Carl Mitcham. Thinking Through Technology: The Path Between Engineering and Philosophy. Chicago: The University of Chicago Press,1994

CHAPTER SIX

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From Philosophy to Technology

The introduction raised the prospect of thinking about technology in a philosophical way and pointed toward different aspects of any such effort. One aspect entails the identification of a basic philosophical stance or attitude; a second involves its instantiation in appropriate conceptual engagements with technology. Philosophy of technology must be both a *philosophy* of technology and a philosophy of *technology.*

Chapters 1 and 2 set out, by means of historicophilosophical investigation, to address the first of these issues. Engineering philosophy of technology was distinguished from humanities philosophy of technology, after which chapter 3 considered mediating approaches but finally argued for primacy of the latter. Chapter 4 sought to articulate in more detail, on the scaffolding of traditional diversions within philosophy, the distinctive stance of humanities philosophy of technology. Chapter 5, by way of supplement, proposed to deepen the discussion by demonstrating the implicit existence of a distinctively premodern humanities philosophy of technology, thereby raising the possibility of a fundamental distinction between ancient and modern technology. Interest in such issues of historical recovery may also be described as typical of the humanities approach to philosophical reflection on technology.

Engineering Objections to Humanities Philosophy of Technology

A proponent of engineering philosophy of technology could, however, raise at least three objections to the philosophical primacy of humanities philosophy of technology (HPT). One is that it is simply not possible to have the humanities without technology. As one prestigious commentator on Benjamin Franklin's definition of the human being as a "tool-making animal"[1] has written, "Inventiveness was the indispensable condition for the survival of the human species. Without fur or feather, carapace or scale, ancestral man stood naked to the elements; and without fang or claw or tusk to fight his predators, without speed to elude them, without camouflage to deceive them or the ability to take to the trees like his cousin, the ape, he was physically at a hopeless disadvantage. What he developed to deal with his deficiencies was [technology]."[2] Second, the defense of HPT as more philosophical "stacks the deck"; HPT is necessarily going to be more weighted with philosophy and philosophical sophistication than engineering philosophy of technology (EPT), since philosophy is one of the traditional humanities and engineering is not. A final objection is that to equate "being more philosophical" with "being primary" begs the question; there are serious weaknesses with so-called humanities philosophy of technology.

The first objection misconstrues if not overindulges itself. Although it has a point, it goes too far. At most it is an argument for the primacy of engineering over the humanities, not of engineering philosophy of technology over humanities philosophy of technology. Furthermore, historical priority does not entail logical primacy. Indeed, the imputed historical priority itself is questionable, since it is in no way clear that premodern and modern technology are not the same—a point repeatedly overlooked in many otherwise sophisticated philosophies of technology.

Nevertheless, there remains a readily appreciable truth that must be acknowledged. To the extent that there is any continuity, however attenuated, between premodern and modern technology, and insofar as the humanities are dependent on technology, then to that degree a philosophy of technology that takes its bearings solely from the humanities rather than from technology must be deficient.

There is also some truth to the second objection, that the defense of HPT as "more philosophical" stacks the deck. Of course it is more philosophical, since philosophy is one of the humanities. Consider the situation if the tables were turned. Were one to distinguish between "engineering technology" and "humanities technology," engineering technology would necessarily be more technological than humanities technology, simply because engineering is a technology whereas the humanities are not. At the same time, if there were humanities scholars making claims for works of literary criticism or even philosophical texts as being instances of technology equal in engineering significance to large bridges or skyscrapers, then surely such scholars would deserve criticism as being insufficiently appreciative of the technological character of technology.

An engineer might still respond with the third objection, Why argue about words? The real issue is not which tradition can make a stronger claim to the word "philosophy," but which is really more philosophical in the sense of doing what needs to be done by way of conceptual analysis and reflective clarification of the lifeworld as it has been influenced or transformed by modern technology. Is EPT not in fact making the more important contributions to this task?

Here the answer is both yes and no. It is important to admit that EPT is doing something that needs to be done. A defense of the philosophical primacy of HPT need not imply that EPT should cease to be practiced—or that HPT is perfect as it stands. In the EPT emphasis on paying closer attention to the real world of engineering experience and discourse, it reveals legitimate analytic work to be done. As American engineer-philosopher Billy Vaughn Koen puts it:

> The study of engineering method is important to understand the world we have. The environment of man is a collage of engineering problem solutions. Political alliances and economic structures have changed dramatically as a result of the telephone, the computer, the atomic bomb and space exploration—all undeniably products of the engineering method. Look around the room in which you are now sitting. What do you find that was not developed, produced or delivered by the engineer? What could be more important than to understand the strategy for change whose results surround us now and, some think, threaten to suffocate, to pollute and to bomb us out of existence?
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> Yet, although we speak freely of technology, it is unlikely that we have the vaguest notion philosophically of what it is or what is befalling us as it soaks deeper into our lives. . . . Now, as we sit immersed in the products of the engineer's labor, we must ask: What is the *engineering* method?
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> The lack of a ready answer is not surprising. Unlike the extensive analysis of the scientific method, little significant research to date has sought the philosophical foundations of engineering. Library shelves groan under the weight of books by the most scholarly, most respected people of history analyzing the human activity called science. No equivalent reading list treats the engineering method. (1985, pp. 1–2)

The British engineer-philosopher G. F. C. Rogers readily agrees. As he says, although "no one can hope to understand the work of more than a few" of the disciplinary specialists contributing to the complex world of contemporary knowledge, we

> can and should try to understand the framework of ideas within which each broad group operates. This is especially necessary when the specialists are engineers or technologists because their power to influence the way in which we live has reached an awesome level. . . . Finding ways of harnessing the power of technology for the greater benefit of mankind, and of moderating the social stresses arising from the ever-increasing rate of technological change, poses unparalleled problems for humanity. There is little hope of accomplishing either of these things unless both the public and government understand the nature of engineering and the ways in which technologies are born and develop. (1983, p. 1)

But insofar as the engineering-philosophical analysis of engineering is taken as the basis for a general explanation of the human world, or even of technology, EPT fails to recognize its own limitations and its place within a larger framework. Something is left out, and it is not clear how EPT can be expanded to include the missing element. Argument to this effect no longer is merely a plea for verbal distinctions, but seeks real ones.

