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ESSAYS

Technology

The Emergence of a Hazardous Concept

LEO MARX

“... the essence of technology is by no means anything technological.”

—Martin Heidegger¹

New Concepts as Historical Markers

The history of technology is one of those subjects that most people know more about than they realize. Long before the academy recognized it as a specialized field of scholarly inquiry, American schools were routinely disseminating a sketchy outline of that history to millions of pupils. We learned about James Watt and the steam engine, Eli Whitney and the cotton gin, and about other great inventors and their inventions. Even more important, we were led to assume that innovation in the mechanic arts is a—perhaps *the*—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 popular children’s encyclopedia, and in the alluring dioramas of Early Man in the New York Museum of Natural History. These exhibits represented the advance of civilization as a sequence of the inventions in the mechanic arts with which Homo sapiens gained a unique power over nature. This comforting theme remains popular today and is insinuated by all kinds of historical narrative. Here, for example, is a passage from an anthropological study of apes and the origins of human violence:

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1. Martin Heidegger, *The Question Concerning Technology and Other Essays*, trans. William Lovett (New York, 1977), 4.

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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.²

This typical summary of human history from stone age tools to Ford cars illustrates the shared “scientific” understanding, circa 2010, of the history of technology. But one arresting if scarcely noted aspect of the story is the belated emergence of the word used to name the very rubric—the kind of thing—that allegedly drives our history. The word is *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 account, the concept of technology—as we know it today—did not exist. The word *technology*, which joined the Greek root, *techne* (an art or craft) with the suffix *ology* (a branch of learning), first entered the English language in the seventeenth century. At that time, in keeping with its etymology, a *technology* was a branch of learning, or discourse, or treatise concerned with the mechanic arts. As Eric Schatzberg has demonstrated in a seminal essay, the word then referred to a field of study, not an object of study.³ But the word, even in that now archaic sense, was a rarity in nineteenth-century America. By 1861, to be sure, it was accorded a somewhat greater prominence by the founders of the Massachusetts Institute of Technology, but they also were invoking the limited sense of the term to mean higher technical education. As for *technology* in the now familiar sense of the word—the mechanic arts collectively—it did not catch on in America until around 1900, when a few influential writers, notably Thorstein Veblen and Charles Beard, responding to German usage in the social sciences, accorded *technology* a pivotal role in shaping modern industrial society. But even then, the use of the word remained largely confined to academic and intellectual circles; it did not gain truly popular currency until the 1930s.

But why, one might ask, is the history of this word important? The answer, from the viewpoint of a cultural historian, is that the emergence of a keyword in public discourse—whether a newly coined word or an old

2. Richard Wrangham and Dale Peterson, *Demonic Males: Apes and the Origins of Human Violence* (New York, 1996), 61.

3. Erik Schatzberg, “*Technik Comes to America: Changing Meanings of Technology before 1930*,” *Technology and Culture* 47 (2006): 486–512. The first use of the amplified sense of the word, referring to the mechanic arts themselves, according to the *Oxford English Dictionary* (OED), was in 1859; variants of the older meaning of *technology*—e.g., *technik*, *technique*, etc.—also had appeared in German, Swedish, French, and Spanish in the late eighteenth century.

word invested with new meaning—may prove to be an illuminating historical event. Such keywords often serve as markers, or chronological signposts, of subtle, virtually unremarked, yet ultimately far-reaching changes in culture and society. Recall, for example, Tocqueville's tacit admission, in *Democracy in America*, that in order to do his subject justice he was compelled to coin the (French) word *individualisme*, "a novel expression to which a novel idea has given birth"; or Raymond Williams's famous discovery, in writing *Culture and Society*, of the striking interdependence (or reflexivity) in the relations between certain keywords and fundamental changes in society and culture. Williams had set out to examine the transformation of culture coincident with the advent of industrial capitalism in Britain, but he found that the concept of *culture* itself, along with such other pivotal concepts of the era as *class*, *industry*, *democracy*, and *art*, was a product of—indeed had been invested with its new meaning by—the very changes he proposed to analyze. Not only had those changes lent currency to the concept of *culture*, but they had simultaneously changed its meaning. I believe that a similar process marked the emergence of *technology* as a keyword in the lexicon we rely on to chart the changing character of contemporary society and culture.⁴

