined word or an old word invested with radically new meaning—often is a marker of far-reaching developments in society and culture. Recall, for example, Tocqueville's tacit admission, in *Democracy in America,* that he could not do justice to his subject without coining the strange new term "individualism" (Tocqueville, 1946, II, p. 98); or Raymond Williams, who famously discovered, in writing *Culture and Society,* a curious interdependence, indeterminacy, or reflexivity in the relation between concurrent changes in language and in society. Williams had set out to examine the transformation of culture coincident with the rise of industrial capitalism in Britain, but he found that the word *culture* itself, like such other key words as *class, industry, democracy, art,* had acquired its meanings in response to the very changes he proposed to analyze. It was not simply that the word *culture* had been influenced by those changes, but that its meaning had in large measure been entangled with—and in some degree generated by—them (Williams, 1983, pp. xiii–xviii). A recognition of this circular process helps to account for the origin—and the significance—of *technology* as a historical marker.

But how do we identify the changes in society and culture marked by the emergence of *technology?* I assume that those changes in effect created a semantic void, that is, a set of social circumstances for which no adequate concept was yet available—a void that the new concept, *technology,* eventually would fill. It would prove to be a more adequate, apt referent for those novel circumstances than its immediate precursors—words like *machine, invention, improvement,* and, above all, the ruling concept of the *mechanic* (or *useful* or *practical* or *industrial*) *arts.* In a seminal essay of 1829, Thomas Carlyle had announced that the appropriate name for the emerging era was "The Age of Machinery" (Carlyle, 1829). But later in the century, *machinery* evidently came to seem inadequate, and the need for a more apt term evidently was felt. The obvious questions, then, are: Why was there a semantic void? Which new developments created it? What meanings was *technology* better able to convey than its precursors? In trying to answer these questions, I also propose to assess the relative merits and limitations of the concept of *technology*.

As for the *hazardous* character of the concept, at this point I need only say that the alleged hazard is discursive, not physical. I am not thinking about weaponry, nor am I thinking about the destructive uses of other technologies; rather, I have in mind hazards inherent in, or encouraged by, the concept itself—especially when the singular noun (*technology*) is the subject of an active verb, and thus by implication an autonomous agent capable of determining the course of events, as we constantly hear in countless variants of the archetypal sentence: "Technology is changing the way we live." When used in this way, I submit, the concept of *technology* becomes hazardous to the moral and political cogency of our thought. My argument, let me add, should not—if sufficiently clear—provide comfort to either the luddites or the technocrats. On the contrary, my hope is that it may help to end the banal, increasingly futile debate between these two dogmatic, seemingly irrepressible parties.

The Mechanic Arts and the Changing Ideology of Progress

By the 1840s, some of the changes that contributed to the emergence of the concept of *technology* were becoming apparent. They may be divided into two large categories, ideological and substantive: first, changes in the prevailing ideas about the mechanic arts, and second, changes in the organizational and material matrix of the mechanic arts.[3] As a reference point for both kinds of change, here is the peroration of a ceremonial speech delivered by Senator Daniel Webster at the opening of a new section of the Northern Railroad in Lebanon, New Hampshire, on November 17, 1847:

> It is an extraordinary era in which we live. It is altogether new. The world has seen nothing like it before. I will not pretend, no one can pretend, to discern the end; but every body knows that the age is remarkable for scientific research into the heavens, the earth, and what is beneath the earth; and perhaps more remarkable still for the application of this scientific research to the pursuits of life. The ancients saw nothing like it. The moderns have seen nothing like it till the present generation. . . . We see the ocean navigated and the solid land traversed by steam power, and intelligence communicated by electricity. Truly this is almost a miraculous era. What is before us no one can say, what is upon us no one can hardly realize. The progress of the age has almost outstripped human belief; the future is known only to Omniscience.[4]

The first ideological development that the word *technology* would eventually ratify, as indicated by Webster's exemplary display of the "rhetoric of the technological sublime," has to do with the perceived relation between innovations in science, the mechanic arts, and the prevailing belief in progress.[5] When Webster depicts the railroad as epitomizing—indeed, as constituting in itself—the progress of the age, he is confirming a subtle modification of the earlier Enlightenment concept of history as a record of progress.

