Rhetorical study of technology will benefit from a broad view of technology that considers it as a cultural phenomenon, including epistemic, artifactual, technical, economic, aesthetic, and political aspects. To understand twentieth-century American technology this way, it is useful to gain some historical perspective on its development, particularly in the past 50 years. Many accounts mark World War II as a turning point in the role of technology in our culture and in the relations of technology with government, science, and industry. This article synthesizes some of these accounts and concludes with four ways that technology should prove to be rhetorically distinct from science.

Learning from History
World War II and the Culture of High Technology

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Many have made the point that science is the hard case for rhetoric, the a fortiori argument, because under its own description science produces truth and not belief. Technology is a hard case of a different kind. It describes itself as producing direct social good in concrete artifacts, without intervening belief, practice, or discourse. This description waves several challenges in the face of the rhetorician: the obscuring of discourse, the presumption of social value, and the denial of suasion.

But if we are to try the case, where do we turn? What do we study when we study the rhetoric of technology? What are the rhetorical artifacts? Where are the rhetorical effects? Who or what are the rhetorical agents? And what are the media and methods through which and in which rhetoric is manifested? The answers to these questions are not at all straightforward. Most of us began such study as an outgrowth of efforts directed toward the rhetoric of science, where the answers are less complicated and multifarious. Although science is now understood to present traditional rhetorical objects for examination (an archive of texts making knowledge claims), technology presents artifacts and methods, tacit knowledge, social and political decisions, contingencies, and probabilities of situated design. Unlike science, technology is not closely identified with its texts or its claims,
nor does it have easily identifiable rhetors. Unlike science, technology
does not produce "public knowledge" (Ziman), nor does it constitute
a "republic" (Polanyi). Technology, especially contemporary "high
technology," is everywhere, but at the same time it is rhetorically
nowhere.

Technology, it would seem, is a broad cultural phenomenon, not
purely epistemic, not solely artifactual, not just technical or economic,
political, aesthetic, or social—yet including all of these dimensions as
well as the rhetorical. And, indeed, technology has been studied from
all these points of view.² Because rhetoric is situated, rhetorical study
will benefit from a broad view of technology that takes all these
dimensions into account and has, in addition, some historical depth.
The benefits include, most immediately, a better understanding of the
rhetorical situations in which technological rhetoric occurs—in Lloyd
Bitzer's terms, the rhetorical exigences that elicit it, the audiences and
constraints that shape and potentiate it, as well as the rhetors and their
motives that initiate it. For these situations arise from and are deeply
embedded within technological culture, and situations, as Kenneth
Burke noted, become condensed into motives (Permanence 29). In his
own discussion of rhetorical situation, by which he meant the situ-
ation of rhetoric as a whole rather than the situation for particular
rhetorical actions, Burke pointed out that "our identification
with . . . two great unwieldy leviathans—technology and the state—is
central to the rhetorical situation as we now confront it" ("Rhetorical"
270).

This article outlines some resources for understanding this rhetori-
cal situation, that is, for understanding technology as an important
aspect of late-twentieth-century American culture, an aspect that is
situated, characterizable, contingent, and historically particular. I do
not reach any conclusions here about the rhetoric of technology in this
context, for that will take detailed inquiry about specific aspects of this
culture. Rather, I hope to provide helpful background that can inform
and shape further studies in the rhetoric of technology. In what
follows, then, I turn both to accounts of current historians and to the
observations of earlier cultural commentators, describing technologi-
cal culture and the relations between science and technology. I focus
on the latter half of this century, a time when by all accounts technol-
ogy became what it is today and something it had not been before.
The fact that this period represents the lifetimes of those of us now
studying the rhetoric of technology makes this material all the more
fascinating. At the end, I note some implications of this history for
rhetorical study, specifically for how the rhetoric of technology may be distinct from the rhetoric of science.

DESCRIBING TECHNOLOGICAL CULTURE

Historian Thomas Hughes has described the century after 1870 as characterized by the building of technological systems, such as the electric power system, the automotive-highway-petrochemical system, and the nuclear technology system. But it is only with the massive involvement of the federal government during World War II that he calls the result a technological culture (Hughes 6). The development and deployment of the atomic bomb in 1945 is the dramatic marker of this period, of course, but the technological culture of the postwar boom years represents a culmination of many forces—economic, international, social, governmental, as well as narrowly technological—in distinctive combination. Although it was World War II that transformed our understanding of technology and the role it plays in our culture, this qualitative change has roots in the period before the war, as well as in the nineteenth century. To provide a picture of the Burkean "rhetorical situation," this section examines different ways that this qualitative change has been described by historians and commentators. They paint a picture in which technology is increasingly influential in all areas of contemporary life, not only through the capabilities of technological products but also through patterns of thought and value that are less obvious but seemingly essential aspects of technology. These patterns of thought and value are rhetorically significant.

The technological culture has been called Fordism by some economic and social analysts. The term was coined by Antonio Gramsci, writing in Mussolini’s prison in the 1930s, to describe what he saw then as a particularly American kind of industrial production technology (greatly admired by Lenin). This technology included not only Henry Ford’s famous assembly line (dating from 1913) but also the division of labor and prescription of work behavior that made it possible, practices that were formalized in Frederick Winslow Taylor’s system of scientific management developed just a few years earlier. Taylor’s methods, widely adopted for their enhancement of productivity and efficiency, promoted standardization, planning, and control, profoundly affecting the organization of work and the rela-
tions between workers, managers, and technical experts. Fordism goes beyond Taylorism, requiring even greater standardization, coordination, hierarchy, and centralized planning; as a consequence, it involves large investments early in production, which in turn require mass production and thus mass consumption, elaborate distribution systems, and the stimulation of demand. These patterns were critiqued by social theorists at the Institute for Social Research in Frankfurt in the 1920s and 1930s and after the war by exiled scholars in the United States. Ford and Gramsci, however, were among the first to see clearly these patterns that have become familiar to us in the late twentieth century.