One of these real distinctions is between different ends or criteria of judgment. Historically, the rise of EPT entailed an explicit rejection of HPT in the form of what might be called premodern philosophy of technology—not for being less philosophical, but because it was less *technological*. Traditional philosophy has done less to change the world than have gunpowder, printing, and the compass, argued Francis Bacon; therefore philosophy itself (that is, especially natural philosophy) should be changed, should become allied with the making of artifacts. But practical efficacy in changing the world is not the highest or most inclusive criterion of judgment. When someone wants to bring about practical change, it always makes sense to ask why or for what?

The argument here can be made in a collateral way by pointing out that humanities philosophy of technology is inherently more inclusive than engineering philosophy of technology. Inadequate examples notwithstanding, because of the humanities commitment to a plurality of perspectives, humanities philosophy of technology must in principle remain open to the engineering perspective. It is not obvious that engineering qua engineering has a similar principled openness. For instance, questioning the world according to engineering criteria such as practical efficacy or efficiency is only one kind of questioning and can itself be questioned. To defend or argue for the primacy of efficacy or efficiency, one has to make use of other criteria. Even to criticize some

particular HPT tendency to slight efficacy and efficiency in defense of tradition or beauty almost necessarily calls for invoking other nonengineering criteria such as democratic principles or economic constraints. When engineering philosophers of technology initiate discussions with humanities philosophers of technology they become more like them than happens when the situation is reversed. Humanities philosophy of technology is more capable of including engineering philosophy than engineering philosophy of technology is of including humanities philosophy.

But why should this kind of inclusiveness be a defining characteristic of philosophy? Isn't engineering or technology inclusive of the humanities, in the practical or material sense that without some technology there would not be any human life, much less any humanities—which also generally use tools of many sorts, from pencils to computers, to perform their distinctive tasks? But the point is that even if engineering includes the humanities on the practical level, once engineers start proposing theories about the nature and meaning of technology they are no longer doing technology but are engaging in a kind of philosophy. Once one starts talking rather than making, then criteria of talk or discourse such as comprehensiveness and inclusiveness properly become factors of judgment, not solely those of practical effectiveness.

Philosophical Objections to Humanities Philosophy of Technology

Yet it is crucial to remember that the defense of humanities philosophy of technology over engineering philosophy of technology is not without its own criticisms of the typical humanities engagements with technology. Humanities philosophy of technology often does fail to pay sufficient attention to engineering experience and technological reality—presuming that it is possible to think on the cheap. It is remarkable, for instance, how little José Ortega y Gasset, Martin Heidegger, and Jacques Ellul seem to know about the real world of engineering. This is not quite so true with regard to Lewis Mumford, but even Mumford, especially in his late works, relies more than one might like on large metaphors that sometimes lose contact with technical experience. There is something going on in EPT that HPT must be altered to include.

There are any number of examples of humanities scholars, especially philosophers, talking about technology in shallow ways. Consider, for instance, Bernard Dauenhauer's phenomenological study *Silence*.[3]

Dauenhauer undertakes to describe various kinds of silence in relation to different kinds of discourse, one of which is technological discourse. But in comparison with his descriptions of scientific, political, moral, religious, and artistic discourse, his characterization of technological discourse is exceptionally thin. The description of political discourse makes references to Aristotle, Montesquieu, Rousseau, the Third Reich, Napoleon; that on artistic discourse to actual works of art such as Picasso's *Guernica* and T. S. Eliot's *The Waste Land*. But in talking about technological discourse Dauenhauer relies on the most general kinds of statements from Heidegger and Marcel. He never appeals to the works and words of engineers themselves.

Although artists and perhaps even politicians might be able to recognize their languages in Dauenhauer's descriptions, it is doubtful whether any engineers could recognize themselves. Indeed, of the four key representatives of the humanities philosophy of technology tradition—Mumford, Ortega, Heidegger, and Ellul—the two professional philosophers exhibit exactly this same weakness in the strongest sense. Although HPT is in principle more inclusive than EPT, it has clearly not exercised or realized this inclusiveness. It is only more technically minded philosophers such as Mario Bunge or more recent contributors to the philosophy of technology such as Don Ihde who begin to rectify this oversight. HPT may be able to be inclusive—but it is not yet nearly inclusive enough. To become inclusive, to realize its full potential, HPT needs to turn *from* philosophy *to* technology, or at least to technological discourse.

The movement at issue is to some extent the opposite of that enunciated by Samuel Florman, a ready representative of engineering philosophy in one of its more expansive forms. On the one hand, in *The Existential Pleasures of Engineering* (1976) Florman is a withering critic of humanities philosophers of technology such as Mumford and Ellul; he defines human beings as inherently technological and defends engineering as itself a liberal art. In *Blaming Technology* (1981) he goes on to defend nuclear power, to argue (contra E. F. Schumacher) that "small is dubious," and to reject the idea of engineering ethics.

On the other hand, Florman admits, and even argues, that engineers cannot be fully civilized by engineering alone; their education should be complemented and enlarged by the liberal arts and the humanities. Indeed, his first book, *Engineering and the Liberal Arts* (1968), was written "to advocate the cause of liberal education for engineers" (p. vii). The first chapter of that book, "The Civilized Engineer," became the

title of a fourth volume, *The Civilized Engineer* (1987), in which he pleads "the cause of a humanistic professionalism, an ennobled engineering that will rise out of the ashes of vocational training" (p. 173).

But the weakness of engineering philosophy of technology is also revealed here in one of its representatives who is most open to the humanities. Florman does not want to reduce the humanities to simple utilitarian value. Yet for Florman the humanities remain fundamentally dependent on technology and thus are at best a kind of desirable epiphenomenon that should be granted some reflective influence on the primary phenomenon of technology.

