THE PUBLIC LIFE OF INFORMATION

Josh Rowe

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Abstract

The mid-twentieth century marked a shift in Americans' fundamental orientation toward information. Rather than news or knowledge, information became a disembodied quantum—strings of ones and zeros processed, increasingly, by complex machines. This dissertation examines how Americans became acquainted with "information", as newly conceived by science. Through the press, through mass culture (in particular, the genre of science fiction), and through the tireless evangelism of a group of self-styled visionaries, Americans encountered a new cultural icon, the computer. The "electric brain" of the 1940s and '50s promised to revolutionize the way information was handled by scientists, businessmen, and economic planners. Like the atom bomb, the computer inspired equal measures of awe and fear; information-processing machines were faster, more reliable, and potentially *smarter* than their organic peers. At midcentury, computer automation was rapidly spread through the American economy; many wondered if human workers (skilled and unskilled alike) would find themselves obsolete relics of a bygone industrial age? I discover that the initial alarmism gave way in the 1960s to a reimagining of the computer and its user as a mutual, cybernetic feedback system that would simultaneously improve productivity, creativity, and workers' wages. In this way, a more humanistic generation of information science "ambassadors" smoothed the computer's acceptance in American society. The computer was thus reconfigured as a user-friendly communication device that anyone, given adequate training, could employ in their work and daily lives. At the same time, human brains came to be viewed through a new prism—as soft machines excelling at the generation of ideas. The human computer, in interface with its silicon cousins, would think in more powerful ways than ever. I track the emergence of a new consensus through popular media and identify its most important exponents. The story of this idea, told through a series of reticulating biographies, helps illuminate Americans' engagement with technology, with the future, and with the nature of thought itself.

"As we have shown that there is a perfect harmony between the two realms of nature, one of efficient, and the other of final causes, we should here notice also another harmony between the physical realm of nature and the moral realm of grace, that is to say, between God, considered as the builder of the machine of the universe, and God considered as monarch of the divine city of spirits." — Leibniz, "The Monadology"

"You're wondering who I am – machine or mannequin
With parts made in Japan, I am the modern man.
I've got a secret I've been hiding under my skin;
My heart is human, my blood is boiling, my brain IBM." — Styx, "Mr. Roboto"

"Computers make excellent and efficient servants, but I have no wish to serve under them." – Dr. Spock, *Star Trek*, "The Ultimate Computer" (1968)

Introduction – A History of the Future

In 1818, a twenty-one-year-old Mary Wollstonecraft Shelley wrote *Frankenstein, Or, the Modern Prometheus*, and gave life to the abiding icon of technological monster. So began, arguably, the cultural life of the *cyborg*—the cybernetic organism. Shelley was writing in response to fears that the technology that enabled man to so thoroughly subjugate the natural world to his command would come, in turn, to take dominion over him.[1] "Why not still proceed over the untamed yet obedient element?" Dr. Frankenstein declares. "What can stop the determined heart and resolved will of man?"[2] The spark of life, the doctor discovers, is just that: electricity—nothing ghostly or magical. Shelley's suspicion of technology run rampant has been retold countless times in Western literature, but it has not quelled the growing fascination with the idea that man is a machine to be engineered—or even built from scratch. In the 19th and 20th centuries, medical science increasingly began to conceive of the human body as an aggregate of interconnected systems, while anthropomorphic automata—both fictional and real (or forged)—turned up in ever greater numbers.[3] Still, Shelley would have had to wait for more than a century before anyone gave serious thought to the possibility of building machines capable of self-organization, learning, even thought.

The twentieth century marked the beginning of a historically significant shift in American civilization in its profound orientation toward information exchange. Many aspects of American society experienced acute changes around information and the computer: the

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[1] Gray, Chris Hables, Steven Mentor and Heidi J. Figueroa-Sarriera. "Cyberology: Constructing the Knowledge of Cybernetic Organism," in Gray, ed., *The Cyborg Handbook*, New York: Routledge, 1995, 5.
[2] Shelley, Mary. *Frankenstein*. New York: Bantam, 1984, 8.
[3] Johnsen, Edwin G. and William R. Corliss. "Teleoperators and Human Augmentation," in Chris Hables Gray, *et al*. eds., *The Cyborg Handbook,* New York: Routledge, 1995, 89.

Cold War (notwithstanding its "hot" conflagrations in Korea, Vietnam and Cambodia) gradually became a contest not of open hostilities but of technological preparedness, of ideas and of propaganda; the manufacturing-centered economy was supplemented by a "post-industrial" service economy dependent upon the computation of information; affordable computing brought high-speed interactive data processing to American homes and offices; networks of computers integrated and expanded Americans' shared knowledge as suburban sprawl spread them over a widened landscape. The transitions discussed in this dissertation began before the Second World War, accelerated at mid-century, and had become highly visible by the beginning of the 1980s. Through new understandings of computers and information science available in the decades following World War II, Americans came to grips with a startling, yet liberating fact—we were all becoming cyborgs.

While it is now fashionable to speak of our present "information age" and even the "virtual" nature of contemporary society, several attempts have been made to excavate the roots of this social/cultural transformation. Some historians have preferred to periodize the "information society" backward into the nineteenth and earlier centuries, pointing to highly developed print cultures in early modern European capitals or to the government-supported system of mails in the United States that effectively underwrote the dissemination of the news.[4] These revisionist histories make a valuable point,

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[4] See for example:
Beniger, James R. *The Control Revolution: Technological and Economic Origins of the Information Society*. Cambridge, Mass.: Harvard, 1989.
Chandler, Alfred D. and James W. Cortada, eds. *A Nation Transformed by Information: How Information has Shaped the United States from Colonial Times to the Present*. New York: Oxford, 2003.
Hobart, Michael E. and Zachary S. Schiffman. *Information Ages: Literacy, Numeracy, and the Computer Revolution*. Baltimore: Johns Hopkins, 1998.
Standage, Tom. *The Victorian Internet: The Remarkable Story of the Telegraph and the Nineteenth Century's On-line Pioneers*. New York: Berkley Trade, 1999.

constituting a well-taken check to the narcissism of our own moment. Perhaps it is more appropriate to speak of different "information ages." Indeed, the widespread sharing of knowledge has fueled most mass movements throughout history, from the French Revolution to mail order catalogue shopping. I will argue, however, that the twentieth century witnessed the dawn of a number of new ideas about information *itself* that rapidly came to predominate in popular culture. By 1950, information had become a quantum, a bodiless measure, a language, and, above all, a rule that governed the behavior of systems, biological and mechanical alike. These new cultural understandings went far beyond the simple signification of information as mere mechanical output, or as socially acquired knowledge, a term familiar to eighteenth and nineteenth century societies. In the coming chapters, I will trace the emergence of a new conception of information and its far-ranging effects on the American popular imagination.

In the late twentieth century, information acquired a distinctly new public image. The present project is a history of this public image and of the spin doctors who crafted it. Information's public image was mediated by the artifact of the electronic digital computer—seen first as a mechanical terror, a "giant brain" in the employ of giant corporations and governments, later as a threat to replace workers on factory floors and in offices alike, and finally as a partner, an intellectual tool that anyone could use to enhance his or her productivity and creativity. But the following pages will also track the emergence of a new pop epistemology: that information is at the metaphysical center of the universe, uniting human minds, computers, biological organisms, and large physical systems as like vehicles for its processing. To some extent, this is a history of conscious myth-making on the part of energetic and charismatic figures in computer and information sciences whose boasts attracted both intellectual prestige and research dollars. But information's history serves also as an example in which popular attitudes feedback to invigorate and influence the shape of research itself, particularly in fields like Artificial Intelligence, time-sharing, and computer networking.

My research examines the channels of transmission between a scientific discourse of information emerging at the turn of the century (coalescing into a full-fledged movement after World War II) and a mass understanding embodied in science fiction literature and film, the commercial personal computer market, and the rise of a distinct computer culture. These channels ought to be seen not as static and unidirectional—bringing scientific wisdom like Promethean fire to a receptive public—but rather as two-way and complex. The avenues of transmission of ideas are mutable, interactive media capable of informing the direction of scientific research as easily as popular received knowledge. I break with much of the established literature by concentrating equally on the creation and consumption of informational thinking (embodied in a new dialect, "information talk") by a culture with a tremendous appetite for these ideas. In the spirit of Ruth Schwartz-Cowan's "consumption junction," I view scientific production as cooperating in a common information culture with a lay public, rather than dictating its character from on high.[5] Moreover, such an informational idiom was a reflection of the culture of the technological society itself, with all its inherent contradictions and internal

[5] Schwartz Cowan, Ruth. "The Consumption Junction: A Proposal for Research Strategies in the Sociology of Technology," in Wiebe E. Bijker, Thomas P. Hughes, and Trevor J. Pinch, eds. *The Social Construction of Technological Systems. New Directions in the Sociology and History of Technology*. Cambridge: MIT Press. 1987, 261-280.

dynamics, and should not be viewed solely as a microcosm of either Cold War military strategy or 1960s counterculture as have alternatively been argued.[6]

This project is divided into five parts, arranged in a rough chronological sequence, that document the shift in the public image of information along several clear modalities. Imagined as a series of reticulating intellectual biographies, each section takes as a central figure an "information ambassador," a maker of popular opinion rooted in public discourse but equally immersed in a loftier scientific culture. These figures set forward the media through which Americans encountered computer technology, and in a broader capacity, *influential* in shaping both the channel of transmission and the directions that scientific research would take. Because they identified a large societal trend and formulated an accessible philosophy of how humans interact with information, they became, knowingly and unknowingly, spokesmen for an otherwise diffuse realm of information science. It could be said that they helped define the boundaries of this subject.

Tellingly, the figures I identify shared more than just a dose of ambition and a gift for rhetoric; they were both technological optimists and admonitory Cassandras, dubious of the gifts computer science would bear, if not wisely guided. In their writings and speeches, I identify a singular emergent theme: that for information technology to truly benefit society, it would have to become more closely integrated into the life of the individual. They argued, ultimately, for the convergence of computing power—accelerating every year since the first electronic calculators—and a human sensibility.

[6] Paul N. Edwards' *The Closed World: Computers and the Politics of Discourse in Cold War America* (1996) and Fred Turner's *From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism* (2006) are two prominent examples of these diverging avenues of thought.

This account traces their intellectual formations and their entry into the role of ambassador. Rather than survey the vast popular literature on computers, I look for where narratives cohere, even as they explore nominally different subject matter. The makers of these narratives had a lot in common.

Part one presents an abridged history of cybernetics, a new interdisciplinary science in the twentieth century that provided many of the conceptual building blocks for the "information age." Its foremost representative was the M.I.T. mathematician Norbert Wiener—as eloquent and civically-engaged a scientist as America has known. I trace his ambassadorship from its origins in the ballistics laboratories of World War II to the pages of *The New York Times*, where he advocated a deeply ambivalent, pacifistic, and humanistic role for the technology he helped create.

Part two tells the story of the first electronic computers, intellectual heirs to the problems of defining and quantifying information that troubled Wiener and his peers. Here I introduce Edmund C. Berkeley, a writer and amateur computer scientist, who briefly became America's most widely known "computer man." Berkeley, like Wiener, thought of computers' long-run evolution and speculated freely on their transformative impact on society. Though often dismissed by history as a crank and an opportunist, we will see that many of Berkeley's predictions were more apt than those of his contemporaries.

Part three picks up a narrative that features intermittently in parts one and two: the challenges posed by computer automation. As cybernetics was formulating a universal theory of feedback, engineers were beginning to apply techniques of communication and control to industrial machinery to mechanize factory and refinery labor. Cheap computing power equally promised to automate much of the information processing done in governments and back offices. As concerns rose that these new machines would steal jobs more rapidly than they inspired new ones, critics of automation stepped up the attack. In response, John Diebold a business theorist and a student of cybernetics, began to conceptualize a defense, centered around rising productivity and standards of living, greater education and a reorientation of the American economy. In the 1960s, theorists of a new *postindustrial* order, including Diebold, foresaw the coming of an economic system in which computers enabled, rather than replaced human labor, and offices were staffed by a new species of laborer, the "knowledge worker," more comfortable with programming and data analysis than the assembly line.

Parts four and five delve into this world of machines as "tools for thought." I trace the careers of two scientists, J.C.R. Licklider and Doug Engelbart, and a pop cultural maven, Stewart Brand who helped reconstruct and rebrand computers as intuitive tools, capable of being used by ordinary Americans, from business executives to housewives and children. All three of these figures defy classification in traditional political schema; they operated simultaneously inside and outside the military-industrial establishment. Engelbart and Licklider eagerly received and directed funds from the Department of Defense while at once opposing military buildup and the dehumanizing effects of corporate bureaucracy. Convinced that the convergence of all information in a form suitable for human consumption could remedy the ills of the Vietnam era, Stewart Brand founded the Whole Earth Catalog that would form a chrysalis from which much of our information culture has sprung. Brand's writings touched more than a few enthusiasts on the West Coast; the Whole Earth Catalog's circulation reached more than a million, while Brand became famous as an evangelist of a radical gospel of self-reliance and environmentalism.

By advocating a world where anyone who wanted a computer could buy and use one, these figures helped inspire the hobbyist culture that contemporary writers such as Fred Turner and Michael Hiltzik have seen at the heart of the "personal computer" revolution. It could be said that Engelbart's laboratory in Menlo Park, California was a direct progenitor of the personal computer of today, and, indirectly, of the entire constellation of "dot-com" enterprises in Silicon Valley. More subtly, Engelbart and his collaborators helped bring to fruition the dreams of Wiener and Berkeley, who believed the only recipe to avert the mechanization of all human affairs to be increasing computer literacy and democracy of access.

Although this project spans four decades and numerous loci of research, debate, and business development, there remain large gaps where our understanding of the relationships and influences that brought about these larger societal transitions remains limited. Untangling the uneasy associations between longhaired computer peaceniks like Brand, Sun Microsystems' Bill Joy, or Engelbart's Augmented Human Intellect (AHI) group to the Pentagon's largesse is a serious project that Turner and Thierry Bardini's biographies only skirt[7]. The irony that a vision of libertarian democracy emerged in such an environment is a difficult problem with which no serious social or economic history has yet wrestled. Further, the question of whether small, personalized computing systems were historically inevitable due to shrinking components and shrinking costs, or whether

[7] Turner's *From Counterculture to Cyberculture*, and Bardini's *Bootstrapping: Douglas Engelbart, Coevolution, and the Origins of Personal Computing* (Stanford 2000), reveal Brand and Engelbart to be uneasy with America's military adventurism, distrustful of centralized power, and hopeful for the potential of small-scale, local, creative action. How they reconciled these attitudes with the tremendous government patronage for computers is a complicated question.

they were spontaneously and actively created by engineers such as Ken Olson of M.I.T. and Bill English of AHI remains unanswered in these pages. I favor the idea that prominent figures within the computer movement wielded disproportionate influence to steer a research agenda in line with their own sympathies, and perhaps those of the literate public; J.C.R. Licklider as an administrator of a Pentagon program with few budgetary constraints certainly attests to this possibility. Yet, only a project of sufficient scale, perhaps employing an ethnography of living computer engineers from the academic, government, and corporate sectors, could more firmly answer these questions. Electing as I have to focus only on the "public image" of information and its architects, a greater discussion of the engineering cultures out of which computer technologies emerged falls too far afield for a deeper treatment.

This is an original contribution to the literature of computer history. Most scholars have taken as their subject a particular period in computers' life cycle; their narratives have been dominated either by themes of military command and control, bohemian consciousness expansion, or ineluctable technological progress through speed, miniaturization, and programming flexibility. This dissertation offers instead an integrative approach: each of these themes finds expression in the writings of America's information ambassadors, but none dominates. The thread that unites their distinct concerns—from the rise of the computer industry to the protection of jobs, from networks of distributed processing power to social networks of plugged-in, "augmented" intellects—is that of the convergence of computer power and the power of mind.

The following story runs counter to each of two received accounts of how computers became commonplace in the lives of ordinary Americans. One narrative is aptly summarized by its progenitor, Stewart Brand, in the title of a piece he wrote for *Time* magazine—"We Owe it All to the Hippies."[8] Brand's is essentially an optimistic narrative; by liberating computer power from large bureaucracies (whether government or private) the counterculture of the 1960s and 1970s set in motion an era of unprecedented individual discovery and creative expression. The story of "how computers became personal" is retold in various forms by the journalists Turner, Hiltzik, John Markoff, and Mitchell Waldrop.[9] Professional historians like Paul Ceruzzi and Martin Campbell-Kelly have also embraced a form of this linear narrative; in their histories computers improve in a deterministic fashion, from vacuum tubes to transistors to integrated circuits, toward ever smaller and faster varieties. Individual scientists and companies like IBM merely participate in this grand historical process.

In opposition to this celebratory teleology is Paul Edwards' declension narrative. For Edwards and a number of postmodern critics, the computer is both outcome and enabler of a paradigm of control, fostered primarily by government technocrats and military strategists. Cybernetics is seen, in this model, as the ultimate science of control, reducing the efflorescent randomness of nature (and of human beings) to a simple, programmable algorithm. This is, for me, a rather unconvincing argument. The computer was many things to many people—it could be either an instrument of control, as it was for corporate managers who directed their supply chains through spreadsheets and databases, or of self-exploration, as it was hobbyists who shared their interest in

[8] Brand, Stewart, "We Owe it All to the Hippies," *Time*, March 1, 1995, 17.
[9] Hiltzik, Michael, A. *Dealers of Lightning: Xerox PARC and the Dawn of the Computer Age.* New York: Harper, 2000.
Markoff, John. *What the Dormouse Said: How the 60s Counterculture Shaped the Personal Computer*. New York: Viking, 2005.
Waldrop, M. Mitchell. *The Dream Machine: J.C.R. Licklider and the Revolution that Made Computing Personal*. New York: Penguin, 2002.

electronics in online user groups. There is simply no single narrative that fits. This is consciously a many-computers history, surveying a number of terrains in which American readers and consumers encountered the technological state of the art. I suggest a guiding theme: that human interaction with computers was increasingly understood, and engineered along the lines of an informational circuit. Nevertheless, there is great variance within this story; the computer iteratively transformed in the American imagination from imitator, replacement, and finally intellectual prosthesis for human beings.

It is my belief that any history of American culture and society in the late twentieth century must deal seriously with the impact of information technology on the lives and imaginations of ordinary Americans. In the Fall 1968 *Whole Earth Catalog*, Stewart Brand remarked perceptively, "We are what we think our future is."[10] Those who shape our cultural attitudes are often visionaries of the future, interested in changes at the margin. By investigating the writers who gave us the language with which to think about technological revolution, I take Brand's observation seriously. This is, by design, a history of the future. Too many studies of "information" or "computers" have confined themselves to the narrow playing fields of industrial or technological history. The present account may be only a first step towards a more synthetic account of information's transformation of our world (and worldview). Nevertheless, beginning with the agents of this public narrative, and exploring the pages of the most widely circulated literature, it is, in my judgment, a proper first step.

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[10] Brand, Stewart. "Review of *The Year 2000*," *The Whole Earth Catalog*, Fall 1968, 17.

Part 1 – The Scientist Who Rebelled

Chapter 1 – The dawn of a new science

Cybernetics is the study of communication and control in systems, living and non-living. The term was coined in 1948 by the American mathematician Norbert Wiener of

M.I.T. from the Greek word for "steersman," *kubernetes*—the same root from which we derive the term "governor." Wiener, cybernetics' most outspoken champion until his death in 1964, felt obliged to invent a neologism for what he saw as an evolving interdisciplinary field in need of a coherent mission statement. Joining with Wiener was the brilliant Hungarian polymath John von Neumann, who would apply cybernetic insights across a range of endeavors from early automatic computers, to economics, to a theoretical model of the brain. Wiener and von Neumann's new field sought to combine the studies of electrical engineering, information and communication theory, neurology, psychology, and social anthropology into a larger science of control. Cybernetics' early formulators evidenced a worldview that was firmly systemic and mechanistic. Their perspective was formed in the context of the complete overthrow of vitalism: organic systems were to be seen as *systems*, while the fundamental point of inspection was the dynamics of the system, not the behavior of the system *in toto*. The theme of technological and social control, embodied in the very word "cybernetics," weaved through all of their work.

Cybernetics did not begin in 1948, nor was it invented by Norbert Wiener. Feedback control mechanisms were known in Ancient Greece, and have been implemented throughout modern history, most famously in the example of James Watt's mechanical governor of his steam engine. The conceptual framework to tie these devices together and underscore their link to biological organisms and social systems was, however, a new phenomenon to the twentieth century. Perhaps the best evidence of a growing attention to the ideas of "systems" and "control"— the sort of thinking required for the constitution of cybernetics as an interdisciplinary field — comes from Wiener's concession that the term "cybernetics" was not entirely new: "Incidentally, I found later that the word had already been used by Ampère with reference to political science, and had been introduced in another context by a Polish scientist, both uses dating from the earlier part of the nineteenth century."[11] It is significant that, in both instances, the idea of control and governance applied to social, not mechanical systems.

Science historian Steve Heims argues that, in the immediate postwar period of the United States, the atmosphere was ripe for the creation of cybernetics. The great wartime achievements of U.S. military scientists (von Neumann and Wiener included) inspired a new faith in (and fear of) the power of applied human knowledge, theoretical and experimental alike. "In the idiom of the day," Heims writes, "applied social science was often referred to as 'human engineering.' In all, postwar circumstances were conducive to a ready acceptance of the political status quo and to a technological or technocratic optimism, even in the face of one frightening recent 'success' in high technology—the atom bomb."[12] While the public reaction to the bombings of Hiroshima and Nagasaki was characterized by great ambivalence and anxiety about the science's power for good, scientists nevertheless found themselves thrust under the spotlight. Important social decisions could no longer be made without consulting scientists.[13] Heims observes, "It was a time…[of] solving problems rather than reflecting on meanings."[14] As Einstein is linked to the transformative power of the atom, history has associated Wiener with the other great discovery of twentieth-century technology—the power of the "bit." More even than nuclear energy, cybernetics (and Wiener himself) explicitly promised to unlock

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[11] Wiener, Norbert. *The Human Use of Human Beings*. New York: Avon Books, 1967, 23-24.
[12] Heims, Steve J. *The Cybernetics Group*. Cambridge, Mass: MIT Press, 1991, 2.
[13] Eisinger, Chester E. *The 1940's: A Profile of a Nation in Crisis.* Garden City, NY: Anchor Books, 1969, xix.
[14] Heims. *The Cybernetics Group*. 4.

connections between social and mechanical engineering. Contemporary observers believed that cybernetics' long-lived progeny, the electronic digital computer, would at last bring 'human engineering' into the world of hard mathematical science.

The watershed moment for cybernetics was the Conference for Circular Causal and Feedback Mechanisms in Biological and Social Systems (after the fourth conference, the title was changed, at the urging of Wiener, to the Conference on Cybernetics), held under the auspices of the Josiah Macy, Jr. Foundation in New York.[15] These ten conferences occurred regularly at the Beekman Hotel from March of 1946 to April of 1953, uniting key thinkers in mathematics and engineering as well as in the physical and social sciences, to deliver informal presentations and share ideas among the various disciplines. The organizer was the Macy Foundation's medical director, Frank Fremont-Smith, and the chairman was the neurophysiologist Warren McCulloch; important figures attending included Wiener, von Neumann, electrical engineer Julian Bigelow, neuroscientist Rafael Lorente de Nó, physiologist Arturo Rosenblueth, psychoanalyst Lawrence Kubie, child psychologist Lawrence Frank, and social anthropologists Margaret Mead and Gregory Bateson, then a married couple. The meetings were attended by a revolving "core" group of about twenty, and by a series of invited guests.[16]

Rosenblueth kicked off the proceedings with a summary of his, Wiener, and Bigelow's 1943 paper, "Behavior, Purpose, and Teleology". This paper and this moment

[15] Heims, Steve J. *John von Neumann and Norbert Wiener: From Mathematics to the Technologies of Life and Death*. Cambridge, Mass: MIT Press, 1982, 203.

[16] Conway, Flo and Jim Siegelman. *Dark Hero of the Information Age: In search of Norbert Wiener, the father of Cybernetics*. New York: Basic Books, 1995, 152. Wiener insisted that the meetings serve no commercial purpose, and hew to the values of openness and free exchange. He had witnessed during the war how state secrecy could retard scientific exchange, and with his work on telephone relays, how a company (AT&T) could squash innovation if it risked cannibalizing established markets. Wiener's concept of the citizen-scientist would later clash with von Neumann's more worldly attitudes, when the latter secured Defense Department funds and a partnership with RCA to build a digital computer at the Institute for Advance Study, and even poached Julian Bigelow from Wiener at M.I.T. for the role of chief engineer.

are rightly viewed as the launching of the first general statement of cybernetic science. Wiener, Rosenblueth, and Bigelow had studied the feedback response of anti-aircraft gunners during the war and developed a mathematical time series to explain their efforts at targeting. To explain the interaction between the human operator and the mechanical gun, the authors introduced a concept they called “circular causality”—a pattern of behavior that recursively referenced its own performance and adjusted accordingly. Under the behaviorist approach, the subject could be conditioned to fire more accurately by positive and negative reinforcement. Circular causality was more dynamic; information about the target’s position was processed by neural circuits that fine-tune the aiming apparatus. A miss yields as much, or more, information as a hit since it allows the gunner to compensate in the opposite direction.

A key feature of circular causality was that it necessarily invited the study of phenomena that behave with *purpose*. The teleological paradigm Wiener and company set forward was markedly different than the then-dominant Vienna school of logical positivism and its American cousin behaviorism. Both logical positivist and behaviorist epistemology ignored the concepts of “mind,” “internal states,” and the intrinsic causes of behavior, and focused instead on observable cause-and-effect. The analysis of feedback or circular causality reoriented behavioral and biological sciences in the mode of communication—turning attention to the structure and organization of the message. Rosenblueth’s warmly received talk heralded the start of a brewing “cognitive revolution” in the psychological sciences—one in which the forays into the nature of human intelligence owed as much to the construction of logical machines as to observation of human behavior.[17]

As the first title suggests, the early conferences were very much organized around the related principles of circular causality and homeostasis. Homeostasis described the tendency of biological systems to exhibit purposive goal-oriented behavior and self-regulation, in order to achieve equilibrium with their environment. The attendees stressed that systems did not obey linear chains of causation, but rather that their behavior was determined through participation with the environment in loops of interrelated feedback. For Wiener's equations to explain *what* was being communicated, "feedback" had to be quantified. In order to formalize these processes, the Macy group needed a mathematical theory of information and communication. Bell Laboratories engineer Claude S. Shannon supplied this model. To apply these principles to the workings of the brain, they also needed a logical model of the neural activity, which was the enterprise of McCulloch and his young collaborator Walter Pitts.