But how, then, are we to identify the specific changes that prompted the emergence of *technology*—the concept, the word, the purported thing itself? My assumption is that those changes, whatever they were, created a semantic—indeed, a conceptual—void, which is to say, an awareness of certain novel developments in society and culture for which no adequate name had yet become available. It was this void, presumably, that the word *technology*, in its new and extended meaning, eventually would fill. It would prove to be preferable—a more apt signifier—for the new agents of change than any of its precursors, received terms such as the *mechanic* (or *useful* or *practical* or *industrial*) *arts*, or *invention*, *improvement*, *machine*, *machinery*, or *mechanism*. In a seminal essay of 1829, Thomas Carlyle had posed a variant of my question: if one had to sum up the oncoming age in a word, he asked, what might it be? His unequivocal answer was: *machinery*. "It is the Age of Machinery," he wrote, "in every outward and inward sense of that word."⁵ During the next half century, however, *machinery*—like the alternatives just mentioned—turned out to be unsuitable. But why? Why did *technology* prove to be preferable? To answer the question, we need to iden-

4. Alexis de Tocqueville, *Democracy in America*, trans. Phillips Bradley (New York, 1946), II:98 (the *OED* credits the Henry Reeve translation of 1835 with the first use of the word in English); Raymond Williams, *Culture and Society, 1780–1950* (New York: 1983), xiii–xviii; *Keywords: A Vocabulary of Culture and Society* (New York, 1985), 11–26 and 315–16.

5. Thomas Carlyle, "Signs of the Times," *Edinburgh Review* (1829), reprinted in *Selected Writings*, ed. Alan Shelston (New York, 1971), 64. Carlyle, incidentally, is credited with the first use of the word *industrialism*, in *Sartor Resartus* (1831).

tify the specific character of the concurrent changes in the mechanic arts—not only the changes within those arts, but also the changes in the interrelations between them and the rest of society and culture.

As for the hazardous character of the concept of technology, here I need only say that I am not thinking about weaponry or the physical damage wrought by the use of any particular technologies. The hazards I have in mind are conceptual, not physical. They stem from the meanings conveyed by the concept *technology* itself, and from the peculiar role it enables us to confer on the mechanic arts as an ostensibly discrete entity—one capable of becoming a virtually autonomous, all-encompassing agent of change.

The Mechanic Arts and the Changing Conception of Progress

By the 1840s, several of the developments that contributed to the emergence of the concept of *technology* had become apparent in America. They fall into two categories, ideological and substantive: first, changes in the prevailing conception of the mechanic arts, and second, the material development of the machinery itself, and of the institutional setting from which it emerged. As a reference point for both kinds of change, and for early traces of the semantic void that eventually was to be filled by the concept of *technology*, here is the peroration of a ceremonial speech delivered by Senator Daniel Webster at the dedication of a new section of the Northern Railroad in Lebanon, New Hampshire, on 17 November 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.⁶

Perhaps the most significant ideological development that the emergence of *technology* eventually would ratify, as implied by Webster's grandil-

6. Daniel Webster, *Writing and Speeches of Daniel Webster* (Boston, 1903), IV:105–7. For a more detailed analysis of the speech in the context of American pastoralism, see Leo Marx, *The Machine in the Garden: Technology and the Pastoral Ideal in America* (New York, 1964), 209–14.

loquent tribute to the progress of the age, is a new respect for the power of innovations in the useful arts to transform prevailing ideas about the world. When he singles out the railroad and the telegraph as embodiments of the progress of the age, he in effect confirms a subtle but important modification of the received Enlightenment view of progress. To be sure, the idea of progress had been closely bound up, from its inception, with the accelerating rate of scientific and mechanical innovation. By the time of Webster's speech, however, the idea of *progress* had become the fulcrum of a comprehensive worldview effecting the sacralization of science and the mechanic arts, and creating a modern equivalent of the creation myths of premodern cultures. Two centuries earlier, the concept of progress had served, in a commonplace, literal sense, to describe incremental advances in explicitly bounded enterprises like the development of new scientific instruments—say, for example, the microscope or telescope. But as more and more specific instances of progress of that sort occurred—progress in that particularized, circumscribed sense of the word—the reach of the idea gradually was extended to encompass the entire, all-encompassing course of human events. By the time of the French and American revolutions, in other words, history itself was conceived as a record of the steady, cumulative, continuous expansion of human knowledge of—and power over—nature. Thus the future course of history might be expected to culminate in a more or less universal improvement in the conditions of human existence.