Of course the idea of progress had been closely bound up, from its inception, with the accelerating rate of scientific and mechanical innovation. To call progress "an idea," incidentally, as if it were merely one idea among many, is to belittle it. By the time of Webster's speech, it had become the fulcrum of an all-encompassing secular world view, and, in a sense, modernity's nearest secular equivalent of the creation myths that embody the belief systems of premodern cultures. In the context of the seventeenth-century scientific revolution, the word *progress* had served, in a straightforward literal sense, to signify a series of incremental advances, within clearly bounded enterprises with specific goals, such as the development of the microscope or telescope. But later, in the era of the American and French revolutions, so many examples of this once clearly defined and bounded kind of progress had become manifest that the word's meaning was extended to the entire—boundless—course of human events. History itself was redefined as a record of the steady, cumulative, continuous expansion of human knowledge of, and power over, nature—knowledge and power that might be expected to result in a universal improvement in the conditions of human life.

But the republican thinkers who led the way in framing this "master narrative" of progress—men like Condorcet and Turgot, Paine and Priestley, Franklin and Jefferson—did not, like Webster, equate progress with innovations in the mechanic arts. They were radical republicans, political revolutionists, and although they celebrated innovations in the mechanic arts, they celebrated them not as constituting progress in themselves, but rather as the means of attaining it; to them the true measure of progress was to be humanity's forthcoming liberation from aristocratic, ecclesiastical, and monarchic oppression, and the establishment of more just, peaceful societies based on the consent of the governed. What requires emphasis here is their strong conviction about the relationship between the arts and the rest of society and culture. To them, advances in science and the mechanic arts were chiefly important as a *means* of arriving at social and political *ends*.[6]

By Webster's time, however, that distinction already had lost most of its force. This was partly due to the presumed success of the republican revolutions, and to the complacent conservatism induced by the rapid growth of the immensely productive and lucrative capitalist system of manufactures. Thus Senator Webster, whose most important constituents were factory owners, merchants, and financiers, did not think of the railroad as merely instrumental—merely a means of achieving social and political progress. He identified his own interests with the company directors and stockholders who enjoyed the profits, and in his view the railroad exemplified a socially transformative power of such immense scope and promise as to be a virtual embodiment—the perfect icon—of progress.

The new entrepreneurial elite for whom Webster spoke was thus relieved of its presumed obligation to fulfill the old republican political mandate. Although the Boston Associates—the merchants who launched the Lowell textile industry—were concerned about the social and political effects of their new industrial venture, they chiefly expressed their sense of social obligation by acts of private philanthropy (Dalzell, 1987). Innovations in the mechanic arts could be relied upon, in the longer term, to issue in progress and prosperity for all. A distinctive feature of the new mechanic arts, moreover, was their tangibility—their omnipresence as physical, visible, sensibly accessible objects. Thus new factories and machines might be expected, in the ordinary course of their operations, to automatically disseminate the belief in progress to all levels of the population. As John Stuart Mill acutely observed, the mere sight of a potent machine like the railroad in the landscape wordlessly inculcated the notion that the present is an improvement on the past, and that the wondrous future is imaginable, as Webster put it, "only to Omniscience" (Mill, 1865, II, p. 148).

But in the 1840s this blurring of the distinction between mechanical means and political ends also provoked ardent criticism. It was denounced by a vocal minority of dissident intellectuals as a sign of moral negligence and political regression. Thus Henry Thoreau, who was conducting his experiment at the pond in 1847, the year Webster gave his speech, writes in *Walden*:

> There is an illusion about . . . [modern improvements]; there is not always a positive advance. . . . Our inventions are wont to be pretty toys, which distract our attention from serious things. They are but improved means to an unimproved end (Thoreau, 1950, p. 46).

And in *Moby-Dick*, Herman Melville, after paying tribute to Captain Ahab's natural intellect and his mastery of the art of whaling, has him acknowledge the hazardous mismatch between his technical proficiency and his irrational purpose: "Now, in his heart, Ahab had some glimpse of this, namely, all my means are sane, my motive and my object mad" (Melville, 1967, p. 161).