The emergence of cybernetics as a cross-disciplinary scientific field inspired an epistemological outlook that viewed mechanical/electrical, social, and biological systems as fundamentally similar self-organizing bodies, and that reified *information* as the ecumenical currency of exchange among and between these systems. Such an outlook redefined what it means to be human, as well as our relationship to the machines we build. Feedback was the circular transition of an immaterial thing called information—the same, whether in traveled through organic or mechanical substrates. The recognition

[17] Gardner, Howard. *The Minds New Science: A History of the Cognitive Revolution*. New York: Basic Books, 1987, 15-20. This "cognitive revolution" led to the development of a distinct field: cognitive science, whose pioneers worked mainly in Norbert Wiener's long Cambridge shadow. As we will see, a cognitive or "informational" study of mind would influence, and draw influence from the development of machine intelligence, and would lead, critically, to a closer integration of computers and their human users.

of information as an abstract quantity was the critical intellectual step necessary to conceive of electronic digital computers, a simultaneous development in the engineering schools serving the war effort. Wiener had begun to formalize a theory of feedback in servomechanisms after visiting the Army's Ballistics Research laboratory where human "computers" labored to calculate trajectories for anti-aircraft guns using his earlier work in differential equations and Fourier analysis.[18] These visits formed the inspiration for "Behavior, Purpose and Teleology." Not coincidentally, the same military imperative had lead to the commission of the University of Pennsylvania's ENIAC, the world's first electronic digital computer, on which von Neumann worked. Indeed, it is fair to say that cybernetics and modern computers arose from a shared environment. Likewise, Wiener's popularization of cybernetic concepts—above all the essential analogy between men and machines—would form the cultural context in which early computers were understood.

Cybernetics effected a revolution in information technology, but it has also transformed popular culture, radically altering the way people relate to machines and the way people conceive of their own subjectivity. Man could no longer be viewed as separate and apart from his technological creations. Thanks to the device of disembodied information, man, nature, and machine were all reduced to the same common variable. The cyborg can be seen as the quintessential cultural icon reflective of this transformation. Cyborgs are posthumans *par excellence*; in a sense, anyone who has already entered into a feedback loop with technology to redefine his or her conditions of life is, by definition, a cyborg. Hearing aids, electric wheelchairs, and canes for the blind

[18] Heims, *John von Neumann and Norbert Wiener,* 184-188.

came to be seen as cybernetic tools.[19] If we are to understand the cultural milieu of the first computers, we must reckon with how cybernetics, articulated by its foremost spokesman, Norbert Wiener, transformed popular consciousness.

Norbert Wiener was a problematic figure both personally and professionally. He moved effortlessly between pure and applied mathematics, biology, physics, history, philosophy and social activism. He had given up his chosen discipline, biology, in 1910 due to his physical clumsiness in the laboratory, but the interest lay dormant.[20] A prodigy schooled by his philologist father in the manner of a young John Stuart Mill, Wiener's interests lay always at the interstices of the sciences, whether in statistical mechanics, genetics, or physiology. Around M.I.T. he became famous for his *Wienerwegs* (Wiener walks), absentminded strolls through the halls where he would engage faculty and students alike in informal conversations covering topics from economics to physical chemistry.[21] Stumbling into physics lectures or mechanical engineering laboratories, he quasi-wittingly helped inspire a collaborative culture at the heart of cybernetics and of the digital computer projects undertaken at M.I.T. a decade later. Wiener was at home in every discipline. Fittingly, he began his famous monograph, *Cybernetics*, with the conviction "that the most fruitful areas for the growth of the sciences were those which had been neglected as a no-man's land between the various established fields."[22]

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[19] Cyborgs and artificial humans, or androids, had existed in the popular imagination as early as Shelley's time, but the development of cybernetics gave modern man a concrete, scientific language in which to express these fantasies. Popular films such as Stanley Kubrick's *2001: A Space Odyssey* (1968), Ridley Scott's *Blade Runner* (1982), and James Cameron's *The Terminator* (1984) have breathed life into these eccentric and often terrifying characters, and authors of popular science fiction like Philip K. Dick, William Gibson, and Stanislaw Lem have persistently explored cybernetic themes.
[20] Heims. *John von Neumann and Norbert Wiener*, 173.
[21] Conway and Siegelman. *Dark Hero of the Information Age*, 82.
[22] Wiener, Norbert. *Cybernetics: or, Control and Communication in the Animal and the Machine*. Cambridge, Mass.: MIT Press, 1965, 8.

While a postdoctoral student in England he struck up a friendship with the evolutionary biologist J.B.S. Haldane, who pointed his attention toward homeostasis and purposive behavior in biological systems. As he had with Haldane, Wiener charmed most whom he met and cultivated wide networks of professional relationships, but poisoned many due to his sensitive ego, volatile temper, and the exaggerated formality of his personal manner. In his appetite for grand statements, he embodies the archetype of the information ambassador I will trace throughout this project. He was very well connected and gifted as a creator of organizations. He wrote in an accessible, yet cultivated idiom even as he traversed the technical frontiers of postwar science. Given to bombast and hyperbole, he never shied from making profound conclusions about the social and economic outcomes of technology. He personified the role of the late twentieth-century ambassador-prophet—a vital medium through which Americans began to comprehend their relationship to the rapidly evolving body of scientific knowledge, and their future.[23]

Deliberately cultivated as a genius by his father, Leo Wiener, the first Jewish full professor at Harvard, Wiener learned Latin and Greek before he was six; he entered Tufts College at age eleven, and was award a Ph.D. in mathematical logic by Harvard in 1912, when he was eighteen.[24] He traveled to Europe to study under Bertrand Russell, G.H. Hardy, and David Hilbert, and returned to serve as a military scientist in World War I. After a stint at General Electric, he became an instructor at the Massachusetts Institute of Technology, where he would spend the rest of his career, building a top-flight program in

[23] In employing the term "ambassador" I am aware of the difficulty of translation. Neither Wiener nor his successors can be said to have been an envoy from any coherent place. The information science they attempted to explain was heterogeneous. Still, they consciously represented themselves as describers of "information science" and as predictors of its future. They constructed the narratives through which the public came to understand cybernetics, information, and computers. Therefore, with some apprehension, I will use the ill-fitting term "ambassador" to denote this complex persona.
[24] Wiener, Norbert. *Ex-Prodigy: My Childhood and Youth*. New York: Simon & Schuster, 1953.

mathematics. At M.I.T. and Göttingen, Wiener worked on Brownian motion and the Fourier integral, among other problems. His studies of Brownian motion, the seemingly random behavior of particles suspended in a fluid, in particular informed the budding science of cybernetics. Wiener developed a stochastic (non-deterministic) process to predict this movement based on the thermodynamic mathematics of the twentieth century physicist Josiah Willard Gibbs. Gibbs had realized that this random motion could only be understood through an application of probability theory, subject to the laws of thermodynamics and entropy. For Wiener, this was a breathtaking exposure to a world of statistics and uncertainty. While cybernetics endeavored to bring many aspects of control and communication into the fold of mathematical science, Wiener cautioned against viewing this science as rigid or deterministic. To Wiener, the physical world as well as the human one was deeply inhospitable to a perfect mapping, but could be predicted through the logic of probabilities.

While he won fame in applied mathematics, the philosophy of the problems he studied remained at the heart of Wiener's concern. A theorist to the core, he always evinced a disinclination for lab work. He was impatient with the slow pace of acquiring experimental data, and his colleagues remarked that he became particularly irritated when it didn't match his theoretical calculations.[25] Unlike his contemporary von Neumann, Wiener was a poor engineer; it would fall to others to embody his abstractions in working models, in actual circuits, and in electronic machines.

Wiener's first exposure to the military applications of mathematics was at the National Ballistics Laboratory at Aberdeen, where he worked to compute ballistics tables

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[25] Hayles, N. Katharine. *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. Chicago: University of Chicago, 1999, 99.

during the First World War. It was here that, later, the mathematical theories of communication he crafted were used in prediction systems for automated anti-aircraft guns. His effort significantly advanced the field of communication engineering through the statistical analysis of a phenomenon he identified as "negative corrective feedback." When a repeated input produced a widening error quantity, the control apparatus would compensate in the opposite direction. It occurred to Wiener that the type of corrective feedback displayed by automated servomechanisms was the same observed in human operators of machinery, for instance when driving a car. He and his young colleague, Julian Bigelow, became convinced that negative feedback played a role in the human control mechanism—the zigzagging pilot as well as the surface-to-air gunnery. Wiener asked the Mexican physiologist Arturo Rosenblueth, of Harvard, if medical science knew of any human pathology that might be associated with the inability to apply negative corrective feedback. Rosenblueth replied that there was; it was known as purpose or cerebellum tremor, where patients attempting to pick up a glass of water might flail wildly, with an increasing oscillating error margin.[26]

Rosenblueth prepared his thoughts on the question in a presentation for the 1941 Cerebral Inhibition Meeting, also organized by Fremont-Smith for the Macy Foundation. This meeting was attended by McCulloch, Wiener, Mead, Bateson, and Frank, and would provide the spark of interdisciplinary interest in cybernetic questions that led to the later Macy Conferences. Rosenblueth identified a large range of phenomena that exhibit circular causality, while Wiener and Bigelow demonstrated that these phenomena could be described with formal mathematics. Further, the information used to govern such

[26] Wiener, Norbert. "My Connection with Cybernetics," in Masani, Pesi, ed. *Norbert Wiener: Collected Works,* vol. 4. Cambridge, Mass.: M.I.T. Press, 1985, 115.

devices as anti-aircraft guns was the same used in the nervous systems of vertebrates, or, for that matter, in any biological system. The information circuits in servomechanisms were a form of "computing machine," just as brains were. Wiener recalled,

> This practical interest in computing machines led me to consider the general philosophy of the problem. On the one hand it became clear that the mechanism of a computation which depended on two value marks for the different digits could be easily adapted for the use of a machine to perform calculations of the algebra of logic, rather than numerical algebra. Here the two digital possibilities would correspond to the two possibilities of truth and falsity. Next we began to see that there was a certain analogy between digital computing machines and the human brain, particularly because of the fact that impulses in the nervous system seemed to be of an all or none nature, or in other words to involve to digital possibilities.[27]

This basic equation, and the mathematical premise upon which it was founded, opened a world of possibilities to the assembled scientists at the Cerebral Inhibition Meeting.

Wiener, Bigelow, and Rosenblueth went on to systematize much of their thinking on the subject of purposive behavior in "Behavior, Purpose, and Teleology", published in the *Journal of Philosophy and Science*. In it, they laid out the agenda for cybernetics, and the promise of the new man=machine paradigm: "In future years, as the knowledge of colloids and proteins increases," the authors hoped, "future engineers may attempt the design of robots not only with a behavior but also with a structure similar to that of a mammal. The ultimate model of a cat is of course another cat, whether it be born of still another cat or synthesized in a laboratory."[28] This last proclamation, with all its subsurface ambition, may be seen as the battle cry for the nascent field of cybernetics.

The first Macy meeting took place on March 8 and 9, 1946, in New York City. Von Neumann and Wiener dominated the proceedings, delving for the first time into the state of the art in general-purpose electronic digital computers. Von Neumann was at

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[27] Wiener, Norbert. "My Connection with Cybernetics." 114.
[28] Wiener, Norbert, Julian Bigelow, and Arturo Rosenblueth. "Behavior, Purpose, and Teleology," Masani, Pesi, ed. *Norbert Wiener: Collected Works,* vol. 4. Cambridge, Mass.: M.I.T. Press, 1985, 185.

work on such a machine at the University of Pennsylvania and viewed them as consummate physical realizations of the cybernetic principles of feedback and information processing. To the Macy group, computers were only one interesting application of the new science. To von Neumann, and, as we will see, to many outside observers, they were at its heart.

Rafael Lorente de Nó also gave a presentation detailing his experiments on the electrical properties of nerve cells.[29] Unfortunately, the transactions of the first five meetings were neither stenographed nor edited, and, for the most part, the participants did not publish their presentations in article-form. The color of these exciting first conferences remained largely ignored as a historical record until Steve Joshua Heims published in 1991 his comprehensive history of the period of the Macy conferences titled *The Cybernetics Group*. Heims undertook the massive project of interviewing many of the attendees and sorting through volumes of their correspondence.[30] Happily, the fifth-through-tenth conferences were edited by Margaret Mead and newly invited "core" group-members Heinz von Foerster and Hans-Lukas Teuber and published under the name *Cybernetics*. These transactions reveal an already lively debate; the wit and personalities of the conferees shine through despite their sincere effort to achieve an "objective," scientific discourse.[31]

The first meeting included some speculation on the philosophical importance of the groundbreaking work being done; otherwise, explicit philosophical exchange was

[29] Heims. *The Cybernetics Group*. 19.
[30] Heims. *The Cybernetics Group*. 18.
[31] Heims. *The Cybernetics Group*. 72. The transactions of the tenth conference, however, are of little use to our discussion here. Teuber, too, thought they had been less stimulating, and wished to resign his editorship from the transactions of the tenth conference. Mead convinced him to stay on the condition that only finished papers and no debate would be included.

muted. According to Heims, "whereas mechanism was an underlying motif, a theme popular after the technological successes in connection with the Second World War, the very existence of human feelings (so subjective!) was consistently played down or explained away over the protest of a few of the participants. Even such anthropocentric social scientists as Mead and Frank became proponents for the mechanical level of understanding, wherein life is described as an entropy-reducing device and humans characterized as servomechanisms, their minds as computers, and social conflicts by mathematical game theory."[32]

Wiener commenced the first conference with the declaration, "The fundamental idea is the message … and the fundamental element of the message is the decision."[33] The conferees were encouraged to regard all physical actions as involving the transfer of information, and this information could be reduced to, at base, a binary choice. At its basic level, all communication was digital: "the transmission of information is impossible save as a transmission of alternatives."[34] Wiener conceived every statement as boiling down to a series of either/or propositions. The capacity of a noisy channel, then, or the ability of a message to get through was a function of a number of dependent likelihoods.

Wiener's assertion conveyed his belief that communication must be at heart a statistical science, best studied in terms of the Gibbsian probabilities that had fascinated him when he looked at the movements of particles in a liquid. Messages could be treated as time series, and statistical methods could be used to analyze predictive error, and to separate signal from noise. In cycles of self-reinforcing feedback, the ever-widening error margins were recursive and posed a problem for classical mechanics. "The

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[32] Heims. *The Cybernetics Group*. 27.
[33] Quoted in Hayles. *How We Became Posthuman.* 52.
[34] Wiener. *Cybernetics* 17.

answer," Wiener found was that the contradictory errors of inaccuracy and hypersensitivity (those of positive and negative feedback) could be reconciled "only on a statistical basis"—via the transmission of new information.[35]

The decision-between-choices—whether they be on/off or yes/no—linked together, in Wiener's mind, all of the work being done by the various Macy attendees. During the first meetings, Wiener spoke on the fundamental concepts in information theory and communication theory, von Neumann on computers and the theory of games, and chairman McCulloch on his and Pitt's logic of the neuron. This pair argued that nervous impulses are a binary, digital process. Neurons are either excited or they are not. Furthermore, like any electrical device, a discharge requires a definite, quantitative threshold voltage, and the fundamental quantity in determining the output of nervous networks is a measurable delay time. Thus the logic neural mechanism was equally amenable to statistical (formal) description as the telephone grid, for example.

Heims' characterization of the climate of the early Macy conferences as objectivist, mechanistic, and mathematical seems accurate. Even the Freudian psychoanalyst Lawrence Kubie had, earlier in his career, done important neurological work on neural nets. His inclusion was part of an attempt to recuperate the field of psychology, and the study of the mind, back into the realm of "hard," masculine science. The relevance of Gestalt psychology was bandied about, but never well represented or fully embraced by the group. German Gestalt pioneer Wolfgang Köhler attended the fourth conference, but feared that his ideas had not been well received.[36] It was

[35] Wiener, Norbert. *I Am a Mathematician: the later life of a prodigy*, Cambridge, Mass: MIT Press, 1966, 244.

[36] Heims. *The Cybernetics Group*. 54. Gestalt theory similarly viewed human beings as systems in an open circuit with the environment, yet saw this circuit as inadequate to describe perception. Psychological

McCulloch's work on neural nets that most powerfully lassoed the mysterious workings of the brain, and brought them under the reign of hard mathematics.

Warren McCulloch chaired all ten Macy meetings and, during his later years, was at the very center of the cybernetics universe. He was never reluctant to exert his commanding influence on the proceedings of the conferences, determining the daily agenda, who was permitted to talk, and for how long. Next to Wiener and von Neumann, he is perhaps the most dynamic and compelling figure in the movement. Born in 1898 in Orange, New Jersey to a deeply religious Episcopalian family, McCulloch entered Haverford College in 1916 with the intention of joining the clergy, but transferred to Yale in order to participate in the Officers' Training Corps there. After serving in the Navy during World War I, McCulloch received bachelor's degrees in philosophy and psychology. He had absorbed Leibniz, Descartes, and Kant, all while being "seduced by mathematics." After earning an M.D. from the College of Physicians and Surgeons in New York, he remained interested in the physiology of perception and thought. The introspective Cartesian questions, "how do we know what we know," and, more specifically, "what is a number, that a man may know it," would occupy him all his life. Fascinated by the epistemic problems of science and mathematics, McCulloch's life's work was to "get at the workings of a machine called a brain." In 1968, a year before his death, McCulloch declared himself "very happy, very puzzled, very hopeful."[37]

In 1941 McCulloch arrived at the University of Illinois College of Medicine in Chicago and met a young logician named Walter Pitts. Pitts was slim, shy, uneducated,

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phenomena were held to be products of innate cognitive patterns rather than observable interactions; hence, more than the sum of their parts. In fact, Gestalt theory can be seen to run counter to the rigidly systemic orientation of the Macy group.

[37] Bateson, Mary Catherine. *Our Own Metaphor*. Washington: Smithsonian Institute Press, 1991, 24.

brilliant, and mentally unstable. His gentle demeanor belied the razor-sharp reasoning and contemptuous manner with which he cut through sloppy logic. The abused son of a plumber, Pitts received little formal education but had taught himself Russell's *Principia Mathematica* so effectively that when he mailed a correction to the English mathematician, he instantly received an invitation (one he was too poor to accept) to study with him at Cambridge. Forever seeking anonymity, he once refused a Ph.D. procured for him on the basis of his earlier work by friends at the Massachusetts Institute of Technology.[38] His colleague Jerome Lettvin recalled, "Walter would attend classes occasionally. He had no money so he couldn't register. He was a homeless waif, living in a shabby room for four dollars a week, but he was quickly recognized as a 'weird kid genius' and given a small stipend from UC."[39] Recognizing his talent, McCulloch invited the itinerant young scholar into his home, and engaged him in work on the logic of the neuron.

The duo's seminal paper, "A Logical Calculus Immanent in Nervous Activity," was published in 1943 and its radical ideas underpinned much of the discussion at the Macy Conferences. The work demonstrated that any activity of mind could be built from a network of simple, binary neurons, without resort to vital energy or anything transcendent. It was founded on the following physical assumptions:

1. The neuron's activity is an "all-or-none" process; its state is either excited or not.
2. A certain fixed number of synapses need be excited within the period of latent addition for a neuron to become excited, and this number does not depend on the previous position or activity of the neuron.
3. "The only significant delay within the nervous system is synaptic delay."
4. The firing of a single inhibitory synapse will prevent the neuron's excitation at that time.

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[38] Heims. *The Cybernetics Group*. 45-46.
[39] Conway & Siegelman. *Dark Hero of the Information Age*, 138.

5. "The structure of the net does not change with time."[40]

McCulloch and Pitts' logical calculus essentially proposed that the mind functioned like the hypothetical logical computers proposed by English mathematician Alan Turing. Turing had famously proven that a machine could accomplish any task as long as it could be explicitly and unambiguously stated by the programmer. These "Turing machines" proved to be the model for later stored-program computer architectures, an innovation introduced by von Neumann. McCulloch recalled,

> Turing had produced a deductive machine that could compute any computable number, although it had only finite number of parts which could be in only a finite number of states and although it could move only a finite number of steps forward or backward, look at one sport on its tape at a time, and make, or erase, 1 or else 0. What Pitts and I had shown was that neurons that could be excited or inhibited, given a proper net, could extract any configuration of signals in its input. Because the form of the entire argument was strictly logical, and because Gödel had arithmetized logic, we had proved, in substance, the equivalence of all general Turing machines – man-made or begotten.[41]

John von Neumann was unambiguous about this equivalence in an interview he gave *The Baltimore Evening Sun*, in 1949. Shedding some clarity on McCulloch's work he explained that modern digital computing machines, like the ENIAC, directly approach the structure of living nervous systems. Logical circuits, he said, "resemble the network of nerve cells in the human brain, although they are very much simpler."[42] Wiener said, "The human brain behaves very much like the machines. The construction of more and more complex mechanisms actually is bringing us closer to an understanding of how the

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[40] McCulloch, Warren and Walter Pitts. "A Logical Calculus of Ideas Immanent in Nervous Activity," in *Embodiments of Mind*. Cambridge, Mass: M.I.T. Press, 1988, 22.
[41] McCulloch, Warren. "What is a number, that a man may know it?" in *Embodiments of Mind*. Cambridge, Mass: M.I.T. Press, 1988, 9-10.
[42] "New Computing Devices Behave Like Nerve Cells," *Baltimore Evening Sun*, April 6, 1949.

brain itself operates."[43] Computers and brains were made of different stuff, but in the essential property of their organization, they were alike.[44]

McCulloch always vociferated for the possibility of such machines and eagerly awaited their arrival. Jerome Lettvin wrote in the introduction to the former's *Embodiments of Mind*, "enthusiasts in AI have long maintained that it is easier to build a human than to analyze one already in operation. That is essentially how Warren McCulloch thought."[45] McCulloch, whose manner was warm, compassionate, and friendly, often said that he preferred the company of machines to people. "I don't particularly like people, never have," he quipped near the end of his life. "Man to my mind is about the nastiest, most destructive of all animals."[46] Notwithstanding such curmudgeonly grumblings, he traveled in a free-spirited bohemian salon with his wife and a coterie of young admirers, swimming, camping, hiking, and discussing philosophy by fireside until late into the night. In an essay, he recommended "fun" as the qualitative criterion for man's existence. Machines, McCulloch believed, were just as capable of "fun" as humans. The wording of McCulloch's restatement of the Turing theorem bears this hope out: "…we can build a machine that will do with information anything that brains do with information—solve problems, suffer emotions, hallucinate on sensory deprivations, what you will—provided we can state what we think it does in a finite and

[43] William Laurence. "Science in Review," *The New York Times*, December 19, 1948, E9.
[44] Turing, who, like von Neumann, would spend his last years working on in the field of machine intelligence, proposed a test of artificial intelligence. This test, which helps form the central paradigmatic metaphor for the field of Artificial Intelligence (AI), offers that if a human operator asks twenty questions to a machine posing as a human, and cannot tell if his interlocutor is machine or man, then the machine must qualify as intelligent. Though Turing was contemplating a serious scientific problem, machines that could pass his test became a staple of popular science fiction and never a laboratory reality.
[45] Lettvin, Jerome. "Introduction," in *Embodiments of Mind*. Cambridge, Mass: M.I.T. Press, 1988, vi.
[46] Heims. *The Cybernetics Group*. 36-37.

unambiguous manner."[47] A further exchange at the sixth Macy conference underscores the depth of McCulloch's relationship to machines.

> *McCulloch:* 'I am a Scot. I think like most all Scots I fall in love with machines and particular machines, and I am a sailor, and I know that almos t every sailor falls in love with a ship, and it becomes as unique as a person, identified in the same manner as our fellow man identifies us. I don't think any greater difficulty rests in the fact that the other machine is a man instead of being made out of wheels or out of canvas…'
> *Mead*: 'But the ship does not fall in love with you.'
> *McCulloch*: 'I am not so sure.'[48]

As much as McCulloch's personality stamped its authority on the transactions of the Macy conferences, it was Wiener's that propelled and inspired them. Wiener was the first to conceive of cybernetics as a "metascience" that transcended all other sciences: a broad paradigm uniquely capable of expressing the most profound physical, philosophical, and social realities of the world.[49] Wiener strove tirelessly to position cybernetics as the fundamental epistemological framework for all twentieth-century research in biology, neurology, informatics, and social science.[50]

Wiener's dealings, particularly with McCulloch, were not without controversy. Several times he attempted to quit the Macy group, citing financial strain, fatigue, and damage to his primary mathematics reputation[51]. While visiting Rosenblueth, then employed in Mexico, he became embroiled in a dispute with Walter Pitts over a lost manuscript, and fell out with Pitts' mentor as well. "Under no circumstances are you to use my name as a reference or recommendation," he wrote the former. "You will understand that will make any continuance of joint scientific effort between us

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[47] McCulloch, Warren. "Where is Fancy Bred?" in *Embodiments of Mind*. Cambridge, Mass: M.I.T. Press, 1988, 220-1.
[48] *Cybernetics: Transactions of the Sixth Conference*. New York: Josiah Macy, Jr. Foundation, 1949, 150.
[49] Hayles. *How We Became Posthuman.* 96.
[50] This was true of other cyberneticists as well; it is no accident that the mathematician Von Neumann is known best for game theory (of which Wiener disapproved), and for his contributions to economic and social theory.
[51] Letters to McCulloch and Fremont-Smith, May 10, 1946. Norbert Wiener Papers (MC22), box 3, folder 71, Institute Archives and Special Collections, M.I.T., Cambridge Mass.

impossible," he told the latter. In his fury, Wiener also cut off relations with his colleagues Oliver Selfridge and Giorgio de Santillana, whom he accused of conspiracy in the matter. The less easily flappable McCulloch responded, gracefully, "You don't know half how well I love you. I leave conspiracies to little men, and would naturally murder in hot blood anyone who so much as fancies that I would stoop to such a trick – but as always you are an exception."[52] The feud was patched up, but the armistice wouldn't last. Pitts became increasingly erratic and unreliable and was disowned by Wiener and McCulloch both, eventually leaving science and becoming an peripatetic Beat mystic.[53] Wiener, whose domestic propriety clashed with McCulloch's joie-de-vivre, came to view McCulloch as a self-promoter and idea thief, and soon after securing him a position at M.I.T., refused to speak with him ever again.[54] These blow-ups were more than a quirk of Wiener's eccentric personality. They reflected a deep sense of righteousness, and the immense social and scientific importance he placed on his work in cybernetics.[55]

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[52] The exchange occurred over the period of April 4 to April 10, 1947. Norbert Wiener Papers, box 3, folder 77.

[53] Though the source of the break remains shrouded in mystery, Conway and Siegelman trace the affair to a sordid family dispute involving McCulloch, Pitts, Letvin, and Wiener's wife and daughter. They speculate that the dispute had little substance and was likely concocted by Wiener's wife Margaret, an exaggeratedly proper woman who held a longstanding animosity toward McCulloch and his flamboyant, bohemian lifestyle (and its influence on Wiener himself). A final break occurred in autumn 1951 when Wiener fired off a letter to the president of M.I.T. that warned that "the present atmosphere is not one in which I can continue my work in cybernetics." *Dark Hero of the Information Age*, 220-221.

[54] Letter to Grey Walter. April 2, 1953. Wiener Papers Box 3, folder 168.