But the radical thinkers who led the way in framing this master narrative of progress—Condorcet and Turgot, Paine and Priestley, Franklin and Jefferson—did not, like Webster, unreservedly equate human progress with the advance of the mechanic arts. They were committed republicans, political revolutionists, and although they celebrated mechanical innovation, they celebrated it only as the means of achieving progress; the true and only reliable measure of progress, as they saw it, was humanity's step-by-step liberation from aristocratic, ecclesiastical, and monarchic oppression, and the institution of more just, peaceful societies based on the consent of the governed. What requires emphasis is the republican thinkers' uncompromising insistence that advances in science and the mechanic arts are valuable chiefly as a *means* of arriving at social and political ends.⁷

By Webster's time, however, that distinction already was losing much of

7. Thus when Benjamin Franklin was offered a potentially lucrative patent for his ingenious new stove, he explained his refusal to accept the patent 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" (*The Autobiography of Benjamin Franklin* [New York, 1950], 132). For other discussions of this topic, see Leo Marx, "Does Improved Technology Mean Progress?" *Technology Review* (January 1987): 32–41, and Leo Marx and Bruce Mazlish, eds., *Progress: Fact or Illusion?* (Ann Arbor, Mich., 1996).

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its force. This was partly due to the presumed success of the republican revolutions, hence to a certain political complacency reinforced by the rapid growth of the immensely productive and lucrative capitalist system of manufactures. Thus, for example, Senator Webster, whose most influential constituents were factory owners, merchants, and financiers, did not regard innovations in the mechanic arts as merely instrumental—a technical means of arriving at social and political goals. He identified his interests with those of the company's directors and stockholders, and as he saw it, therefore, wealth-producing innovations like the railroad represented a socially transformative power of such immense scope and promise as to be a virtual embodiment—a perfect icon—of human progress.

Thus the new entrepreneurial elite for whom Webster spoke was to a large extent relieved of its tacit obligation to carry out the republican political mandate. Consider, for example, the Boston Associates—the merchants who launched the Lowell textile industry. They, to be sure, were concerned about the inhumane conditions created by the factory system—and they surely wanted to be good stewards of their wealth—but they assumed that they could fulfill their republican obligations by acts of private philanthropy.⁸ They believed that innovations in the mechanic arts could be relied upon, in the long run, to result in progress and prosperity for all. Their confidence in the inherently progressive influence of the new machines was reinforced, in their view, by the distinctive material tangibility of the machines—their omnipresence as physical, visible, sensibly accessible objects. In the ordinary course of their operations, accordingly, the new factories and machines unavoidably disseminated the ideology of social progress to all who saw and heard them. As John Stuart Mill acutely observed, the mere sight of a potent machine like the steam locomotive in the landscape wordlessly inculcated the notion that the present was an improvement on the past, and that the future promised to be so wondrous as to be “known,” in Webster's high-flown idiom, “only to Omniscience.”⁹

But in the 1840s the blurring of the distinction between mechanical means and political ends also provoked an ideological backlash. To a vocal minority of dissident artists and intellectuals, the worshipful view of material progress was symptomatic 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

8. Robert F. Dalzell Jr., *Enterprising Elite: The Boston Associates and the World They Made* (Cambridge, Mass., 1987).

9. John Stuart Mill, “M. de Tocqueville on Democracy in America,” *Edinburgh Review* (October 1840), reprinted in John Stuart Mill, *Dissertations and Discussions* . . . (Boston, 1865), II:148.

toys, which distract our attention from serious things. *They are but improved means to an unimproved end.*¹⁰

And in *Moby Dick* (1851), Melville, after having Ishmael, his narrator, pay tribute to Captain Ahab's preternatural intellect and his mastery of the complex business of whaling, has the crazy captain acknowledge the hazards he courts by placing his technical proficiency in the service of 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."¹¹

This critical view of the new industrial arts marks the rise of an adversary culture that would reject the dominant faith in the advance of the mechanical arts as a sufficient, self-justifying, social goal. Indeed, a more or less 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 1849 recommendation, in "Civil Disobedience," to "Let your life be a counter-friction to stop the machine" to Mario Savio's 1964 exhortation to Berkeley students: "You have got to put your bodies upon the [machine] and make it stop!" From its inception, the countercultural movement of the 1960s was seen—and saw itself—as a revolt against an increasingly "technocratic" society.

The Construction of Complex Sociotechnical Systems

Turning now to the substantive or material changes in the character and organizational matrix of the mechanic arts in nineteenth-century America, it is evident that they too helped to create the semantic void that the concept of *technology* eventually would fill. In his 1847 speech, Webster depicted the railroad and the telegraph as wondrous mechanical innovations with a far-reaching capacity to alter prevailing ways of life. During the early phase of industrialization, innovations in the mechanic arts typically had been represented as single, free-standing, more or less self-contained mechanical devices: 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 being replaced, as the typical embodiment of the new power, by a new kind of sociotechnological system. The railroad was one of the earliest and most visible of the large-scale, complex systems of the modern era.¹² A novel feature of these elabo-