This critical view of the new industrial arts marked the rise of an adversary culture that would reject the dominant faith in the advance of the mechanic arts as a self-justifying social goal. Indeed, a direct line of influence is traceable from the intellectual dissidents of the 1840s to the widespread 1960s rebellion against established institutions—from, for example, Thoreau's recommendation, in "Civil Disobedience" (1849); to "Let your life be a counter-friction to stop the machine" (Thoreau, 1950, p. 644); to Mario Savio's 1964 exhortation to Berkeley students: "You've got to put your bodies upon the [machine] and make it stop!" (Lipset and Wolin, 1965, p. 163). From its inception, the countercultural movement of the 1960s was seen—and saw itself—as a revolt against an increasingly "technocratic society."[7]

The Construction of Complex Sociotechnological Systems

I turn now to the substantive changes in the material character and organizational matrix of the mechanic arts that also helped to create the void to be filled by the new concept of *technology*. In Webster's view, these changes were embodied in the new machine itself—the railroad as a material and social artifact. Early in the industrial revolution innovations in the mechanic arts had been typified by single, freestanding, more or less self-contained mechanical inventions: the spinning jenny, the power loom, the steam engine, the steamboat, the locomotive, the dynamo, or, in a word, machines. By Webster's time, however, the discrete machine was replaced, as the typical embodiment of the new power, by a new kind of sociotechnological system. The railroad was one of the earliest, most visible of these large-scale, complex systems in the modern era.[8] A novel feature of these systems is that the crucial physical-artifactual, or mechanical component—

the steam locomotive, for example—constitutes a relatively small part of the whole.

Thus, in addition to the engine itself, the operation of a railroad required: (1) various kinds of ancillary equipment (rolling stock, stations, yards, bridges, tunnels, viaducts, signal systems, and a huge network of tracks); (2) a corporate business organization with a large capital investment; (3) specialized forms of technical knowledge (railroad engineering, telegraphy); (4) a specially trained work force with unique railroading skills, including civil and locomotive engineers, firemen, telegraphers, brakemen, conductors—a work force large and resourceful enough to keep the system going day and night, in all kinds of weather, 365 days a year; and (5) various facilitating institutional changes, such as laws establishing standardized track gauges and a national system of standardized time zones.

Eventually these large, tightly organized yet amorphous networks—like the telegraph and wireless systems, the electric power and use system, and so on—led to the replacement of the traditional family (father and sons) firm by the corporation as the dominant American form of business organization, and to the emergence of a new kind of professional or (as it later would be called in the United States) "scientific" management (Bijker et al., 1987, pp. 51–82; Chandler, 1977, pp. 79–120). A prominent feature of these complex, messy, ad hoc systems is the lack of clear boundary lines between their constituent elements. Of central significance here is the blurring of the boundary between the material-artifactual component (the mechanical equipment or hardware) and the rest: the cognitive, technical, or scientific components; the hierarchically organized work force; the financial apparatus; and the method of obtaining raw materials.

Another development that contributed to the complexity, scale, and singularity of the new systems was the increasing convergence, in the nineteenth century, of scientific knowledge and the mechanic arts. Webster had alluded to electricity and the telegraph, and had linked the advent of the railroad to "scientific research into the heavens, the earth, and what is beneath the earth." The fact is that the building of the railroads did mark a new departure in this respect. Whereas most earlier innovations of the industrial revolution had been made by practical, mechanically adept, rule-of-thumb tinkerers with little or no scientific education, a number of West Point-trained military engineers brought a more formal kind of technical education, in part derived from the Ecole Polytechnique, to the building of the American railroads (hence the emergence of *civil* engineering, to distinguish the civilian from the military branches of the profession).[9] By 1847, the joining of science and the practical arts was under way, but it was not until the end of the century, with the growth of the electrical and chemical industries, that the large-scale amalgamation of science and industry helped to call forth the concept of a new realm of innovation and transformative power—a new entity—called *technology* (Noble, 1977).