[55] Wiener would enter into priority disputes as a matter of habit throughout his career. George Stibitz, the engineer behind Bell Labs' electrical relay calculator, and a collaborator of Shannon in the development of a mathematical theory of communication, objected to the press' portrayal of Wiener as the "father of the computer." Wiener himself encouraged this portrayal, Stibitz felt, in his book *Cybernetics*, in which he gave credit to thinkers like Leibniz and Babbage as early vanguards of digital computation, but failed to recognize contemporary engineers like Stibitz. In a latter dated March 18, 1951, Stibitz wrote: ""The argument in the minds of reporters seems to go something like this: Professor Wiener invented Cybernetics. Automatic computers, servos, prediction etc. are branches of Cybernetics. Therefore, Professor Wiener invented automatic computers, servos, prediction, etc. As a result, you were referred to in one place [in *Life* magazine] as a co-inventor of the automatic computers. This hurts a bit, because both Howard Aiken and I had designed and built computers with most of the important features of the present 'Giant Brains' long before you took an interest in the subject, to the best of my knowledge. The only major features, in my estimate, that were not incorporated independently by us were (a) electronic circuits for computation, and

Moreover, they were a symptom of the tireless personal energy Wiener invested in everything; his passions would animate all his endeavors from his wartime ballistics research, to his later antiwar activism, to his part as the public face of information science near the end of his life.

Wiener's chief contribution to the Macy group lay in his ability to cut across boundaries of subject and discipline, applying ideas readily from one field in another. Like no one else, Wiener could formulate the cosmological significance of cybernetics as a universal science, and, leveraging his status as one of America's leading mathematicians, ensure that his voice was heard. His centrality in American science of the 1940s and '50s can thus be seen in terms of the coupling or intermixture of diverse concepts. By the time of the Macy Conferences, Wiener was no longer predominantly a mathematician; he was a philosopher of the greater problem, and a popularizer of scientific ideas.

Wiener debated, for example, with Gregory Bateson the compatibility of psychoanalytic practice and communication theory. Because the crucial component in communication systems is information rather than energy, Wiener suggested that the Freudian emphasis on the libido was misplaced. He conjectured that the physical basis of so-called "functional disorders" in psychiatry was, as in the malfunctioning of a

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(b) means for handling commands in the regular numerical channels....To the best of my knowledge no automatic digital computer, no component part, no specific suggestion of how to perform any function of automatic computation and no idea even remotely patentable in any such computer ever built could be traced to you. And so, although I am glad you quickly recognized the value of such computers, I must disagree with any statement that you were a 'co-inventor.' Of course, as you probably recall, I pointed out the analogy between the nervous system and the control circuits of the really computers to you and others of my audience at Brown University in February 1945, but to say that this was a contribution of Cybernetics to automatic computers seems to me to be stretching the term beyond its elastic limit. To do so would probably class me as a co-inventor of Cybernetics." Wiener Papers, Box 3, folder 135.

computer, due to "instructions," "messages," "programs," and "memory."[56] The focus on information, divested of meaning, was an aspect of the cybernetic project to situate human problems in the context of objective formal logic. Such linkages were at the heart of what Wiener's new science was all about. To Gordon Pask, cybernetics effectively was "the science of manipulating defensible metaphors."[57] Outside observers readily perceived cybernetics' explicit connection between the study of feedback in electrical circuits and in biological systems. This was Wiener's great skill: formalizing in mathematics a relationship that many already suspected. "It is a scientific approach to an old problem," *The Wall Street Journal* observed. "The underlying purpose of this new technique is to help people to be as smart as they are constitutionally able to."[58] Cybernetics was thus seen to embed a directive toward applied social engineering.

Postwar science, for Wiener, required as an essential operating requirement that information be dematerialized: "Information is information, not matter or energy," he insisted in his 1948 book, *Cybernetics.* "No materialism which does not admit this can survive at the present day."[59] Wiener's dual concerns—information and self-organization—synthesized themselves in the problem of systems that organized themselves into a rhythm, such as the vascular system of a vertebral embryo. He postulated that the organs functioned in the double role of senders and receivers of information. Their impulses affect other cells; in turn, their action is modified by the reception of received impulses. This non-linearity allows for organization.[60] Because

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[56] Heims. *The Cybernetics Group*. 304-5.
[57] Umpbleby, Stuart. "Defining Cybernetics," *American Society for Cybernetics*, 2000. Accessed 31 Aug. 2010. <http://www.asc-cybernetics.org/foundations/definitions.htm>
[58] "Pepper and Salt," *The Wall Street Journal*. July 2, 1948, 4.
[59] Wiener. *Cybernetics*. 132.
[60] Wiener. "My Connection with Cybernetics." 118-119.

they are engaged in feedback loops with the cells around them, they are able to collectively form an organized system. Hence the cybernetic focus on circularity, the nature of the feedback-loop, was predicated on the *disembodiment* of information.

Wiener was involved, at least tangentially, in almost every major scientific debate of the mid-twentieth century: atomic energy, the importance of information processing, and nature and structure of DNA.[61] He possessed a tremendously adaptable and quick mind, and an ability to cultivate professional networks both larger and more diverse than those of his colleagues. He also worked comfortably in a language of abstraction, a common interface protocol similar to the "trading zones" Peter Galison identifies within the field of physics.[62] In Wiener's hands, complex ideas could be rich in meaning, and widely applicable—a rare combination. Wiener's most unique talent, however, lay in making notions such as these accessible to the general public. The 1948 publication of *Cybernetics* defined the field. Testimony to Wiener's linguistic panache, it was also a blockbuster—the rare technical mathematics book that crossed over to bestseller lists. One trait common among public promoters of science is a functional interest in pedagogy. Perhaps due to his father's influence, Wiener followed closely research in educational methods and developmental psychology. Among his papers can be found

[61] Kay, Lily. *Who Wrote the Book of Life: A History of the Genetic Code*. Palo Alto: Stanford, 2000. Galison, Peter. "The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision," *Critical Inquiry* 21 (Autumn 1994): 228-266.

[62] When, for example, Wiener and the engineer Bigelow spoke of "information circuits" or feedback, social scientists like Mead could participate in the dialogue, viewing these concepts in terms of communication networks and the organization of gender roles in primitive societies. Wiener served as an "agent" facilitating transaction—familiar with the symbolic language of communications engineering, the biological workings of the nervous system, and the anthropologists' mapping of social structures. Galison, Peter L. *Image and Logic: A Material Culture of Microphysics*. Chicago: University of Chicago, 1997, 783-786.

many clippings on the teaching of math and science in primary schools and on the incubation of intelligence.[63]

As an old-fashioned *homme de lettres*, he also believed in the value of communication. "I was brought up in an atmosphere where it was expected that a person would write. My training was as much classical as scientific," he told a *New York Times* reporter.[64] His correspondents included his elected officials and popular writers, social theorists like Kenneth Boulding and Marshall McLuhan, the architect Richard Neutra, the pugilist Joe Louis, his philosophical mentor Bertrand Russell, and his close friend, the evolutionary biologist J.B.S. Haldane. As much as he cultivated his ideas in private, he demonstrated an abiding desire to convey difficult material to the public. In 1941 he even wrote Orson Welles, offering a spec script on the founding of AT&T.[65] Wiener's orbit only reached so far, however; Welles never responded.

The outlook that inspired Wiener to such cross-disciplinary excursions was summarized in a prologue he wrote for a 1950 M.I.T. performance of Karel Çapek's science fiction play *R.U.R.* In a society of increasing technical complexity, he said, "either the engineers must become poets or the poets must become engineers." Clearly, he saw himself as both.[66] Along with Claude Shannon, he was an avid, albeit closeted reader of science fiction. In 1949, hoping to capitalize on the success of *Cybernetics*, he submitted a science fiction story to Random House titled "The Brain," about a Chicago gang boss who is lobotomized and goes straight.[67] Wiener further developed an epistolary relationship with Groff Conklin, editor of the pulp serial *Galaxy Science*

[63] Wiener Papers, Box 25c, folder 377.
[64] Davis, Harry M. "An Interview with Norbert Wiener," *The New York Times*. April 10, 1949, BR23.
[65] Letter to Orson Welles, Wiener Papers, Box 4, folder 60.
[66] Prologue to *R.U.R.*, 1950. Wiener Papers, Box 29B, folder 657.
[67] "The Brain," May 16, 1949. Wiener Papers, Box 6, folder 98.

Fiction. Both men agreed that the quality of contemporary science fiction literature was declining as a result of its mass production. One favorite target was the leading rag, *Astounding Science Fiction*, edited by one of Wiener's former students, John Campbell. To imbue the industry with some gravitas, Wiener sent Conklin two stories for publication under the transparent penname W. Norbert; he wished to distinguish his literary and scientific personae, because "in the future I may either do a piece of scientific work which might be confused possibly with science fiction, or some sort of hoax which might endanger my scientific reputation if it came under my name."[68]

Such science fiction daydreams cross fertilized his serious writings: in 1950's *The Human Use of Human Beings*, Wiener speculated that it would be theoretically possible to telegraph a human being, an idea that found its way into the 1960s' television series *Star Trek*, in the form of Scotty's transporter. Organisms, Wiener stressed, are fundamentally messages, not matter. "We are but whirlpools in a river of ever-flowing water," he wrote. "We are not stuff that abides, but patterns that perpetuate themselves."[69] Once human beings could be conceptualized as being made up entirely of information, or "patterns", such a possibility seemed considerably less remote. Part of Wiener's appeal to the general public that knew him as the most prominent face of American mathematics was that he possessed all the imaginative capacity for wild fantasy of a science fiction writer. His works were warmly reviewed in science fiction publications, like the *Fantasy Advertiser*, which curiously saw *The Human Use of Human*

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[68] Letter to Groff Conklin, May 28, 1953. Wiener Papers, box 12, folder 173.
[69] Wiener. *The Human Use of Human Beings*, 130. Wiener summarized, "The distinction between material transportation and message transportation is not in any theoretical sense permanent and unbridgeable," 134. As if startled by his own conclusion, he reflected on human individuality, which could now only be defined in terms of its continuity of process, not any physical characteristic. He continued, "In terms of the computing machine, the individuality of a mind lies in the retention of its earlier tapings and memories, and in its continued development along lines already laid out." (138) A human duplicate, passed through Scotty's transporter, would thus be party to this individuality.

Beings as a significant outlet of technological optimism.[70] Science fiction authors generally recognized their debt; one sent Wiener a joking letter of condemnation for stealing all of his material.[71] One writer, Bernard Wolfe, even dedicated his cybernetic novel *Limbo* to Wiener.[72]

Norbert Wiener was only too content in his position as cybernetics' public face. As cybernetics' star rose, propelled by the mounting interest with the electronic machines it purported to explain, Wiener was omnipresent in the public eye. In December 1950, he was featured in several *Life* magazine full-page photo spreads. The pictures made for a compelling graphical representation of the analogies between man and machine. Parkinsons tremor patients were shown alongside a servomechanism Wiener and Bigelow built to exhibit an identical purpose tremor: each was the product of a harmonic overcompensation in the feedback-response cycle.[73]

Wiener's private lectures, often to broad scientific and lay audiences were frequently covered by publications like *The New York Times* and *The Atlantic.*[74] He penned popular articles for *Scientific American* and *Electronics*, and gave interviews to the likes of *U.S. News and World Report*.[75] "Every sentence is forcefully voiced and rhetorically impeccable," raved *The Times*. In writing, he could mix equations with

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[70] Clipping of review from *The Fantasy Advertiser*, 1953. Wiener Papers 28c, folder 597.
[71] Letter from Erik Fennel. 1949. Wiener Papers Box 6, folder 87.
[72] Wolfe, Bernard. *Limbo*. New York: Carroll & Graf, 1987.
[73] *Life*. December 18, 1950, 82.
[74] Wiener, Norbert. "Communication and Secrecy in the Modern World." *The Atlantic Monthly*, May 25, 1949. Wiener Papers, box 28D, folder 633.
New York Times, May 29, 1949 clipping, Wiener Papers, box 25c, folder 378.
[75] Norbert Wiener. "Cybernetics." *Scientific American* 179 (1948), 14-18.
Norbert Wiener. "New concept of communication engineering." *Electronics* 22 (1949), 74-77.
Joshua Lederberg. "Machines Smarter Than Men? Interview with Dr. Norbert Wiener, Noted Scientist." *U.S. News and World Report*, (24 February 1964): 84-87.

"sparking, literate and provocative prose."[76] Wiener even crossed over to the new medium of television, appearing on CBS' "You and the World," to discuss cybernetics' cosmological significance with newsman George Crothers.[77] More than any single factor, Wiener's public profile accounted for the mass appeal of cybernetics as a stock of metaphors to describe the information machines Americans would encounter in the second half of the twentieth century.

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[76] Davis. "An Interview with Norbert Wiener."
[77] Wiener Papers, box 11, folder 170.

Chapter 2 – Information, feedback, and homeostasis

In summarizing the new science of cybernetics, we will need to review three topics that undergirded all of the discussions at the Macy Conferences. Of these phenomena—information, feedback, and homeostasis—none were first discovered by the early cyberneticists. But all three became unifying principles across the concerned fields, and were imbued with a new importance when scientists began to regard communication and control as similar in animal, human, and machine. While these phenomena could be measured and modeled—as cyberneticists did, often for the first time—they were all subject to a degree of epistemological uncertainty, the constraints of the human observer. And a new understanding of information, feedback, and homeostasis allowed for the building of complex, sophisticated machines, they also revealed how rudimentary was our knowledge of the functional aspect of biological and social systems.

The transactions of the sixth through tenth Macy Conferences, taking place between 1949 and 1953, are without doubt our richest source of information on this seminal period of dialogue in cybernetics. The field had a name; a feeling buzzed among the gatherees that the new science, so constructed, was not only vastly important, but also hugely useful in each of their own disciplines. Preserved by Margaret Mead, the transcripts capture the formation of a number of conceptual structures that would merge several fields under cybernetics' umbrella: information, feedback, and homeostasis. Organized after the landmark success of Wiener's *Cybernetics*, they also reveal a group of scientists beginning to reckon with the now apparent social relevance of an idea just out of its infancy.

The sixth conference opened with an address by Macy medical director Frank Fremont-Smith that laid out the overarching project of cybernetics. Fremont-Smith stressed "the need to break down walls between the disciplines and get interdisciplinary communication." He added, "This failure in communication between disciplines seems to be a major problem in every phase of science. Such communication is particularly difficult for the physical and biological sciences on one hand, and the psychological and social sciences on the other." Fremont-Smith's mission is best expressed in his declaration, "in the study of man we may find eventual unification of all the sciences."[78] Cybernetics was no longer a hypothesis; it represented a much more ambitious program. Fremont-Smith, who did not give a presentation of his own, nevertheless reiterated this ambition on several occasions; he saw connections between the abstracted flow of information among different material substrates to achieve a working system and the need for communication between scientific disciplines.

John Stroud of the U.S. Naval Electronics Laboratory had presented on the efficiency of human operators of complex machine guns, and, like Wiener, concluded that human brains functioned in the same manner as error-controlled servomechanisms. Stroud presented a theory of how this actually worked in the brain. When humans track targets, we do not see motion. Instead, just as in a servomechanism, we receive discrete data regarding the target's position, and hypothesize the likely motion of the target.[79] While the perception of motion appears to us in real-time, it is really a series of snapshots, or frames, giving us precise information (terms) about the relative position of

[78] *Cybernetics: Transactions of the Sixth Conference*. 9.
[79] *Cybernetics: Transactions of the Sixth Conference*. 32.

objects. Each term can theoretically be quantified as a "bit"; this new term, suggested by statistician John W. Tukey, stood for "binary digit."[80]

Certainly the electrical impulses, waves, and rhythms in the brain had analogical properties. But memory and the information itself were seen foremost as digital mechanisms. This distinction in the human apparatus was sufficiently sharp for von Neumann and Wiener to comfortably characterize the brain as an essentially digital processing machine, and the body as an analog effector and receptor.[81] As a conceptual model this distinction was exceedingly powerful. Foremost, it linked man's brain to the mechanisms in early computers in a clear, compelling analogy. Further, it reinscribed the old Cartesian mind/body duality in a radical new way—the mind, a pattern of digital possibilities, was now effectively freed from the "meat" of body. Finally, it achieved the complete erasure of embodiment as a determining factor in perception, awareness, personality, memory, learning, etc.

If the mind functionally operated on "information," the term needed a consistent mathematical formulation in order to be scientifically useful. This task fell to Macy visitor and Bell Labs communication engineer Claude E. Shannon. Coincident with the fifth conference, he published *The Mathematical Theory of Communication* in the *Bell System Technical Journal* (1948). Shannon deferentially credited Wiener with much of the groundwork necessary to establish information as a statistical construct. Wiener had,

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[80] *Cybernetics: Transactions of the Seventh Conference*. Heinz von Foerster, ed. New York: Josiah Macy, Jr. Foundation, 1950, 13. Here we encounter a distinction that the Macy group would make again and again: while the muscle and tissue of the human apparatus was quite obviously analogical in nature, the nervous system, like a computer, was primarily digital. Ralph W. Gerrard clarified the meaning of the terms, at Mead's request, at the seventh conference: "an analogical system is one in which one of two variables is continuous on the other, while in a digital system the variable is discontinuous and quantized." A waveform is a classically analog representation, while an abacus is the most frequently cited example of a digital calculating machine.

[81] *Cybernetics: Transactions of the Sixth Conference*. 89.

for example, showed that mode in which to best understand information was not classical mechanics, but thermodynamics. Information entropy, measured in probabilities, was for Wiener a calculation of the degree of uncertainty in a message. Shannon posited that the information content of a message was a function of its amount of, for want of a better word, surprise. A fair coin toss has information content of one bit; an unfair coin conveys less uncertainty about the toss' outcome, and therefore less information entropy.

In particular, Shannon admitted that his new theory of communication was "heavily indebted" to Wiener's previously classified wartime work for Vannevar Bush's National Defense Research Council on anti-aircraft gun systems.[82] Shannon however went several steps beyond Wiener's first explorations. His model accomplished two things: it quantified information as the logarithm (base two) of the number of available choices, and it divorced information from meaning for engineering applications. Shannon's mathematical formulation showed precisely how best to encode a message; telephone engineers interested in sending information across a noisy channel could tell the exact minimum amount of content necessary to transmit. As noise in the channel increased, Shannon's theory explained, increased redundancy was needed to ensure accurate transcription. Any message was composed of a set of possibilities. In an idealized case, if there were eight possibilities (seven degrees of freedom), the message contained three bits. In layman's terms, a minimum of three yes or no decisions (the first half of the first half of the first half of the set) could isolate the sender's intended

[82] Shannon, Claude E. and Warren Weaver. *The Mathematical Theory of Communication*. Urbana: University of Illinois Press, 1964, 3. Wiener's report, nicknamed the "yellow peril" because of the color of its cover and the difficulty of its mathematics, was circulated in 1942 and covered the smoothing of statistical time series by harmonic analysis. Wiener found that prediction of aircraft trajectories could be optimized by applying a noise filter to a series of stationary aleatory signals.

variable. To transmit a letter of the twenty-six letter English alphabet, five such binary digits are required.

In Shannon's formulation, for a number n of elements in a message set,

$$I = \log_2 n.$$

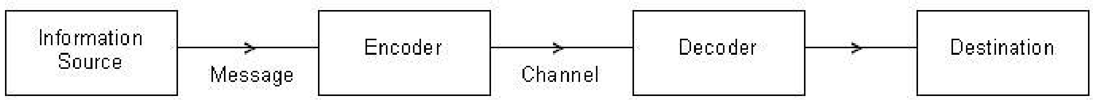
The base two is a matter of practical convenience, binary decisions being easiest to quantify. When the message elements were not equally likely, the amount of information becomes a summation of the probability function:

$$I = -\Sigma\, p(s_i)[\log_2 p(s_i)],$$

where $p(s_i)$ is the probability that the element s_i will be selected. These probabilities depend on the preceding choices. The amount of information received is therefore dependent on the statistical likelihood of any element of a message set being selected. The letter "x," for instance, conveys more information to an English speaker than does "e," because of the statistical redundancy of "e" in English. Shannon thus mathematized a philosophical problem identified by Wiener by turning the information content of a message into a sum of the probabilities of an individual unit's selection. Shannon's work provided a new toolkit to telephone engineers endeavoring to efficiently zip messages around the system. It also laid a basic mathematical foundation for cyberneticists to measure the information that traveled through computing machines as well as neural circuits and social groups.

At the same time, Shannon argued that the information content of the message must be divorced from its meaning since semantic connotations cannot necessarily change media along with the message when it is communicated. While the engineering aspects of the communication may not be irrelevant to the semantic aspects, the semantic aspects were seen as irrelevant to the engineering aspects.[83] Shannon's collaborator Warren Weaver explained, "The word information in communication theory relates not so much to what you *do* say, as to what you *could* say. That is, information is a measure of one's freedom of choice when one selects a message."[84]

At the seventh conference, Shannon appeared in person to elucidate his theory. His presentation reproduced a schematic from *The Mathematical Theory of Communication*, but, for simplicity's sake, excluded a noise source that had been situated at the center of the diagram.



Shannon described his schematic to the group:

> We can idealize a communication system, from our point of view, as a series of boxes, of which I want to talk mainly about the first two. The first box is the information source. It is the thing that produces the messages to be transmitted. For communication work we abstract all properties of the messages except the statistical properties which turn out to be very important. The communication engineer can visualize his job as the transmission of the particular messages chosen by the information source to be sent to the receiving point. What the message *means* is of no importance to him; the thing that does have importance is the set of statistics with which it was chosen, the probabilities of various messages. In general, we are usually interested in messages that consist of a set of discrete symbols or symbols that at least can be reduced to that form by suitable approximation.[85]

In a speech to the Institute of Radio Engineers, Wiener explained that a single unit of information, a message, is a choice between alternatives. "If I send a man a message by telegraph, it is worthless unless his opinion or actions, or something else about him could

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[83] Shannon, Claude E. and Warren Weaver. *The Mathematical Theory of Communication*. Urbana: University of Illinois Press, 1964, 8.
[84] Shannon & Weaver. *The Mathematical Theory of Communication*. 8-9.
[85] *Cybernetics: Transactions of the Seventh Conference*. 123.

have been different if he had received another message."[86] Bateson later put it more succinctly; information, he said, is "a difference that makes a difference."[87] Communication over wires and in biological systems each shared this property. Wiener further remarked, "The human nervous system transmits messages. The result is that any thoroughgoing theory of messages will inevitably throw a great deal of light on the nervous system of man and the lower animals." Besides helping telephone engineers measure the capacity of the wires and route signals accordingly, Shannon's conception of information became the *sine qua non* of cybernetic descriptions of causal circuits. Mechanical, biological, social, and ecological systems—the same signals flowed through all of these. Whether words or numbers, electrical or chemical impulses, systems' responses were governed by the transduction of sets of alternatives. Because Shannon identified information as only a choice between alternatives—irrespective of what those alternatives *were*—the Macy group could readily apply the concept across platforms.

There arose some difficulty in applying Shannon's model to real-world social situations. Verbal communication involves a great many psychological factors that make it complicated to determine what is signal and what is noise. There are, Shannon allowed, "ambiguities that come in at the psychological level. If a person receives something over a telephone, part of which is useful to him and part of which is not, and you want to call the useful part the signal, that is hardly a mathematical problem. It involves too many psychological elements."[88] For example, at the eighth conference, McCulloch wondered whether Shannon's theory could be used to explain the social

[86] "Cybernetics," a lecture to the Institute of Radio Engineers, New York, March 24, 1948. Wiener Papers box 28a, folder 576, 2.
[87] Bateson, Gregory. *Mind and Nature: A Necessary Unity*. New York: Bantam Books, 1979, 99.
[88] *Cybernetics: Transactions of the Seventh Conference*. 155.

psychologist Alex Bavelas' group-communication experiments. Bavelas' experiments required five people to pool information given to them on a slip of paper, without speaking, in order to solve a puzzle. Shannon replied that he did not see "too close a connection" between information as imagined in communication theory and in Bavelas' work on social psychology. Shannon insisted, "I don't see quite how you measure any of these things in terms of channel capacity, bits, and so on. I think you are in somewhat higher levels semantically than we who are dealing with straight communication problem."[89] Shannon recoiled from attempts by the likes of Bavelas and von Foerster to contaminate a mathematical measurement of degrees of organization by interjecting a level of semantic analysis. His calculations paved the road for a distinct "information science" in psychology, communications, and management, yet Shannon publicly repudiated what he called "the information bandwagon" as confused and sloppy pseudoscience.[90]

By keeping his construct of information mathematically "pure", Shannon meant to give it over almost exclusively to the domain of computer engineers, who could, on the basis of his earlier work, arrange electric circuits to store messages, instructions, and to replicate the formal statements of digital logic such as "and," "or," "nor," "nand," and "not." From the vantage point of communication engineers, "information" was a strictly technical term that expressed the amount of pattern in a message. The term was chosen carefully; it derived from the Latin root verb *informare*, meaning "to give form, or structure." Shannon would have greeted with distress the contemporary conflation

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[89] *Cybernetics: Transactions of the Eighth Conference*. Heinz von Foerster, ed. New York: Josiah Macy, Jr. Foundation, 1951, 22.
[90] Shannon, Claude E. "The Bandwagon", *IRE Transactions on Information Theory* 2 (March 1956), 3.

(paradoxically enabled by digital computers) of the term "information," meaning "knowledge" or "intelligence," with his purely formal mathematical construction.

If information is the fundamental generative element of the universe, it is unsurprising to see it accounted for in the laws of thermodynamics. That information was proportional to entropy was immediately apparent to Wiener and Shannon as they developed their theories of communication. After all, information depended on choices, and the freedom of choice. The process of selection serves to determine order from randomness. Wiener identified information with negative entropy, since "the natural tendency of a message, when subject to the various possible transformations which may be performed on it, is to lose order and not to gain it. Information is equivalent to order, and a message may be garbled, but never ungarbled."[91] In the introductory note to the transactions of the eighth conference, the editors aligned with Wiener in noting information's trend toward a more improbable state. Shannon and Weaver, to the contrary, held that as entropy or randomness increases, so too does the amount of information conveyed by a message. Whether information was the inverse of, or proportional to randomness was essentially an argument over terms. Was randomness thought of as disorder in the system or the level of surprise in the message? Shannon and Wiener agreed on the fundamental, thermodynamic nature of the new quantity. Regardless of the sign, the correspondence between entropy and information greatly expanded information's reach as an all-embracing model.