Another account traces the twentieth-century transformation farther back to a nineteenth-century crisis in the industrial revolution—a "crisis of control," in which the capacities of transportation and manufacturing technologies outstripped the abilities of people to handle the information necessary to manage them. This crisis precipitated what historian James R. Beniger calls the "control revolution," a series of developments in production, distribution, and consumption focused in the period from 1820 to 1880 but continuing into the late twentieth century (427). New controls over production included some of the developments highlighted by the Fordist analysis: interchangeable parts, integrated factories, modern accounting techniques, professional managers, continuous-process production, Taylor's scientific management, the assembly line, and statistical quality control. New controls over distribution included developments such as the railroads, the postal system, the telegraph, standardized time zones, commodity dealers, the department store, and machine packaging. And new controls over consumption included the development of the rotary printing press and the subsequent creation of the mass media, the mail-order catalog, broadcasting, market research, and statistical sampling methods (17-20). These developments and the results of the control revolution, Beniger claims, constitute what is now known as the "information society."

Beniger also points to the development of large bureaucratic organizations as important to prewar control methods, citing Max Weber's discussion of such organizations as methods of control. Writing in the first decade of the century, Weber described bureaucracy as a method of increasing the ability to process information and "rationalization" (ever-increasing reliance on means-ends rationality) as a method of reducing the amount of information to be processed. Weber saw the process of rationalization as relentless:
The modern economic order . . . is now bound to the technical and economic conditions of machine production which to-day determine the lives of all the individuals who are born into this mechanism, not only those directly concerned with economic acquisition, with irresistable force. Perhaps it will so determine them until the last ton of fossilized coal is burnt. (181)

Mature Fordism, in David Harvey’s characterization, is a postwar development, a “fully-fledged and distinctive regime of [capitalist] accumulation” (129) that stayed largely intact for more than 25 years, from 1945 until 1973, when the recession and the OPEC oil embargo began to weaken it. It became, he says, not merely a system of mass production but “a total way of life” (135). International in scope, it is based in industrial technologies that had developed rapidly during the war effort—transportation, steel, petrochemicals, electrical and electronic goods, and construction (132)—and it rests on a “tense but nevertheless firm balance” (133) between labor, capital, and the state. After 1973, with changes in technology and in the international economy, Fordism is replaced by what we call the information society, an economy in which the majority of the Western labor force engages in information processing and service activities, and economic wealth is increasingly generated from information goods and services (Beniger 426).

Beniger points out that even though the transformations he describes have deep historical roots, our perceptions of them are much shallower: The culture in which we are living strikes us as a distinctively postwar development. He notes the large number of labels that have been given to changes described as in progress or imminent from 1950 through 1984, listing 75 such labels—from David Reisman’s lonely crowd in 1950, to Kenneth Boulding’s postcivilized era in 1964, Herman Kahn’s posteconomic society in 1970, and James Martin and David Butler’s information society in 1981 (4-5). These labels, both critical and appreciative—as well as the urge to create them—suggest that the rhetorical environment has been perceived as distinctive yet all-encompassing and that any means of persuasion is therefore highly constrained (although each label points to somewhat different constraints).

Perhaps the most famous and enduring characterization of the postwar culture of technology was made by Dwight Eisenhower in his 1961 presidential farewell address that warned about the growing influence of what he called the “military-industrial complex.” The speech is worth quoting at some length for the way it ties this charac-
terization directly to the war and for its chilling prescience about our rhetorical situation today:

Until the latest of our world conflicts, the United States had no armaments industry. . . . But now we can no longer risk emergency improvisation of national defense; we have been compelled to create a permanent armaments industry of vast proportions. . . . This conjunction of an immense military establishment and a large arms industry is new in the American experience. The total influence—economic, political, even spiritual—is felt in every city, every State house, every office of the Federal government. We recognize the imperative need for this development. Yet we must not fail to comprehend its grave implications. Our toil, resources and livelihood are all involved; so is the very structure of our society. In the councils of government, we must guard against the acquisition of unwarranted influence, whether sought or unsought, by the military-industrial complex. The potential for the disastrous rise of misplaced power exists and will persist. (1038)³

Four other characterizations are worth mentioning because they were similarly influential and because each points to specific conditions for rhetoric—which rhetors will be ethically potent, what presumptions and warrants may be invoked, what issues will be worth attention, and what claims are likely to prevail. In 1956, sociologist C. Wright Mills described an American “power elite” distinguished by “the coincidence of interests among economic, political, and military organizations” (292). He noted that “within the span of one generation, America [became] the leading industrial society of the world, and at the same time one of the leading military states,” suggesting that there had been a “great structural shift of modern American capitalism toward a permanent war economy” (215).

In 1967, economist John Kenneth Galbraith identified a distinctive feature of postwar economic organization: the fact that “the guiding intelligence—the brain—of the enterprise” was not management but rather a “technostructure” of “all who bring specialized knowledge, talent or experience to group decision making” (84). The technostructure is necessitated by increased reliance on technology, which “for[e]s the division and subdivision of any . . . task into its component parts . . . [so that] organized knowledge [can] be brought to bear on performance” (31). The major effects of technology on industry, which are due to this process of division, are consistent with the Fordist account: increases in the length of time needed to complete tasks and in the amount of capital committed to production, a decrease in the flexibility of these commitments of time and money, and
greater need for specialized knowledge, organization, and planning (32-35).

Daniel Bell also dates to the immediate postwar period the “birth-years” of what he calls the “post-industrial society.” He instances the radical transformations of these years: the bomb, the first digital computer (the ENIAC, developed in 1946 at the government’s Aberdeen Proving Grounds), the creation of new relationships between science and government with the foundation of the Atomic Energy Commission (AEC) and the National Science Foundation (NSF), new techniques of macroeconomic analysis that became “intertwined with public policy” (such as the gross national product, first used in 1945) and the Council of Economic Advisers established in 1946, and, finally, a “pervasive change in moral temper—a new ‘future-orientation’” based on the “technological and scientific possibility of controlling” change. The themes common to these events and their effects became, says Bell, the “hallmarks” of the new age: rationality, planning, and foresight (346-48).