As early as 1828, to be sure, the prospect of amalgamating science and industry already had elicited an explicit statement—evidently the first ever made—about the need for that new concept. In a series of lectures at Harvard entitled "The Elements of Technology," Jacob Bigelow, a Boston botanist and physician, put the case this way:

> There has probably never been an age in which the practical applications of science have employed so large a portion of talent and enterprise . . . as in the present. To embody . . . the various . . . [aspects] of such an undertaking, *I have adopted the general name of Technology, a word sufficiently expressive, which is found in some of the older dictionaries, and is beginning to be revived in the literature of practical men at the present day.* Under this title . . . [I will attempt] to include . . . the principles, processes, and nomenclatures of the more conspicuous arts, particularly those which involve applications of science, and which may be considered useful, by promoting the benefit of society, together with the emolument of those who pursue them.[10]

But Bigelow was far ahead of his time. The concept of *technology* did not gain currency in the intellectual world for almost a century. His greatest success in disseminating the new term probably was its precocious use in naming a new institution of learning—The Massachusetts Institute of Technology—in 1862. (He also became a trustee of MIT.) But even at the mid-century, few writers availed themselves of the term. Karl Marx and Arnold Toynbee (a forebear of the twentieth-century historian), both of whom wrote extensively about the changes effected by the new machine power, seldom if ever used it. As late as the first (1867) edition of *Capital*, where Marx's subject—the way "machinery . . . forms new systems of manifold machines"—cries out for the new concept, he relied on terms like *factory mechanism,* and other relics of the old mechanistic lexicon (Marx, Karl, 1978). At points in Toynbee's influential lectures on the Industrial Revolution, composed in 1880–81, where *technology* would have been apposite, he also relied on conventional older terms like *mechanical discoveries, improvements,* or *inventions.*[11]

Early in the twentieth century the avant-garde of the modernist movement in the arts, with its several technology-affirming submovements—including the vogue of "Machine Art" and of machine-like styles in Futurism, Precisionism, Constructivism, Cubism, and the International Style in architecture—helped to elevate motifs formerly treated as merely instrumental to the plane of intrinsic (verging on ultimate) aesthetic value. In the Bauhaus aesthetic, design was married to industry. Indeed, the entire modernist turn to Mondrian-like abstraction—the new respect accorded to novel geometric, rectilinear, nonrepresentational styles—comported with the markedly abstract, mathematical, cerebral, practical, artificial (that is, not "organic" or "natural") connotations of the emerging concept, *technology.*

But the word itself did not gain truly popular currency until well after the astonishing explosion of inventions in the decades (roughly 1880–1920) bracketing the turn of the century. That decisive period, sometimes called the Second Industrial Revolution, marked the advent of electric light and power, the automobile, the radio, the telephone, the airplane, and the moving picture. As compared with the innovations of the first industrial revolution, these inventions were marked by their relative cleanliness, and by their dependence on advances in science. Each of these artifacts eventually formed the material core of a large, complex sociotechnological system. Each also was sufficiently impressive for inclusion in the iconology of progress. Of all the enduring testimonials to the dynamism of that era, none conveyed a more vivid sense of the accelerating rate of change keyed to new inventions than *The Education of Henry Adams* (first published privately in 1907). Adams announced the appearance of a new American, "born since 1900," who was

> the child of incalculable coal-power, chemical power, electric power, and radiating energy, as well as new forces yet undetermined—[and who] must be a sort of God compared with any other former creation of nature. At the rate of progress since 1800, every American who lived to the year 2000 would know how to control unlimited power. He would think in complexities unimaginable to an earlier mind (Adams, 1973, pp. 496–97).

Adams rarely if ever used the term *technology*, and in retrospect indeed his preferred vocabulary—*energy, power, forces*—often seems more vivid and evocative, more effective rhetorically, than the new term. But in spite of—or perhaps because of—its lack of connotative resonance, *technology* began to take hold of the imagination of writers in the early years of the new century. By 1904, Thorstein Veblen, who perhaps did more than any of his contemporaries to popularize the idea of *technology* and its unique transformative power, asserted that "The factor in the modern situation that is alien to the ancient regime is the machine technology, with its many and wide ramifications." He contended that this radically innovative mode of making and doing would literally transform the mental processes of those who used it.