The transcripts' editors regarded circular causality as a concept closely allied to information theory. Everywhere in nature they saw the old pattern of cause and effect

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[91] Wiener, Norbert. "Thermodynamics of the Message," in Masani, Pesi, ed. *Norbert Wiener: Collected Works,* vol. 4. Cambridge, Mass.: M.I.T. Press, 1985, 206.

supplanted by bidimensional circularity. Applications ranged from Gibbsian physiochemical systems to steady states of human blood, and from social behavior to statistical biology and ecology. From circular causality it was a small cognitive leap to conceive the possibility of goal-seeking autonomous systems.[92] Shannon had demonstrated an application of communication theory by creating a maze-solving machine that learned through trial and error—glibly dubbed an "electronic rat." Mead, von Foerster, and Teuber pronounced, "the fascination of watching Shannon's innocent rat negotiate its maze does not derive from any obvious similarity between the machine and a real rat; they are, in fact, rather dissimilar. The mechanism, however, is strikingly similar to the *notions* held by certain learning theorists about rats and about organisms in general."[93] Certainly, the power of the analogy was limited: "we all know that we ought to study the organism, and not the computers, if we wish to understand the organism. Differences in levels of organization may be more than quantitative." Yet, self-organization and circularity could not be ignored as properties of machines and biological organisms alike. "[T]he computing robot provides us with analogues that are helpful as far as they seem to hold, and no less helpful whenever they break down."[94]

All of these ideas coalesced in a redefining of the biological property of homeostasis, articulated most prominently at the Macy conferences by the British psychiatrist W. Ross Ashby, a guest at the ninth conference. Homeostasis is, simply stated, the tendency in organisms and cells to regulate their physiological processes to achieve internal equilibrium. Environmental changes must incite changes within the

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[92] *Cybernetics: Transactions of the Eighth Conference*. xiv.
[93] *Cybernetics: Transactions of the Eighth Conference*. xvii.
[94] *Cybernetics: Transactions of the Eighth Conference*. xviii.

organism, or it will die. As an analogue for self-governing machinery, homeostasis was highly apposite.

Ashby stated the problem of maintaining a biological steady state as follows:

> I shall consider the organism, then, as a mechanism which faces a hostile and difficult world and has as its fundamental task keeping itself alive. I ask, what sort of mechanism can it be that can do this in an almost limitless variety of environments…I assume that if the organism is to stay alive, a comparatively small number of essential variables must be kept within physiologic limits. Each of these variables can be represented by a pointer on a dial. They include such things as the animal's temperature, the amount of sugar in its blood, the amount of water in its tissues, and say, the pressure on its nose, for an animal that runs fast must try to run in such a way as not to get intense pressures suddenly on its nose.[95]

Of course, these problems were in no way peculiar to living organisms: "An engineer, sitting at the control panel in a ship, has exactly the same task to do. He has a row of dials, some of which represent essential variables in the ship, and it is his business to run things so that the needles always stay within their proper limits. The problem, then, is uniform between the inanimate and the animate."[96]

Ashby thus defines a system of feedback including both the organism, with its effectors and receptors, and the environment.[97] The important aspect of the feedback loop, for Ashby, was that it was informationally closed.[98] The system was isolated so that the causal cycle would remain uncontaminated by outside influence; it could go round and round forever. Inspired by Shannon's "rat," Ashby constructed an organism, the "homeostat," which maintained its internal state through corrective feedback. The

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[95] *Cybernetics: Transactions of the Ninth Conference*. Heinz von Foerster, ed. New York: Josiah Macy, Jr. Foundation, 1953, 73.
[96] Ibid.
[97] This systemic view of ecology became very important in the later work of the anthropologist and naturalist Gregory Bateson who seized on the theory in biology of a coevolutionary ecosystem. Homeostasis was a recurring theme in Bateson's writings. Later interpreters, like Paul Ehrlich and Stewart Brand, were influenced by Bateson in seeing feedback as an organizational property of all nature. Their philosophies, though liberally applying concepts developed early in cybernetics' life-cycle, departed from the strictly mechanistic input-output model proposed by Ashby. Bateson stressed the great variety of input variables, of which the observer was inevitably one.
[98] *Cybernetics: Transactions of the Ninth Conference*. 81.

mechanism was fed "random" variables from a table simulating the environment; when these went outside its normal limits, it switched its polarity to restore its optimal position.[99]

Ashby's feedback system prompted objections from Julian Bigelow. Bigelow contested that the "randomness" of the feedback loop was not truly random, but in fact was tightly controlled within set parameters. Thus it was an imperfect representation of the environment. Bigelow jeered, "it may be a beautiful replica of something, but heaven knows what."[100] Bigelow complained too that Ashby's attribution of "learning" to his device was unjustified. Unlike Shannon's "rat," the homeostat might make the same mistake again and again. Bigelow likened its problem-solving apparatus to shaking a box with a ball inside and a hole at the bottom: sooner or later the ball will fall through.[101] Despite Bigelow's protests, the Macy conferees generally accepted the homeostat as a fairly accurate mockup of a larger phenomenon. Indeed, as Katharine Hayles observes, one of the chief attractions of cybernetics to the scientific and lay public alike was that it produced *things*, models that actually worked.[102] Wiener, Rosenblueth, and Bigelow had predicted that as our models become more sophisticated, the map would gradually come to rival the territory. At its infinite limit, a computer *was* a brain, just as a cat was a perfect model of a cat. Despite some objections, Shannon and Ashby's tangible creations were seen as endorsements of this principle.[103]

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[99] *Cybernetics: Transactions of the Ninth Conference*. 95-98.
[100] *Cybernetics: Transactions of the Ninth Conference*. 95.
[101] *Cybernetics: Transactions of the Ninth Conference*. 104-5.
[102] *Cybernetics: Transactions of the Ninth Conference*. 63.
[103] Another famous autonomous electric robot was the British psychologist W. Grey Walter's "turtle." Using only a small number of circuits, a number of turtles built between 1948 and 1949 exhibited complex behaviors such as avoiding obstacles and navigating itself to a recharging station.

Mead, von Foerster, and Teuber also pointed out that circular causality has paid dividends in the world of neurology. "Perceptual constancies," required for motor operation and basic sanity, were ascribed to circular, sustained activity in neural circuits. The nervous system, as Lorente de Nó had proven, was not "a mere reflex-organ"; rather it was capable of self-sustained processes.[104] These reverberating neural nets could be the neurological basis for hallucinatory flashbacks, or for the perceived sustained feeling in the lost organs of amputees.

This systemic paradigm as articulated by Ashby and others presumed that systems, as objects of consideration, were independent and objectively observable—that is, they went about their functions in much the same way whether they were regarded by an observer or not. While inherently recursive, homeostasis was an idea with roots in the linear tradition of Enlightenment rationality. Several Macy participants, notably Mead, Fremont-Smith and von Foerster, raised the subversive possibility that this observer always and inherently affects the system he or she considers.[105] In effect, he or she would inevitably become part of the system of feedback itself. Though it was played down at the Beekman hotel, the idea of the "observer effect" would have a long life subsequent to the Macy Conferences, and became a major epistemological snare in the fields of biology, ecology, sociology, and cultural anthropology.[106]

[104] *Cybernetics: Transactions of the Ninth Conference*. xv.
[105] Von Foerster's 1981 compendium, *Observing Systems* demonstrates the reflexive epistemology that he would more fully embrace after the conclusion of the Macy conferences.
[106] The inclusion of the observer in the observed system formed the basis for so-called "second-order cybernetics". A philosophical outline of the problem was defined by von Foerster in:
von Foester, Heinz. *Cybernetics of Cybernetics*, Urbana: University of Illinois, 1974. Likewise, observer feedback was introduced to the biological sciences by Humberto Maturana and Francisco Varela in *The Tree of Knowledge* (1988), and by Bateson in *Steps to an Ecology of Mind* (1972). Observer effects have been also documented in a number of human sciences; a small sample would include the Hawthorne effect in business management, the placebo and nocebo effects in pharmacology, and Pygmalian effect in education.

As early as 1936, Norbert Wiener had remarked the potential significance of indeterminacy, an idea borrowed from quantum mechanics, for the whole of human knowledge:

> The indeterminacy of the world is genuine and fundamental. There are no clean-cut laws of motion which enable us to predict the momentum and position of the world at future times in any precise way in terms of any observable data whatever at the present time. In other words, our observations which themselves disturb our world, this account has only statistical validity, and cannot be brought closer to precision by any chain of observations.[107]

Physics, Wiener believed, was in need of a "thorough logical housecleaning." The laws of physics were only a convenient language that held together observations and the readings of physical instruments. There was no "mystical world of reality" to which they apply: "Whatever view we have of the 'realities' underlying our introspections and experiments and mathematical truths is quite secondary: any proposition which cannot be translated into a statement concerning the observable is nugatory."[108] Wiener was no hyper-rational science chauvinist, dissecting an objective world with a razor of logic. He was at heart a humanist, one who had studied classics and Eastern philosophy with equal diligence. If calculating machines purporting to render the world finite and comprehensible bore his imprint, he was chagrined. Likewise, if Einstein and Bohr struggled to reconcile quantum indeterminacy with the nineteenth-century reductionist, determinist epistemology in which they were educated, Wiener relished its overthrow. He was at home in the fuzzy world of feedback loops and complex biological systems; he embraced cybernetics' incompatibility with classical physics. The new field looked somewhat different.

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[107] Wiener, Norbert. "The Rôle of the Observer," in Masani, Pesi, ed. *Norbert Wiener: Collected Works,* vol. 4. Cambridge, Mass.: M.I.T. Press, 1985, 888.
[108] Wiener. "The Rôle of the Observer." 889.

Wiener realized that indeterminacy was a problem at the core of mathematics as well. In 1931, Kurt Gödel demonstrated that in any formal system such as mathematics it was possible to introduce statements that were both true and unprovable.[109] Gödel's discovery showed that no formal language could be both consistent and complete, answering negatively a challenge posed by the German mathematician David Hilbert. It has often been assumed that Gödel's incompleteness theorem limits the possible scope of machine logic; a mind may know that a formula is true, but no formal system will be able to generate a proof that it is so.[110] In other words, men will always know things that machines cannot prove. Wiener likely would have agreed; though he was quite taken with the power of logical machines like those von Neumann was developing, he recognized this boundary of formal logic. He expressed his relativistic view in a newspaper editorial, titled "We Can't Attain Truth Without Risk of Error." Gödel's discovery, Wiener wrote, "could have been anticipated by those who realize that logic is essentially an account of a process which goes beyond its formal rules, but this rather intuitive anticipation does not have one-tenth the force of Gödel's demonstration that this incompleteness belongs to the nature of logic itself."[111] Circularity and feedback were inherent in all logic; cybernetics would be the first universal science to apply these ideas across a range of problems. Further, the reflexive dynamic Wiener and his colleagues

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[109] A similar challenge was posed by Hilbert in 1928, asking whether an algorithm (a clearly delineated finite process) could determine any formal statement within the axiom system to be true or false. The answer was provided in 1936-1937 by Alonzo Church and Alan Turing, with great implications for theoretical computer science: no. In his unorthodox approach, Turing suggested that while "universal machines," capable of doing the logical work of any other machine could be constructed, there existed problems which could not, a priori, be determined computable.

[110] Thus Gödel's theory has been seen to erect a boundary to the mindlike-ness of artificially intelligent systems.

Lucas, J.R. "Minds, Machines and Gödel," in Anderson, Alan R., ed. *Minds and Machines*. Englewood Cliffs, NJ: Prentice Hall, 1964, 12-14.

[111] Wiener, Norbert. "We Can't Attain Truth Without Risk of Error," November 28, 1953. Wiener Papers, box 29c, folder 744.

observed militated against unqualified certainty in social matters. “This enhanced role of the observer in modern logic may be extended to a study of the observer in all normative sciences, and this leads to some very timely remarks concerning ethics, law, and politics in the modern world,” he noted.[112] When Wiener presented cybernetics to the public, he dressed it not in normative language, but in a rather more subjective guise that belied its claims to universal relevance.

[112] Outline for “A Treatise on Cybernetics,” 1952, Wiener Papers, box 29c, folder 683.

Chapter 3 – Cybernetics' public reception

If the early development of cybernetics was a collaborative process, the popularization of its findings fell uniquely to Norbert Wiener. In two landmark books—*Cybernetics* (1949), and *The Human Use of Human Beings* (1953)—Wiener reached out to a mass audience and found it, surprisingly, welcoming. Cybernetics was about more than feedback control, the formalization of information transfer, and demonstration models. As Wiener explained, it heralded a new social revolution, symbolized best by the development of automatic, electronic logic machines known as digital computers. It meant that machines could be designed to perform erstwhile human activities, including thinking. It meant too that humans and machines might become incorporated in complex systems of informational feedback. And, most importantly, it meant the destructive forces in society, whether the government war machine or corporate capitalism, would be amplified by the greater power of the electronic computer. A new watchfulness, predicated on mass education, was in order. Wiener's two books and his many interviews to the eager press waged a constant battle for interpretive clarity, and against fear and confusion. In this chapter we will see how a vigorous public response elevated Wiener's ideas to a new celebrity, but in so doing, sometimes erased their subtlety.

When *Cybernetics* hit bookstores, it generated a great deal of excitement among both scientific and lay audiences. Scientists saw it as providing a useful new template for understanding phenomena in their own disciplines, while general interest reviewers focused on the analogies between biological and artificial systems. Wiener's volume, notwithstanding its heavy mathematical content, was the first lucid explanation of the workings and the significance of new the computing machines that were making headlines across the country. The publisher John Wiley & Sons promoted it heavily as "stimulating," and "easy reading," like no other book of speculative science. Though it included chapters of equations and graduate-level math, describing such difficult phenomena as information transfer, homeostasis, and purposive systems, Wiener's writing seemed to offer something of value to everyone. After *Cybernetics*' thrust him into public consciousness, Wiener received letters of acclaim from all quarters. Economists, architects, librarians and biologists all wrote Wiener to thank him for his pioneering insights into their own fields. Many felt that cybernetics had turned the leaf of research practice and would come to define scientific culture for generations. The linguists Alfred Korzybski and Roman Jakobson, for example, heralded the importance of feedback and information in their studies, each independently describing Wiener's book as "epoch-making" in personal letters.[113]

Cybernetics was, first and foremost, a work of eclectic philosophy. Though it served as a primer on many of the discoveries of his Macy associates—McCulloch and Pitts' neural models, Ashby's automata, Shannon's theory of communication—above all, Wiener took pains to reinforce the idea that a new intellectual orientation was in the first stages of flower. Feedback, homeostasis, and information circuits were hallmarks of an original statistical science. Leibniz viewed living organisms in the frame of clockwork technology; his monads were perfect automata, wound up by their creator. In the nineteenth century the study of the organism took on a different, contemporary gloss – that of the heat engine burning glucose and expelling carbon dioxide and urea. *Cybernetics* set another path forward. "The new study of automata," Wiener wrote,

[113] Letter from Korzybski, January 19 1949. Wiener Papers, box 6, folder 88; Letter from Jakobson, February 24, 1949. Wiener Papers box 6, folder 92.

"whether in the metal or in the flesh, is a branch of communication engineering, and its cardinal notions are those of the message…quantity of information, coding technique, and so on."[114] Now sensory input, patterns of intention, complex interactions with the environment would become indispensible to biophysics (and by extension, the emerging field of molecular genetics) equally as to the behavioral sciences. Information linked all these diverse areas together.

But Wiener did more than author a conceptual primer on the bold paradigm of the Macy meetings. He introduced the reader to real-world examples of positive and negative feedback in every kind of system: the neuromuscular reflexes of a cat's leg, the temperature-regulating mechanisms of a steel furnace, the duck hunter and his rifle, the interactions of a pilot and antiaircraft gun operator and their machines. Nearly every system in the mechanical and biological spheres was thus controlled by feedback circuits.[115] Human brains, Wiener further argued, were working physical models of such a control system, just as were the primitive logical calculators von Neumann had helped create in the years just after the war. "The logic of the machine resembles human logic," Wiener stated flatly, "and following Turing, we may employ it to throw light on human logic."[116] Neurons, with their on/off character, were "ideally suited to act as relays."[117] Machines built out of relays or vacuum tubes likewise, possessed a capacity for increased sophistication and self-reflection: "There is nothing in the nature of the computing machine which forbids it to show conditioned reflexes."

[114] Wiener, *Cybernetics*, 54.
[115] Wiener, *Cybernetics*, 132-135.
[116] Wiener, *Cybernetics*, 153.
[117] Wiener, *Cybernetics*, 145.

Analogies between nervous systems and digital computers occupied the greater part of Wiener's attention throughout *Cybernetics*, even as he moved in and out of mathematical abstraction. Autobiographically, he related how, when Walter Pitts joined him at M.I.T. in 1943, the studies of the Boolean logic of telephone relays (developed by Shannon in Cambridge a short time earlier) and of neural circuits became conjoined. "It became clear to us that the ultra-rapid computing machine, depending as it does on consecutive switching devices, must represent almost an ideal model of the problems arising in nervous systems," Wiener recollected.[118] Memory in the animal and artificial memories in the machine must also have been stored in structurally parallel ways.

In September 1940, Wiener had had the opportunity to see one of these digital devices in action. At a meeting of the American Mathematical Society at Dartmouth College, Wiener, along with the later ENIAC's co-creator John Mauchly, stopped to watch a demonstration by Bell Labs' George Stibitz of a relay-based complex number calculator. The machine was located in Murray Hill, New Jersey, but Stibitz communicated with it remotely via teletype and a long-distance phone line.[119] It was a Damascene moment for the founder of cybernetics; he had theorized the possibility of powerful mathematical logic carried out by networked relay switches, but had never witnessed in person such a purpose-built example. Stibitz' calculator, too rudimentary to perform most of the logical operations of a general purpose computer, convinced Wiener not just of these machines' feasibility, but of their inevitability. If the Macy Conferences gave the builders of logical apparatus a fruitful philosophical establishment for

[118] Wiener, *Cybernetics*, 23.
[119] Conway & Siegelman, *Dark Hero of the Information Age*, 105.

information processing in animal and machine, they in turn inspired much of the theory by showing how such kit could be practically engineered.

Very soon, these machines were being constructed for the war effort. Wiener's wide circle also took him to the laboratories of Howard Aiken (the engineer behind the electro-mechanical Harvard Mark IV), and Herman Goldstine (a colleague of von Neumann on the ENIAC project) who were each sympathetic: "The vocabulary of the engineers soon became contaminated with the terms of the neurophysiologist and psychologist."[120] On a visit to Haldane in Great Britain in 1947, Wiener had occasion to speak with Turing at the National Physical Laboratories in Teddington and the team behind the Manchester computer, a close cousin to the ENIAC.[121] Wiener conceived of the digital computer as a system approaching full automation. Writing to Vannevar Bush during the war, he stressed that "The entire sequence of operations [should] be laid out on the machine itself so there should be no human intervention from the time the data were entered until the final results should be taken off, and that all logical decisions necessary for this should be built into the machine itself."[122] Thus the computer ought to function in their own limited arena as a self-sufficient organism, liberating its operators from the slow tedium of constant input, output, and error-checking. Wiener's exhortation anticipated the principle, later formalized by von Neumann, of a machine storing its own program. Stored-program architecture allowed a computer to perform a function, in the form of what would later become known as "software" without rewiring or reconfiguration. General purpose computers in the Wiener/von Neumann mode, unlike

[120] Ibid.
[121] Conway & Siegelman. *Dark Hero of the Information Age*, 32.
[122] Wiener, letter to Vannevar Bush, in Masani, Pesi, ed. *Norbert Wiener: Collected Works,* vol. 4. Cambridge, Mass.: M.I.T. Press, 1985, 174.

the digital calculators Stibitz and his Bell Labs colleagues constructed, or the analog differential analyzers favored by Vannevar Bush decades before, could be imbued with a sort of decision-making autonomy—the ability to evaluate and respond to their own feedback characteristic of biology.[123] As much as biological language infected the engineering of computing machines, Wiener's entire narrative of cybernetics' history made inescapable reference to computers. To read *Cybernetics* for the first time was not only to be introduced to a new science; it was to be invited to see the computational side of everything.

Notwithstanding its resolute confidence in the progress of free scientific inquiry, *Cybernetics* came with dire social warnings. Full factory automation, Wiener posited, was no more than one or two decades away and posed all the potentialities for destructiveness of the atom bomb.[124] Technical applications of cybernetics bent very definitely in the direction of automatic machinery—machinery that, by design, performed simple and repetitive tasks better than human beings. In an economy where this man-machine equivalence extended from the assembly line to the back office, "the average human being…has nothing to sell that is worth anyone's money to buy."[125] Wiener's engagement with social problems was no meager dalliance; he thought very deeply and seriously about economics and sociology. His experience with Mead and Bateson, and to a lesser extent with fellow Macy conferee Paul Lazarsfeld, the sociologist behind Columbia University's Radio Project, and his colleagues Robert Merton and Talcott

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[123] Bush's Differential Analyzer (constructed between 1928 and 1931) was an analog computer capable of integrating differential equations by use of wheels and disks on a graph. See: Hartree, D.R. "The Bush Differential Analyser and its Implications." *Nature* 146 (September 1940), 319.
[124] Wiener, *Cybernetics*, 36-37.
[125] Wiener, *Cybernetics*, 38.

Parsons, convinced Wiener that cybernetics had profound, if problematic, connotations for the social sciences.[126]

Wiener's alarmism was somewhat muted by the belief that, although the cat was already out of the bag, a well-informed society could yet step back from the precipice of self-obsolescence. Still, the United States, of which Wiener was always lovingly critical, would have to reorient its supreme principle away from maximum economic efficiency. He worried that prevailing opinion, smitten with the chauvinism of the "Fifth Freedom" articulated by the National Association of Manufacturers and the *Saturday Evening Post*, might assess the possibilities of cybernetic technology purely in the terms of the open market, of cost savings.[127] Wiener, affecting Einstein's cautionary stance on nuclear technology, considered this a disastrous approach. Free competition was not, as some believed, a homeostatic process; rather modern civilization was in the grip of some very adverse cycles of feedback error, like the uncontrollable oscillations of Rosenblueth's purpose tremor patients. World Wars, booms and busts, political revolutions—market logic, taken almost as an article of faith by the body politic, would lead only to the exploitation and misuse of computing machines.[128] *Cybernetics* thus declared (in rather humanistic tones) that "The answer, of course, is to have a society based on human values other than buying or selling. To arrive at this society we need a good deal of planning and a good deal of struggle."[129] Wiener assumed this responsibility personally. He and his co-conspirators stood in a "not very comfortable" moral position, he confessed.[130]

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[126] Conway & Siegelman write that Lazarsfeld was so convinced of the value of circular feedback in sociological research that he organized his own conference at Columbia in 1945, inspiring both Merton and Parsons to begin work in this area. Conway & Siegelman, *Dark Hero of the Information Age*, 161.
[127] Wiener, *Cybernetics*, 37.
[128] Wiener, *Cybernetics*, 186.
[129] Wiener, *Cybernetics*, 38.
[130] Wiener, *Cybernetics*, 38-39.

Cybernetics was thus an attempt at outreach and enlightenment; a public informed of the spectacular dangers of automatic machinery could see to its more salutary development.

Cybernetics was, to everybody's surprise, a smash hit. Neither Wiener nor his original publisher conceived that a technical book, one-third full of equations, could reach such a broad audience: "When it became a scientific best-seller we were all astonished, not least myself."[131] But these same pronouncements of novelty and danger spoke instantly to those who had witnessed the creep of feedback control machinery in the factory or the office, had read speculative robot science fiction, had purchased a car with an automatic transmission, or had heard of the amazing new "electronic brains" cooked up in the science labs of M.I.T. and Harvard. In a moment when science and technology seemed to be accelerating beyond everyday comprehension, there was a great public appetite for expository works such as *Cybernetics*.

An editor from the *Sunday New York Times* wrote Wiener to request a piece on cybernetics that would state "what machines can do and cannot do and whether there is any possibility of their taking the place of the human mind, such as it is?"[132] The "thinking machine" and its threat to man's place in the universe was consistently the frame of reference through which journalists insisted on regarding cybernetics. Wiener was deemed the authority in these matters. He became, de facto, America's information science laureate. He replied to the *Times*: "Machines can do anything of which the pattern can be clearly and unambiguously laid out in words or mathematical formulas. They can run assembly lines, play games of intellect up to a certain indefinable level, regulate chemical plants and the like. They can even be so made as to learn." What they

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[131] Conway & Siegelman. *Dark Hero of the Information Age*, 182.
[132] Letter from *The New York Times*, June 3, 1949. Wiener Papers, box 6, folder 99.

could not do was to ask themselves the proper question, or clarify the object in their user's minds. Wiener judiciously compared electronic computers to W.W. Jacobs' fable of "The Monkey's Paw"; they return exactly what is requested of them. Therein lay their social danger: "If what we ask for is not what we really wish, Heaven help us… The golem may not be hostile to man, but it is certainly formidable, if only because of its indifference to the human race."[133]

In a profile that ran a few months earlier, the *Times* had reported that since "*Cybernetics* itself has attracted many lay readers," Wiley had commissioned four more books.[134] The first of these would be 1950's *The Human Use of Human Beings*, the first book directly applying cybernetic insights to the organization of society. The topic was the subject of mass speculation amid the hubbub over electronic computers' increasing consequence to business and government. Though Wiener entered the fray at first reluctantly, it was becoming apparent that he was in the midst of a career-shift: from a mathematician moonlighting in the public eye, to a full-time evangelist of technological sobriety. An advertisement in the *New York Times Book Review* announced that *The Human Use of Human Beings* would reveal "the shape of very strange things to come in the age of the thinking machines."[135] Wiener's book demonstrated "that to human beings, human things are all-important, and that the role of machines must be recognized as that of replacement of human labor only when that labor does not make worthy use of human capacities." Wiley assured that "this is emphatically a book for the layman, direct and challenging and wise."

[133] Letter to *The New York Times*, June 9, 1949. Wiener Papers, box 6, folder 99.
[134] Davis. "An Interview with Norbert Wiener."
[135] *The New York Times Book Review*, 1953 clipping, Wiener Papers, box 29b, folder 653.