> The "roots" of a civilized society are the technical accomplishments that relieve people of brute effort and make humanity possible. When we speak of the "fruits" of our efforts, of the "flowering" of civilization, we refer to art, philosophy, and science. If the fruits and the blossoms are not returned to nourish the soil, then life loses strength and its flowering becomes less radiant. . . . [I]f technology is not enriched by new beauty and insight, then the growth that follows is less luxuriant and all of humanity is the loser. (1987, p. 181)

Florman fails to give an adequate account of the humanities task, to see that the humanities are themselves a root of civilization.[4]

Given Florman's genuine if failed attempt to take account of the humanities, it is especially appropriate that humanities philosophy of technology make a genuine effort to engage technology on its own terms and not, like Dauenhauer, remain at a superficial distance. With this in mind the focus of attention in part 2 properly shifts from the humanities *philosophy* of technology to humanities philosophy of *technology*—or what may be termed, without qualification, philosophy of technology simpliciter.

Two Usages of the Term "Technology"

In the spirit of this shift it is appropriate to begin with a consideration of the very term "technology." The word "technology" has, in current discourse, narrow and broad meanings, which roughly correspond to the ways it is used by two major professional groups—engineers and social scientists. The latter usage also indicates the way humanities scholars most often employ the term. It is important to recognize such distinctions at the outset, because tension between these two usages, which stretch across a spectrum of conceptual references, easily results in analytic confusion.

Engineering Usage

The engineering usage is more restrictive. To begin with, the word "engineer" itself has etymological and sociological connotations that cast shadows over any engineering concept of "technology."

Etymologically the word "engineer," rooted in the classical Latin *ingenero*, meaning "to implant," "generate," or "produce," readily connotes producing or making, but not only of an artificial sort; the Latin (as in *ingeneratus*, "innate" or "natural") is associated with *natura* as well as with *ars* or *techne*. Yet today engineers often distinguish not just between bringing into being by nature and by technique, but also between engineers and technicians. The engineer works with nature and its laws as revealed by science, whereas the technologist focuses more on the actual construction. The engineer makes with the mind, the technician with the hands; the former is a white-collar worker, the latter a blue-collar worker. Such a difference is exemplified, for instance, in professional distinctions between a bachelor of science degree in engineering and the bachelor (or associate) of technology degree in the applied or industrial arts.

Historically, however, this usage can be contrasted with the original meaning of the term "engineer" and its cognates, which first appeared in the Middle Ages (Latin *ingeniator*) to designate builders and operators of battering rams, catapults, and other "engines of war."[5] Later, somewhat independently, in the eighteenth century the term was used to designate the operators of steam engines. Indeed, attenuation of both references is quite recent.

Reflecting this background, Samuel Johnson's *Dictionary of the English Language* (1755) defines the engineer as "one who directs the artillery of an army," and Noah Webster's *American Dictionary of the English Language* (1828) describes him as "a person skilled in mathematics and mechanics, who forms plans of works for offense or defense, and marks out the ground for fortifications." There is, however, a shift in emphasis between Johnson and Webster; the latter begins to identify the engineer as the one who "forms plans" or thinks things out—albeit with regard to military fortifications. This picks up on a supplementary connotation from the Latin, one that enters English by way of the French. Because natural objects exhibit cohesion within themselves (they "work") and with their environment (they "fit"), an artifact that exhibits either set of properties can be described as *ingeniosus*. Thus the Old French *engignier* is one who contrives or schemes to make things fit—with an implication, perhaps, that they might not otherwise do so. Because of the vaguely impious character of competition with nature, the fourteenth-century English "engynour" who plots and lays snares, even though he may well work with his mind and not with his hands, has certain unsavory connotations.[6]

Originally, then, the distinction between the white-collar engineer and blue-collar technician did not exist—all engineers were khaki-collar soldiers—or it existed in other forms. Outside the realm of military affairs, for example, the general name for one who designs and directs the construction of large-scale artificial structures was "architect"—Latin *architectus*, Greek *architekton*, from *archi-* (primary or master) plus *tekton* (carpenter or builder). Here there is an implied distinction between the designer who exercises a superior or more inclusive view and the technician or worker. Thus Vitruvius's *De architectura*, a work in ten books published at Rome in the first century C.E., deals primarily with urban planning, options in building materials, aesthetic principles, general construction strategies, hydraulics, geometry, mechanics, and so forth.

John Smeaton (1724–1792) was the first person to call himself a "civil engineer." Having initially gone up to London in 1742 to study law, he joined the Royal Society and became involved in scientific works. After serving as architect for rebuilding of the Eddystone Lighthouse in the late 1750s, he began in 1768 to refer to himself as a "civil engineer" to distinguish both his professional origins and his works, although certainly in peacetime many military engineers were employed in tasks similar to his own. While retaining a broad nonmilitary connotation on the Continent, "civil engineering" has come to refer in the English-speaking world more narrowly to the designing, constructing, and maintaining of roads, bridges, water supply and sanitation systems, railroads, and such—that is, publicly funded and utilized projects that are conceived more from the point of view of utility and efficiency than in terms of aesthetic form or symbolic meaning.[7]

The eighteenth century thus witnessed a lateral separation of civil engineering from military engineering among the upper classes. At the same time there occurred a vertical distinguishing of mechanical engineering from mechanics among the lower classes. As an offshoot of the multiple inventions and utilizations of the steam engine, the term "engineer" was used to designate a person, usually of lower-class origins, who operated the same. Closely associated were the "mechanics" who constructed, maintained, and operated these machines.[8] James Watt (1736–1819), for example, was said to be a "practical engineer," to dinstinguish him from the slightly more theoretically based representatives of military and civil engineering.[9]

With the development of "mechanical engineering" as a profession distinct from but allied with artisans, inventors, operators, and scientists—that is, engineers as persons with technological engagements and scientific-mathematical training—the 1800s promoted the Enlightenment vision of a union between science and the practical arts in which science would provide a method for solving practical problems and thus serve as a foundation for systematic progress. Since then engineering has expanded its method to consider a broad range of materials, energies, or products, as in chemical engineering, electrical engineering, radio engineering, electronic engineering, aeronautical engineering, nuclear engineering, and computer engineering.