> The machine compels a more or less unremitting attention to phenomena of an impersonal character and to sequences and correlations not dependent for their force upon human predilection nor created by habit or custom. The machine throws out anthropomorphic habits of thought. It compels the adaptation of the workman to his work, rather than the adaptation of the work to the workman. . . . [It] gives no insight into questions of good and evil, merit and demerit. . . . The machine technology takes no cognizance of . . . rules of precedence; . . . it can make no use of any of the attributes of worth. Its scheme of knowledge . . . is based on the laws of material causation, not on those of immemorial custom, authenticity, or authoritative enactment. Its metaphysical basis is the law of cause and effect, which in the thinking of its adepts has displaced even the law of sufficient reason (Veblen, 1932, pp. 303, 310–11).

Veblen, along with Frederick Winslow Taylor and Howard Scott—who led the Technocracy Movement of the 1930s—also helped to popularize the seductive idea, foreshadowed in Webster's 1847 speech, that the miraculous improvements in the conditions of life made possible by technology might enable society to dispense with politics as its primary means of directing social change. This line of thought may be said to have culminated in the "liberal consensus" of the Kennedy era, when enthusiasm for the power of technology to replace politics became the quasiofficial doctrine of the administration; it was accompanied by confident academic predictions of the forthcoming "end of ideology."

Technology *Fills the Void*

At the outset I suggested that Daniel Webster's 1847 speech points to the existence of a conceptual void that would eventually be filled by the idea of *technology*. What was missing, from an ideological standpoint, was the concept of a form of power—of progress — that far exceeded, in degree, scope, and scale, the relatively limited capacity of the merely *useful* (or *mechanic* or *practical* or *industrial*) *arts* to generate social change. What was needed was a concept that did not merely signify, like the useful arts, a means of achieving progress, but rather one that signified a discrete entity that, in itself, virtually constituted progress. Besides, the idea of utility had long borne the stamp of vulgarity. Ever since antiquity, the useful arts in their various guises, had been regarded as intellectually and socially inferior to the *high* (or *fine, creative,* or *imaginative*) arts. The concept of the *useful arts* and its variants implied, if only because it explicitly designated a subordinate branch of the all-inclusive entity, the arts, a limited and limiting category. Indeed, the distinction between the useful and the fine arts had served to ratify a set of invidious distinctions between things and ideas, the physical and the mental, the mundane and the ideal, body and soul, female and male, making and thinking, the work of enslaved men and that of free men. By associating the railroad with science, business, and wealth, Webster and his contemporaries created the need for a term that would erase this derogatory legacy and elevate the useful to a higher intellectual and social plane.

All of these ideological purposes, and more, were served by the relatively abstract, indeterminate, neutral, synthetic-sounding term *technology*. Whereas the *mechanic arts* called to mind men with soiled hands tinkering at workbenches, *technology* conjures up images of clean, well-educated, white male technicians in control booths gazing at dials, instrument panels, or computer monitors. And whereas the mechanic arts were thought of as belonging to the mundane world of everyday work, physicality, and practicality—of humdrum handicrafts and artisanal skills—*technology* is identified with the more elevated social and intellectual realm of the university. This abstract word, with its vivid blankness, its lack of a specific artifactual, tangible, sensuous referent, its aura of sanitized, bloodless cerebration and precision, helped to ease the introduction of the practical arts—especially the new engineering profession—into the precincts of the higher learning.

Turning to the other half of the conceptual void, what was missing, from an organizational and material standpoint, was a name for the novel entity—a distinct new kind of sociotechnical formation—which emerged in the nineteenth century. This new entity has been called "a large-scale technological system," but that term begs an important question: Which aspect is technological? Where, exactly, is the *technology*? To be sure, the indispensable material component of these formations invariably is a distinctive material device, a piece of equipment designed to facilitate production, transportation, communication, or for that matter any form of human making or doing. But as we have seen, over time that pivotal artifactual component had come to constitute an increasingly minute part of the whole. Think of the computer chip!