Where *Cybernetics* had applied a probabilistic worldview to the sciences of communication, *The Human Use of Human Beings* went a step beyond, attempting a thorough review of social modes of communication via the same indeterminate lens. In the early pages, Wiener insisted that the essential concept in a broad meta-study of the organization of life must be Gibbsian thermodynamics. "The functional part of physics," he attested "…cannot escape considering uncertainty and the contingency of events."[136] *The Human Use of Human Beings* was as a continuation of the statistical mechanics worldview into modern life – the consideration not of one, linear world, but of many possible worlds. Statistical thermodynamics, in one sense, is concerned with order and chaos, the more probable and the less probable. The natural state of the universe, as the Second Law tells us, is to degrade the organized and to destroy meaning—the tendency, in Gibbs' mechanics, for entropy to increase. Wiener and Shannon had previously equated the information content of a message to its degree of pattern and organization. Now Wiener declared that the amount of information in a statement was "essentially the negative of its entropy."[137]

At the informational level (cybernetics' domain), life was all about order. Both animals and machines possessed the ability to make decisions that create local zones of order.[138] Without resort to ambiguous terms like "soul" or "vitalism," it was now

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[136] Wiener. *The Human Use of Human Beings*, 15.
[137] Wiener. *The Human Use of Human Beings*, 31.
[138] To demonstrate the negative correlation between information and entropy, Wiener employed the example of Maxwell's hypothetical demon. James Clark Maxwell had imagined a fluid system, in which some atoms were excited and others not. He theorized that if a purposeful agent (a "demon") inhabited such a system, it could allow only the excited atoms to leave through a tiny gate, and thus create two boxes—one with maximal entropy, the victim of heat death, and a new one with far less. The deliberate separation of two sub-systems would have increased the total order of the larger system, in violation of the Second Law of thermodynamics. For nearly a century, Maxwell's thought experiment resisted any conclusive rebuttal and remained a curious puzzle in physics. Wiener, however, pointed out that what the demon was really doing was extracting *information* about which atoms were excited and operating on the

possible to describe how organisms behave, for a time, anti-entropically.[139] Their lever in this process was information. Complex organisms achieved the same effect through higher order processes. Language, an order of abstraction beyond Shannon's "information", is a system of codes for embedding communication with meaning—whether phonetic, semantic, or behavioral. Dogs wag their tails, humans speak words, and computers output ones and zeros. If scientists were to fully grasp the transcription and transmission mechanisms, all such language would be acquiescent to statistical analysis. There was some promise, then, in extending cybernetics to the grander and more subtle arenas of human communication. "Speech," Wiener concluded, "is a joint game by the talker and the listener against the forces of confusion."[140]

Through feedback, a control program could produce "a temporary and local reversal of the normal direction of entropy," just like a living being.[141] It could also learn. If the reintroduction of the results of past performance merely regulate the behavior of the system, as in a thermostat, then the larger system was informationally closed. If, however, the information proceeding backward from performance could alter the method of performance itself, a process resembling learning would begin to take shape.[142] Ashby, in his powerful essay, *Design for a Brain*, suggested that the process need not even be deliberate. In biological evolution, a stochastic dynamic results in any number of accidents that collectively achieve an equilibrium state. Though lacking in

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basis of that information. Since it is not possible to reduce entropy locally without deriving knowledge (information) about the system, the overall systemic level of entropy must be conserved. In the view of cybernetics, information-processing organisms functioned exactly like Maxwell's demons, reducing, for a while, the entropy of the of their local environment through the informatic mechanism of biology. Of course, they too are subject to death and decay, so in the long run, the Second Law would win out.

[139] Wiener. *The Human Use of Human Beings*, 46.
[140] Wiener. *The Human Use of Human Beings*, 125.
[141] Wiener. *The Human Use of Human Beings*, 35-36.
[142] Wiener. *The Human Use of Human Beings*, 84.

any grand design, this sort of homeostasis was also anti-entropic. “Not only can we build purpose into machines,” Wiener explained, “but in an overwhelming majority of cases a machine designed [only] to avoid certain pitfalls of breakdown *will look for purposes it can fulfill*.” [emphasis mine][143] Wiener drew fundamental, quasi-spiritual lessons from this fact. The kind of agency he implied was manifestly not the writing of humanity into machines. It was the description of a natural, statistical phenomenon that happened to resemble purpose. Even though life itself may be a happy accident, doomed by raw chance to a disastrous end, Wiener argued that enlightened humans ought to frame sets of values so that this accident, notwithstanding its “fugitive character,” might inspire us with the virtuous balance of homeostasis.[144] In the end, *The Human Use of Human Beings* participated in an ages-old agonistic ethics, albeit from the somewhat dry perspective of scientific neutrality. This reconciliation between randomness and morality encapsulated much of Wiener’s own metaphysical outlook—strongly principled, at times fatalistic, but mostly hopeful.

The Human Use of Human Beings was just as warmly received as its predecessor. Critics were drawn to its prescriptive tones and its underlying moralism. The *Times* review proclaimed it a work of paramount social significance, and featured a large picture of the ENIAC. “Dr. Wiener shows that the brain itself may be regarded as a calculating machine with circuits far more complex than any yet designed in the laboratory,” the *Book Review* wrote. The analogy had implications for how we govern our affairs as a society: “Since computing machines require free access to complete information or coded instructions to operate efficiently, Dr. Wiener holds that society itself will be improved to

[143] Wiener. *The Human Use of Human Beings*, 55.
[144] Ibid.

the extent that the principle of complete information is applied to human beings. Or, as he puts it: 'To live effectively is to live with information.'"[145] *The New York Herald Tribune* saw Wiener's new book in the same lens. In *Cybernetics*, the critic Stuart Chase wrote, Wiener had "described the vast new computing machines which have memory and can think, provided a man 'tapes' them so they have something to think about. These monsters worry Mr. Wiener too, and the present book revolves around their probable impact upon human society and culture, and the incidental light they throw on the processes of human thought."[146] Wiener emphasized that hierarchies, bureaucracies, and entrenched military power more often than not impeded the free flow of information, and were thus cybernetically inefficient, unnatural, and inhuman.

Though its purview was drawn wider, a good portion of the book discussed what Wiener called the "second industrial revolution," a revolution in information processing as the first was in physical force. Where the eighteenth and nineteenth-century variety transformed navigation, transportation, and textile production, the contemporary revolution was transforming the collection and use of data. He likened the electric motor to the vacuum tube, a singular tool, relatively unheralded upon its arrival, that unlocked a universe of potential. The great Victorian inventor Charles Babbage, Wiener recalled, had foreseen the great utility of digital computing machines, but, lacking vacuum tubes, was unable to built them economically.

Automation had its roots in the problems Babbage encountered, yet only recently had made its presence felt on the industrial stage. "The notion of programming in the

[145] Pfeiffer, John. *New York Times Book Review*, "A Machine-Eye View of Why We Behave like Human Beings," August 20, 1950, 171.
[146] Review of *The Human Use of Human Beings*, in *The New York Herald Tribune*, August 20, 1950 clipping. Wiener Papers box 28c, folder 597.

factory had already become familiar through the work of Taylor and the Gilbreths on time study," Wiener wrote, but now could be readily "transferred to the machine."[147] Suddenly aware of the capabilities of automatic machinery, Wiener wrote to Vannevar Bush in 1940 that the fully automatic factory was firmly "on the horizon." Controlled not by devices for rapid calculation, but engines of logic and refined communication (sampling processes, sequential analysis, linear regression), these factories would surpass those animated only by physical labor in their productivity, efficiency, and quality. The prospect, for Wiener as for his reading public, was exciting and scary:

> In the first place, we can expect an abrupt and final cessation of the demand for the type of factory labor performing purely repetitive tasks. In the long run, the deadly uninteresting nature of the repetitive task may make this a good thing and the source of leisure necessary for a man's full cultural development…. Be that as it may, the intermediate period of the introduction of the new means…will lead to an immediate period of disastrous confusion.[148]

It was the responsibility of managers and public officials to guide this transition with the human foresight and sensitivity of which the new machines were still deficient. Shortsighted executives who destroyed their own base of demand in a quest for short-term profits were unwitting villains. In the same manner, scientists who built terrible new machines of war in the hope that they would be dismantled when peace was assured certainly played the role of modern Frankensteins. "Let these wise men who have summoned a demoniac sanction for their own private purposes remember that in the natural course of events, a conscience which has been bought once will be bought twice," Wiener declared ominously.[149] Here Wiener might have provided as fitting an epigraph as any for his own biography. An irony that had begun to dawn on him was that his own conscience had once been purchased, in the service of surface-to-air warfare, and indeed

[147] Wiener. *The Human Use of Human Beings*, 204.
[148] Wiener. *The Human Use of Human Beings*, 218-219.
[149] Wiener. *The Human Use of Human Beings*, 177.

in the service of automation. *The Human Use of Human Beings* would, as we will see, mark the beginning of a conscious evolution in his public persona, from a great man of science, a rival of Einstein, to a moral watchdog for society at large.

Though cybernetics might pose incomparable dangers to the laborer, Wiener's book avowed its lessons for a better alignment of science and society. Law, for instance, could be understood as a series of coded cybernetic messages that formed the basis of civilization. Since communication was the ultimate form of order, it followed that openness and transparency could only augur a greater degree of life-supporting homeostasis. There were implications for patents and copyrights; new techniques of information transfer now penetrated the walls of firms and the frontiers of nations. At the same time as telephones and telegraphs facilitated sharing, they created new private incentives to secrecy. In a stroke of predictive inspiration, foreshadowing the libertarian yearnings of Internet users four decades hence, Wiener suggested that information by its nature wants to be free.[150] Ideas cannot be stored away from the decaying effects of entropy, but sharing them could provoke new, more sophisticated communication across the whole system of society. Wiener wrote that it was impossible to keep a secret, even a military secret, forever.[151]

Sadly, *The Human Use of Human Beings* was penned under just this Cold War climate of secrecy. Wiener lamented the influence of "Senator McCarthy and his imitators," and worried about the health of scientific discourse. If cutting-edge research was to be increasingly subsumed under the watchful direction of the Cold War state, or into the top-secret laboratories of the largest corporations, Wiener had little hope of man's

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[150] See Barlow, John Perry. "A Declaration of the Independence of Cyberspace." 1996. Accessed 31 Aug. 2010. <https://projects.eff.org/~barlow/Declaration-Final.html>
[151] Wiener. *The Human Use of Human Beings*, 155-161.

ability to solve the problems of his own making. Neither the official technocracy nor corporate managers could be trusted with the technologies of war and mass production; information needed to see the light of day. His books invited scientists, artists, writers, and all interested readers into the medium of discussion. Put simply, "The integrity of the channels of internal communication is essential to the welfare of society."[152]

The success of *Cybernetics* and *The Human Use of Human Beings* came with unintended consequences. As a celebrity scientist, Wiener was naturally exposed to quackery aiming to leech the success of cybernetics. Foremost among Wiener's unwanted followers was L. Ron Hubbard, the creator of the pseudo-scientific fad therapy, "Dianetics." On the heels of the success of *Cybernetics* and *The Human Use of Human Beings*, Hubbard and his associates mounted a longstanding campaign to attract Wiener's endorsement. The editor of *Astounding Science Fiction*, John Campbell, wrote Wiener of a study he was publishing called "How to Build a Thinking Machine," that supposedly employed an "electronic-cybernetic approach." The conclusions, he claimed, were entirely symmetrical with Hubbard's findings. He thought that Wiener ought to be greatly interested in Dianetics, "both as suggesting a new direction or development of the work from the cybernetic side, and because of your great interest in the human mechanism."[153] Wiener responded tersely that he doubted Hubbard's good faith and distrusted his "charlatan-like" tactics of announcing discoveries and keeping his "research" secret from any peer-reviewed scientific forum. "Dianetics," he observed, "sounds like the attempt of an illiterate to capture the swing of Cybernetics."[154] Wiener wrote to Hubbard to request he remove his name from any Dianetic literature, and

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[152] Wiener. *The Human Use of Human Beings*, 179.
[153] Letter from John Campbell, 1950. Wiener Papers, box 6, folder 113.
[154] Letter to Fred Schuman, July 8, 1950. Wiener Papers, box 6, folder 121.

threatened a lawsuit to force compliance.[155] It is an irony of history that the popularity of Dianetics would greatly outlive that of cybernetics.

Wiener's books also attracted the attention of literary critics who likened cybernetics to the moral certainty of pseudosciences like Dianetics. The proper response to rising mechanization and computerization, Wiener felt, was not ennui or a resignation into aesthetics, but thorough investigation.[156] Responding to a critique by Waldo Frank in *The Saturday Review of Literature*, Wiener grumbled that "the facile after-sight with which the literary man regards the evils of the machine neither gives sufficient basis for understanding its operation, human as well as mechanical, nor does it lead on its part to anything but vague exhortations, such as those of which you accuse me, to modify the society in which we are living)."[157] Wiener succumbed, as had Shannon, to a tradition of hard scientists' resistance to the cooption of their ideas by less rigorous minds. Cybernetics, he insisted, was a real approach to a real problem, and not an existential statement about modern civilization. Frank replied that he in fact shared Wiener's concerns. Humanists, he believed, could be faithful and honest interpreters of science: "I am profoundly interested in the problem – not of superseding the values of the great moralists (as you seem to imply) but in the problem of making them cogent in the infinitely more efficient way which our crisis demands."[158] Though the responsibilities of ambassadorship were foremost education, mediation, and translation, there was an inescapable moral character to Wiener's writings.

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[155] Ibid.

[156] On the retreat into the aesthetic see Lears, T.J. Jackson. "A Matter of Taste: Corporate Cultural Hegemony in a Mass Consumption Society," In *Recasting America: Culture and Politics in the Cold War*, Larry May, ed. Chicago: University of Chicago, 1989, 38-43.

[157] Letter to Waldo Frank, November 21, 1950. Wiener Papers, box 9, folder 130.

[158] Letter from Waldo Frank, November 26, 1950. Wiener Papers, box 9, folder 130.

Wiener's popularity extended beyond critical circles. A 1954 advertisement for the National Shawmut Bank of Boston exposed how profoundly his ideas had penetrated. The ad, titled "1954—Era of Cybernetics," featured a large illustration of an industrial humanoid robot moving freight, observed by two besuited executives on a catwalk above. The bank claimed,

> Cybernetics is making an impact that is beginning to remake our whole way of life. It will bring us more production, more jobs, more income and far, far more leisure. The world of the future is in fact already here...And just as in the past the National Shawmut Bank has always moved forward with each wave of profound new progress—so, today, this modern bank is cooperating with forward-looking businessmen who are putting Cybernetics to work in their factories, plants, warehouses, and offices... Shawmut is in step with the most significant development in our lifetime – the marvel of Cybernetics.[159]

Here, "cybernetics" stood in for "mechanization," a phenomenon that had not been as neatly formalized. But it meant more than the introduction of industrial machines—the principles of feedback control and improved information gathering also portended better forecasting, the elimination of waste, and the potential efficiency of the natural processes they imitated.

Readers of *Cybernetics* looked to it for an elucidation of what electronic computers meant. An article in the *Chicago Journal of Commerce* described the new field of computer research with the lead "Mechanical Brains Awe Scientists as Human Performance is Eclipsed."[160] Computer performance was always framed in these anthropomorphic terms, the endowment of Wiener's man-machine metaphors. "Dr. Norbert Wiener, mathematician at the Massachusetts Institute of Technology, has given it a name—Cybernetics—and written a book about it," the *Journal* explained, "but actually the movement far antedates him and its modern phase seems to have been in full swing

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[159] National Shawmut Bank of Boston advertisement, 1954 clipping. Wiener Papers, box 25c.
[160] February 23, 1949 clipping. Wiener Papers, box 25c.

for a decade without the public knowing very much about it."[161] It listed among the mechanical computers' ancestors clocks and adding machines, but saw novelty in the "new scientific 'Frankensteins'…use of electronics and electric circuits which are surprisingly like the 'brain waves' which have been detected." Simplistic commentary such as this appeared in regional publications nationwide as journalists attempted to place computers in an intellectual framework their readers might understand. Wiener provided them a buzzword and an academic stamp of authority.

Wiener was keen to assert this intellectual tradition, crediting Leibniz, Frege, and Boole with the foundations of a symbolic calculus of logic.[162] The birth of symbolic logic marked the true point of departure for automatic computing machines. Indeed, Wiener pointed out that both Pascal and Leibniz had hoped to construct actual computers in the metal: "It is therefore not in the least surprising that the same intellectual impulse which has led to the development of mathematical logic has at the same time led to the idea or actual mechanization of processes of thought."[163] As he saw it, digital computers were descendants of previous generations' automata. He wrote, "The gradual encroachment of automatic machinery on the function of mankind and its social significance is no novelty. For a considerable period toward the end of the last century Samuel Butler had been preaching that the machines were endowed with a sort of pseudo-life of their own, and that they were destined to develop this pseudo-life into a

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[161] Wiener did have considerable contacts with computer scientists beyond his involvement in cybernetics. He had observed Howard Aiken's electro-mechanical Harvard Mark I and corresponded with von Neumann over the latter's work on ENIAC. In 1941 he had, with Shannon's Bell Labs collaborators Harry Nyquist and Hendrick Bode, met with John Atanasoff who was building a digital computer at Iowa State. As early as 1928 he had helped Vannevar Bush build an analog machine for solving boundary problems in partial differential equations. Stibitz' attack on Wiener's computing credentials was somewhat misplaced. See Wiener Papers box 3, folder 58; Wiener Papers box 3, folder 61.
[162] Wiener. *Cybernetics*, 12, 41.
[163] Wiener. *Cybernetics*, 20.

rather complete life, and to struggle with mankind for the control of human destiny." Man-machine analogies were, of course, figures of speech, but some figures of speech "possessed such vitality that they were often conjectural statements about the future rather than mere metaphors."[164] Near the end of his life, Wiener wrote a book, *God & Golem, Inc*., postulating that the programmability of logical machines would have a similar revolutionary impact on our ideas about individuality, free will, and religion.[165] Popular discussions of cybernetics never strayed far from such weighty philosophical matters; Wiener encouraged the discussion.

A 1950 *Time* cover story explored cybernetics' relationship with computers' in greater depth. On January 23, a drawing of Harvard's Mark III mechanical calculator graced the cover; the text contrasted Wiener's philosophical pronouncements with somewhat more prosaic engineering details described by laboratory technicians. "The success of the automatic calculators set off an explosion of high, wide and handsome pondering that is still reverberating," *Time* reported. Wiener's *Cybernetics* was the first, and most potent of these tremors. *Time* called Wiener a "rarity among scientists," one able to talk intelligibly about almost any subject: "His wide-ranging interests (too widely ranging, some of his detractors think) saw in them qualities and possibilities that more practical men had missed."[166] Wiener argued that the newest machines bore an "extraordinary resemblance" to the human brain, while *Time* noted that Warren McCulloch believed brains actually *to be* digital computers.[167] Wiener's

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[164] Wiener, Norbert. "The Future of Automatic Machinery," 1953. Wiener Papers, box 30c, folder 728.
[165] Wiener, Norbert. *God and Golem, Inc: A Comment on Certain Points Where Cybernetics Impinges on Religion*. Cambridge, Mass: MIT, 1966.
[166] "Science: The Thinking Machine," *Time*. January 23, 1950. Accessed 31 Aug 2010. <http://www.time.com/time/magazine/article/0,9171,858601,00.html>
[167] Just like brains, computers were seen to be victims of psychiatric troubles: memory failure, cognitive glitches, and fatigue. Stretching the metaphor Wiener suggested such psychoses might be cured "by rest

anthropomorphism was more than a rhetorical trope: “Computers have no senses or ‘effectors’ (arms and legs), but why shouldn't they have? There are all sorts of artificial eyes, ears and fingertips (thermometers, strain gauges, pressure indicators, photo-electric tubes) that may be hooked up to the machines. The machines can already work typewriters. They can be built to work valves, switches and all of the other control devices common in modern industry.”[168] Their impact on commerce, Wiener told *Time*, would truly amount to a “second industrial revolution.” Soon, he warned, “there will be wholly automatic factories with artificial brains keeping track of every process. They will order raw materials, inspect them, store them, route them through the plant. They will pay bills, blow the factory whistle and pay the help (if any).”

Potential early entry points included weather forecasting, digital recordkeeping as memory costs came down, predictions of new chemical compounds, and automatic recording of dictation. At the same time, *Time* profiled engineers less given to “sensationalism.” Howard Aiken, creator of the Mark III, claimed machines would always lack imagination, whatever that was. Other “practical computermen” found McCulloch’s metaphor of “memory” difficult; vacuum tubes, while 1,000 times faster than neurons, lacked flexibility, and computers’ punched cards and paper tapes were more like static libraries of information than dynamic thought processors.[169] Still, *Time’s* sympathies seemed to fall with Wiener and McCulloch. It speculated, “Perhaps the computing machines, by lifting more of the thinking burden, will prove a last step in the

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(shutting down the machine), by electric shock treatment (increasing the voltage in the tubes), or by lobotomy (disconnecting part of the machine).

[168] “Science: The Thinking Machine,” *Time*.

[169] Ibid.

long, slow process of mental collectivization. Men may come to specialize on the simple, narrow tasks of serving the machines."

That cybernetics piqued such unexpected interest in lay quarters is testament both to the energetic and eloquent proselytizing of Norbert Wiener. It must also be attributed to the durability of its human-machine analogy. The public was receptive to this point above all because it suggested a science-fiction terror, and the paradoxically ego-gratifying possibility that humans might at last be able to engineer nature. The mechanical man, a troublesome figure since before Shelley's Frankenstein, was coming, Wiener told Americans. And he might be coming for their jobs.

Chapter 4 – The triumph of the machines

The takeover of the factory, of the office, and of the military by automatic machines posed a frightening prospect. In the decade following 1950, no one was better placed to address the popular concerns than Norbert Wiener. It is instructive to follow the camber of his career as he rose from a somewhat inconspicuous architect of a new discipline with a funny name, to a household figure in postwar America. Rather than bask in the fame (and soak up the royalties) from *Cybernetics* and *The Human Use of Human Beings*, Wiener waged a public battle with the military scientists and workflow optimizers who might have seized upon his work. One former ally whose vastly different approach placed him in Wiener's crosshairs was John von Neumann. Though von Neumann never fell out with his cranky rival to the degree that others did, they tread two different paths; von Neumann's last years were dedicated to building artificial consciousness, Wiener's with consciousness-raising.[170] In his mediations between the scientific community and a larger public, Wiener set an example to would-be information evangelists, most of whom shared his concerns. He identified and explained a set of (often worrisome) social consequences of the technological transformations currently in progress, authoring informed suggestions about how science and society could work together in each other's interests. This is the example we will trace in forthcoming chapters.

The success of cybernetics' metaphors inspired worry in many. That mechanical processes could reduce manpower requirements in agriculture, textiles, and heavy manufacturing surprised no one. But Wiener's proclamations that, just as the industrial

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[170] See von Neumann, John, *The Computer and the Brain*. New Haven, Yale, 1958.

revolution had supplanted the use of man's muscles, a "second industrial revolution" was on the verge of supplanting his mental faculties were more troublesome.[171] Cybernetics had persuasively demonstrated that man and machine were alike in structure. For decades commentators would argue whether they were, in fact, substitute goods. These incipient fears, stoked by sensational headlines, snowballed into a national controversy in the late 1950s. As Wiener foresaw, computer automation was a can of worms; *Cybernetics* and *The Human Use of Human Beings* were early warnings that would ignite a vital debate.

A survey of newspaper coverage of Wiener's books reveals the most prominent theme embraced by journalists to be the replacement of man by machine. A front-page article in the *Boston Traveler* led with "Thinking Machine Seen Replacing Man: MIT Scientist Sees Day When Unskilled Labor Will Be Obsolete."[172] Such headlines were the rule. Upon *Cybernetics*' publication, some shape of the "Robots to Replace Humans" formula appeared in papers from the *New Orleans Times-Picayune* to the *Charlestown Gazette*, to the *Des Moines Register*.[173] In February of 1950, *The St. Louis Post-Dispatch* featured a half-page photo spread of the Harvard Mark III computer with the incendiary title, "Is Revolution of the Machine Coming?: Prof. Norbert Wiener Believes It Is – Foresees Day When Robots Will Take Over Most Jobs."[174] The paper advised all but the most senior executives to find a full-time hobby once "the mechanical millennium rolls around." To reporters trucking in melodrama, Wiener's literary affectations heightened his attraction. A stodgy, somewhat ruffled figure, Wiener evoked the grandfatherly

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[171] Pfeiffer, John. "The Stuff that Dreams Are Made On," *New York Times Book Review*. January 23, 1949, 27.
[172] April 12, 1949 clipping. Wiener Papers, box 25c.
[173] Wiener Papers, box 25c.
[174] February 2, 1950 clipping. Wiener Papers, box 25c.

Prussian *Herr Professor*, the man of great worldly sensitivity who could uniquely make science explicable. The cult of personality that formed around Wiener in the press positioned him as the kind of man the public could trust as its ambassador to the scientific establishment. Of course, Wiener was equally science's ambassador to the public.

The press' excitement continued to crescendo with the release of *The Human Use of Human Beings*, in which Wiener directly addressed the social effects of information machinery. A partial review, "Danger of Enslavement by Machines Sounded," was syndicated through the Hearst newspaper network in 1951. Calling Wiener the "father of automation," the reporter quoted him: "Human beings are being treated as though they were just machines, while machines are being invented which not only control themselves significantly, but are escaping human control in a menacing manner. There is a danger to man."[175] The *Louisville Courier Journal* also ran with the siege theme: "Machines that 'Think': Electronic computers and automatic controls move deeper and deeper into American life—but is there not danger in this 'invasion'?"[176] The *Boston Globe* was slightly more circumspect: "Does [cybernetics] mean the replacement of men with machines on a vast scale. Does it mean serious unemployment and other social problems? Or are the scientists showing us the way to a new golden age of plenty such as men have never imagined in their wildest dreams? No one, of course, can answer these questions."[177] The *Globe*'s audience may have preferred a tone of journalistic objectivity more consonant with *Time*'s story on "The Thinking Machine." The greater part of the reporting on *The Human Use of Human Beings*, however, supposed that humanity's position at the apex of the intellectual food chain was under threat.

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[175] 1951 clipping, Wiener Papers, box 25c.
[176] January 17, 1954 clipping. Wiener Papers, box 25c.
[177] August 23, 1953 clipping. Wiener Papers, box 25c.

Such articles were, in the main, short on substance and long on wild speculation. Science reporters were not above tabloid-style excess, particularly in markets where the general level of science education was modest. Nevertheless, it would be foolish to dismiss such a concerted response as gross fearmongering. Wiener, McCulloch, and other eminent scientists sincerely believed there was little to limit the potential of so-called "thinking machines." Judging by the mimetic repetition of the motif, readers too were genuinely concerned. These stories were embellished by sensationalism, but Wiener's public relations outreach was their engine. In subsequent chapters, I explore how the public response to automatic computers was mediated by a class of professional interpreters following in Wiener's footsteps. In the immediate aftermath of the Macy meetings and with his newfound celebrity, Wiener was essentially content to allow the popular press to write the script. Having prospered as a popularizer, Wiener assumed a new role as the conscience of the scientific establishment.

In 1951, Wiener's now octogenarian mentor, Bertrand Russell, published an essay on cybernetics in a popular magazine. "Are Human Beings Necessary?" hailed *The Human Use of Human Beings* as a "book of enormous importance," and predicted that if the current trend persisted, workers might soon punch the clock for no more than an hour a day. More disturbing to Russell was mechanized industry's uneven impact with regard to economic class. "The inventing of the robots will be an extremely skilled job," Russell said, "and those who are engaged upon it will form an elite in the employment of the holders of power."[178] Russell worried that machines would have a fragmenting effect on the dynamics of economic power, but he also fretted that those the machine replaced could lose their own dignity and self-worth. When you take away a man's livelihood,

[178] Russell, Bertrand. "Are Human Beings Necessary?" *Look*. September 15, 1951, 379.

Russell argued, you take away his reason for being. If the cybernetic interpretation of man's kinship with mechanical systems were correct, as Russell suspected, little could be done to arrest the incremental dominance of machines.