As a final characterization of postwar technological culture, the work of Lewis Mumford is particularly vivid. Mumford’s thinking, most scholars agree, was dramatically transformed by the war, both by the loss of his only child (a son in the army) and by the atomic bomb. His prewar work on the historical role of technology in human culture, Technics and Civilization (1934), was basically optimistic, rooted in the ideology of progress that was prevalent in the 1920s but tempered during the Depression by the sense that social values should direct technological development (Hughes and Hughes 5). Immediately after the war, Mumford published essays and lectures sharply critical of nuclear weapons, and his criticism peaked in the late 1960s with his two-volume Myth of the Machine. The “myth of the machine” is that same ideology of progress, the belief that technological change is both inevitable and beneficial. He used the concept of the “megamachine”—an image of technological size—to describe the complex of technology, esoteric knowledge, and centralized or bureaucratic power that made possible both the building of the pyramids of ancient Egypt and the development of the atomic bomb, characterizing this complex as simultaneously constructive and destructive, capable of great technical achievements but also authoritarian and usually militaristic (Myth of the Machine: Technics 189-200). He inveighed against the modernized megamachines that emerged from World War II in both the United States and the Soviet Union, systems that, “instead of being dismantled as a regrettable temporary wartime
necessity, were elevated into permanent institutions in what has now become a permanent war: the so-called Cold War. As it has turned out," he went on, "this form of war, with its ever-expanding demands for scientific ingenuity and technological innovations, is by far the most effective device invented for keeping this overproductive technology in full operation" (Myth of the Machine: Pentagon 266). The megamachine, he concluded, had given technology unwarranted but complete priority in human affairs (Myth of the Machine: Pentagon 283).

THE ROLE OF WORLD WAR II

World War II represents for us the transition between one way of life and another, a new culture in which technology plays a dramatically different and greater role. But why was the war the turning point? How did it happen that, as historian Bruce Smith says, "the experience of World War II was the decisive event transforming the nation's approach to science and technology" (36)? There are at least three interrelated reasons that World War II serves as this grand transition: the creation of new institutional relationships between the federal government, industry, and the research community; the development of new relationships between science and technology; and the appearance of new forms of technology itself. All of these make technology a greater and more pervasive dimension of culture and also provide a new set of conditions for rhetoric.

New Institutional Relationships

The war effort in the United States was based on a set of institutional relationships that linked scientific research, technological development, and industrial production in unprecedented ways. The Manhattan Project to develop the atomic bomb and the work on radar at the MIT Radiation Laboratory were the two most important sites of linkage, but there were many others. Many of these links were handled during the war by a powerful centralized government agency, the Office of Scientific Research and Development (OSRD), headed by Vannevar Bush. But the new relationships extended far beyond the war effort, leading to what one analyst has called a "new American state" that, in effect, turned the centralizing powers of the prewar New Deal to industrial mobilization during the war and to national security after the war, thus redefining the federal govern-
ment’s relationship with industry and creating two distinct industrial sectors—civilian and defense. Defining features of the postwar period, according to this account, were the strong links between the defense sector and the state, through Pentagon planning and control of spending (Hooks). Another significant feature, according to a different study, is the link forged between expertise and most federal agencies (Balogh 12). This “fusion of professional and administrative capacity” (303) changed the postwar political landscape and redirected government expenditures and public decision making for decades.

The debate about what form postwar arrangements would take, specifically what role the federal government should play in promoting scientific research and technological development, was complex and protracted, extending at least from the introduction of the first congressional bill in 1942 until the founding of the NSF in 1950.10 This debate included, of course, the problem of how atomic bomb technology would be controlled, both domestically and internationally. Some forces in Congress and in the Truman administration wanted to ensure that the demonstrably successful research and development (R&D) machinery of the war would be reshaped to be responsive to social needs and priorities and controlled by the political process rather than by business or academic interests (Kevles, “National”).

But a variety of other forces combined to ensure that there would be greater freedom and less accountability for both science and industry; these forces included, according to David Noble, the scientific and military establishment in the OSRD, the National Academy of Sciences, and the National Association of Manufacturers (17). Indeed, one historian claims that the reconversion to a peacetime economy was strongly influenced by big business, with the largest military contractors ensuring their own continued influence (Pursell 6); another charges that powerful financial and industrial interests, by deliberately underestimating supplies, creating scarcities, and suppressing evidence, maneuvered to shape the reconversion process to their own purposes (Bernstein 160-61). Both academic science and industry, for different reasons, opposed congressional efforts to ensure public control of postwar R&D; both groups favored government support of basic research and opposed its support of applied research. In his account of industry’s interests in and influence on this debate, Daniel Kleinman notes that the legislation authorizing the NSF was a victory for industry, both because it focused on basic research con-
trolled by scientists and because it failed to prevent patent rights for developments supported by public funds from going directly to private industry.

A series of new postwar government agencies reflects the institutionalization of the links between science, technology, industry, and government. In 1946, the AEC was created both to manage the sensitive knowledge about atomic weapons and to promote the use of that knowledge in developing further weapons and exploring the peacetime uses of atomic energy; the AEC would become a powerful agency with enormous budgets to spend. In that same year, Congress established the Office of Naval Research, and the Army Air Forces began Project RAND, an R&D initiative within the Douglas Aircraft Corporation, which would later become the independent RAND Corporation, the first of many specialized military contract-research organizations. In 1947, the military services were united in the new Department of Defense, giving them greater political and economic influence, and the National Security Act created the CIA and the National Security Council. The NSF, as noted earlier, was founded in 1950, and Associated Universities, Inc., was chartered in 1951 to manage government research laboratories. The National Security Agency was secretly created in 1952 to centralize and strengthen communications intelligence activities.