10. Henry Thoreau, *Walden and Other Writings* (New York, 1950), 46 (my emphasis).

11. Herman Melville, *Moby Dick* (New York, 1967 [1851]), 161.

12. I add the qualification, "the modern era," to acknowledge the provocative theory, advanced by Lewis Mumford, to the effect that the first "machine" was in fact such a system, the systematic organization of work contrived by the Egyptians to build the pyramids. A fatal shortcoming of Mumford's theory is that it omits the indispensable artifactual component of both the *machine* and also, when it later emerges, the concept of

rate systems is that the single, typifying, tangible, physical-artifactual, or mechanical component—the steam locomotive, for example, despite its commanding symbolic stature—constitutes a relatively small but crucially definitive part of the whole.

Thus, in addition to the crucially important engine itself, the operation of the railroad required: (1) several 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 workforce with unique railroading skills, including civil and locomotive engineers, firemen, telegraphers, brakemen, conductors—a workforce large and resourceful enough to keep the system functioning day and night, in all kinds of weather, 365 days a year; and (5) various facilitating institutional changes, such as regulations establishing standardized track gauges and a national system of standardized time zones.

With the formation of these large, sociotechnical systems—the telegraph and wireless systems, the electric power and use system, the urban water and waste disposal systems—the private family (father & sons) firm was supplanted by the anonymous, public corporation as the typical form of American business organization, and a new kind of professional or (as it later would be called) “scientific” management.¹³ A prominent feature of these complex, ad hoc systems is the blurring of the borderlines between their constituent elements—notably the boundary separating the artifactual equipment (the machinery or hardware) and all the rest: the reservoir of technical—scientific—knowledge; the specially trained workforce; the financial apparatus; and the means of acquiring raw materials.

The complexity and scale of these systems were augmented by the increasingly systematic application of science to the improvement of the mechanic arts. In 1847 Webster, referring to the railroad and the telegraph, had ascribed the singularity of the age to scientific research, and indeed the building of the railroads marked a new departure in that respect. Unlike the innovations associated with the eighteenth-century Industrial Revolution, which often had been introduced by practical, rule-of-thumb mechanics with relatively little formal scientific training, many of the engineers who worked on the railroads had been educated at West Point, where the cur-

technology. Lewis Mumford, *The Myth of the Machine: Technics and Human Development* (New York, 1966); for a more extended critical analysis of Mumford’s theory, see Leo Marx, “Lewis Mumford, Prophet of Organicism,” in *Lewis Mumford, Public Intellectual*, ed. Thomas P. Hughes and Agatha C. Hughes (New York, 1990), 164–80.

13. Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch, eds., *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, Mass., 1987), 51–82; Alfred D. Chandler Jr., *The Visible Hand: The Managerial Innovation in American Business* (Cambridge, Mass., 1977), 79–120.

riculum bore the imprint of the scientifically advanced École Polytechnique. That French influence, incidentally, led to the establishment of *civil* engineering, thereby institutionalizing the distinction between the civilian and military branches of the ancient, but newly professionalized vocation.¹⁴ Although the confluence of the sciences and the practical arts was well under way by 1847, it was not until the final quarter of the century, with the rise of the electrical and chemical industries, that the large-scale amalgamation of science and industry helped to create the semantic void that would eventually call forth the new concept—*technology*.¹⁵

As early as 1829, however, Jacob Bigelow, a physician and botanist who taught at Harvard, had announced that he was resurrecting the arcane word *technology* for use in the title (*Elements of Technology*) of his lectures on applied science. In his preface he made such grand claims for the extended applicability of this odd word that for well over a century historians mistakenly credited him with having anticipated the latter-day meaning of *technology* (referring to the mechanic arts themselves) as against the earlier, received meaning (referring to the study of those arts). There “has probably never been an age,” he explained, “in which the practical applications of science have employed so large a portion of talent and enterprise . . . as in the present.” And, therefore, he wrote, “to embody . . . the various . . . [aspects] of such an undertaking, I have adopted a 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.”¹⁶

But those twentieth-century scholars—among them Dirk Struik, David Noble, and myself—who credited Bigelow with having anticipated the latter-day sense of *technology* were wrong.¹⁷ The truth, as more recent scholarship has revealed, is that he too was using the word in its old, pre-indus-

14. Colleen Dunlavy, *Politics and Industrialization: Early Railroads in the United States and Prussia* (Princeton, N.J., 1994); Forest G. Hill, *Roads, Rails, and Waterways: The Army Engineers and Early Transportation* (Tulsa, Okla., 1957). At West Point, the military engineers, trained in the tradition of the École Polytechnique, acquired a more sophisticated knowledge of geometry, physics, and of science generally than most American engineers of that era. A number of them left the army to become “civil” engineers and worked on the railroad. I am grateful to Merritt Roe Smith for calling my attention to this development.