These cries of alarm compelled Wiener to adopt a more mollifying rhetoric. "Our science fiction writers and a considerable sector of the public are expecting that the triumph of the machine will be complete all along the line," he told an audience at Western Reserve University in December 1952. Developments in automatic chess-playing and forecasting were already leading to "wild expectations of the super-humanly perfect chess machine, of the super-humanly perfect computing machine for meteorological and economic policy."[179] Wiener took exception to Russell's dire predictions; the future, he argued, does not follow a straight-line path from the present. Exaggerated headlines ought to be taken with a pinch of salt. With respect to Russell, Wiener chafed, "It is somewhat surprising to see a writer of his status accepting uncritically the extravagant claims of the science fiction press." Rather, the computer was only a "competitor with man in certain ranges of human activity. It is important both intellectually and practically to differentiate between the fields essentially belonging to man and those better surrendered to the machine."[180] Still, Wiener privately expected to witness a major transformation of the labor economy. He wrote a letter to his congressman to exhort an overhaul of land policy: "In…centers of industrial population, I foresee an eventual replacement of the majority of those doing repetitive tasks in industry

[179] Wiener, Norbert. "The Electronic Brain and the Next Industrial Revolution," address given at Western Reserve University, December 10, 1952. Wiener Papers, box 29c, folder 692, 1.
[180] Wiener. "The Electronic Brain and the Next Industrial Revolution," 2.

by the machine. These displaced people will have to find some new mode of living which will very probably be subsistence farming."[181]

The fear and doubt Wiener expressed over the direction of science's technical marvels had been growing since the end of the war. He had taken several public stances against what he saw as unchecked technocentrism, and, after the war's end, persistently opposed the militarization of science. The apparent conquests of the computer bred a certain mechanistic view of human organization, particularly in the circles of Taylorist rationalizers and Defense Department mandarins. In their embrace of automation, Wiener "sense[d] the desires of the gadgeteer to see the wheels go round… The whole idea of push-button warfare [had] an enormous temptation for those who are confident of their power of invention and have a deep distrust of human beings."[182]

Within the cybernetics community, these objections led to a schism between Wiener and his friend and fellow mathematician John von Neumann concerning America's Cold War defense posture. Wiener became one of the first of a group of scientist-citizens, many with ties to the defense establishment, who articulated a vision of computers and automation that was distinctly anti-authoritarian and humanistic. Against the backdrop of a society rapidly absorbing information-processing machinery, and without directly condemning it, Wiener was a voice of guidance, wisdom, and a defender of human dignity. Successive would-be information ambassadors looked to Wiener's model and were inspired not only by the explanatory power of cybernetics, but by his ability to influence public opinion.

[181] Letter to Angier Goodwin, May 1950, Wiener Papers, box 8, folder 120.
[182] Wiener. *I Am a Mathematician*, 305. Wiener cites the hurried use of the atomic bomb by generals who neither truly understood the technology nor took heed of the concerns of scientists who did, like Einstein, Szilard, and Fermi.

Historian Paul Edwards has characterized the history of the computer as, at base, a story of military command and control. In his view, the computational solutions that arose from Wiener's work on anti-aircraft ballistics trajectories are emblematic: they seek to predict the actions of a rational enemy, they assume a limited number of possible inputs, they export a simulated laboratory answer to the battlefield, and "play" for a simple, final solution.[183] For Edwards, digital computers operate in a "closed world," where military strategy and economic optimization are logical problems, amenable to computational answers. He cites examples of the miscellaneous advances in computers made under the Pentagon's aegis: magnetic core memory, conditional branches, computer networks, etc. Wittingly or not, researchers in computers, feedback, and information theory putatively furthered a military imperative: to develop rational, closed processes where highly placed planners could exercise perfect communication and control. In contrast, pacifists within the scientific establishment, like Wiener, are problematic for Edwards' thesis. He is quick to brush off their objections to the computerization of the military. It is true that the Pentagon remained by far the largest benefactor of information research through the 1960s. But Wiener and those he influenced, as we will see, were able to gain a certain persuasive high ground that is not so easily dismissed. Social thinkers and computer prophets, both within and outside of the military-industrial establishment, began to subtly change the terms of the debate toward more humanist, individualist, and anti-bureaucratic ends. Wiener's political activism set a powerful example.

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[183] Edwards, Paul. *The Closed World: Computers and the Politics of Discourse in Cold War America*, Cambridge, Mass: MIT, 1996.

Wiener was in fact no stranger to political activity. A committed anti-fascist, he had attended meetings of the American League for Peace and Democracy and the China Aid Council in the 1930s. A Jew married to a German gentile, Wiener had studied in Göttingen and traveled in Peking and Tokyo, working with prominent East Asian mathematicians. As a consequence, he was deeply and personally connected to world events in the 1930s and a fervent cheerleader of the United States war effort. Wiener valued the international scholarly community. He patroned promising scholars from abroad, passing recommendations on to Einstein and von Neumann. When, after the war, the State department tightened its Visa requirements for foreign students, Wiener fired off an angry letter to Dean Acheson.[184] He appeared at the Massachusetts state house to protest the firing of several university professors over favorable comments toward Soviet Science. For Wiener, the scientific community was a familial network; when the community mobilized for war, he was among its strongest partisans.

He was deeply troubled by the accommodation, and sometimes outright enthusiasm, of some of his European colleagues toward Nazism. Moral outrage mixed with personal betrayal; Wiener had always believed his work in ergodic theory (a branch of statistical mechanics that deals with the behavior of dynamical systems in time and space) had been better received in Europe than at home, and saw himself as a "continental" mathematician.[185] When politics intruded on amicable relationships, Wiener was quick to denounce his friends, and even toyed with the idea of feeding false information to their state sponsors.[186] For Wiener's friend von Neumann, the escalating conflict was equally personal. After accepting his position at the "scholar's paradise"—

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[184] Letter to Dean Acheson, 1950. Wiener Papers, box 6, folder 92.
[185] Heims. *John von Neumann and Norbert Wiener*, 178.
[186] Ibid.

The Institute for Advanced Study in Princeton, New Jersey—in 1938, he struggled for months to get immigration status for his family and fiancée Klara, who still lived in Budapest.

Steve J. Heims describes World War II as the "watershed," not just for Wiener and von Neumann personally, but for Western science more generally. It opened up new vistas of funding and prestige, and allowed physical scientists to exert a new influence over government (as had Wiener's M.I.T. colleague, Vannevar Bush, during the first war). Wartime engineering problems put in bold relief the importance of computation to both applied mathematics (in Wiener's ballistics work, for example) and experimental physics (in von Neumann's work with the Manhattan project). For Wiener, it was also the beginning of a moral awakening that would dominate his later philosophy.

Wiener had always had misgivings about nuclear science. He was approached to work on the Manhattan project but demurred, wary of the ultimate purpose of atom splitting.[187] When the bombs burst over Hiroshima and Nagasaki, Wiener's unease heightened. Two months after the Fat Boy explosion, in October 1945, he wrote his M.I.T. colleague de Santillana that he was "recovering from an acute attack of conscience," and would never allow his services to be employed in World War III. He predicted that escalating tensions with the Soviet Union would lead to an unprecedented arms race, and that scientists would be forced to take sides. "I feel it most intensely personally," he grieved.[188] Fears of a nuclear Armageddon were widespread throughout the scientific community, which mobilized a "scientists' movement" to promote arms

[187] Kargon, Robert and Arthur P. Mollela. "The City as Communications Net: Norbert Wiener, the Atomic Bomb, and Urban Dispersal." *Technology and Culture* 45 (October 2004), 764-777.
Wiener, *I am a Mathematician*, 293-294.
[188] Heims, *John von Neumann and Norbert Wiener*, 188.

control in the early 1950's.[189] An international initiative to motivate world leaders to disarmament was launched in 1955 by Wiener's friends Einstein and Russell. Wiener himself looked on with an ironic fatalism, which he expressed well in a 1949 letter to Haldane: "I still think that we are living on this earth on borrowed time, and I am afraid that somebody not 'unconnected with the State Department' is likely to foreclose the mortgage."[190]

Two years later, his position had hardened; asked to give an address at a Navy-sponsored symposium on information science, he declined on the grounds that military science could only contribute to mass slaughter. Cooperation, Wiener replied, "can do nothing but endanger us by encouraging the tragic insolence of the military mind."[191] To clarify his stance, he published an essay in the January 1947 *Atlantic Monthly*, titled "A Scientist Rebels." Wiener's beliefs caught the scientific establishment off guard and struck many as a publicity stunt. A number of journalists declared that Wiener was engaged in a "hopeless boycott".[192] Humanists were more pleased; literary critics Cleanth Brooks and Robert Penn Warren re-published the essay in a textbook on rhetoric.[193]

Wiener explained that his anti-militarism was not a matter of simple preference, but a moral calling:

> If therefore I do not desire to participate in the bombing or poisoning of defenseless peoples – and I most certainly do not – I must take a serious responsibility as to those to whom I disclose my scientific ideas. Since it is obvious that with sufficient effort you

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[189] Boyer, Paul. *By the Bomb's Early Light: American Thought and Culture at the Dawn of the Atomic Age*. Chapel Hill: University of North Carolina, 1994, 49-59.
[190] Letter to Haldane, February 21, 1949. Wiener Papers, box 6, folder 92.
[191] Wiener, Norbert. "A Scientist Rebels." *The Atlantic Monthly*, January 16, 1947 clipping. Wiener Papers box 25c, 377.
[192] Ibid.
[193] Brooks, Cleanth and Robert Penn Warren. *Fundamentals of Good Writing*. New York: Harcourt Brace, 1950.

> can obtain my material, even though it is out of print, I can only protest pro forma in refusing to give you any information concerning my past work...I do not expect to publish any future work of mine which may do damage in the hands of irresponsible militarists.[194]

Characteristically, Wiener did not express his views quietly. Here was a man who valued his public reputation; his boycott was not a decision of private conscience but a bold public pronouncement. As he had with cybernetics, Wiener treated consciousness-raising as part of his job description. Proving that his public position was more than mere grandstanding, Wiener backed out of a 1947 conference organized by Howard Aiken at Harvard on emerging computer technologies. A few weeks after "A Scientist Rebels" ran, Wiener wrote to McCulloch that he was "giving up all work on the computing machine because it is too closely associated with the guided missiles project."[195]

Any late entry into the grand theater of the Cold War political drama naturally solicited a reaction from the political establishment. The FBI started a dossier on Wiener the same year, with the bureau's Boston field agent reporting (inaccurately) at intervals to J. Edgar Hoover that Wiener was a communist.[196] Wiener of course distrusted Soviet bureaucracy as much as he distrusted American bureaucracy; however much he favored détente, he abhorred authoritarianism. Yet he was not averse to treading into activism. When a former student, Norman Levinson, was called before the House Un-American Activities Committee for his prior membership in a Boston communist group, Wiener avowed his public support for Levinson's refusal to name names.[197] When, in April 1947, the Massachusetts legislature began its own copycat hearings on "subversive activities," threatening to blacklist members of suspect organizations from public

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[194] Wiener. "A Scientist Rebels"
[195] Conway & Siegelman. *Dark Hero of the Information Age*, 242.
[196] Conway & Siegelman. *Dark Hero of the Information Age*, 256.
[197] Conway & Siegelman. *Dark Hero of the Information Age*, 265.

employment (including those at research universities), Wiener signed his name to a statement of protest.[198] Wiener agonized over the publication of *The Human Use of Human Beings*, even telling his psychiatrist in 1950, "You know how much red pepper it contains… I shall find myself simmering above a brisk fire… I wonder what the McCarthy's are going to do?"[199] Wiener detested the climate of secrecy and paranoia in the 1950s because of its destructive effect on the scientific community he loved. Nothing illustrates better the conflict between scientists inside and outside the establishment than the different paths traveled by Wiener and his friend and rival, John von Neumann.

Wiener and von Neumann cut very different figures within the field of cybernetics—Von Neumann: suave, cultivated, personable, confident; Wiener: tousled, verbose, absent-minded, hyper-sensitive. Wiener had always possessed an exaggerated sense of honor, duty, and personal integrity—ethics von Neumann regarded as more situational. Wiener viewed the games theory von Neumann had developed with economist Oskar Morgenstern as cynical and fundamentally immoral.[200] In the bombs' wake, Wiener briefly considered retiring from M.I.T. to live out his days on a farm. Distrustful of the utopianism of large, centrally managed Soviets, the rustic communalism of the old New England town, he found rather more appealing. Unlike von Neumann, who hailed from a cosmopolitan European capital, Wiener endorsed a decidedly American romantic individualism. "Small, closely knit communities have a considerable measure of homeostasis," he wrote.[201] Homeostasis represented natural law; it was an essentially conservative doctrine of stability and preservation.

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[198] Conway & Siegelman. *Dark Hero of the Information Age*, 258.
[199] Conway & Siegelman. *Dark Hero of the Information Age*, 264.
[200] Heims. *John von Neumann and Norbert Wiener*, 188.
[201] Ibid.

The functional amorality of game theory struck Wiener as irresponsible. In a von Neumann game, "there is no homeostasis whatsoever." Wars raise the stakes, the rules shift, and "everyone loses."[202] Wiener was particularly alarmed that games theory might be employed by governments in a strictly mechanical way to dominate the field of international diplomacy. Wiener's autobiography, *I Am a Mathematician*, included a chapter titled "The Moral Problems of a Scientist," wherein he lamented the deep incompatibility of probabilistic strategy and real war. He wrote of a tendency among economists and policymakers "to regard a war in the light of a glorified football game, at which at some period the final score is in, and which we have to count as either a definite victory or a definite defeat."[203] The field of international relations was, in Wiener's estimation, just another complex system, where such instrumental reason utterly failed. Human actors, notwithstanding some cocksure misreadings of cybernetics, were neither fully rational machines nor pliable to perfect prediction. In any case, nuclear weaponry changed the dynamic, loosing any number of endgame scenarios that made an assessment of "victory" quite impossible.

Science, Wiener thought, should make no such Faustian bargain with politics.[204] This basic distrust of power, a hallmark of Wiener's conspiratorial personality, dictated a policy of noncompliance. The Powers-That-Be were neither as knowledgeable of the international system as they imagined, or as sensitive to the philosophical and moral ramifications of their choices as Wiener himself. Furthermore, wartime science

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[202] Heims. *John von Neumann and Norbert Wiener*, 307.
[203] Wiener. *I Am a Mathematician*, 299.
[204] In many ways, Wiener correctly anticipated the approach the Pentagon took to the Cold War. See Fakiolas, Efstathios T. "Kennan's Long Telegram and NSC-68: A Comparative Analysis," *East European Quarterly*, Vol. 31, no. 4, January 1998. Under Robert McNamara, the Defense Department employed trained rational choice theorists, such as the future dissident leaker Daniel Ellsberg, who conceptualized deterrence as a class von Neumann game.

introduced an element of secrecy, so anathema to the cosmopolitan Wiener's ideal of unhindered global scientific communication. "At no time in the foreseeable future could we again do our research as free men," he wrote.[205]

The divergence between Wiener and von Neumann's attitudes on this question forms the central rubric of Steve Heims' admirable double biography, *John von Neumann and Norbert Wiener: From Mathematics to the Technologies of Life and Death*. Heims shows that, though the two mathematicians shared a profound mutual respect, they cleaved to very different visions of what a cybernetic world might look like. To von Neumann, the prospect of nuclear war was a classic zero-sum game, suited to simple economic analysis. "It will not be sufficient to know the enemy has only fifty possible tricks and that you can counter every one of them, but you must also invent some system of being able to counter them practically at the instant they occur," he said.[206] The atomic bomb was just such a checkmate; he joined the Manhattan project without reservation. Perhaps as a result of his Hungarian upbringing, von Neumann potently despised Russian imperialism; after defeating the Nazi menace, he immediately turned his attention toward defeating the Red menace. An oft-quoted remark disclosed his attitude toward preemptive strikes: "If you say why not bomb them tomorrow, I say why not today? If you say today at five o'clock, I say why not one o'clock?"[207] Wiener saw such statements as a terrifying herald of science's divorce from embodied human ethics.

In a 1957 speech, "A Scientist's Dilemma in a Materialistic World," Wiener gave voice to these simmering anxieties. "Superficially the present time seems to be the heyday of science," he began. "Never before has the scientific career been publicly

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[205] Wiener. *I Am a Mathematician*, 307.
[206] Heims. *John von Neumann and Norbert Wiener*, 316.
[207] Blair, Clay. "The Passing of a Great Mind." *Life*, February 25, 1957, 152.

touted as one inviting the ambitions of able and eager youth to the extent that it now is." Young physicists and mathematicians were flocking to the centers of Cold War research, like Wiener's M.I.T. He continued: "It might easily be supposed that the present day represented a totally new valuation of the scientist and the first opportunity for him to take his position in world activity as a significant figure. Apparently all is well and the goose hangs high."[208]

Below the surface, however, Wiener perceived in science the properties of a bubble, the same effervescent inflation experienced by government and private industry during the 1950s. "If one talks with the young men who have responded to this seductive call," Wiener cautioned, "one will have the sensation of an almost universal feeling of vague malaise." A catastrophe—economic, political, or military—was looming. The current age, according to Wiener, was "in reality, the age of a consistent and unrestrained exploitation."[209] Exploitation of natural resources, of primitive societies, of workers—and of science. He was personally distressed that his ideas had "fallen into the wrong hands," and that he bore ultimate moral responsibility.[210] Particularly dangerous was the improvement of automatic control devices—computers, sensors, actuators, automatic regulators—as a result of cybernetic understandings of communication and feedback. The rise of industrial automation was a result of science's unrelenting drive to efface the importance of the individual mind. After 1953, when the last Macy meeting concluded, Wiener broke off relations with the majority of the group and never resumed his cybernetic investigations. According to Oliver Selfridge, the disputes between Wiener

[208] Wiener, Norbert. "A Scientist's Dilemma in a Materialistic World," 1957 speech. Wiener Papers, box 32a, folder 820.
[209] Ibid.
[210] Heims. *John von Neumann and Norbert Wienger*, 338-9.

and his collaborators "really fucked up cybernetics…because here you've got the guy who invented the term and invented the idea right there with you, but there was no interaction at all… This breakup did a lot of damage."[211] That cybernetics' mystique as the quintessential science of the automatic age dimmed is a result partly of the rising gravity of computer science within the halls of the academy and in the public arena. But another contributing factor was Wiener's sudden abandonment; without his dedicated effort, cybernetics lacked a single prominent figure capable of commanding publicity and motivating research.

The founder of cybernetics' attention was in his later years devoted to averting the societal ills that automatic machinery might wreak. The immediacy of the Hiroshima explosion certainly catalyzed Wiener's thought toward moral matters. Even before the war's end, he had begun to consider a complex of problems surrounding high-speed computing and automation. By that time, he recalled, "I had come to the conclusion that as the essence of the computing machine lay in its speed and in its programming, or determination of the sequence of operations to be performed by means of a magnetic tape or punched cards, the automatic factory was not far off. I wondered whether I had not got into a moral situation in which my first duty might be to speak to others concerning material which could be socially harmful."[212] These were amorphous questions that could not be solved as easily as a Fourier integral. Automation was not in itself dangerous; Wiener's reflexive understanding of cybernetics led him to the conclusion that the issue hinged on how machines were to be employed, and to which ends. "When the human being is being used mechanically," he explained, "simply as an inferior sort of

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[211] Conway & Siegelman. *Dark Hero of the Information Age*, 233.
[212] Wiener. *I Am a Mathematician*, 295.

switching or decision device, the automatic factory threatens to replace him completely by mechanical agencies."[213]

Wiener did not elect to resign from public life. Quite the contrary; if he was complicit in bringing about an era in which human beings were fundamentally devalued, he could not, all at once, turn away aghast. Indeed, Wiener knew that his was a voice of authority, and he could perhaps steer decision-makers in a more careful, humanistic direction. He wrote, "I thus decided that I would have to turn from a position of the greatest secrecy to a position of the greatest publicity, and bring to the attention of all the possibilities and dangers of the new developments."[214] The decision to assume the role of information ambassador was driven by more than pure bravado; it represented a conscious effort to shape the future of information technology by influencing those it most affected. Wiener's first target was the labor unions.

Beginning in 1950, Wiener maintained a long, friendly correspondence with Walter Reuther, president of the United Auto Workers of America. Labor leaders like Reuther reported that machine tools were already costing jobs, and automatic computers would only expand their reach. In Reuther, Wiener found "both an understanding of my problems and a willingness to give my ideas publicity through his union journals."[215] Wiener and Reuther even discussed forming a joint council of scientists and trade unionists to more carefully guide technological change.[216] Nothing came of this particular proposal, but Wiener, in acknowledgment of his own culpability, continued to

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[213] Wiener. *I Am a Mathematician*, 296.
[214] Wiener. *I Am a Mathematician,* 308.
[215] Wiener. *I Am a Mathematician*, 309.
[216] Triclot, Mathieu. "Norbert Wiener's politics and the history of cybernetics," in *The Global and the Local: The History of Science and the Cultural Integration of Europe*. Proceedings of the 2nd ICESHS (Cracow, Poland, September 6-9, 2006), M. Kokowski, ed. 764.

reach out to organized labor for the rest of his life. Executives too comprised a ready audience: "I heard hard-boiled engineering administrators express views which sounded remarkably like the writings of William Morris. Above all, I had everyone backing me in cautioning that the new displacement of human beings from the repetitive labor of the factory must not be taken as a devaluation of the human being and a glorification of the gadget."[217]

As Heims explains, Wiener had evolved an ambivalent philosophy of technology in common with Einstein, Russell, and the architecture critic Lewis Mumford.[218] Technological progress, he believed, could give modern society a temporary economic fillip if guided by wise minds. But political and commercial decision makers were too often blind to the long-term social consequences of the newest gadget. Wiener's views often isolated him among his peers; some resented his exaggerated media profile, and others felt that, in his social commentary, he ventured too far outside of his area of expertise.[219] The media, for its part, was overjoyed that a scientist of such standing would treat lay audiences so seriously. *The Christian Science Monitor* described Wiener as a "modern Jeremiah," with all the intellectual gusto of the great American moral philosopher William James.[220]

Wiener's fear, as outlined in *The Human Use of Human Beings*, was not of automatic machinery *per se*, but of the larger trend of systemization and mechanization of human processes like university research or politics. He explained,

> I have spoken of machines, but not only of machines that have brains of brass and thews of iron. When human atoms are knit into an organization in which they are used, not in

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[217] Wiener. *I Am a Mathematician*, 310.
[218] Wiener. *I Am a Mathematician*, 343.
[219] Ibid.
[220] "Man Among Animals and Machines," *The Christian Science Monitor*, August 26, 1950, B7.

> their full right as responsible human beings, but as cogs and levers and rods, it matters little that their raw material is flesh and blood … Whether we entrust our decisions to machines of metal, or to those machines of flesh and blood which are bureaus and vast laboratories and armies and corporations, we shall never receive the right answers to our questions unless we ask the right questions.[221]

Wiener understood that computers were not magical artifacts suddenly unearthed. They were the product of a long-lived evolution in technology and society toward systematic rationalization of intellectual processes. In their logical architecture they were a reflection of the circuits of information in large companies or government bureaucracies. If there was a threat to our individuality it was equally from this mechanical outlook as from the machines themselves. Wiener also anticipated the arguments of later computer thinkers, notably J.C.R. Licklider and Douglas Engelbart, who thought computers excellent tools to resist bureaucratic conformity, if they could be made responsive to the needs of the individual user. To "ask the right questions," is not only to perceive the threat from computing machines; it is also a matter of programming. As computers were classic subjects of the "garbage in, garbage out," phenomenon, which Wiener likened to W.W. Jacobs' fable of the Monkey's Paw, they might be reprogrammed not to compute optimum profit, but in service of stable employment and improved quality of life. The human use of human beings (or of electronic computers) demanded such farsighted thinking.

Concerns over the direction of society and the place of cybernetics in it would trouble Norbert Wiener to his grave. In 1962, two years before his death, he reflected on the many unresolved questions his ideas had unleashed. At the time many of these questions centered on the subject of machine learning; machines were rapidly increasing in skill at chess, artificial feedforward neural networks, loosely based on the model

[221] Wiener. *The Human Use of Human Beings*, 185.

described by McCulloch and Pitts, were exhibiting the ability to organize themselves into greater complexity; optimism (and funding) for the field of artificial intelligence was at its height. A few years later, M.I.T. cognitive scientist Marvin Minsky would remark that, "within a generation, the problem of creating 'artificial intelligence' will substantially be solved."[222] For Wiener, these developments were disquieting. The fundamental problem posed by learning machines was, in his mind, no different than that of unrestrained automation. He wrote,

> There are some very important things to be said about the social consequences of learning machines. A learning machine is not completely programmed when it is built; much of its programming comes later, from its experience. This means that learning machines are going to be very unpredictable tools because of the very property they are used for – the ability to do more than has been explicitly put into them at the start. If we use them to make decisions, the good to the use of their decisions will depend on the experience to which the machine has been subjected after it was built… This will result in tremendous risks in the future. Because the learning machine is not completely predictable, it is quite possible that it will develop policies that have not been thought of before, resulting in consequences that have not been considered before the machine was used. There is no reason to believe that the new values the machine develops will be those we want the machine to have.[223]

Paul Edwards' argument that computers became the singular artifact of Cold War military logic would seem to confirm Wiener's worst fears. In opposition, Wiener's ambivalent, reflective public leadership found a receptive audience in an America awed by the massive demonstration of atomic technology's destructive potential at the end of World War II. Owing in part to his example, the military conquest of information science remained incomplete. If they hoped to banish uncertainty and rationalize away the human element in decision systems, computer scientists failed. Indeed, a generation inspired by Wiener, including computer pioneers J.C.R. Licklider and Douglas Engelbart,

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222 Crevier, Daniel. *AI: The Tumultuous History of the Search for Artificial Intelligence*, New York: Basic Books, 1993, 109.
223 Wiener, Norbert. "The Mathematics of Self-Organizing Systems," in Masani, Pesi, ed. *Norbert Wiener: Collected Works,* vol. 4. Cambridge, Mass.: M.I.T. Press, 1985, 15.

technological democrats like Edmund Berkeley, and cybernetic philosophers like Stewart Brand, would ensure that a different vision of the "information society" came to prominence—one much more inclusive of the human creative potential.

Chapter 5 – The 13-ton television celebrity

November 4, 1952 was election night in America, and the voting public was tuning in. The mass medium of television was a new creature, just claiming its place at the American family's hearth, next to the RCA radio receiver. Between 1945 and 1955, television sets were installed in two thirds of American homes, and families were getting their first, black and white glimpses of radio stalwarts like Jack Benny and Burns and Allen.[224] In 1951, newsman Edward R. Murrow vaulted his CBS radio broadcast "Hear It Now," to the tube—rechristened "See It Now." Televisions transformed Americans from a nation of eavesdropping listeners to spectators with a visual imagination.

The presidential election of 1952 marked the birth of primetime television as political theater, with Republican General Dwight Eisenhower and his Democratic adversary Adlai Stevenson each taking to the airwaves to make their pitch to voters. Eisenhower waged an aggressive campaign of 20-second spots, aired during episodes of *I Love Lucy* and *The Adventures of Ozzie and Harriet*. Composed by TV adman Rosser Reeve—author of the M&M candies "melts in your mouth, not in your hand" slogan—this series featured the diffident general before a blank studio, with a paternal downward glance, offering brief solutions to the everyday problems of ordinary Americans.