These new institutional structures reinforced the wartime pattern: Large defense budgets for R&D were contracted out to civilian scientists at research universities, to consultant groups and think tanks, and to major corporations. The Korean War, according to Daniel Kevles, continued the relationships initiated after World War II, "making civilian big science bigger," tying it more closely to the state, and intensifying the arms race ("K1S2" 332). The Sputnik alarm in 1957 only intensified the relationships. Finally, with management changes introduced by the Kennedy-Johnson administration in 1961, came what Seymour Melman has called "a basic alteration . . . in the governing institutions of the United States," which he calls a "state-management" (1). This new industrial-style management by the state concentrates political and economic power, monopolizes public funds, and has a "built-in" tendency to grow (5-6).11 The management changes created new rhetors and buried them under layers of bureaucracy, created new interests that in turn produced new exigences and constraints, and altered the means of persuasion.
New Relationships Between
Science and Technology

The second reason that World War II serves as a cultural transition is that it led to new relationships between science and technology themselves. Our current, everyday senses of "science" and "technology" date only to the nineteenth century, although they derive from distinct traditions that are much older—science from natural philosophy and philosophy itself (the speculative, epistemic enterprises concerned, in Aristotelian terms, with certainty and necessity) and technology from the practical and mechanical arts (the productive enterprises concerned with contingency and emergence). Yet, by the middle of the twentieth century, these enterprises with such different roots had become entangled with and implicated in each other.

Both Big Science and high technology are usually dated to the immediate postwar period, and these terms may simply describe two sides of the same coin of massive federal investment in innovation; at times, indeed, the difference between them seems immaterial. In his 1963 discussion of Big Science, for example, Derek Price gives as examples of Big Science many wartime projects: the Manhattan Project, the development of rocketry, the discovery of penicillin, and the invention of radar and computers (2). Price’s observations about the size of science concern the proliferation of quantifiable constituents (number of publications, abstracts, or scientists). However, his interest in the exponential growth rates of quantitative measures does not point to any qualitative change or specific transformation to Big Science.

Alvin Weinberg, director of the Oak Ridge National Laboratory from 1955 to 1974 and credited by Price with naming Big Science, also talks about the relative size of research budgets but is more interested in qualitative distinctions. He noted that big science posed difficult problems of budget allocation and that it had unfortunate effects on universities and on the motives of individual scientists. Similarly, in an afterword to a recent collection of historical essays on Big Science, Bruce Hevly notes that “big budgets and big instruments” are only indicators of more substantial changes, which include the “increasing concentration of resources into a decreasing number of research centers, the dedication of these special facilities to specific goals,” and the “attachment of social and political significance to scientific projects” (Galison and Hevly 356-57). He suggests that the need for external
justification of projects has altered the relationship between science and technology in the era of Big Science.

Price's list of Big Science projects emphasizes this problematic relationship, for in their orientation to production and utility, these projects are more clearly technological than scientific. More recently, Joseph Rouse has repeated this conflation in his description of how science has extended its influence beyond the laboratory into "massive social and technical systems for utilizing newfound scientific understanding and its capacities for manipulation and control" (245). Rouse's examples also are primarily of technology: the creation and distribution of electric current and various forms of electromagnetic radiation, the synthesis of substances through organic and petrochemistry, the achievement of sustained nuclear fission, and the invention of various means of pharmaceutical and surgical medical interventions (227). Within each of these enterprises, we can see places for what we used to think of as the distinctive roles of science and technology, but teasing them apart has become difficult.

Big Science and high technology together became technoscience. The Frankfurt School critique was really of technoscience because the Nazi political and military system conflated the powers of science and technology, or more specifically their modes of thought, into a single program (Feenberg 165). Bruno Latour has used the expression technoscience to emphasize that "technics and sciences are . . . much the same phenomenon," because

the problem of the builder of "fact" is the same as that of the builder of "objects": how to convince others, how to control their behaviour, how to gather sufficient resources in one place, how to have the claim or the object spread out in time. (Science 131)

Latour sees technoscience as a "network" of facts and artifacts, as well as of people, prior statements, instruments, and natural objects: a network with "resources . . . concentrated in a few places—the knots and the nodes—which are connected with one another—the links and the mesh: these connections transform the scattered resources into a net that may seem to extend everywhere" (Science 180). If there is a rhetoric of technology distinct from that of science, these new relationships, and new ways of thinking about such relationships, make it harder to discern.
New Technologies

The final reason that World War II serves as the transition to the new technological age is that postwar technologies themselves seem to have distinctive characteristics—a transformation signaled by the expression "high technology." Nuclear weapons and nuclear power, computer technology and automation, chemical pesticides and antibiotics, space flight, television—all have roots in the war effort, and all are part of what we now know as high technology. In an early characterization of postwar American technology, historian Max Lerner called it "big technology." His 1952 article, jingoistic by today's standards, pointed specifically to six distinctive features of the "empire" of big technology in America: transformations of power (water, petroleum, and electric); precision machine tools; the principle of interchangeable parts; assembly-line production; "automaticity," especially in process industries; and the vacuum-tube principle, especially in "robot machines"—all of these again consistent with the Fordist and control revolution accounts (100-01).

The United States Department of Commerce officially characterized high technology in 1983 according to two economic measures: "(1) an above average level of scientific and engineering skills and capabilities, compared to other industries (alternatively R&D expenditures relative to sales can be used); and (2) a rapid rate of technological development" (3). But the Department of Commerce's actual list of high technologies was based only on R&D expenditures; it included aircraft and parts, computers and office equipment, electrical equipment, optical and medical instruments, drugs and medicines, plastic and synthetic materials, engines and turbines, agricultural chemicals, scientific instruments, and industrial chemicals.

High technology has also been characterized by its fundamental technical nature, its complexity, its opacity to the user, its large scale and apparent momentum, and its risks; each of these characterizations is described briefly in the following paragraphs. In a discussion focusing on the nature of technical developments, Werner Rammert attributed the rise of high technologies to a "paradigm shift from mechanical engineering to information engineering" (194). This "deep shift" (195) is not the result of any specific technology or innovation but of a fundamentally different conceptualization that is the consequence of many technical and scientific developments, including cybernetics, information theory, microelectronics, telecommunications, and computer science. Rammert sees this shift as independent
of the postwar military-industrial context and rooted, rather, in pre-
war conceptual developments within specific scientific and engineer-
ing cultures (204).