Thus practiced, engineering has come to be defined, in the words of *Webster's New International Dictionary* (1959) and the *McGraw-Hill Dictionary of Scientific and Technical Terms* (3d ed., 1984)[10] as "the science by which properties of matter and the sources of energy [Webster]/power [McGraw-Hill] in nature are made useful to man in structures, machines, and products." Ralph J. Smith, an authoritative engineering educator, commenting on his own version of this definition—"engineering is the art of applying science to the optimum conversion of natural resources to the benefit of man"[11]—has proceeded to conclude that "the conception and design of a structure, device, or system to meet specified conditions in an optimum manner is engineering."[12] Furthermore, "it is the desire for efficiency and economy that differentiates ceramic engineering from the work of the potter, textile engineering from weaving, and agricultural engineering from farming."[13] "In a broad sense," Smith writes later, "the essence of engineering is design, planning in the mind a device or process or system that will effectively solve a problem or meet a need."[14]

The engineer, then, is not so much one who actually makes or constructs as one who directs, plans, or designs, as is reflected in such metaphorical usages as "the general engineered a coup," meaning he planned or organized it—thought it all out—not that he picked up a gun. "Engineer" continues to be able to refer, in a more restricted sense, to one who operates engines, as in the expression "railroad engineer." Yet in the latter case there is no "engineering" to learn, only the skill of how to control a train. Engineering as a profession is identified with the systematic knowledge of how to design useful artifacts or processes, a discipline that (as the standard engineering educational curriculum illustrates) includes some pure science and mathematics, the "applied" or "engineering sciences" (e.g., strength of materials, thermodynamics, electronics), and is directed toward some social need or desire. But while engineering involves a relationship to these other elements, artifact design is what constitutes the essence of engineering, because it is design that establishes and orders the unique engineering framework that integrates other elements. The term "technology" with its cognates is largely reserved by engineers for more direct involvement with material construction and the manipulation of artifacts.

In fact, engineers (reflecting and influencing the culture at large) tend to take the two cognate chains, technics-technical-technician and technology-technological-technologist (two cases of abstract noun-adjective-practitioner), and conflate them to form the grammatical hybrid technology-technical-technician. This explains how the terms "technical" and "technician" can be in greater currency when qualifying practices or naming practitioners of specific making or manipulating activities, while aspects of these same pursuits can be referred to abstractly as "technology."[15]

This "materialist" or practice-oriented usage is also the foundation of the term "technological sciences" (= systematic *knowledge* of making, or sciences of the industrial arts), which is meant to include traditional military and civil engineering, agricultural engineering, and the new disciplines related to space, computers, and automation.[16] This is the meaning implicitly adopted for "technology" (as a kind of condensed form of "technological sciences") when it is defined by the *McGraw-Hill Dictionary of Scientific and Technical Terms* (1984) as "systematic knowledge of and its application to industrial processes."

In light of such a definition the technician, as someone directly involved with acquiring and using technical knowledge (technology), is naturally less sophisticated than the engineer. The engineering researcher establishes protocols and methods that the technician employs to collect data; the technician likewise uses such data to carry out designs formulated by the engineer. It is this understanding that lies behind, for instance, Smith's distinctions between engineer, scientist, technician, and craftsman:

> The engineer is a man of ideas and a man of action. . . . He develops mental skills but seldom has the opportunity to de-

> velop manual skills. In concentrating on the application of science he can obtain only a limited knowledge of science itself. . . . The primary objective of the *scientist* is "to know," to discover new facts, develop new theories, and learn new truths about the *natural* world without concern for the practical application of new knowledge. . . . The engineer is concerned with the *man-made* world. He has primary responsibility for designing and planning research programs, development projects, industrial plants, production procedures, construction methods, sales programs, operation and maintenance procedures and structures, machines, circuits, and processes. . . . The *technician* usually specializes in one aspect of engineering, becoming a draftsman, a cost estimator, a time-study specialist, an equipment salesman, a trouble shooter on industrial controls, an inspector on technical apparatus, or an operator of complex test equipment. . . . [The] technician occupies a position intermediate between the engineer and the skilled *craftsman*. The craftsman, such as the electrician, machinist, welder, patternmaker, instrument-maker, and modelmaker, uses his hands more than his head, tools more than instruments, and mathematics and science rarely.[17]

Without rejecting such a formulation, some engineers nevertheless further distinguish "technologist" and "technician." Philip Sporn, for instance, in his classic little volume *Foundations of Engineering*, distinguishes technician, technologist, and engineer by the comprehensiveness of their abilities. Technicians make particular devices (motors), technologists have mastered some whole field (electric power production), whereas engineers are concerned with a system including the socioeconomic context (electric power systems).[18]

Variations on this view are reflected in such philosophical papers as James K. Feibleman's "Pure Science, Applied Science, and Technology: An Attempt at Definitions" (1961) and C. David Gruender's "On Distinguishing Science and Technology" (1971). For Gruender, the chief distinction between applied science and technology "is in the scope or generality of the problem assigned. Those of broader scope we are inclined to think of as problems of 'applied' science [= engineering?]; those that are closer to being specific and particular we think of as 'technology'" (p. 461).

Thus, just as the adjective "technical" connotes a limited or restricted viewpoint, so the engineering technician works from a more limited standpoint than the engineer. The technician or technologist might, for instance, know how to perform a test, operate a machine, assemble a device (and even be involved in directing others who have a less comprehensive view of some particular operation or construction project), but not necessarily how to conceive, design, or think out such a test or artifact. Consider, for example, such terms as "lab technician," "medical technician" or "medical technologist," and "drafting technician."[19] In each case the person referred to is designated as proficient at performing some operation or construction, but not at fully organizing or understanding the procedures involved. The engineer has a superior or more inclusive view of a material construction than the technical assistant.

Social Science Usage

For social scientists, however, the term "technology" has a much broader meaning. To begin with, it includes all of what the engineer calls technology, along with engineering itself. Such usage has some basis in engineering parlance, as when an engineering school is termed an "institute of technology." Yet this continues to limit technology to those making activities influenced by modern science. Engineering schools are quite recent additions to the academic arena and focus on special kinds of making; making pots, for instance, is not a conspicuous feature of the curriculum at MIT.