15. David Noble, *America by Design: Science, Technology, and the Rise of Corporate Capitalism* (New York, 1977).

16. Jacob Bigelow, *Elements of Technology* (Boston, 1829). Bigelow’s lectures were supported by the endowment of Count Rumford, who, in his 1815 will, had left Harvard \$1,000 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. See Dirk Struik, *Yankee Science in the Making* (Boston, 1948), 58 and 169–70.

17. Struik, 169–70; Noble, 3–4; and Marx, *The Machine in the Garden* (n. 6 above), 149.

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trial sense, to name the mechanic arts as a field of study, or as a treatise in those arts, but not in the current sense, as a reference to the arts themselves. Having proposed the resurrection of the “sufficiently expressive” word *technology* in the title of his lectures, moreover, Bigelow abandoned it. He made no significant use of the word in the body of his lectures, and when he republished the book in 1840, he retitled it *The Useful Arts*.¹⁸ It was not until after the founding of the Massachusetts Institute of Technology in 1861 (of which he, incidentally, was a trustee) that *technology* (in the limited, bibliographic sense of the word), came into more general if sporadic use.

In fact the latter-day meaning of *technology* did not gain wide currency for almost a century. The new sense of the word was rarely invoked before 1900. As late as 1880–81, for example, Arnold Toynbee delivered his influential lectures on the Industrial Revolution—a topic that would seem in retrospect to have made references to *technology* unavoidable—yet he relied exclusively on the long-established lexicon featuring such terms as *mechanical discoveries*, *improvements*, and *inventions*.¹⁹ As late as 1911, the *Encyclopaedia Britannica* contained no entry on *technology*, whereas the entry on “Technical Education” noted that the word *technology* might be an acceptable alternative to *technical*.²⁰ An important exception, however, is the erratic practice of Karl Marx, who formulated a sophisticated, historically precocious concept of technology as early as the 1860s but for some reason failed to use it consistently. In the body of the long, detailed, painstakingly documented chapter of *Capital* devoted to “Machinery and Modern Industry,” he chiefly relies on the old lexicon—*machine*, *machinery*, *mechanism*—along with such awkward relics of the James Watt era as *factory mechanism*, *implements of a mechanism*, and *mechanical implements*. But then he inexplicably tucks away his striking ideas about the significance of *technology* in a long footnote—one that contains tantalizing allusions to Darwin’s work in “the history of Nature’s technology,” and to the need for “a critical history of technology,” along with this cogent summary of what that history might be expected to reveal:

Technology discloses man’s mode of dealing with Nature, the process of production by which he sustains his life, and thereby also lays bare the mode of formation of his social relations, and of the mental conceptions that flow from them.²¹

18. Ruth Oldenziel, *Making Technology Masculine: Men, Women, and Modern Machines in America* (Amsterdam, 1999), 23; Schatzberg (n. 3 above).

19. Arnold Toynbee, *The Industrial Revolution* (Boston, 1960).

20. *Encyclopaedia Britannica*, 11th ed., XXVI:487.

21. Karl Marx, *Capital: A Critique of Political Economy*, ed. Friedrich Engels (New York, 1906), 406n2. The text is that of the first American edition of the initial (1867) English translation.

Even more puzzling is the fact that Marx, after having developed this sophisticated conception of *technology* and its pivotal role in human history, repeatedly avoided using the word where it patently was apposite—a conundrum to which I will return.

Early in the twentieth century the avant-garde of the modernist movement in the graphic arts and architecture, along with a variety of technologically oriented offshoots—such as the vogue of “Machine Art,” the geometric styles in the graphic arts associated with Futurism, Precisionism, Constructivism, and Cubism, and, most conspicuously, the International Style in architecture—all helped to invest incidental mechanistic motifs with the aura of intrinsic aesthetic value. In the Bauhaus aesthetic, moreover, design was married to industrial production. In 1923 Walter Gropius, the group’s founder, coined the slogan, “Art and Technology: A New Unity.”²² Indeed, the sudden modernist turn toward Mondrian-like abstraction—the new respect accorded to novel geometric, rectilinear, non-representational subject matter—comported with the markedly abstract, mathematical, cerebral, practical, and artificial (as distinct from “organic” or “natural”) connotations of the emerging conception of *technology*.