The fact that increasingly powerful technology is also increasingly
complex underlies the crisis of control described by Beniger, because
increased information and coordination become necessary to manage
the technology. The extreme complexity of late-twentieth-century
technology has been described vividly and conceptualized in some
detail by sociologist Charles Perrow. High technology, like the nuclear
reactor at Three Mile Island whose behavior could not be understood
and controlled by its operators or industry specialists, is composed of
so many tightly coupled, interacting components that not all interac-
tions can be anticipated or explained (Perrow). The technological
system thus comes to seem opaque to the human mind, because the
causes of at least some of its behavior are not discernible. In a related
discussion, Chris Demchak argues that complex technology almost
invariably leads to increased complexity in the organization that owns
and manages the technology, because complexity produces surprise
("rogue outcomes") and because of the knowledge burden such tech-
nology places on an organization: High technology requires extensive
and/or scarce knowledge that itself must then be managed and
controlled.15

Analysis of technological complexity is indebted to Karl Marx’s
discussion of how labor was transformed by the industrial revolution.
Marx saw that the difference in complexity between the tool and the
machine produced a difference in kind, based primarily on the rela-
tionship between a human laborer and the technology: The amount
of knowledge, control, and discretion possible was qualitatively different
(ch. 15). Similarly, observers now claim that machines of the nine-
teenth century and complex technical systems of the twentieth century
are qualitatively different. As the tool is an extension of the individual
person in relation to a recalcitrant physical world, the machine is an
extension of several persons with their tools, and the technical system
is an extension of a human organization—a large number of persons
with different interests and expertise. As a consequence, according to
Langdon Winner, "members of the technological society actually
know less and less about the fundamental structures and processes
sustaining them. The gap between the realities of the world and the
pictures individuals have of that world grows ever greater" (295).
Nathan Rosenberg suggests, furthermore, that one of Marx’s "endur-
ing accomplishments" was to see "the inevitability of the trend toward
bigness” in technology (67). In his chapter “The General Law of Capitalist Accumulation,” Marx points not only to the economies possible with large-scale production but also to new motives for further growth that arise from sufficiently large production—for example, the use of byproducts and capital-saving improvements in production technology (ch. 25).

High technology is large in scale in the additional sense that it requires the labor and knowledge of many to develop and produce it and the investment of more money than a few inventors or purchasers can supply. Technologies of this scale require such extensive commitments—of expertise, money, pride, other supporting technologies, and sometimes political power—that they acquire “momentum.” 16 Momentum, the force exerted by a body in motion, makes such technologies hard to stop—to change, avoid, or cancel. 17 Such technologies or technical systems thus seem to have, if not a life of their own, a force of their own: They come to seem “autonomous.” As Winner has pointed out, technologies come to seem autonomous when we ourselves do not feel in control. And losing control, Winner notes, means losing one of the primary ideals of modern Western culture—the Baconian ambition for the power over nature that comes with knowledge of it. Thus, as technology gets larger, more complex, and more pervasive, it seems to undercut its own justification: Rather than making us feel we have more control, it makes us feel we have less (19-30).

Another way of understanding the transformation to high technology has recently been offered by Ulrich Beck, a German sociologist. We are entering, he suggests, a period in which the “social production of wealth is systematically accompanied by the social production of risks”; the central social problem is thus no longer the distribution of wealth but the distribution of risks (19). The technological and economic development we have known as modernity, he notes, was concerned “with making nature useful, or with releasing mankind from traditional constraints,” but now we are concerned “also and essentially with problems resulting from techno-economic development itself” (30); therefore, he claims, modernization is becoming “reflexive.” Beck also suggests that debates about risk distribution make evident the vast differences between scientific or technical rationality and social rationality (30). This fissure is also characteristic of our technological culture.

Just as some of the characterizations reviewed above are approving and some sharply critical, high technology today has two opposing
tonalities. In the pages of Fortune magazine or a Department of Commerce report, high technology represents the basis of economic competitiveness, of our victory in the Persian Gulf War, and of the American claim to world leadership. As sociologist Denton Morrison noted in 1983, the advocacy of "hi tech" carries a sense of moral urgency in a presupposed project of capitalistic growth and affluence (240). In the alternative press, however, high technology is usually understood specifically as inappropriate technology because it presumably devalues (and deskills) labor, is energy and resource intensive, dehumanizes the workplace, and permits manipulation of the private lives of individuals (240-43). In most thoughtful explorations of it, the culture of high technology is unpleasant and dangerous, not only because of the specific hazards of technologies themselves but also because of the values and social patterns they promote. That the appearance of new forms of technology and of a technological culture in the postwar period is accompanied by concerted criticism may be another sign of the distinctiveness of this period. And the impersonality, turgidity, and hermetic qualities of technological rhetoric have also taken their share of criticism. The history reviewed here should help us understand the cultural sources of such rhetorical qualities and see them as symptoms and indexes, not merely as perversities.

TECHNOLOGY AND SCIENCE

The relationship between science and technology may be as much a matter of ideology as of empirically demonstrable connections. Four ways of understanding this relationship developed in the postwar era; I call these the hierarchical, monolithic, interactive, and reverse hierarchical models. These models condition our understanding of the rhetoric of technology in somewhat different ways; each provides somewhat different warrants in debates about this relationship, debates having to do with the allocation of resources or the nature of expertise, for example.

The understanding that prevailed for a long time into the postwar era, both in academic and in policy circles, is represented by what Barry Barnes and David Edge have called a hierarchical model, with science the privileged enterprise, initiating discovery and producing new knowledge. Knowledge is then passed down as applied science to technology, an application that involves the routine working out in practice of the implications of that knowledge (Barnes and Edge). The
hierarchical model also confirms and continues the long historical valorization of science over technology. It is, in effect, a rhetorical move that helps maintain the status of science and scientists.