In light of their disciplinary origins, one might expect the social sciences to have adopted precisely this restricted usage. Jay Weinstein, for example, has argued at length that both "technology and social science are the specific products of Europe's industrial revolution" and that in each of its three independent beginnings during the middle to late eighteenth century in England (Adam Smith and others), in late eighteenth- and early nineteenth-century France (Henri Saint-Simon and Auguste Comte), and in mid- to late nineteenth-century Germany (Karl Marx) social science arose to remedy defects in technology and extend its aims and methods into society.

> In light of the development concept, technology was seen as knowledge to transform humanity and nature for the better, to free man from the limitations on his powers that were once accepted as inevitable. Social science was to be an adjunct to technology because it is required to help understand these objects: humanity and nature, knowledge, and freedom. In addition, it became clear . . . that social science must be used in understanding the interest and behavior of participants in technological activity: owners, technicians, workers, etc., that

these too are consequential and scientifically comprehensible parts of the innovation process. From these observations it followed that social science and technology are mutually dependent means to achieve their common end: development, progress through the application of scientific principles to human affairs.[20]

Yet social science usage, stimulated by recognition of the social significance of making activities allied with modern natural science—vide the sociocultural reaction to, and now the sociology of, the Industrial Revolution—has extended the term even further to refer to all making of material artifacts, the objects made, their use, and to some extent their intellectual and social contexts. Even crafts such as potting become technologies in this loose sense, because there are certain modern technologies (e.g., industrial ceramics) of which potting is a remote precursor, and because the ways potting affected premodern society are presumed continuous with the impact modern technology has had on the social fabric. Indeed, in the history of technology, which is the primary social science study of technology, technology has sometimes been defined so as to include even the making of nonmaterial things such as laws and languages—although the implications of such definitions have not been widely thought through or adopted.

Compare, for instance, the understandings of "technology" found in the *McGraw-Hill Encyclopedia of Science and Technology* and in *A Dictionary of the Social Sciences*. In the former technology is defined as "systematic knowledge and action, usually of industrial processes but applicable to any recurrent activity" and "closely related to science and to engineering."[21] In the latter the term is defined, first, in regard to primitive societies, as denoting "the body of *knowledge* available for the fashioning of implements and artifacts of all kinds," and second, in regard to industrial societies, as denoting "the body of *knowledge* about (a) scientific principles and discoveries and (b) existing and previous industrial processes, resources of power and materials, and methods of transmission and communication, which are thought to be relevant to the production or improvement of goods and services.[22] Although this definition overemphasizes the cognitive component in technology, both ancient and modern, it nevertheless indicates the much wider range of the social science concept.

Other social science definitions have, however, gone even further. According to the *International Encyclopedia of the Social Sciences*, for instance, "Technology in its broad meaning connotes the practical arts. These arts range from hunting, fishing, gathering, agriculture, animal husbandry, and mining through manufacturing, construction, transportation, provision of food, power, heat, light, etc., to means of communication, medicine, and military technology. Technologies are bodies of skills, knowledge, and procedures for making, using and doing useful things. They are techniques, means for accomplishing recognized purposes."[23]

Some social scientists, it is true, prefer to limit "technology" to modern industry[24] or to distinguish between "technics" and "technology," letting the former stand for primitive arts and crafts and the latter for more sophisticated engineering.[25] Both approaches nevertheless remain minority usages. More characteristic is the view of Peter F. Drucker, who maintains that the subject matter of technology is not so much "how things are done or made" as "how man does or makes."[26] For Drucker, technology includes not only successful but also failed making and all human undertakings insofar as they are (intentionally or unintentionally) oriented toward making and using—so that the history of technology includes a history of work, invention, economics, politics, science, and so forth. Economist Nathan Rosenberg, likewise, prefers to write not about technology so much as "technological phenomena," taking "diversity and complexity" among such phenomena "as axiomatic."[27]

The Extension of "Technology"

Distinctions in the usage of the term "technology" could, of course, be expanded. Michael Fores, for example, in an analysis complementary to that just given, appeals to British usage to distinguish four senses of "technology": (1) that of science policy studies, in which technology encompasses all scientific *and* engineering activities; (2) that of government statistics, in which labor activities in the technology category include all workers up through and including engineers as *opposed* to scientific workers; (3) that of engineers, who would limit technology to craft techniques; and (4) the common dictionary or etymologically correct definition of technology as the "science of the industrial arts."[28] But (1), (2), and (4) are simply aspects of the broad social science usage, whereas (3) is the narrow engineering usage.

This tension between the narrow engineering usage and the broad social science usage of the word "technology" cannot be neatly resolved; it can only be accommodated. One such accommodation would attempt to stipulate around the problem ("We will define technology as . . ."); another might use subscripts to distinguish engineering usage (technology$_1$) from social science usage (technology$_2$). Still another could provisionally adopt the more extensive meaning, with the intention of gradually formulating distinctions within it by whatever means become available and appear appropriate during the course of a deeper analysis. This third approach is preferable as both less arbitrary or artificial and more open to whatever distinctions naturally emerge.

Without anticipating subsequent analyses, then, one can suggest that together both the engineering and social science usages point, first, toward the conceptual primacy of the making of material artifacts then, second, toward a large number of elements and influences that go into and arise out of this primary activity, influenced by and influencing its different forms. The thesis is that "technology" is not a univocal term; it does not mean exactly the same thing in all contexts. It is often, and in significant ways, context dependent—both in speech and in the world.[29] But neither is it a pure equivocal such as "date," which can refer to wholly unrelated things on a calendar or a palm tree. There is a primacy of reference to the making of material artifacts, especially since this making has been modified and influenced by modern science, and from this is derived a loose, analogous set of other references. An initial need in the philosophy of technology is for some mapping out or clarification of this conceptual one and many, a conceptual one and many that can be assumed to reflect a real diversity of types of technologies with various interrelations and levels of unity.