And yet, to repeat, this expanded sense of *technology* did not gain wide currency until after the eruption of mechanical inventions, sometimes called the “Second Industrial Revolution” (c. 1880–1910), that gave us the electric light, the phonograph, the radio, the telephone, the X-ray, the airplane, the moving picture, and—arguably—the automobile. In contrast with the typical breakthroughs of *the* Industrial Revolution, these innovations stemmed more directly from advances in science, and several of them, notably the lightbulb and the telephone, became the artifactual fulcrum of these large, complex socio-technological systems. Henry Adams gives a particularly vivid, telling account of this sudden, unprecedented acceleration of the rate of change—and its consequences—in *The Education of Henry Adams* (which he first published privately in 1907). Here he announces the appearance of what he takes to be a uniquely empowered human being, an American “born since 1900”:

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.²³

And yet Adams never—so far as I know—adopted the concept of *technol-*

22. Cited by Peter Schjeldahl, “Bauhaus Rules: The Making of a Modern Aesthetic,” *The New Yorker*, 16 November 2009, 82.

23. Henry Adams, *The Education of Henry Adams*, ed. Ernest Samuels (Boston, 1973), 496–97.

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ogy, and indeed the language he preferred—*energy, power, forces*—seems more descriptive, accurate, evocative, and telling. But most American social scientists felt differently. In spite of—or perhaps because of—its abstract, inert, general character, its very lack of denotative specificity—the word *technology* attracted their attention soon after the turn of the century. By 1906 Thorstein Veblen, who was familiar with the German literature on *Technik* and who probably did more than any of his Anglophone contemporaries to disseminate the concept, asserted that “the machine technology has become a cultural force of wide-reaching consequence,” and, indeed, *the* “factor in the modern situation that is alien to the ancient regime.” He predicted that the introduction of the new technology would—in addition to its far-reaching material and economic consequences—transform the mental habits and, most importantly, the moral and metaphysical assumptions of those who worked with 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.²⁴

And later, in the 1930s, when Veblen (like Howard Scott and Frederick Winslow Taylor) was associated with the Technocracy Movement, he helped to disseminate the seductive notion that the engineers, with their pragmatic, matter-of-fact outlook, might replace politicians as the specialists entrusted with making social policies. This fantasy gained a certain credibility during the Kennedy administration, when adherents of the “liberal consensus” became proponents of instrumental rationality and adopted, as their political watchword, the “end of ideology.”

24. Thorstein Veblen, “The Place of Science in Modern Civilization,” in *What Veblen Taught*, ed. Wesley C. Mitchell (New York, 1945), 20; Thorstein Veblen, *The Theory of Business Enterprise* (New York, 1932), 303 and 310–11. For a detailed analysis of Veblen’s pivotal role in introducing the concept of technology in America, see Schatzberg (n. 3 above).

Technology Fills the Void

These radical turn-of-the-century developments in the mechanic arts mark the final stage in the formation of the semantic void that soon would be filled by the concept of *technology*. On close inspection, in fact, an inchoate, anticipatory sense of the void already was discernible in the peroration of Daniel Webster's 1847 speech. His characterization of the era, as noted, differed markedly from that of Thomas Carlyle, who had confidently proclaimed that the spirit of the age was best summed up by the idea of the *machine*. It was "the *Age of Machinery*," he had proclaimed, "in every outward and inward sense of that word." But in Webster's view some eighteen years later (as we have seen) neither *machine* nor any other word then available could convey the defining character of the age. Though he was certain that the age was typified by mechanical innovations born of "the application of this scientific research to the pursuits of life," he belabored his inability to adequately describe, much less explain, the extent to which those innovations were transforming the fundamental conditions of life. Resorting to a version of *paralipsis*, the rhetorical device which paradoxically enables us to represent something by declaring our inability to represent it, Webster insisted that no change of comparable magnitude ever had occurred before, neither in antiquity nor in the recent past. The "present era," he contends, is "altogether new," all but "miraculous"—so much so, in fact, that it has almost "outstripped human belief." (Along with human belief, we might add, the new age also seems to have outstripped Webster's expository resources.) To verify the existence of an emerging semantic void—the gap in the collective vocabulary that later would be filled by the concept of *technology*—it would be hard to find more persuasive evidence than Webster's heartfelt paralytic tribute to human progress.