The most influential statement of the hierarchical model during the postwar era was made in 1945 by Bush. During the course of the protracted debate about the reconversion to a peacetime government and economy, Bush prepared a report to the president titled *Science, The Endless Frontier*, which has been called "one of the most influential policy documents in the nation's history," one that "set the tone and boundaries of the debate on science policy for nearly a generation" (Smith 43). It was also reportedly "an instant smash hit," the subject of widely positive news stories and editorial commentary (qtd. in Kevles, "National" 23). The report overall is an argument for the value of basic research and the need for the federal government to support it and to provide for the training of research scientists. It is seen as the initial step in the process that led to the creation of the NSF in 1950. One of Bush's major arguments was that science should be controlled by scientists, not by government policy or by the needs of mission agencies: "Scientific progress on a broad front results from the free play of free intellects, working on subjects of their own choice, in the manner dictated by their curiosity for exploration of the unknown" (12). Scientific progress is justified as essential to national defense, economic health, and the public welfare and thus deserving of public investment. Once such investment is made in the pure scientific enterprise, an invisible scientific hand would guide the creation of scientific knowledge, and an invisible technological hand would guide the use and application of that knowledge for public good. As an argument about science and science policy, Bush's report obscures the role of technology by foregrounding the central motivating role of high-prestige, academic-based, investigator-initiated science. It also preserves the interests of business and industry in the postwar era by encouraging public investment without public control.18

Bush's appeal to freedom was echoed by Michael Polanyi in 1962, when consensus about Bush's argument was beginning to fray both in the United States and in England, where Polanyi wrote to protest suggestions that scientific inquiry should be explicitly directed toward serving the public welfare. He argued that scientific progress is "autonomous" (63), requiring that scientists "freely mak[e] their own choice of problems and pursu[e] them in the light of their own personal judgment" (63, 54). The "Republic of Science," he claimed,
must be a "free society" (72) in which the individual efforts of scientists are coordinated by an "invisible hand" (56) in the same way that the relations between producers and consumers are optimized by the operation of markets.

By 1961, when Eisenhower delivered his farewell address, the hierarchical model had begun to come under challenge (partly because an economic slump meant that the public benefits to investment in science were not forthcoming), and a monolithic model began to replace it. In a less-quoted part of his speech, Eisenhower portrayed a near conflation between science and technology:

Akin to, and largely responsible for the sweeping changes in our industrial-military posture, has been the technological revolution during recent decades. In this revolution, research has become central; it also becomes more formalized, complex, and costly. A steadily increasing share is conducted for, by, or at the direction of, the Federal government. . . . The prospect of domination of the nation's scholars by Federal employment, project allocations, and the power of money is ever present—and is gravely to be regarded. Yet, in holding scientific research and discovery in respect, as we should, we must also be alert to the equal and opposite danger that public policy could itself become the captive of a scientific-technological elite. (1038-39)

The recent success of the term technoscience reflects the appeal of the monolithic model, and the conflation of science and technology has been facilitated in certain ways by public policy and institutions. Although the US government has been deeply committed to science policy ever since World War II, it has been officially skittish about having a technology policy. The assumption made in the Bush report and widely accepted in the immediate postwar period was that technological application would follow new scientific knowledge "almost automatically" (Smith 37, 85); thus, technology policy has been an implicit, or perhaps covert, element of government science policy. Throughout the period from 1960 to 1985, basic research received only about 10% of all federal R&D funding, applied research 20%, and development about 70%, with research mainly supported as an overhead cost on development (161). However, there has never been a federal budget specifically designated for R&D; all funding of R&D is tied to and justified through the needs of various "mission agencies" (162). Thus, science funding has been based on technological justification, and science, although officially privileged, has been dependent on technology.
Historians and sociologists have decided that the hierarchical model does not reflect the evidence of historical events or actual practice, and Barnes and Edge claimed in 1982 that advocacy of the model was in decline and perhaps already "defunct" (149). They proposed as a corrective an "interactive" model, in which science and technology are separate but closely related "subcultures" with distinguishable "bodies of lore and competence" (150); both are creative enterprises, both draw on their own traditions, and both make creative and contingent use of the other's products on occasion. But Jean-François Lyotard has proposed yet a fourth model with his suggestion that the hierarchical relationship promoted by Bush has been reversed, that it is technology, with its criterion of efficiency or "performativity," that now drives science—the search for power having replaced or co-opted the search for knowledge (as well as for justice) (Lyotard 45-47). The use of technological justifications for science funding can support this model as well as the monolithic model.

Each of these four models has its uses. If the hierarchical model serves as a "legitimizing device" in policy discussions, as Barnes and Edge suggested (148), and the monolithic and reverse hierarchical models enable certain kinds of critique, the interactive model serves as a device that legitimates certain kinds of open academic inquiry, specifically inquiry that takes technology seriously on its own terms: It permits the reanalysis of technoscience into its components without presuming any particular relation between them. On the other hand, the bland neutrality of the interactive model may also serve to obscure the reversal that Lyotard discerns. Part of the rhetoric of science and technology is the (often implicit) promotion or presumption of one or another of these models.

As an example, I will look briefly at a report responding to the Bush report in the debate about postwar support for science. It was prepared for the Army Air Forces by Theodore von Kármán, an aerodynamics specialist who founded what became in 1942 the Jet Propulsion Laboratory. This multivolume report, Toward New Horizons, included an assessment of current capabilities and knowledge as well as projections for future technical development and policy recommendations. The report by von Kármán seems to accept the hierarchical model of science and technology, but it argues strenuously against the centralization of research funding that Bush had promoted. von Kármán relies heavily on free-market arguments with which Bush would have had to agree: "If free enterprise and initiative are necessary for
maintaining a sound economy within a nation, certainly they are even more necessary in scientific life" (69). von Kármán uses these arguments to support his contention that the Air Forces must be able to retain control of the science they support: "The Air Forces should have the freedom to call on institutions and individuals whose assistance they deem to be of the greatest benefit for their program" (70).