Although in common parlance nowadays this material aspect often is what the concept of *technology* tacitly refers to, such a limited meaning—as we saw in the case of the railroad—is ambiguous and misleading. It is ambiguous because, for one thing, the artifactual component only constitutes a part of the whole system, yet the rest is so inclusive, so various, and its boundaries so vague, that it resists being clearly designated. This ambiguity surely is a large part of what Heidegger had in mind when he enigmatically asserted that "the essence of technology is by no means anything technological," and it also goes, as we shall see, to my assertion that *technology*, as the concept is used in public discourse nowadays, is hazardous. For in the major contemporary technologies the material component—*technology* narrowly conceived as a physical device—is merely one part of a complex social and institutional matrix. In capitalist societies that matrix typically takes the form of a private corporation, bank, or public utility with a large capital investment. (It is of course relevant that the concept emerged at the end of the era characterized by what Alan Trachtenberg has called "the incorporation of America" [Trachtenberg, 1982]). But these large technological systems also may be embedded in other kinds of macroinstitution, for example, branches of government, such as the military or the space program, or universities. They typically include an organized body of technical know-how; a cadre of specially trained experts and workers; and a related university teaching and research program. Moreover, the functioning of these systems, or technologies, often entails the creation of special legislative and regulatory bodies, as well as ancillary organizations for the supply of raw materials and the distribution of its products.

There is a compelling logic implicit in the emergence of this ambiguous, unspecific, indeterminate, well-nigh indefinable concept, *technology*, as a name for these ambiguous, messy, incoherent, new formations. This congruence takes us back to Raymond Williams's insight into the curious interdependence, or reflexivity, involved in the social construction of historical markers like *culture* or—in this case—*technology*. Earlier, I noted the blurring of the lines of demarcation—internally as it were—between the various components of a particular mechanic art, and the reduced relative importance of the material-artifactual component. But even more significant, perhaps, is the breakdown of the boundary separating whole technologies from the rest of society and culture.

Consider, for example, automotive technology. Its defining, indispensable material core is of course the internal combustion engine, plus—naturally—the rest of the automobile chassis. But surely it also includes the mechanized assembly lines, the great factories, the skilled work force, the automotive engineers, the engineering knowledge, the corporate structures with their stockholders and their huge capital investments, and their networks of dealers and repair facilities. But where do we draw the boundary separating all of this from the rest of society and culture? Do we include, as part of automotive technology, the road-building and maintenance systems, the trucking industry, the indispensable feeder industries—glass, rubber, steel, aluminum, plastic, and so on? What about the mines that provide the raw materials? Indeed, what about the global oil industry—an offspring of automotive technology that vies, in size, wealth, and influence, with its parent? At its outer limits, the intricate interpenetration of automotive technology and the rest of society and culture seems boundless and, finally, indescribable. The economic role of automotive technology, in its most comprehensive sense, is incalculable; as a source of jobs, for example, it may well account for as much as a fifth of the American work force. To speak, as people often do, of the "impact" of a major technology like the automobile upon society makes little more sense, by now, than to speak of the impact of the bone structure on the human body. But it is when we speak of the overall impact of *technology*, when the term putatively represents a discrete category of human activity, that its most hazardous consequences come into view.

The Hazards of Reification

The hazardous character of the concept of *technology* is a direct consequence of the history just outlined. That history has two major strands. We encounter one strand in common parlance nowadays, when *technology* is used as if it referred to a tangible, determinate entity—a kind of thing. This usage is traceable to the word's tacit place in that familiar lineage of material artifacts, from stone tools to automobiles, introduced at the outset. Indeed, historians and other scholars in the human sciences now tend to project the concept of *technology* backward in time to encompass the entire history of tools. Yet, as we have seen, the concept only came into general use when, at the end of the nineteenth century, the age-old artifactual lexicon of the mechanic arts had become inadequate. That is where the second strand in the history of the term comes in. The idea of tools or machines or, for that matter, any other material artifacts did not begin to convey the complex, quasiscientific, corporate character of the new sociotechnical formations that emerged at that time. The curious fact is that the discursive triumph of the concept of *technology* is in large measure attributable to its vague, intangible, indeterminate character—the fact that it does *not* refer to anything as specific or tangible as a tool or machine. If the first strand gives us a concept of technology that overemphasizes the tangible, the second is so inclusive as to be amorphous. But then, we finally are compelled to ask, what sort of entity is technology? What does its history reveal about its essential nature?