Becoming aware of this spectrum of conceptual references is philosophically important on two counts. First, in discussions of the social and ethical consequences of technology debates inevitably arise about whether technology can be limited or even eliminated. But much of the disagreement rests on a failure to clarify differences in assumed definitions. On the one hand, if by technology one means the making activity in general and the using of material artifacts, then obviously technology can never be abandoned and is in fact coeval with if not prior to the emergence of human life (since animals also make and use artifacts such as spiderwebs and bird's nests). On the other hand, if by technology one means some particular form or social embodiment of this general human endeavor, then clearly technology is expendable; technologies have been abandoned repeatedly throughout history, under both peaceful and violent circumstances. Indeed, the history and sociology of technology depend on this interpretation when cultures are analyzed in terms of technological change.

Second, in the formative philosophical discussions a large number of apparently incompatible definitions have been offered for technology. Technology has been variously conceived

- as sensorimotor skills (Feibleman)
- as applied science (Bunge)
- as rational efficient action (Ellul 1954) or the pursuit of technical efficiency (Skolimowski 1966)[30]
- as "tactics for living" (Spengler), means for molding the environment (Jaspers 1949), or control of the environment to meet human needs (Carpenter 1974)
- as means for socially set purposes (Jarvie)
- as pursuit of power (Mumford 1967)
- as "systematic application of scientific or other organized knowledge to practical tasks" (John Kenneth Galbraith) or "knowledge of techniques" (Nathan Rosenberg)[31]
- as means for the realization of "the gestalt of the worker" (Jünger) or any supernatural self-conception (Ortega)
- as self-initiated salvation (Brinkmann 1946)
- as invention and the material realization of transcendent forms (Dessauer 1927 and 1956)
- as a "provoking, setting-up disclosure of nature" (Heidegger 1954)

Some conceptions evidently differ only in words. Yet even after this is taken into account, there remains a variety of definitions, each of which—it seems reasonable to suggest—highlights some real aspect of technology, guided by a tacit restrictive focus. Argument over the truth or falsity of such definitions thus too often hinges on the exclusiveness of a limited perspective. The disagreements at issue call for a more open description of technology that delineates its different types and their interrelationships. As one perceptive observer has argued, what is needed is "not definitional but characterological" framework.[32] Only such an analysis can provide a foundation for assessing the relative truth and significance of each prospecive definition.

Initiating such an open characterization, technology can be described as the making and using of artifacts. Human making, in turn, can be broadly distinguished from human doing—for example, political, moral, religious, and related activities. Admittedly, this does not reflect the etymology of the word "technology" (which became current in the nineteenth century to refer to the industrial arts), nor does it always accord with various feelings and intuitions entrenched in the

English language. Nevertheless, it does serve to demarcate what should be the full scope of a philosophical concern with technology and to draw out what is unique to this study.

Modern philosophy of human action has concentrated almost exclusively on doing—the province of ethics, political philosophy—at the expense of making. The only exception is some limited discussion of making in the philosophy of art and aesthetics. Under the stress of contemporary problems and needs, however, human beings are called to reflect on making in a more comprehensive and fundamental manner—and in ways that find echoes in premodern thought. Similarities and differences in the many aspects of technology await disclosure through an analysis of its various constitutive elements. Where analysis warrants typological relations, these will be denoted by some qualifying adjective (as with the expression "scientific technology") or by distinct words properly defined (as with "technique"). Such constitutes an initial conceptual program in the philosophy of technology.

A Framework for Philosophical Analysis

In undertaking an analysis of diverse types of technology, however, one cannot just dive in. The rich complexity of the subject forces one to adopt at least a provisional classifying or categorizing scheme. Numerous frameworks or preliminary typologies have been proposed and used—although these have often been more for technical, historical, encyclopedic, or educational and heuristic than philosophical purposes.

With regard to technical purposes, there are typological frameworks utilizing distinctions between the various branches of engineering (civil, mechanical, chemical, electrical, etc.), as well as those grounded in differentiations of engineering functions or operations (designing, developing, production, etc.). The former are often also the basis for divisions of labor in social science studies such as Singer et al.'s *History of Technology* (1955–1984) and Kranzberg and Pursell's *Technology in Western Civilization* (1967). The latter can influence economic as well as technical studies.

With regard to uniquely historical purposes, there are the standard periodizations (Greek, Roman, medieval, seventeenth century, etc.) and modifications thereof. Bertrand Gille's *History of Techniques* (1978) relies on such standard divisions of history, in order to write narratives that synthesize, say, civil and mechanical engineering in "The Modern Technical System." Mumford (1934) modifies the standard divisions

to distinguish what he terms eotechnic, paleotechnic, and neotechnic phases in the history of technical activity. But as even historians admit, neither approach is completely satisfactory.[33]

With regard to encyclopedic concerns, no classification scheme is so highly articulated as that developed under the tutelage of philosopher Mortimer Adler and found in the fifteenth edition of the *Encyclopaedia Britannica.*[34] In this scheme all knowledge is divided into ten subject areas, beginning with that which bears on (1) matter and energy, that is, physics, and (2) the earth, moving on through (3) the sciences of nonhuman and then (4) human life to (5) human society, (6) art, (7) technology, (8) religion, (9) history, and (10) the branches of knowledge itself, including both science and philosophy. Although its proximity to art is revealing, technology is easily the most anomalous of these major categories; it is, for instance, the only one that does not appear at all in the first edition of the *Britannica* (1771) and is not accorded an entry in the classic eleventh edition (1911), or indeed even in the immediately preceding fourteenth edition (1974).[35] When technology arrives on stage in the *Britannica*, it comes as a star.

As part 7, technology is approached from three main perspectives: its historical development and social impact (particularly on work), its internal divisions (energy conversion, tools, measurement and control, extraction of raw materials, industrial production), and its major fields of application (agriculture, industrial production, construction, transportation, information processing, the military, the city, earth and space exploration). In a kind of echo, "The Technological Sciences" are considered the seventh and last subdivision under science in part 10, with a four-part analysis in terms of history, professional branches (civil, aeronautical, chemical, electrical, mechanical, etc., engineering), agricultural sciences, and interdisciplinary technological sciences (bionics, systems engineering, cybernetics). Although gratifyingly inclusive, any attempt to conceptualize this plethora of divisions quickly produces as much confusion as insight.