What he manifestly sought, in other words, was to identify—to name—a novel form of human power with far greater efficacy and scope than that previously ascribed to the mechanic or useful arts. The power attributable to those age-old arts was limited because, for one thing, they had for so long been identified with the handicrafts—the skilled handiwork of individual artisans. Besides, the very notion of arts devised for mere utility carried a stigma of coarseness or vulgarity. Ever since antiquity, the *useful arts* in their various guises had been considered intellectually and socially inferior to the *high* (or *fine*, or *creative*, or *imaginative*) *arts*. The stock distinction between the *useful* and the *fine arts* had served to ratify an analogous—often invidious—lineup of distinctions between things and ideas, the physical and the mental, the mundane and the ideal, body and soul, making and thinking, the work of slaves and of free people. But now Webster's generation, by associating epoch-making machines like the railroad and the telegraph with science, business, and wealth, was seeking an entirely new category—a distinctively novel referent—untainted by the machine's derogatory legacy of social

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and intellectual inferiority and hence capable of elevating the *useful arts* to a higher plane—a plane closer to that of the *fine arts*.

What Webster was striving to express, in other words, was the need to replace the language associated with the mechanic arts, and to identify—literally to name—a wholly new form of human power that the abstract, intangible, neutral, and fittingly synthetic idea of *technology* was destined to fulfill. Whereas the term *mechanic* (or *industrial*, or *practical*) *arts* calls to mind men with soiled hands tinkering at workbenches, *technology* conjures clean, well-educated, white male technicians in control booths watching dials, instrument panels, or computer monitors. Whereas the *mechanic arts* belong to the mundane world of work, physicality, and practicality—of humdrum handicrafts and artisanal skills—*technology* belongs on the higher social and intellectual plane of book learning, scientific research, and the university. This dispassionate word, with its synthetic patina, its lack of a physical or sensory referent, its aura of sanitized, bloodless—indeed, disembodied—cerebration and precision, has eased the induction of what had been the *mechanic arts*—now practiced by engineers—into the precincts of the finer arts and higher learning.

Turning to the other, organizational and material aspect of the semantic void, what was needed, by way of modernizing the outmoded lexicon of the *mechanic arts*, was a concept capable of representing the novel formations which historians of technology describe as “large-scale, complex technological systems.” However, that clumsy term begs a puzzling question: which aspect of these formless, sprawling entities accounts for their distinctively *technological* character? Where, exactly, is their *technological* identity located? To be sure, the indispensable artifactual component of these formations invariably is a specific mechanical device, like a locomotive or other physical contrivance designed to facilitate transportation, production, communication, or, for that matter, any humanly designed process of making or doing. The locus of its specific technological identity has become an increasingly pressing question, however, because over time the artifactual component has come to form a smaller, less conspicuous part of the whole. Think of the transistor or the computer chip!

In common parlance, nonetheless, when we refer to one of these complex systems as a *technology*, the material component more often than not serves as the tacit referent. But that restricted sense of the word, as in the case of the railroad, can be ambiguous and misleading. It is ambiguous because the whole system, apart from the hardware, is so inclusive, so various—its boundaries so vague as to defy exact representation. This ambiguity evidently is what Heidegger had in mind by his paradoxical if telling assertion that “the essence of technology is by no means anything technological.”²⁵ In advanced industrial societies, of course, most technological

25. Heidegger (n. 1 above), 4. For my criticism of Heidegger’s argument, see “On

systems serve a predominantly economic purpose. In capitalist economies they characteristically take the form of private-sector manufacturing corporations, banks, or public utilities with large capital investments. It is noteworthy that the concept of *technology* gained currency during the “incorporation of America,” as Alan Trachtenberg persuasively describes the era during which “machines became working parts of a dynamic system, and the motives for change, the source of industrial dynamism, lay not in the inanimate machine but in the economic necessities perceived by its owners.”²⁶

There is a compelling logic in the retrospective application of the nebulous adjective *technological* to these hybrid, dynamic, expansionary profit-making enterprises. It exemplifies the congruence of *technology* and corporate capitalism, recalling Raymond Williams’s observations about the circularity, or reflexivity, involved in the social construction of keywords—words like *culture*, *industry*, *democracy*—which came to serve as historical markers for the periods when they acquired new, fundamentally altered, meanings. So with *technology*. It is now customary to single out the transformative power of *technology* as the defining characteristic of the era when, in response to remarkable advances in the mechanic arts, the meaning of the word *technology* underwent a radical change. The term that formerly had named a field of study now referred to the society’s entire stock of technical knowledge and equipment. Williams’s analysis is borne out, in the case of *technology*, by the blurring of the boundary between the material (physical, or artifactual) components of these large socio-technological systems and the other, bureaucratic and ideological components. Even more significant, perhaps, is the erosion of the “outer” boundaries, as it were, those separating the whole technological system from the surrounding society and culture.