A significant result of that history, with its unstable marriage of artifacts and socioeconomic structures, is that the concept, *technology*, is peculiarly susceptible to reification. To borrow George Lukacs's lucid definition, reification occurs when "a relation between people takes on the character of a thing and thus acquires a 'phantom-objectivity,' an autonomy that seems so strictly rational and all-embracing as to conceal every trace of its fundamental nature: the relation between people." A distinctive result of reification observed by Karl Marx, Lukacs reminds us, is the power exerted by commodities over human beings; in that case social relations between people were mysteriously endowed with an objective, even autonomous character (Lukacs, 1971, pp. 83–87). I believe that something similar has happened with technology, which also has taken on an objective character, as if it existed independent of its human creators, and is capable of controlling them by virtue of an autonomy alien to them (Winner, 1977).

But it will be said that, whatever its limitations, the concept *technology* remains indispensable as the name for an increasingly large portion of human activity at the end of the twentieth century. Witness its widespread use nowadays to convey a sense of the accelerating diffusion of new technologies; the rapidly expanding universe of gadgetry; the deepening involvement of innovative technologies in every imaginable aspect of contemporary life. Today, it is true, *technology* is the word we rely on to refer to each and all of these developments. It is a key word, in fact, in our discourse about the "new world order," with its global market organized around a technological armature of electronic communications. The commonplace is that the transformation of global society is being "driven" by the electronic revolution in technology (Smith and Marx, 1995).

The striking fact is, however, that the concept of *technology*, when invoked on this plane of generality, is almost completely vacuous. It rarely enables us to say anything of genuine interest or value, to attribute any characteristic applicable, across the board, to all or most technologies. It is impossible, for example, to say anything meaningful about the moral import of technology or technological innovation in general. We have long realized that some of our technologies are unequivocally evil, useful only for destruction, such as those used to produce nuclear bombs, land mines, or poison gas; and of course we also have unequivocally benign medical technologies, such as those capable of eliminating hitherto incurable diseases, or of performing unimaginably delicate, microscopic surgical procedures. Thus, technology, according to a banality most of us encountered as children, is capable of enhancing and destroying life; it is good and bad, and this inherent contradiction makes the futility of the unceasing debate between Luddites and Technocrats all too obvious. One reason that technology is hazardous, then, is that it stifles and obfuscates analytic thinking. When we try to explain why that is so, the answer points to the fact that we cannot say what the word means.

Earlier I asked, "What sort of entity is technology?" But the truth seems to be that it is not an entity at all. An entity, according to my dictionary, is something that exists as a particular and discrete unit. But technology, in the sense of the mechanic arts collectively, lacks both particularity and discreetness, and indeed it is no sort of unit whatever. This elusive nonentity cannot be identified with any particular kind of artifact, or any particular social group, profession, or institution; nor does it represent any specifiable body of ideas, methods, or principles. This semantic vacuity is tacitly confirmed by the apparent inability of philosophers to say exactly what they mean by *technology*. Definitions of the word have been notoriously unsatisfactory. Heidegger defines it chiefly by saying what it is not, and among the other influential attempts, perhaps the most frequently cited is that of Jacques Ellul, who locates *technology* in any manifestation of *technique*. By identifying it with every act of making or doing, material or social, he drains it of all particularity and discreetness; the result is that it has little or no useful, specifiable meaning (Ellul, 1964). The vacuity of the concept might not matter very much were it not for its omnipresence, and its implicitly portentous consequences. Today an immense chorus of intelligent people laments the fact that "we" (humanity), in the trite phrase, "do not know where technology is taking us."

The chief hazard attributable to the concept of *technology*, as currently used, is the mystification, passivity, and fatalism it helps to engender. Today we invoke the word as if it were a discrete entity, and thus a causative factor—if not *the* chief causal factor—in every conceivable development of modernity. Although we cannot say exactly what that "it" really is, it nonetheless serves as a surrogate agent, as well as a mask, for the human actors actually responsible for the developments in question. Because of its peculiar susceptibility to reification, to being endowed with the magical power of an autonomous entity, technology is a major contributant to that gathering sense, at the close of the millennium, of political impotence. By attributing autonomy and agency to technology, we make ourselves vulnerable to the feeling that our collective life in society is uncontrollable. The popularity of the belief that technology is the primary force shaping the postmodern world is a measure of our growing reliance on instrumental standards of judgment, and our corresponding neglect of moral and political standards, in making decisive choices about the direction of society. To expose this hazard is a vital task for the human sciences.