Turning to educational or heuristic purposes, options continue to proliferate. Not only are there all the possibilities already mentioned—each appropriate to different pedagogies—but a host of others emerge. Just to mention a few examples: There is the medieval division of the seven mechanical arts in Hugh of St. Victor;[36] Jacob Bigelow's division first by materials used and then by human uses;[37] André Leroi-Gourhan's anthropological classification of techniques into those that do not go beyond the direct action of the hand in grasping, striking, and such and those that extend into fabrication, acquisition, transportation, and consumption;[38] Leo Marx's literary contrasts between technology as consciousness and as machine;[39] Donald W. Shriver Jr.'s axiological perspectives on technology as means, ends, politics, and evolutionary development;[40] Daniel Callahan's Freudian distinctions between preservation, improvement, implementation, destruction, and compensatory technologies;[41] John G. Burke's "typology of technology" as physical, chemical, biological, and social;[42] and so forth.

The inadequacy of such typologies is witnessed by the exclusiveness of their diversity. Each serves as a vehicle for a more or less special argument but proves mostly unable to carry on any sustained dialogue with the others.

A well-considered definition that moves in the right direction is proposed by Frederick Ferré in the Prentice-Hall Foundations of Philosophy series volume *Philosophy of Technology* (1988). Ferré briefly notes many of the ambiguities considered at greater length here and inventories debates about whether technologies are essentially material, science based, possessed by animals, natural or unnatural. He further observes that definitions prescribe as well as describe, and as such must steer a careful course between excessive breadth and restrictive narrowness. His own definition of technology as *"practical implementations of intelligence"* (p. 26), although not developed against any explicit background references to alternative proposals, is nevertheless a judicious advance on previous efforts. Because of their practicality, technologies are not ends in themselves (like the arts and other doings); because they are implementations they are material (thus excluding language per se); and their intelligence is broadly construed to include both the tradition based and the theory based.

Ferré's argument, however, is more concerned to bring technology within the purview of a focused philosophical discussion—to justify philosophy of technology as a subfield of philosophy comparable to philosophy of science, of religion, of language—than to throw light on technology itself. It reaches out to philosophers and near philosophers but not to engineers or technologists. Engineer-philosophers such as Samuel Florman are conspicuous by their absence. Although it is not nearly as parochial as Dauenhauer's discussion, it is nevertheless doubtful that engineers and technologists would find its analyses at many points confirmed by technical experience. It also fails to carry its definition forward into a disciplined consideration of the modes and manifestations of technology, but concentrates instead simply on mapping out existing philosophical discussions surrounding technology.

Explicitly philosophical typologies that do reach out to engineering experience and discourse have been proposed, although usually with some restrictions. Egbert Schuurman (1972), for instance, in his "philosophical analysis of modern technology," distinguishes technological objects and the twin activities that contribute to their fabrication: technological forming and technological designing.[43] Dieter Teichmann (in Rapp, ed. 1974) considers five bases for the "'internal' classification of the technological sciences"—historical development, types of science or laws of nature used, kinds of production supported, functional place in the general productive process, and structural characteristics of the objects produced. He concludes, however, that "the only meaningful classification . . . will be one which takes into account both the objective structure of technology, the classification of the natural sciences and the teaching structures."[44] Mario Bunge (1979b) discerns four branches of technology: material (the traditional forms of engineering), social (psychology, sociology, economics, military science), conceptual (computer science), and general (automata theory, information theory, optimization theory). Stanley Carpenter (1974) differentiates among technology as object, as knowledge, and as process.

Schuurman and Teichmann limit their analyses to modern technology, and Bunge merely "discerns" his, revealing no inherent rationale in the one and the many so discerned. Carpenter both uncritically assumes the primacy of cognition over affectivity and introduces the term "process," connoting a system of repetitive operations, to cover all human technical activities. As is even more evident in Carpenter (1978), his framework is biased toward epistemological issues and routine performances as against metaphysical questions and varieties of technological activity (inventing, designing, etc.).

It remains, then, to propose and develop a typology that can encourage an active dialogue with such previous attempts, protecting and ordering the insights they contain. While disclosing similarities and differences where necessary and appropriate, this typology should also reflect on ancient and modern making and using as is encouraged by social science studies.

The path toward such a philosophical framework is pointed out by one of the most general philosophical analyses to date, Robert McGinn's attempt to answer the question, "What is Technology?" (1978), especially as developed in two later publications. McGinn treats "technology as a *form of human activity* [comparable to] science, art, religion, and sport" (p. 180). (Note the echoes of the *Britannica* scheme.) The key characteristics of this activity are that it (1) has material outcomes, (2) fabricates or is constitutive of those outcomes, (3) is purposive, (4) is resource based and resource expending, (5) utilizes or generates knowledge, (6) is methodological, (7) takes place in a sociocultural-environmental context, and (8) is influenced by individual practitioners' mental sets. As N. Bruce Hannay and McGinn (1980) summarize matters in a subsequent paper, "technology can be characterized as that form of cultural activity devoted to the production or transformation of material objects, or the creation of procedural systems, in order to expand the realm of practical human possibility" (p. 27).

Unlike the Schuurman, Teichmann, Bunge, and Carpenter typologies, McGinn's characterology encompasses both modern and premodern technology and leaves room for most of their insights. The most obvious weakness of McGinn's descriptive analysis of technology as human creative activity is that it seems to imply a restrictive typology in which both artifacts and their use fail to qualify as primary aspects of technology. An artifact, for instance, is the outcome of technology but not itself technology; and McGinn explicitly rejects cloud seeding and agriculture as technology in any strong sense (1978, p. 182).

McGinn's analysis is complemented by his colleague Stephen Kline's response to the same question, "What is Technology?" (1985).[45] In a slight but pointed proposal, Kline recognizes four definitions of technology as artifacts or hardware, as sociotechnical systems of production, as technique or methodology, and as sociotechnical systems of use. Unlike McGinn, Kline recognizes both making and using as technological activities and grants that artifacts can be termed technology.