Consider, once again, automotive technology. Its defining, indispensable material core was of course the internal combustion engine, plus—naturally—the rest of the automobile chassis. But surely the technology also includes the mechanized assembly lines, the factories, the skilled workforce, the automotive engineers, the engineering knowledge, the corporate structures including the stockholders and the huge capital investments, and the networks of dealers and repair facilities. Where, then, do we draw the boundary between the system and the rest of the society and culture? Do we include among the facets of automotive technology the road-building and maintenance systems, the trucking industry, the indispensable feeder industries—glass, rubber, steel, aluminum, plastics, etc.? What about the mines that provide the raw materials? The extended economic or societal

Heidegger’s Conception of ‘Technology’ and Its Historical Validity,” *The Massachusetts Review* 25 (winter 1984): 638–52.

26. Alan Trachtenberg, *The Incorporation of America* (New York, 1982), 55.

reach of this technology is almost incalculable. As a source of jobs, indeed, it for a time accounted for a large fraction—perhaps a sixth—of the national workforce. And finally, what about the global oil industry? It is in large part an offspring of automotive technology, yet at one point it probably surpassed its parent in size and wealth, not to mention its ecological costs and geopolitical influence. Estimating the “impact” of this technology on our society is a bit like estimating the impact of the bone structure on the human body.

Why the Concept of *Technology* Is Hazardous

The hazardous character of *technology*—the word, the concept—is a consequence of the history just outlined. As I have argued, the generality of the word—its lack of specificity, the very aspect which evidently enabled it to supplant its more explicit and substantial precursors—also made it peculiarly susceptible to reification. Reification, as the philosopher George Lukacs famously explained, is what occurs when we endow a human activity with the characteristics of a thing or things. It thereby acquires, as he put it, “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.”²⁷ In contemporary discourse, private and public, technologies are habitually represented by “things”—by their most conspicuous artifactual embodiments: transportation technology by automobiles, airplanes, and railroads; nuclear technology by reactors, power plants, and bombs; information technology by computers, mobile telephones, and television; and so on. By consigning technologies to the realm of things, this well-established iconography distracts attention from the human—socio-economic and political—relations which largely determine who uses them and for what purposes. Because most technologies in our corporate capitalist system have the legal status of private property, vital decisions about their use are made by the individual businessmen who own them or by the corporate managers and government officials who exercise the virtual rights of ownership. The complexity and obscurity of the legal relations governing the use of our technologies, abetted by the reification that assigns them to the realm of things—all of these help to create the aura of “phantom objectivity” that envelops them.

We amplify the hazardous character of the concept by investing it with agency—by using the word *technology* as the subject of active verbs. Take, for example, a stock historical generalization such as: “the cotton-picking

27. George Lukacs, *History and Class Consciousness: Studies in Marxist Dialectics*, trans. R. Livingstone (Cambridge, 1971), 83–87. See also Langdon Winner, *Autonomous Technology: Technology-out-of-Control as a Theme of Political Thought* (Cambridge, 1977).

machine transformed the southern agricultural economy and set off the Great Migration of black farm workers to northern cities.” Here we tacitly invest a machine with the power to initiate change, as if it were capable of altering the course of events, of history itself. By treating these inanimate objects—machines—as causal agents, we divert attention from the human (especially socioeconomic and political) relations responsible for precipitating this social upheaval. Contemporary discourse, private and public, is filled with hackneyed vignettes of technologically activated social change—pithy accounts of “the direction technology is taking us” or “changing our lives.”²⁸

To invest the concept of technology with agency is particularly hazardous when referring to technology in general—not to a particular technology, but rather to our entire stock of technologies. The size of that stock cannot be overstated. By now we have devised a particular technology—an amalgam of instrumental knowledge and equipment—for everything we make or do. To attribute specific events or social developments to the historical agency of so basic an aspect of human behavior makes little or no sense. Technology, as such, makes nothing happen. By now, however, the concept has been endowed with a thing-like autonomy and a seemingly magical power of historical agency. We have made it an all-purpose agent of change. As compared with other means of reaching our social goals, the technological has come to seem the most feasible, practical, and economically viable. It relieves the citizenry of onerous decision-making obligations and intensifies their gathering sense of political impotence. The popular belief in technology as a—if not *the*—primary force shaping the future is matched by our increasing reliance on instrumental standards of judgment, and a corresponding neglect of moral and political standards, in making judgments about the direction of society. To expose the hazards embodied in this pivotal concept is a vital responsibility of historians of technology.

28. In 1996–97, in writing the first iteration of this argument, I conducted an unscientific survey of the uses of the concept of technology in public discourse. Among the typical items I found were a special issue of the *New York Times Magazine* from 28 September 1997 devoted to a discussion entitled “What Technology Is Doing to Us”; since then I have also encountered Anthony Doerr, “Which Way Will Technology Take Us?” *Boston Globe*, 2 October 2005.