Notes

1 Heidegger, 1977, p. 4. For my earlier assessment of Heidegger's argument, see "On Heidegger's Conception of 'Technology' and Its Historical Validity" (1984).

2 The first use of the word in this sense reported by the *Oxford English Dictionary* was in 1859; but as noted below, Jacob Bigelow had used it as early as 1829, and it evidently had appeared in German, Swedish, French, and Spanish in the late-eighteenth century. Thus Johann Beck-

mann, a German professor, is credited by Siebicke (1968) and Gille (1986) with its first use in a book title, *Anleitung zur Technologie* (1777). See also Morere (XII, 1966). My version of this history, it should be said, is not based on the kind of comprehensive examination of primary sources that an authoritative account requires. Such a study, especially one that examines the history of the word in several modern languages, would be invaluable, but to the best of my knowledge, does not yet exist.

3 Although I rely on American examples, I believe that British and western European equivalents exist for many of them.

4 Webster, 1903, IV, pp. 105–107. For a more detailed analysis of the speech, see Leo Marx, 1964, pp. 209–14.

5 The "technological sublime" refers to the extension of the concept of sublimity, originally applied chiefly to the transcendent, quasitheological attributes of natural phenomena, to the new industrial artifacts. I discuss this tendency elsewhere (Marx, 1964, pp. 195–99); David Nye has made a comprehensive study of the subject (Nye, 1995).

6 Thus when Benjamin Franklin was offered a potentially lucrative patent for his ingenious new stove, he explained his refusal to accept by invoking the communitarian republican notion that inventions are valued for their contribution to the polity. "I declined it from a principle which has ever weighed with me on such occasions, 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" (Franklin 1950, p. 132). For other discussions of this topic, see also Marx, 1987, and Marx, 1996.

7 Roszak, 1969, p. 5. Theodore Roszak, who helped to define the character of the student revolt, refers to the rebels as "technocracy's children," and "the technocracy" as "that social form in which an industrial society reaches the peak of its organizational integration. It is the ideal men usually have in mind when they speak of modernizing, updating, rationalizing, planning" (Roszak, 1969, p. 5).

8 I add the qualification, "the modern era," to acknowledge the provocative theory, advanced by Lewis Mumford (1966), that the first "machine" was in fact such a system, the systematic organization of work contrived by the Egyptians to build the pyramids. The trouble with this theory is that it ignores the artifactual component of the concept of the *machine* and, when it later emerges, the concept of *technology*. For a more extended analysis of this theory, see my essay, "Lewis Mumford, Prophet of Organicism" (1990, pp. 164–80).

9 Dunlavy, 1994; Hill, 1957. At West Point, the military engineers, trained in the tradition of the Ecole Polytechnic, acquired a more

sophisticated knowledge of geometry, physics, and of a general scientific viewpoint than most American engineers at the time. A number of them left the army and became "civil" engineers, and worked on the railroad. I am grateful to Merritt Roe Smith for calling my attention to this development.

10 Bigelow, 1829, pp. iii–iv (emphasis added). Bigelow's lectures were supported by the endowment of Count Rumford who, in his 1815 will, had left Harvard $1000 a year for lectures designed to teach the "utility of the physical and mathematical sciences for the improvement of the useful arts, and for the extension of the industry, prosperity, happiness and well-being of society" (Struik, 1948, pp. 169–70). Struik seems to have been the first historian to credit Bigelow with first using the modern sense of the word *technology*.

11 Marx, 1978, p. 403; Toynbee, 1960. Marx's discussion in *Capital*, I, Part IV, Ch. XV, "Machinery and Modern Industry," is of particular pertinence (Tucker, 1978, p. 403). As late as its eleventh (1911) edition, *The Encyclopaedia Britannica,* which contained no separate entry on *technology,* was offering the word *technology* as a possible alternative to the (preferred) use of *technical* in the entry on "Technical Education" (*The Encyclopaedia Britannica,* 11th ed., XXVI, p. 487).

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