McGinn goes some way toward adopting Kline's enlarged framework in his book *Science, Technology, and Society* (1991), although he continues to resist according artifacts full status as technology. Moreover, McGinn's later synthesis of the elements in his characterology is skewed toward technological conceptions. To McGinn's mind, many human activities "can be analyzed in terms of six key aspects or components: their inputs, outputs, functions, transformative resources, practitioners, and processes" (p. 16). But to suggest that such categories are equally adequate or revealing for "*art, law, medicine, sport,* and *religion*" (p. 15, his italics) tends to reduce all such human pursuits to technological form. It was in engineering, not the humanities, that the language of inputs and outputs, resources, and processes, was first developed and is most appropriate. This is a language that engineer-

philosophers are wont to use in translating the humanities into engineering terms.

McGinn, Kline, and their philosophical predecessors can nevertheless be brought together by a simple observation implicit in their analyses, although its potential has not been fully explored. Technology is pivotally engaged with the human. As such it is to be considered in relation to the essential aspects of a philosophical anthropology—with differences drawn between its manifestations in the mind, through bodily activities, and as independent objects that take their place in the physical and social world.[46] On such a basis distinctions can readily be articulated between technology as knowledge, technology as activity, and technology as object—three fundamental modes for the manifestation of technology.

In this conceptual framework, however, there is one arguable oversimplification. The anthropological interior need not, and in truth should not, be restricted to cognition. The will is an equally real if subtle aspect of the human. McGinn suggests the same by calling attention to the fact that when "material outcomes possess properties resulting from the operation of [chemical, biological, or physical] laws [they] may in a sense be said to be due to the volition of the practitioner" (1978, p. 182). Technology as volition must thus be added as a fourth mode of the manifestation of technology.

The resulting framework can be summarized by means of the diagram in figure 1. A full defense of this framework would require a comprehensive metaphysics, epistemology, philosophical psychology, and philosophical anthropology. For present purposes, however, it is sufficient to note that the framework proposed is not meant to be final or ultimate. It is enough that it be more comprehensive than previous ones, capable of adaptation to alternative positions on major issues in the philosophy of technology, a means to take philosophy more deeply into the realm of the technological, and open to further criticism or modification in response to future considerations.

The present framework is, then, provisional in character. Like the informal procedure of Aristotle's *Categories,* it is put forward by intuitive appeal to a commonsense metaphysics and anthropology. There is much to be said for beginning with commonsense notions, although one must be conscious that this is a beginning only, and that there is a rich and varied tradition of philosophical interpretation of humanity and the world against which commonsense hypotheses should be tested. Indeed, in the course of the analysis a number of efforts will

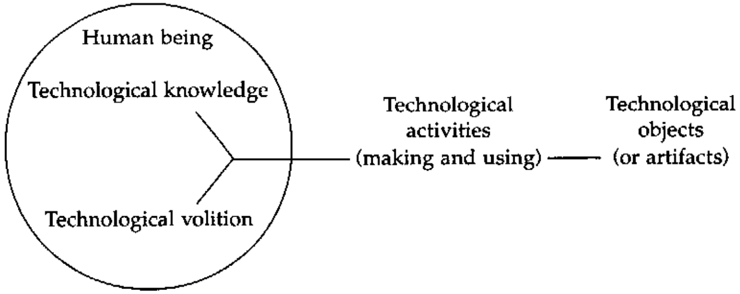

Figure 1. Modes of the manifestation of technology.

be made to do precisely this—that is, to bring into the discussion philosophical ideas, both traditional and modern, that bear on the adequacy of the proposed framework.

At the beginning, then, a framework should be both definite enough to provide some guidance and open enough to allow for adjustments and the possibility of winding up with new ideas. If it is to be philosophical, it should raise philosophical questions while remaining hospitable to different responses to those questions. Thus it is relevant to observe that the framework at hand can support either a technological determinism (in which objects or ideas exercise a controlling influence on human activity) or a theory of human freedom (in which individual volition or creative knowledge plays a dominant role). Technology as knowledge is further interpretable in terms of instrumental reduction or cognitive transcendence. The precise metaphysical status of technological objects is not fixed in advance, nor the structural features of technological activity. All these remain open as diverse paths for a deeper understanding of technology in each of the modes of its manifold forms. Recognizing that one aspect of its adequacy will be the degree to which this fourfold framework functions to orchestrate technological phenomena and philosophical questions, let us turn to more specific analyses.

CHAPTER SEVEN

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Types of Technology as Object

Artifacts—material objects such as tools, machines, and consumer products—are what most readily come to mind when the word "technology" is mentioned. As engineer David Billington has said, "When people talk about technology today, they usually mean the *products* of modern engineering: computers, power plants, automobiles, nuclear weapons" (1986, p. 87).

Technology as object is the most immediate, not to say the simplest, mode in which technology is found manifest, and it can include all humanly fabricated material artifacts whose function depends on a specific materiality as such. Depending on one's understanding of the terms, there may be some redundancy in this definition. Artifacts might be taken as by definition human fabrications. But in order to exclude nonhuman animal fabrications, which have also been argued to be artifacts, a little redundancy may be useful. Specifying materiality excludes sociotechnical systems from being technological objects in a primary sense—although these may well be derivative manifestations of technology. The qualification of effective functional dependence on some particular kind of material further excludes writing insofar as it can, unlike the hammer, effectively perform a function whether it consists of three-inch-high wooden block letters or of light patterns projected on a movie screen. This last qualification, like that relating technology as object to human beings, should nevertheless remain open for consideration of how far it is true even in a case such as writing. As Ivan Illich (1993) has shown, for instance, differences in the physical characteristics of writing as a physical object can subtly transform its function. For present purposes, however, technology as object will include such artworks as paintings and sculpture, but not poems or novels—only the physical books in which literature may be printed.

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THINKING THROUGH TECHNOLOGY

The Path between Engineering and Philosophy

CARL MITCHAM