With the election unfolding live on television, viewers paid increasing attention to the real-time predictions of pollsters and political pundits, most of whom forecast a dead heat, with the Democrat perhaps enjoying a slight advantage. On the morning of the election, Americans opened their newspapers to a full-page ad, paid for by CBS, exhibiting a photo lineup of the reporters and experts who would cover the returns as they

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[224] Spigel, Lynn. *Make Room for TV: Television and the Family Ideal in Postwar America*. Chicago: University of Chicago, 1992, 2.

came in—Murrow, Bob Trout, Eric Sevareid, Don Hollenbeck, Douglas Edwards, and a likeable young anchor named Walter Cronkite. But CBS had an ace up its sleeve; beside this who's-who, the network promised a new exclusive, its youngest and smartest expert, Remington Rand's new "magic brain," the UNIVAC computer.[225]

What was a "magic brain"? What kind of sorcery did TV viewers expect from a room-sized machine of buzzing tape and blinking lights? How did UNIVAC's electric brain, massaged carefully by its programmer, University of Pennsylvania mathematician Max Woodbury, outshine the flesh-and-blood brains trust assembled by CBS, across the teletype in its New York news studio?

Even by 1952, this chapter will show that Americans had ample cause to revere and fear the conclusions of so-called "brains" like UNIVAC. Anyone marginally au courant of the rapid advances of postwar science, any semi-regular reader of the *New York Times Sunday Book Review*, any casual acquaintance of popular science fiction would recognize the term "magic brain," and know to what it referred.[226] The mechanisms of electronic information processing were beginning to filter from the knowledge of a small cadre of mathematicians, physicists, engineers, and military officials to a wide and receptive public imagination. Throughout the 1950s and 1960s, the cultural preoccupation with computers paralleled their spectacular advances in speed and power. Computers cut to size formerly insoluble puzzles of organization and control. America in the immediate post-war was an age of algorithms, of technocratic solutions to big challenges.

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[225] CBS News advertisement, "Starting at 8 P.M. and all through the night…" *Washington Post,* November 4, 1952, 15.
[226] Apparently, this terminology achieved some universality. The contemporary Chinese term for "computer" is "dian nao" (电脑), literally "electric brain."

In May of 1950, Harry Truman signed into law an act creating the National Science Foundation, the fruition of Vannevar Bush's call for beefed-up government patronage of basic research.[227] Among the first grant awardees, in 1952, were physics Nobelists Max Delbruck and Burton Richter, and sociobiologist E.O. Wilson.[228] Formally, most remember the launch of the *Sputnik* satellite, on October 4, 1957, as the spark that ignited the space race, but as early as 1952, the former Nazi rocket engineer and spaceflight trailblazer Wernher von Braun had published a series of articles, titled "Man Will Conquer Space Soon!" in *Collier's Magazine*. These essays detailed problems of survival, ship construction, lunar landing, physical and psychological tests, and even the construction of orbiting space stations and permanent lunar bases.[229] More than a symptom of scientific optimism, computers helped enable the shift to big projects, big spending, and national-scale research coordination. But if an elite science establishment had, in the immediate postwar years, laid the red carpet for arrival of the digital computer on the public scene, November 4, 1952 marked its smash debut on the top-rated primetime news program. Most Americans' invitation to the computer age came, fittingly, on TV.

By 8:30 p.m. Eastern Standard Time, well before the close of the crucial California polls, the CBS broadcast was gearing up for a long, closely contested election night. The Democratic candidate, Stevenson, was favored by a small margin in most of the advance opinion polls. It was then that CBS correspondent Charles Collingwood received a teletype message from Remington Rand's Eckert-Mauchly computer division

[227] Bush, Vannevar. "Science: the Endless Frontier," *The National Science Foundation*. July 1945, Accessed 1 Sept. 2010. <http://www.nsf.gov/about/history/nsf50/vbush1945.jsp>
[228] Blanpied, William A. "The National Science Foundation Class of 1952," *The National Science Foundation*, June 1999. Accessed 1 Sept. 2010. <http://www.nsf.gov/about/history/nsf50/nsf1952class.jsp>
[229] collected as von Braun, Wernher *et al*. *Across the Space Frontier*. New York: Viking, 1952.

in Philadelphia—the electric brain calculated with 100-1 odds that General Eisenhower would win in a landslide. The UNIVAC was not a "brain" at all, its creators insisted. It was an algorithm, a deterministic program. "The earliest admonition we had about the computer was to quit using the phrase electric brain," Cronkite has said. "The folks in Philadelphia tried to convince us that the UNIVAC didn't have a brain, and that whatever we fed into it would determine what we got out of it."[230]

But CBS had been certain UNIVAC would produce the right answer. Confused, news producer Sig Mickelson decided not to air the UNIVAC data. Woodbury crunched a second set of data, and a half-hour later CBS announced that UNIVAC had predicted a narrow Eisenhower victory with 8-7 odds. But Woodbury's data has miscalculated Stevenson's vote count in New York State by a factor of 10. When he found the error, UNIVAC again reported the original odds of 100-1.

Over the course of the night, viewers watched the electoral votes pour in for Eisenhower, ultimately 442 to Stevenson's 89; UNIVAC's prediction had called for a count of 438-93, within 1% of the actual total. CBS, with exclusive access to the first and only commercial general-purpose computer, called the election before any of its rivals. Americans were treated for the first time to the applied intelligence of a machine that had been used only in the analysis of census returns, aircraft trajectories, and weather maps. The impact of the computer model's stunning accuracy was somewhat blunted, as the network delayed several days before reporting UNIVAC's original outputs. Later that week, a Washington Post editorial waxed sympathetic for the jilted machine:

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[230] Goff, Leslie. "Univac predicts winner of 1952 election," *Computerworld: Flashback 1952*, CNN.com, April 30, 1999. Accessed 31 Aug. 2010. <http://www.cnn.com/TECH/computing/9904/30/1952.idg>

> Well, it now seems that Professor Univac, the celebrated mechanical brain, damn well knew what he was talking about when, in answer to the questions put to him, he asserted early last Tuesday night that General Eisenhower would get the electoral votes of 40 States and Governor Stevenson those of only 8. The trouble was that none of those stupid humans, including his inventors, would believe him, so they started jiggling with his levers or buttons or tubes or whatever they were, and ended by throwing the poor thing out of whack entirely.[231]

Most evident in the Post's tongue-in-cheek criticism is a penchant for describing the computer in anthropomorphic—indeed in distinctly human—terms. "We can't help feeling sorry for Professor Univac, even though he and his kind may put us all out of business one of these days," the newspaper wrote. "The sad part about being a genius is that one is never properly understood or appreciated except by other geniuses." Further, the machine's bravo performance elicited a number of other ponderings of its status as a brain, distinct and apart from human intelligence. If a computer could best an army of professional political analysts, what human barriers could it not knock down? The *Post* continued,

> Of course, it's easy enough to say that a machine has no feelings, and therefore we needn't worry about having damaged the feelings of Professor Univac. But we can remember having heard the same thing said about certain animals and even about certain races of mankind. How can we know that the professor has no feelings to hurt? Has anybody ever tried to talk to him about life, love, art, poetry, or the nature of beauty, or indeed, about anything except abstruse mathematical problems?... It seems to us that if the professor is capable of performing intellectual operations far beyond the cerebral powers of any human being, it is at least possible that he may have an unrecognized emotional organization so complex as to make him sensitive to a degree quite beyond the power of our coarse and callous species even to imagine.[232]

It is not the undisguised romanticism of this portrait that is most remarkable, but rather the emphatic tendency to reduce emotion, artistic capacity, even love, to a cognitive program or intellectual endeavor. Such a materialistic vision of the human spirit, in a middlebrow publication such as the *Post*, was possible only in the full bloom

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[231] "Unhappy Univac," *The Washington Post*, November 8, 1952, 8.
[232] Ibid.

of postwar science, with the analytical and operational methods applied to cracking codes and building servomechanisms, now employed in the service of engineering, commerce, and social planning.[233] The historian of technology Leo Marx has written how "the Machine" metamorphosed, after the iron and coal of the first industrial revolution, to include biological image of man and nature. Marx's narrative of earlier technical transformations might just as well be applied to the dawning of the computer age: "At first, admittedly, it seemed odd, even paradoxical, that our gifted nineteenth-century writers had responded to the invention of the novel artifacts of the Industrial Revolution by reverting to—or instinctively reinventing—the pastoral, one of Western culture's oldest modes of thought and expression."[234] Mid-century writers covering computers hardly revived Marx's pastoral mode. But they did adopt older, expressive forms—chiefly that of the automaton (the Tin Man, Frankenstein's monster, E.T.A. Hoffmann's Olimpia). The available vocabulary to writers seeking to understand a world where logic was no longer the sole providence of biological minds was that of anthropomorphism and romanticism.

It may be said that the Post's editors failed to understand the workings of the UNIVAC's "neurons" (though many popularly available schematics had likely crossed its desk), or that the machine's humanity was simply played up in a bit of literary metaphor, notwithstanding Eckert-Mauchly's cautions. But it is precisely this metaphor that warrants investigation, since it was not the exclusive domain of the news staffs covering

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[233] Boyer, Paul. *By the Bomb's Early Light: American Thought and Culture at the Dawn of the Atomic Age*. Chapel Hill: University of North Carolina, 1994.
Galison, Peter. "The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision." *Critical Inquiry* 21 (Autumn 1994): 228-266.
[234] Marx, Leo. *The Machine in the Garden: Technology and the Pastoral Ideal in America*. Oxford: Oxford University, 2000, 377.

the 1952 election, nor the viewing public treated to CBS's all-night election coverage. At least by 1952, and increasingly thereafter, metaphors linking electronic and human cognition were embraced by the gamut of American society, from the silver screen of Hollywood, to the halls of Washington, to the trading pits of Wall Street, and in the suburban TV rooms of millions of Americans.

This metaphor fascinates and compels because it is not as simple as it seems. Indeed, there have always been many who dispute its utility entirely, or who see the equation of information processing with thought as distracting—or, deliberately misleading. The nation's foremost expert on automation, John Diebold, thought it so in 1952, writing,

> The popular imagination has been captured by the automatic control of guided missiles and by the electronic computers. These uses of control devices incite journalistic fantasy, for it is all too easy to draw superficial parallels between the operation of certain military equipment and the operation of industrial machinery…The confusion has not been lessened by the analogy that has been drawn between the operation of certain control systems and the operation of human and animal nervous systems. While this comparison may be useful for pedantic purposes, it applies at best to only limited areas. There are close analogies between electronic circuits and the nervous system, but the resemblance is frequently overdrawn. Widely publicized statements by responsible people that computing machines have *nervous breakdowns* and respond to *shock therapy* add to misunderstanding.[235]

Diebold aimed this critique squarely at the audience of nervous businessmen, many of whom harbored sincere fears of a fully automated apparatus of executive decision-making. As we shall see, computers were inextricably caught up in the debate over the wisdom or folly of automation, an argument that raged from the first introduction of digital calculators into accounting offices through the virtual battlefields of Vietnam War strategy. But Diebold's words put a logistical gloss over what was, for others, an epistemic fear of man's losing his place.

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[235] Diebold, John. *Automation: The Advent of the Automatic Factory*. New York: Van Nostrand, 1952, 3-4.

Mortimer Taube, a librarian experimenting with automated document recovery, was less guarded. To frame the work of electronic digital computing as thinking, he argued, amounted to a deception. Scientists had much to gain from exaggerating claims of their machines' capabilities: computers sold as "thinking machines" were "science fiction to titillate the public and to make an easy dollar or a synthetic reputation."[236] Computers could predict elections, manage corporate payrolls, and route freight train traffic but they failed at the simplest of human tasks, like parsing an English sentence, or beating a mediocre human chess player. Surely there was more to higher thought than reasoning by mathematical logic. Intuition, induction, subtext: here all the "thinking machines" of the 1950s fell short.

Computer scientist C. Dianne Martin has analyzed what she calls the "myth of the awesome thinking machine." She documents the prevalence of the "brain" metaphor to describe early machines—"Army's New Wonder Brain," proclaimed the *Philadelphia Inquirer*; "No problem too tough for Robot," gushed the *Boston Post* in 1946 about the University of Pennsylvania's ENIAC.237 Similar headlines announced the unveiling of Britain's Pilot Model ACE and Harvard's Mark II and Mark III. So powerful was this dialect that it was absorbed almost without reservation by many laypeople. A 1963 survey of 3,000 Americans indicated that the preponderance of respondents believed that the new machines,

1) think as a human being thinks
2) may soon exceed human capabilities
3) will someday make most important decisions for us
4) will replace human workers, causing unemployment

[236] Taube, Mortimer. *Computers and Common Sense: The Myth of Thinking Machines*. New York: Columbia, 1961.
[237] Martin, C. Dianne. "The myth of the awesome thinking machine." *Communications of the ACM* 36 (April 1993): 125.

5) and are strange and frightening.238

There was a clear inheritance between the new technical marvels and older forms of technological alchemy. "[T]he bubbling retort, the sparkling wires and the mysterious dials are often regarded as a grave threat," observed a contemporary commentator. "The machine which was a product of science was also magic, understandable only in terms of what it did, not how it worked. Hence the lack of comprehension of control, hence also the mixture of dread and anticipation."239 The *Washington Post* writer and forecasters like Diebold were both culprits in the reductive black-boxing of the computer's mechanism. By treating the computer as a character in a larger social narrative, science writers contributed to feelings of antagonism, dislocation, or of mystery.

Science journalists weave dramatic headlines. As Martin notes, they trade in "drama, aberration, and controversy." As the major go-between between non-technical Americans and the postwar scientific establishment, popular writing about computers had tremendous influence in creating a climate of awe and mistrust. Yet, by 1971, another poll of 1001 Americans found that more than half had used a computer at work. More than eighty-five percent no longer felt that the machines were frightening. The metamorphosis of the electronic digital computer from mechanical monster to beneficial tool will be the subject of this and subsequent chapter. Still, thirty-nine percent of those polled in 1971 agreed with the characterization of computers as "electronic brains" or "thinking machines."240 This section explores how the exotic became familiar, how what was once rival became nonrival and even friendly.

[238] Martin. "The myth of the awesome thinking machine," 121.
[239] Martin. "The myth of the awesome thinking machine," 122.
[240] Martin. "The myth of the awesome thinking machine," 121.

Why, then, was this metaphor so sticky? Why were the cautions of Diebold, Taube, and dozens of other critics relatively unheeded? Some of the answer is to be found in the language of science itself. Several historians have shown that metaphor is implicit in communicating new knowledge. Certain ready, obvious cognitive linkages are natural vehicles of diffusion for new discoveries. Stephen Doheny-Farina views technical communication not as a static transfer of ideas, but as "a series of personal constructions and reconstructions of knowledge, expertise, and technologies by the participants attempting to adapt technological innovations for social uses."[241] The computer, technology built explicitly for wartime, and later for industry, is of course inseparable from its social use.[242] Further, the metaphor is a simple tool to make these applications evident; metaphors can serve as a bridge between the unrecognizable and the known.[243]

But why *this* metaphor? Why not, by contrast, the metaphor employed by Charles Babbage when building his analytical engine in the 19th century – the "driving force of steam?"[244] The choice of terms is important. Human language, indeed, was preferred by mediators seeking emotion-laden terms to invoke action—technological adoption. As Bernadette Longo has written, technologies are to begin with "mirrors of our ideas about

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[241] Doheny-Farina, Stephen. *Rhetoric, Innovation, Technology: Case Studies of Technical Communication in Technology Transfer*. Cambridge, Mass: MIT, 1992, ix. In the study of technology transfer, the spread of technical knowledge between communities of adepts and the wider public (often in the body of government institutions or corporations) is effected primarily by "brokers"—skilled communicators who are able to apply scientific concepts across disparate circumstances. Wiener and Edmund Berkeley clearly fulfilled this role.

[242] Nearly all hardware and software advances can be seen as improving either the speed, efficiency, or ease of calculation. Later developments, particularly in artificial intelligence, lack this basic justification. Here we will see social utility was assumed as given, or framed in much more tortuous circumlocutions.

[243] Baake, Ken. *Metaphor and Knowledge: The Challenges of Writing Science*. Albany: SUNY, 2003, 57, 172.

[244] Beniger, James. *The Control Revolution: Technological and Economic Origins of the Information Society*. Cambridge, Mass: Harvard, 1986
Mindell, David A. *Between Human and Machine: Feedback, Control, and Computing before Cybernetics*. Baltimore: Johns Hopkins, 2002.

what it means to be human; they reflect what we believe about ourselves."[245] Metaphors do much of the imaginative work of inventing; they instruct humans how to think about the world, and they can, when so designed, create entire fictions out of whole cloth. That the biological metaphor achieved popularity suggests that cybernetics had quite successfully persuaded journalists of the mechanical character of biology, and *thinking* in particular.

But they are also unavoidable. If critics might have complained that *Cybernetics* was a really a rather facile essay in scientific analogy, Wiener replied with an impassioned defense of the use of figurative language, "The Nature of Analogy."[246] It was true that *Cybernetics'* great insight was to compare the purpose and function of human-made mechanisms to organisms found in nature. To describe natural phenomena, Wiener argued, is to describe observed patterns. Language itself is nothing other than a pattern—one that we hope bears a close enough resemblance to the described phenomena to be recognizable. Mathematics is another such pattern. Insofar as the pattern of the descriptive mechanism bears similarity to objective reality, all language is, at base, analogy. Getting to the heart of such a semiotic quandary would require a philosophical inquiry deeper than Wiener cared to undertake. But he proposed a workaround. Light in its wave form may be productively compared to sound, though one is described by the theory of electromagnetism, and the other a theory thermodynamics, and bear little experimental similarity to each other. This is because they exhibit structural similarities of behavior, if not of kind. Thus the language of science itself is at times concerned with

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[245] Longo, Bernadette. "Metaphors, Robots, and the Transfer of Computers to Civilian Life." *Comparative Technology Transfer and Society* 5 (December 2007): 253-273.
[246] Wiener, Norbert. "The Nature of Analogy." September 1950, Norbert Wiener Papers (MC22), box 29B, folder 655, Institute Archives and Special Collections, M.I.T., Cambridge, Mass.

purpose or teleology. Just so, *Cybernetics* concerns itself with the "essential similarity of pattern in certain mathematical processes and certain nervous-mental processes."[247]

At the level of function, or purpose, brains *were* digital logic systems. The matter of conveying these likenesses to a scientific public entails not an inconsiderable amount of abstract language, usually in the form of physical diagrams or mathematical formulae. But to speak to an intelligent lay public, as Wiener also intended, required yet more abstraction. Metaphor was the most appropriate tool, though it necessitated a degree of misunderstanding, at least until the public have "made themselves more or less masters of the mathematician's point of view though not necessarily of his phraseology."[248]

Metaphors also, as Marshall McLuhan cautions, tell us as much about their social context as their object of reference. Those that are accepted reveal much of the background, the values and commonsense assumptions of the society that receives them. We learn much from the stuff that goes without saying, from the stuff that is said. In this vein, the most guileful achievement of the computer enthusiasts Taube censured may not have been to elevate a young technology to equivalence with the sacred plateaus of Enlightened humanism. What was more radical, and alarming for critics, was refashioning of human thinking as something logical, mechanical, and computer-like. Cognitive and physiological approaches to the human mind were beginning to supplant the mystical, behavioral, and psychoanalytic. By midcentury, government, business, and war had regimented human activity in hitherto unseen organization. It is fair to say that in the publicity of the early information age that computers not only became men, but men became computers.

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247 Wiener. *Cybernetics*, 2.
248 Wiener, *Cybernetics*, 3

Taube and other skeptics fought a wall of public opinion. The metaphors that so pervaded popular discussion by 1960 did not appear ex nihilo. Rather, they were engineered by individuals, as Taube perceived, with a skin in the game. Computer buzz was built, from a trickle in the immediate post-war period into a flood by decade's end. The agents of the gestalt shift that brought "electronic brains" to the fore were a youthful class of "computer men"—technical, as well as farsighted and utopian—and their willing accomplices, the press. These computerati were a new breed; their formative experience was the War, and its singular image was a technological one—the atom bomb.[249] Their world was exploding in information, and they sought technical, logical solutions to handle this mass of data. If the order of fallible human judgment, fuzzy inductive reasoning, was to be swept aside, so be it. Chief among these computer evangelists was a man whose historical reputation remains very uncertain, Edmund Berkeley. Berkeley is viewed today as a marginal, eccentric figure, responsible for none of the instrumental developments that drove the early computer industry. A popularizer by his own admission, Berkeley in his day was viewed as much more—a leading expert at the cutting edge of science.[250] In this section we will attempt to bridge that divide, and along the way explore the world Berkeley inhabited, in between the laboratory and the press room, where the "myth of thinking machines" was made.

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[249] Boyer, Paul. *By the Bomb's Early Light*.
[250] Note to John Wiley & Sons, January 18, 1950. Edmund C. Berkeley Papers (CBI 50), box 40, Charles Babbage Institute, University of Minnesota, Minneapolis.

Chapter 6 – Early thinking machines and their times

To Wiener, the world was made of analogy. This is true especially of literature on technology. "Information talk" is its own language, tangled with many meanings. Contemporary commentators rarely had in mind the precise idea we do when speaking of "computer," "robots," or even "information." Among the easiest mistakes to make when reading historical literature is to assume a continuum: it is clear that in fact ideas evolve, even while often analogies do not. In presenting a narrative, the historian chooses a number of important moments, selecting from body of others. Evidence is not the same as proof; still, in selecting the many popular accounts I have chosen, I hope to present the reader a sort of discontinuous, digital timeline of the centrality of computers in the imaginative environment of the mid-20th century.

With this in mind, it is worthwhile to remember that *the computer* never existed; instead, there were *computers*. As the historian of science Mike Mahoney suggested, after the history of computing is told, there will be the *histories* of computing.[251] "Thinking machines" evolved not in linear succession, but rather, as in the fossil record, by a series of branchings. When a frisson of fanfare descended upon the ENIAC and its digital cousins in 1947, analog computers were happily employed in solving differential equations for topographical models structural engineering of aircraft. Just as Intel and AMD produced powerful "computer-on-a-chip" microprocessors in the late 1970s, jump-starting the rapid growth of the personal computer market, the largest markets for microchips remained out of sight—in electric appliances, peripheral devices like printers, calculators, and modems, and large-scale industrial systems.

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[251] Mahoney, Michael S. "Review of Ceruzzi, Paul E. *A History of Modern Computing*," in *IEEE Annals of the History of Computing* 22 (July-September 2000): 93.

Thus the old does not disappear and make way for the new. It persists, often out of sight, as history moves in multifold directions, sometimes doubling back. Historian David Nye offers this caution:

> From the vantage point of the present, it may seem that technologies are deterministic. But this view is incorrect, no matter how plausible it may seem. Cultures select and shape technologies, not the other way around, and some societies have rejected or ignored even the gun or the wheel. For millennia, technology has been an essential part of the framework for imagining and moving into the future, but the specific technologies chosen have varied. As the variety of human cultures attests, there have always been multiple possibilities, and there seems no reason to accept a single vision of the future.[252]

It is essential, then, to separate the *language* used to greet new technology and the technology itself. Such a warning ought to seriously constrain this account. Yet here I posit a rupture, a break in how Americans viewed information machines after cybernetics. Evidence of such large-scale phenomena is always slippery. Language rarely appears out of nowhere, announcing itself as new. But it does shift, sometimes slowly and sometimes radically. We must pay attention to these shifts. This chapter describes the earliest reactions to digital computers and the growing presentiment, both among certain elements of the press, and among the creators of the ENIAC itself, that these were devices of untapped commercial potential.

Machines as diverse as Vannevar Bush's 1927 Differential Analyzer, the paper tape-fed Harvard Mark I (completed in 1944), M.I.T.'s massive and powerful Whirlwind computer (1947), and IBM's transistorized 608 calculator (1955), and were described as possessing the capacity for "thinking." Commentators were just as likely to ascribe cognition to unwieldy boxes performing simple algebra as to room-sized behemoths employed in complex multivariate statistical analysis. The ability to manipulate math in an organized, logical fashion—that is to mimic human computers—seemed to be the

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[252] Nye, David E. *Technology Matters: Questions to Live With.* Cambridge, Mass: MIT, 2007, 210.

baseline criterion. Observers with more discretion limited their enthusiasm to machines of the "automatic" variety, displaying programmability, or ultimately the stored-program concept, which became a condition of the definition of the modern "computer."[253]

Given these widely divergent machines and the engineering environments out of which they were born, we shall have to look for the "big picture." It was not the architecture of any individual machine; rather, information technology as a whole seemed so full of promise. Through the 1950s, the technological menace highlighted by Wiener was given a face: the electronic computer. Though these new machines certainly posed frightening questions about the automation of decision-making, they were also regarded as essential instruments of a rational, technological transformation of business and government. Information processing was a source of anxiety, but, thanks to the advocacy of computer enthusiasts, it also generated a lot of excitement. How did the cumbersome plug-programmed ENIAC, and its daughter, the more flexible stored-program UNIVAC become such mysterious, powerful icons?

While digital computers designed along the principles laid out by Charles Babbage remained a dream, analog computers were built for the purposes of solving differential equations on both sides of the Atlantic.[254] The British Navy constructed such a Differential Analyzer for naval gunnery during World War I, while American engineer-laureate Vannevar Bush built a more complex mechanical model at M.I.T. in 1927.

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[253] "The Modern History of Computing." *Stanford Encyclopedia of Philosophy*. June 9, 2006. Accessed 1 Sept. 2010. <http://plato.stanford.edu/entries/computing-history>

[254] Babbage, a 19th-century English inventor and civil servant pioneered the concept of the automatic calculator (his "Difference Engine") and the stored-program computer (1837's "Analytical Engine.") Always short of resources—both component technology and funding—Babbage was unable to construct effective working models of his designs. The architecture of the Analytical Engine directly influenced the construction of Howard Aiken's Harvard Mark I machine in the 1940s, and the general pattern of all subsequent digital computers. For a more complete portrait of Babbage, see Hyman, Anthony. *Charles Babbage: Pioneer of the Computer*. Princeton, 1985.

Though the machine was not publicly unveiled until 1941, when it was hailed by M.I.T. president Karl Compton as "one of the greatest scientific instruments of modern times,"[255] the press was already aware of the computer's potential.[256] A 1927 *New York Times* cover story trumpeted its arrival: "Thinking Machine Does Higher Mathematics; Solves Equations That Take Humans Months."[257]

The *Times'* language is striking, particularly when one considers its 1920s milieu. Automatic fire control was not yet a reality in the aftermath of the Great War, much less a formalized theory of cybernetics. Further, there was little abstract about the Differential Analyzer's workings—it could hardly be imagined to "think" at all. Analog computers work by constructing a direct model—an *analog*—of a physical environment to be measured. Rods, gears, and wheels relative positions constitute numerical inputs, while the curves they trace (or integrate) onto paper determine output data. To solve another equation, Bush's analyzer would need to be fully reconfigured, all its parts reset. Analog computers do not operate on logic; they attempt to directly calculate physical quantities.