The report set into motion the mechanisms that would lead to the RAND corporation and its daughter think tanks and contract-research organizations, as well as the movements that would become technology forecasting and technology assessment. It also had the effect of weakening Bush's proposals for centralized science support: Most federal support for basic research (let alone applied) was to come from separate mission agencies, such as the AEC, the Department of Defense, the National Academy of Sciences, and the National Institutes of Health, rather than from the NSF. Yet, von Kármán's work is much less widely studied and cited than Bush's. Both were influential, but Bush's influence was overt and von Kármán's largely covert. The report by von Kármán promoted technological interests by co-opting science; it may also represent one of the earliest examples of the reversal of the Bush hierarchy.

IMPLICATIONS FOR RHETORIC

Whichever model of the relationship between science and technology we might adopt, we have to find a way to identify the rhetorical elements of technology, teasing them out of the vast complex of technological culture. It is also helpful to keep in mind that this vast complex supports several different phenomena that constitute the rhetoric of technology. These phenomena comprise, at least, what we might call rhetoric about technology, often more-public representations or debates in public policy forums; rhetoric within technology, or the private, proprietary discourse by which technological work gets done; and rhetoric from technology (perhaps the most interesting category), the ways in which values and thought patterns developed by technological work extend to and pervade other cultural arenas. These three categories are probably not mutually exclusive.

Because science is by now better understood rhetorically than technology is, it may be helpful to think contrastively to identify the rhetorical features of technology that emerge from the material reviewed here. I can suggest four such distinct differences between
science and technology understood in broad outline, differences that should matter to articulating any of the three types of rhetoric of technology.

1. *Technology emphasizes practice; science emphasizes knowledge.* Technology is conceived as concrete, interventionist, productive, and science is conceived as abstract, abstruse, theoretical. Although there are, of course, practices in science and theories in technology, they are means, not ends. As practice, technology involves a search for effectiveness or "performativity," whereas science’s interest in knowledge involves a search for truth. Lyotard’s discussion connects technology directly to power (46), and technology and science come to represent the poles of Michel Foucault’s collocation *pouvoir/savoir,* or "power/knowledge." The coinage *technoscience* similarly reminds us of Foucault’s emphasis on the mutual relations of the discourses of knowledge and the deployment of power. Joseph Rouse has pointed out that in traditional views of power and knowledge, they remain “extrinsic to one another” even though they interact and that when we begin with knowledge, which has always been the privileged philosophical concept, there are limits to the influence and relevance of power (13). Studying technology requires us to begin with power instead, to place epistemic claims in the background and examine the discourses of performance, control, and effectiveness; studying technoscience requires us to inquire into the specific relationship of power and knowledge in any given case.

2. *Technology is anonymous; science is eponymous.* The anonymity of technology is related to its association with the middle and working classes, not the privileged or leisured classes. But furthermore, as a practice, technology is developed by teams, produced by shifts, and used by fungible clients and customers; action and ownership are claimed by corporations not individuals. There are exceptions, of course—the stories about the founding of Apple Computer, the heroizing of Edison—but as an enterprise, technology does not identify its actors and rhetors; the reputations of Bush and von Kármán present contrasting cases in point. In science, although much work is collaborative and some research is submerged in proprietary corporate ends, the cycle of credit still ends at the mind of an individual scientist as thinker, after whom the finding is named, to whom the prize is awarded. Science has texts as its primary product—knowledge-bearing texts with identified authors, texts that are easy to identify and isolate as critical objects—but in technology, discourse appears as a byproduct, as whatever lies
between artifacts and methods, contingencies and decisions, and causes and effects, most of which remain proprietary and therefore hidden. Objects for rhetorical study in technology are thus harder to locate and define.

3. Technology is autonomous; science is controlled. No one ever talks about science as being autonomous or having its own momentum. Our sense of agency in the two enterprises is quite different. Science seems to be under the control of scientists—those who know, those who design and perform experiments. Occasionally, an experiment may go out of control, with an escaped virus or a radiation leak, but these are aberrations. In contrast, it is in technology’s nature to assume control: In fact, we delegate control to technologies deliberately, as Latour has emphasized (“Mixing”). Because of the apparent autonomy of technology, in addition to its anonymity, orators and audiences are harder to discern than in science; for example, the relatively anonymous writers of the AEC’s Rasmussen report of 1975 (the report that exonerated the risks of nuclear power and helped to promote the now-powerful discourse of risk analysis) may easily be viewed as mouthpieces for a vast complex of sociotechnical forces, with effects less on specific audiences than on subsequent arguments (United States Nuclear Regulatory Commission). The rhetoric of technology, then, may be a rhetoric of systems—perhaps a rhetoric of ideologies—in that social actors are not so much the creators of texts as the agencies through which beliefs and practices are reproduced.

4. Technology is ubiquitous; science is esoteric. Because technology is artifacts as well as practices and knowledge, we are aware of it surrounding us—the video games and answering machines in our homes, the computers and assembly lines in the workplace, the parking lots, the processing plants, the power lines, and the waste dumps in our communities and in the countryside. Technology inserts itself into our everyday lives in a way that science, shut up in laboratories with the experts, does not; technology is part of the economy, of politics, of everyday culture—and is public in that respect, although its processes remain proprietary and its consequences unanticipated. And with the public artifacts come the practices and the knowledge, shaping our lives and our minds. Walter Ong, among others, has noted that technology is an inherent part of human culture: “Artificiality is natural to human beings” (82-83). But here is where the differences between low and high technology matter. Because of its complexity (which relies on knowledge that is more specialized than ordinary individuals have)
and because of its scale (which involves not individuals but teams and organizations), high technology seems inhuman, unnatural. Its ubiquity combined with its complexity and autonomy make it seem invasive.

The question that technology poses for us, then, is how it comes to have these effects or to make these impressions (How does technology propagate itself? How does an anonymous set of practices acquire cultural power?) This question has been posed before, most sharply by the German social and critical theorists. Weber described the progressive rationalization of society, an insistent expansion of the areas subject to an instrumental form of rationality; Marcuse noted that technological rationality was “spread[ing] over society” (415); Habermas saw technocratic consciousness “migrating” into the “sociocultural life-world” (113). Rhetorical studies should have a great deal to say about this question, if we are not to make vitalist assumptions about the literal autonomy of technology, to presuppose a conspiracy of technical elites, or to conclude that humans and technologies are equal “actors” in the same “network” (Latour, “Mixing”).¹⁹ The phenomenon of propagation, migration, or expansion points to rhetorical processes, to the suasive uses of arguments and images, to changing beliefs, and to the manifestations of power in language.

Rhetorical studies of technology should help us understand the wide dissemination, diverse applications, and cultural potency of technology as a shaper of our lives and minds; they should reorient our understanding of technoscience and at the same time stretch and test our conceptions of rhetoric. A rhetorical description of action, exchange, and objects in technology (which of course all be described in other ways) helps connect the impersonal and mechanical to the social and cognitive. Rhetoric then becomes the very substance of the networks that Latour posits to explain the sociotechnical complexes at the heart of contemporary life; by the same token, technology becomes the Burkean situation or scene for the rhetoric by which contemporary life is socially constructed.

NOTES

1. It might be argued that, post-Kuhn, this description no longer has much currency among scientists, but the vigor and rancor of the debates about science studies that have become known as the “science wars,” especially post-Sokol, suggest otherwise.
2. Studies of science preceded those of technology in just about all of these areas. Philosophy of science, for example, is at least a century old—philosophy of technology only a couple of decades. History of science preceded by a significant time the newer work in history of technology, and sociology of scientific knowledge (SSK) has spun off a new research program in the social construction of technology (SCOT).

3. The description that follows has been informed primarily by David Harvey’s book on postmodernity.

4. Edwin Layton suggests that Taylorism can be seen in part as an “assimilation” of management into the engineering profession (136); it thus represents the capture by technological thinking of what had been an intuitive or personal managerial art. Business historian Stephen Waring has made the case that Taylorism, as a management theory, also survived into the postwar period, taking a variety of new forms that attempted to overcome its technical limitations but remained committed to its basic premises. These transformations of Taylorism include operations research and cybernetics as well as recent versions of the human-relations school of management.

5. This critical tradition, stemming from Marx and Weber, includes the work of Marcuse, Heidegger, and Habermas, and, in a less direct way, Ellul. David Held provides a useful introduction to the specific views of members of the Frankfurt School.

6. An earlier, related work is Yates’s study of the development of communication technologies and their increasing use as control systems in industry from 1850 to 1920.

7. Two recent discussions that indicate the continuing utility of this term are by Bruce Brunton and Sheldon Ungar. Brunton suggests that the military-industrial complex can be most helpfully conceptualized as a set of five “institutions,” not as a system of groups or interests. The institutions he identifies are (1) reliance on private contractors for peacetime military procurement, (2) the revolving door, (3) defense pressure groups, (4) the preparedness ethos, and (5) state support of strategic industry (47).

8. See Martin Medhurst’s detailed discussion of the role these arguments played in the entire speech and Charles Griffin’s discussion of the genesis of the speech.

9. Bush, often described as the most influential wartime scientist, was actually an engineer who had been dean at MIT and president of the Carnegie Institution in Washington. Daniel Kleinman characterizes Bush as a “boundary elite” with close connections to science, the military, and industry (58).

10. For useful examinations of this debate, see Kevles, “K1S2,” “National,” “Scientists”; Kleinman; Smith.

11. These institutional relationships are reflected in the “consensus ideology” that historian Godfrey Hodgson discerns in America during the 1950s, which he describes as a “strange hybrid, liberal conservatism,” formed in the prosperity of the postwar period. This ideology, consisting mainly of confidence “to the verge of complacency” about domestic affairs and extreme anxiety about foreign affairs, especially the threat of communism, “blanketed the scene and muffled debate” (73). The key assumptions included a commitment to capitalistic free enterprise and the economic growth it promoted and a confidence that social problems could be solved in the same way as industrial problems: with analysis, expertise, and financial resources (76).

12. See Leo Marx’s discussion of the origin of the term technology, its early uses, and the ways it contrasts with the earlier term mechanic arts.

13. The terms themselves appear somewhat later. Big Science was coined in 1961, and early references to high technology have been dated to the late 1970s (Morrison 239),
although the Oxford English Dictionary gives the earliest use in 1964, with several references in the early 1970s.


15. Demchak gives the example of the army’s supertank, the M1 ABRAMS, which was intended to be simple to operate and to repair. However, it could not be repaired without a significant amount of help from the contractors, and some symptoms mystified even the contractors’ engineers. The army responded by contracting for another machine—"alternate test equipment"—which was supposed to tell the repairer what the problems might be in the bigger and unexpectedly complex supertank. But as time went on, the smaller machine could not be repaired without special help, and the army created a new job specialty for that task as well. Those who operated the machine were trained separately; those who maintained it were given new job categories. Finally, faced with enormous unexpected costs, the organization began to monitor the parts for the tank on a worldwide basis. In sum, the tank that was meant to be simple, cheap, and reliable turned out to be complex, expensive, and surprising. (1-2)

16. The term was first used about technology by historian Thomas P. Hughes in 1969 in his discussion of the hydrogenation technology developed in Germany during World War I (Staudenmaier 149). After the war, the interests and people involved in the technology cooperated with the Nazis to acquire the continued support necessary for the technology to grow. Hughes attributed this association with the Nazis to the momentum in the complex of technology, interests, and investments.

17. The cancellation of the superconducting supercollider (SSC) by Congress may be one of the first instances of such magnitude. Whether the SSC is primarily to be thought of as science or as technology is a matter for inquiry, not pronouncement.

18. For useful discussions of the Bush report, see England; Kleinman; Reingold.

19. See Myers for a recent argument about the heuristic advantages of this latter assumption, together with a useful overview of the work that makes use of it.

REFERENCES


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