Yet, the *Times* anticipated the jargon associated with computers of much broader genius and flexibility. The Differential Analyzer solved equations that would have taken many human minds many days of computing in trial-and-error fashion. Numerical reasoning in humans is abstract and discontinuous; in the analog computer it took the shape of a physical model. No matter. By effecting mind-power (like horsepower in its automotive cousins), the differential analyzer functionally became a mind. This single,

[255] Nyce, James M. and Paul Kahn, *From Memex to Hypertext: Vannevar Bush and the Mind's Machine*. Boston: Academic Press, 2002, 4.
[256] *Life* magazine (January 14, 1946) later resuscitated the mind metaphor in a pictorial featuring the machine, titled "Giant electro-mechanical brain."
[257] Quoted in Slade, Giles. *Made to Break: Technology and Obsolescence in America*. Cambridge, Mass: Harvard, 2006, 137.

early reference suggests more than the elasticity of the comparison. The existence 1927 "thinking machine" reveals that the ballyhooed inventions of the 1940s did not somehow unlock the machine-mind equation; rather, popular culture itself was becoming keenly attuned to such an analogy. As technological command and control got "smarter," a ready-made comparison awaited them. Digital computers were the apotheosis of this phenomenon, not its genesis. Machines had taken the place of bodies, and if minds were biological *things*, than machines could do their work too. Indirectly, the *New York Times* invoked the new field of neuroscience, the breakthroughs in "mapping the mind" of Paul Broca, John Hughlings Jackson, and Franz Joseph Gall.[258]

A similar testimonial from the nonprofit Science Services' *Science News Letter* appealed to the same principle of intellectual mechanization. Dated November 1934, the leaflet describes a large "Robot-Brain" capable of solving simultaneous equations, proclaiming, "Engineers hail this latest mechanical 'slave.'"[259] Again, this language called to mind the equivalence of body-power and brainpower, a fitting unity in a world of breathtaking new machines. It also raised quietly the question of automation and worker exploitation. "Robot," in particular, is a term not deployed casually a mere thirteen years after its first imprint by the Czech playwright Karel Čapek. Čapek's Robots, more than slaves, were a commentary on work, automation, and the rational optimization of human society. We will revisit this topic later, in the context of the automation debate that raged during the 1950s and 1960s.

Early digital computers made good celebrities as well. Digital computation, where numbers or truth statements are represented by discrete electrical pulses, resembles

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[258] Zimmer, Carl. *Soul Made Flesh: The Discovery of the Brain—and How It Changed the World*. New York: Free Press, 2004.
[259] "Engineers hail this latest mechanical 'slave'," *Science News Letter*. November 1934.

organic thinking not only in its function, but, at least superficially, in its form. The earliest digital automatic calculator in the United States was built at Harvard by a physics professor and naval commander named Howard Aiken. Visiting his lab in 1944, *Popular Science* heralded the introduction of his Mark I machine with a gushing preview of the computer age, "Robot Mathematician Knows All the Answers."[260] This 10,000-pound box, powered by a 5-horsepower motor, could perform "scientists' tedious mathematical chores, and do such work about 100 times as fast as a man." The relief from such labor could, the magazine proclaimed, "accelerate exploration of nearly every field of knowledge."[261] The Harvard Mark I, applied to mathematical tasks, could solve a flexible array of problems without reconfiguration, from plotting lunar tables, to calculating pi to 700 decimal places, to deriving the motions of heavenly bodies. "Harvard's Robot Super-brain," as it was dubbed by *American Weekly,* could take on exceedingly complex partial differential equations that surpassed the limits of the human computers who tackled them. Aiken was more cautious in his enthusiasm. He had not built a brain, he told *Time* in 1947. "These humanitarian terms are unfortunate," he rebuked. Instead of memory, Aiken preferred the modest term: "storage of numbers". Still, he admitted that his machine did function, in some narrow respect like an extremely fast, purpose-built brain.262

But Harvard's electro-mechanical calculator too was limited. Aiken had effectively reverse engineered Babbage's Difference Engine, after finding a simple

[260] Torrey, Volta. "Robot Mathematician Knows All the Answers," *Popular Science Monthly*. October 1944, 224-230. The Harvard Mark I computer had an official name: the IBM Automatic Sequence-Controlled Calculator.
[261] Torrey, Volta. "Robot Mathematician Knows All the Answers," 224.
[262] "Science: A Robot's Job," *Time.* January 20, 1947. Accessed 1 Sept. 2010. <http://www.time.com/time/magazine/article/0,9171,854305,00.html>

prototype built by Charles' son Henry in a Harvard storeroom. It could not perform a conditional branch—reprocessing a program on the basis of a prior saved result, or "eating its own tail," in Babbage's phrase.[263] There were thus inherent boundaries of flexibility and autonomy: "Although called a super-brain, it does not really think. It merely obeys a mathematician's orders, and if he errs, the results are wrong," wrote *Popular Science*.[264]

This essential tension – that a machine could be both a "brain" and a "slave" to programming reverberates through much of the literature on early computers and their capabilities. The new digital behemoths could perform mundane labor better than humans certainly, but they embodied at least the potential to make critical and creative decisions. The computer debate was thus a mirror for two abiding questions about human thinking. The first asks whether decision-making is an art or a science, and further, to what extent can it be scientized. The second, an undercurrent in much of the copy written on the future of computing, is the problem of human agency. Are we in fact capable of thoughts original to our brains, or are we just automata, following our genetic and environmental command code? Though these profound and difficult puzzles have never been resolved during the short history of the digital computer, I will argue, the excitement over the introduction of "thinking machines" pushed the needle slightly closer to the interpretations of human agency as scientific, instrumental, and teleological or purposive. The entry "Computer," for the 1962 *Collier's Encyclopedia* echoed a refrain heard commonly in early discussions of the potential of the device:

[263] Campbell-Kelly, Martin and William Aspray. *Computer: A History of the Information Machine*. Cambridge, Mass.: Westview, 2004, 73.
[264] Torrey, Volta. "Robot Mathematician Knows All the Answers."

> Are there any limitations as to what automatic machines for handling information can do? Can these machines think—will they eventually think? …. Scientists in the computer field are divided as to the answers to these questions. Some maintain that the machines do not think; others maintain these machines can or will perform all specified operations of thinking. Some scientists point out that these machines do only what they are programmed to do, and the programming comes from human beings. *Other scientists point out that human beings also, certainly the vast majority of them, do only what they are programmed to do (educated, trained, accustomed to do) subject to some kind of unpredictable factor, which can be built into a computing machine whenever desired.*[265] [emphasis mine]

The computer was a new window on the mind of humankind, and showed us to be perversely logical and illogical in different ways. The new technological marvels shone a spotlight on the algorithmic, programmatic aspects of business decisions, economic forecasting, and routine daily planners. Though computers (perhaps like their makers) were mere tools, they could nevertheless vastly extend our capacity to systematize human life.

While the Harvard Computing Laboratory collected its funding from IBM, the Mark I was a strictly scientific endeavor. IBM, initially Aiken's third choice behind calculator manufacturers Monroe & Marchant and National Cash Register, leapt at the chance to put its brand behind important work in physics and naval operations. Thomas Watson, a former salesman aware of the value of a good public image, bestowed the initial $15,000 to construct Aiken's device.[266] Later, as Aiken persistently played down IBM's contribution—even failing to acknowledge his benefactors at the Mark I's public unveiling—the office machine behemoths pulled out, and the Navy intervened to fill their

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[265] The author of this provocative selection was none other than Edmund Berkeley, who is destined to play a greater role in this history. Berkeley Papers, box 68, folder 55.
[266] Agar, Jon. *The Government Machine: A Revolutionary History of the Computer*. Cambridge, Mass.: MIT, 2003, 55.

place.[267] IBM, stung by the disappointment of its glamour project, would not reenter the computer business until 1952.

Indeed, Howard Aiken, a famously stubborn and irascible engineer, failed always to conceive of any commercial application of a tool best suited for solving nonlinear partial differential equations, as in his research into the physics of vacuum tubes. In 1947, as work began on a series of second-generation machines, he is thought to have said, "Only six electronic digital computers would be required to satisfy the computing needs of the entire United States."[268] Such a remark is perhaps apocryphal; nevertheless, Aiken declined an invitation to attend the inaugural meeting of the first computer club in America, the Eastern Association for Computing Machinery, disbelieving that so many people could be interested in instruments for such abstruse scientific purposes.[269] The famous comment is consistent with his public posture on computer hype. High speed office calculation was, for Aiken, a task beneath the stature of a machine such as the Mark I.[270]

There were, however, those in Aiken's lab who anticipated a more democratic future for computing. Among them was a mathematician and Navy lieutenant named Grace Hopper, assigned to Harvard by the Bureau of Ships. Working under a "large and rather appalling" Commander Aiken, she learned to program the cumbersome apparatus, and developed several of the first "software" applications.[271] Hopper's interest in programming later took her to the offices of UNIVAC where she built the first compiler,

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[267] Campbell-Kelly & Aspray. *Computer*, 73.
[268] Ceruzzi, Paul E. *A History of Modern Computing*. Cambridge, Mass.: MIT, 2003, 13.
[269] "Notes on the EACM." Berkeley Papers, box 8, folder 2..
[270] Robert Hawkins Oral History (CBI OH 64), February 1984. Charles Babbage Institute, University of Minnesota, Minneapolis, 15-17.
[271] "In the Beginning – Reminiscences by the Creators." *Twentieth Anniversary of the ACM*. August 30, 1967. Berkeley Papers, box 10, folder 3.

and laid the groundwork for natural English programming languages, FLOWMATIC and COBOL, designed to democratize access to computers beyond professional engineers.

Another of Howard Aiken's lieutenants was Edmund Berkeley, who was to become the greatest PR force for early computing. As an actuary obsessed with efficient methods and programmable logic, the war years 1945-1946 at Harvard Computing Lab were Berkeley's first experience with machines capable of automating much of the labor of calculating actuarial tables. Diving into the guts of the machine, the jejune insurance man quickly became sophisticated both in its operations and its potential. "Shortly after coming to Professor Aiken's laboratory," he remembered, "I realized that these mechanical brains would have no difficulty with any symbolism, and could do not only numerical operations but also logical ones to the fullest extent necessary."[272] The correspondence between numerical calculation and symbolic logic was the central axis of Berkeley's comparison of minds and machines. It was a special revelation, common to the earliest pioneers in Artificial Intelligence, including Allen Newell and Herbert Simon, and present in Claude Shannon's revolutionary master's thesis on the mathematics of telephone relays. The Mark I was a base-10 digital machine, but in practice, much of its operation was binary, either/or propositions that, as Berkeley saw, could be reduced to a simple linguistic algebra invented by the 19th-century English philosopher George Boole. The applicability of Boolean algebra to computers opened up new vistas of possibility, including mimicking the logic of the human mind.

If Aiken's Mark I promised a new future of applied electronic digital computing, it was the ENIAC (Electronic Numerical Integrator And Computer) that made it real.

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[272] Berkeley, Edmund C. "About the author." Memo to John Wiley & Sons, 1948. Berkeley Papers, box 10, folder 40.

Built at the University of Pennsylvania's Moore School of Engineering by John Mauchly, a physics professor, and electrical engineer J. Presper Eckert, the ENIAC was room-sized electrical Goliath that dimmed the lights of all West Philadelphia when it was turned on. It was also the first all-electronic automatic computer realized in the United States.[273] ENIAC was unveiled with great circumstance in February of 1946 – the fastest, largest, and most expensive calculating machine ever built.

Proclaiming "Lightning Strikes Mathematics," *Popular Science* heralded the arrival of this "30-ton numerical monster," that would save countless man-hours in calculating weather patterns, astronomical movements, or the thermodynamics of engine cylinder design.[274] The ENIAC was 100 times faster than Harvard's computer, thirty times as expensive, suggested much more in cost savings. Similarly, *Popular Mechanics* crowed, "It Thinks With Electrons": "In its first run the machine solved in two weeks calculations which would have required 100 man-years of trained computer's work."[275] These articles' new bank of images proposed size, power, and frightening voltage and contrasted with the diligent, docile servant portrayed in press descriptions of the Harvard machine. *Newsweek* rushed to pointed out the "fifty-foot brain's" applications in aircraft manufacture, banking and insurance, electrical engineering, and meteorology.[276] *Scientific American* proposed solutions in nuclear physics, weather modeling, and

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[273] A 1973 patent settlement bestowed the intellectual property for such a machine on John Atanasoff, a physics professor from Iowa State University. John Mauchly visited Atanasoff's laboratory in June 1941 and observed a prototype computer with binary electronics, the Atanasoff-Berry computer. The visit was clearly inspirational, and may have been Mauchly's first introduction to digital computation techniques. Atanasoff was however called away to the Naval Ordnance Laboratory in Washington, D.C, and could not complete his machine. Mauchly built one; a thirty-year legal dispute followed.
[274] Rose, Allen. "Lightning Strikes Mathematics," *Popular Science*. April 1946, 83-85.
[275] "It Thinks With Electrons," *Popular Mechanics*. June 1946, 139.
[276] "Answers by Eny," *Newsweek*. February 18, 1946.

building jet engines or gas turbines.[277] The realization of commercial, and indeed non-mathematical everyday application was a rhetorical shift employed by writers about this new breed of digital computers. Like Bush's differential analyzer, the ENIAC was too cumbersome and expensive for widespread relevance; but, if the press was to be believed, it would not always be so.

What ENIAC *did* do was determine artillery trajectories for the U.S. Army, a task that during the war had challenged legions of human "computers" working around the clock—among whom Norbert Wiener had once served.[278] The machine was a thoroughly wartime effort, begun in summer 1943 with a U.S. Army bursary. From 1947 to 1955 it was in continuous use computing artillery firing tables at the U.S. Army Ballistic Research Laboratory in Aberdeen, Maryland. Impressive in speed and versatility, ENIAC was truly awesome in the scope of its complexity: 17,000 vacuum tubes, 10,000 capacitors, 70,000 resistors, and more than 5 million joints, all soldered by hand. It was far more flexible than either Bush's or Aiken's computers; it could be programmed to perform loops, branches, and subroutines, each requiring meticulous manipulation of a wall of switches and cables. In its first conception, it could not, however, store its programs. This development was the subject of the foundational controversy that split the ENIAC team, and led to the commercial UNIVAC.

Storing instructions in the same random-access registers as data allows for several advantages in programming. First, the machine need not be reconfigured manually each time a new program is entered. It is as simple as feeding new input. Second, the machine itself can modify its own program, specifically the addresses to which

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277 "Electronic Calculator," *Scientific American*. June 1946, 248.
278 Mindell. *Between Human and Machine*, 282.

instructions refer. Thirdly and most importantly, the stored-program concept makes possible second-order programs which work on other programs—assemblers, compilers, and all the tools of automated programming used by coders to write in terms more logically abstract and intuitive than direct machine language. In essence, simpler code could be used to write more complicated code.

Stored-program architecture makes practical the "universality" of Alan Turing's universal Turing computer.[279] A computer used for numerical calculation can be reinstructed to search English language text, or to draw a picture. In fact, it doesn't matter what errand it is put to; if instructions can be spelled out in formal logic, the machine can execute them. Rather than building a new logical architecture for each task, only the most simplified relationship between input, registers, and the computational unit is necessary.

The story of the ENIAC was a state secret during its construction in the early 1940s. Before it was unveiled to journalists, the Moore School's machine was a classified United States Army project. The squabbles and personality conflicts among its creators make for a fascinating genesis, revealing the tense, sometimes fractious, erratic laboratory culture behind most breakthrough technologies. Yet it interesting to us as well; the schism between the ENIAC's makers emblematizes several of the contests that energized the early debates about the future of information-processing machines. Was computing, for example, more interesting as theory or practice? Was it a non-saleable public good or a tempting business opportunity? Was it simply glorified form of advanced calculation, or a grand philosophical formalization of the processes of thought?

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[279] Davis, Martin. *The Universal Computer: The Road from Leibniz to Turing*. New York: Norton, 2000, 185. Indeed Turing was contemptuous of the cumbersome ENIAC – "too much equipment" he scoffed.

Though we are concerned broadly with the public reception of computers, it is worthwhile to venture briefly behind the scenes and see how many of these questions were prefigured.

While the ENIAC was still in development, the Moore School team received a second Army contract to build a successor, called the EDVAC. One of the engineers on the project was a young mathematician, Herman Goldstine, who in June 1944 met the famous John von Neumann on a railway platform in Aberdeen.[280] Overcoming his awe and nerves, he approached the great mathematician and struck up a conversation about his current project at the University of Pennsylvania. To his surprise, von Neumann was particularly interested (he had been working on similar problems of calculation in his other top secret enterprise—building an atom bomb). Von Neumann toured the facility and rapidly began studying the technical details with Eckert and Mauchly.

From the start, von Neumann brought a different perspective to the project, one perhaps familiar to his colleagues in the cybernetics school. He wanted to build flexible, adaptive, more human-friendly machines that could be put to wider purposes. Indeed, as befitted his interests, he saw in the logical designs for the ENIAC a model of the organizational structure of the brain. In his memos, he was among the first to label numerical registers as "memory."[281] Further, von Neumann maintained an emphasis on interactivity, especially graphics. "In many cases the output really desired is not digital (presumably printed) but pictorial (graphed)," he wrote. "The natural output in such a case is an oscilloscope, i.e., a picture on its fluorescent screen. In some cases these

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280 Waldrop, M. Mitchell. *The Dream Machine: J.C.R. Licklider and the Revolution that Made Computing Personal*. New York: Penguin, 2002, 101.
281 Campbell-Kelly and Aspray. *Computer*, 93.

pictures are wanted for permanent storage … in others only visual inspection is desired. Both alternatives should be provided for."[282]

Mauchly, a physicist with a background in electrical engineering, was a newcomer to electronic computers; during the war his work with vacuum tubes inspired him to create a digital computer to model their physics. Working on his simulation, Mauchly remembered thinking the machine could be speeded up using vacuum tubes. Not all of Mauchly's colleagues saw the utility of his new project. One visitor to the Moore School ballistics laboratory was more excited. There was a "man in the hall I didn't know, a small sort of interesting fellow who kept telling me that computers were great and this was the beginning of something that would turn out to be revolutionary."[283] The visitor was Norbert Wiener. Wiener had had his introduction to the digital computer at mathematician George Stibitz' famous remote computing experiment, when he operated an automatic calculator at Bell Labs' headquarters in New Jersey by teletype from Dartmouth College. As his cybernetic ideas evolved, he became increasingly excited about computers as a working embodiment of the theory. Wiener became a fervent supporter of Eckert and Mauchly's work.[284]

There were, however, tensions between the relatively obscure engineers at the Moore School and Von Neumann, the swashbuckling celebrity in the employ of the U.S. government. Above all, acrimony arose over who received credit for the stored-program principle. In June 1946, Goldstine condensed a series of memos written by von Neumann concerning the proposed design and circulated them as a paper, "First Draft of a Report

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[282] Goldstine, Herman H. *The Computer from Pascal to von Neumann*. Princeton, 1980, 246.
[283] "In the Beginning – Reminiscences by the Creators," Berkeley Papers, box 10 folder 3.
[284] Wiener's "Memorandum [to Vannevar Bush] on the Mechanical Solution of Partial Differential Equations," (1940) described and endorsed the Moore School team's work on the first generation ENIAC. Wiener Papers, box 28A, folder 557.

on the EDVAC." Among the field of computer researchers, this memorandum was a bombshell. Today, the stored-program setup used in nearly all computers is identified as "von Neumann architecture." The revolutionary ideas discussed in "First Draft" were certainly not von Neumann's alone. Eckert claimed subsequently that the design was initially his, while von Neumann's contributions remained largely philosophical and cosmetic. Eckert remembered his first meeting with the Hungarian polymath thus:

> I was not familiar with great mathematicians so I hadn't heard f him. Von Neumann didn't mean any more to me than Joe Apple or something… I got to know von Neumann and I thought he was very quick mentally in mathematics and things. He grasped what we were doing quite quickly. I didn't know he was going to go out and more or less claim it as his own. He not only did that, but he did it at the time when the material was classified, and I was not allowed to go out and make speeches about it. And he went out and made them anyway without clearance and got out of it because nobody wanted to come down with the Espionage Act on a prestigious guy. If I had done it, they would have come down on me with a ton of a bricks.[285]

Not only did von Neumann claim originality for these ideas, his release of proprietary designs essentially into the public domain invalidated patent applications the ENIAC's creators were drawing up.[286] Von Neumann, ever the public intellectual, resisted the concept of computers as an entrepreneurial opportunity, though he maintained cozy relationships with institutional patrons at General Electric. Eckert in particular resented what he viewed as a kind of hypocrisy from his better-compensated rival. He relates the story of a dinner shared by the EDVAC team in which von Neumann's oysters were inadvertently left off the bill. When the check was being split, von Neumann at first claimed the rebate as his and refused to pay.[287] Though the quarrel was settled amicably,

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[285] J. Presper Eckert Oral History (OH 13), October 1977. Charles Babbage Institute, University of Minnesota, Minneapolis, 35-36.

[286] U.S. Patent 3,120,606, for the ENIAC, was voided in April 1973, in part due to common design details make public by von Neumann's *First Draft*.

[287] Eckert Oral History, 73.

it is reflective of the first introduction of commercial competition into the infant computer industry.

In due course, business considerations would lead to the fracture of the ENIAC team and the departure of Eckert and Mauchly from the Moore School. In the spring of 1946, as the University of Pennsylvania was endeavoring to reorganize its relationships with business enterprise, an engineering professor, Irven Travis, was appointed director of the ENIAC project. Travis' attempt to centralize and standardize accounting procedures for the department, Eckert and Mauchly were repeatedly presented with a letter requiring them to sign over all intellectual property rights from their inventions to the university. The ENIAC team refused, and refused again.[288] Eckert recalled bitterly, "By that time, some of the fuddy duddy people were in control. The head of the University at that time was an English professor. He started worrying about whether it was really ethical for the University to accept money from GE and this, that and the other…Keeping it proprietary was they felt, keeping the public from getting enough use of it at reasonable rates."[289] The University administration was united in their efforts with von Neumann and Goldstine, who advocated the public ownership of all scientific breakthroughs (while on payroll of some of the more jealously secretive patent holders in corporate America).

Ultimately this game of brinksmanship ended, as they often do, with University administrators holding the bag, and Eckert and Mauchly forming a private venture—what would be called the Eckert-Mauchly Computer Corporation (EMCC). EMCC continued

[288] McCartney, Scott. *ENIAC: The Triumphs and Tragedies of the World's First Computer*. New York: Walker, 1999, 109-130.
[289] Eckert Oral History, 55-56.

the work that had begun on the EDVAC.[290] By 1948, the two computer pacesetters had signed a contract with the Census Bureau to deliver a state-of-the-art machine, the EDVAC-II, renamed the UNIVAC, for tabulating the 1950 census. The company ran into short-term financing difficulties preparing machines for the Army, Navy, Air Force, and the Northrop Corporation, and in February 1950 was acquired, becoming the UNIVAC division of Remington Rand.[291]

ENIAC's birth, universally pronounced by the augurs of the press corps a world-shifting event, was misunderstood in many quarters. While the sanguine predictions issued in *Popular Mechanics* and *Newsweek* foretold a new dawning of scientific research and speed in calculation, ENIAC's most direct impact was on business. We will see in the coming pages how the industrial manufacture of computers—and the next-generation growth of the software industry—were far more important drivers of technical innovation and end demand than military research. Crucially, many of the first observers were likely to miss the multitude of purposes to which digital computers would be applied: these announcements focus narrowly on computers as high-speed calculators, not as tools of analysis, logic, or communication. Indeed, the cardinal virtue of digital computation was not its speed, or even its accuracy (ENIAC's calculations rarely excelled in precision those of Bush's differential analyzer by more than a few decimal places), but its adaptability through the critical intermediary of *software*. So too, the "thinking" metaphor was adapted. *Popular Science* did at least anticipate that

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[290] Eckert Oral History, 74.

[291] An offer from National Cash Register was rebuffed, as numerous industrial information machinery manufacturers faced the question of whether or develop in-house capabilities to meet the prospect of increased digital computer demand, or to acquire a start-up. The early years of the first computer company are well documented in
Norberg, Arthur. *Computers and Commerce: A Study of Technology and Management at Eckert-Mauchly Computer Company, Engineering Research Associates, and Remington Rand, 1946-1957*. Cambridge, Mass: MIT, 2005.

calculations need not all achieve the high drama of answering long unsolved astronomical equations: "Other machines using the same principles need not be so complicated…there is also a great need for simpler highspeed machines that can handle less complex problems."[292] What followed the *annus mirabilis* of 1946 in public awareness mirrored the insights derived inside Eckert and Mauchly's laboratory: namely that digital computers could be purposed to mundane tasks, that Aiken's formulation was wrong, and that business' growing reliance on rapid computer-aided logistics would be an opportunity for profit.

The bigger picture had begun to emerge by 1949 with the founding of EMCC, as a *Fortune* magazine feature on the industry revealed. Titled "Mechanical Brains," the piece, authored by Louis Ridenour, an astrophysicist at the University of Illinois, made explicit reference to the coming upheaval: "An entirely new class of high-speed automatic computing machines, with rudimentary organs of memory, judgment, and mathematical logic, points to the second industrial revolution."[293] This constitutes one of the first deployments of the phrase "second industrial revolution," a powerful coinage (by Norbert Wiener) that would find popular expression in a family of sociological texts, from Daniel Bell to Alvin Toffler to Fritz Machlup to Jacques Ellul, on the new world of information technology. The idea, as Wiener had articulated, was that as the industrial revolution had contrived control mechanisms to act on matter using *force* where human manual labor had previously been required, the technology of the computer, like the brain, acted on information using *logic* where once human intellect had been used. The proposed equivalence suggested not only that computation was a successor to mechanical

[292] Rose, Allen. "Lightning Strikes Mathematics," *Popular Science*, April 1946, 85.
[293] Ridenour, Louis. "Mechanical Brains," *Fortune*, May 1949, 109-118.

advantage, but that its potential impact was as great as the introduction of hydrocarbon power—a singular transformative moment in human history.

In the three years since ENIAC's début, the world had changed. Wiener's *Cybernetics* had been published, making the new science a household word. Eckert and Mauchly had begun taking orders for the UNIVAC computer. Scientific management, systematized and mathematized during World War II, had morphed into the budding field of Operations Research. It was clear that the universal computer had applications far beyond the boundaries of differential equations. Ridenour's article, describing the computer's systems in terms of organs of sense, memory, and computation, actually went further. Inspired by McCullough and Pitts' models of the neuron, it compares the binary arithmetic of the brain to the digital logic of a computer: "The action of each neuron is an all-or-none affair: either it is excited by a stimulus or it is not. In terms of numbers, then, a neuron can sense, or reproduce, or transmit the number *zero* (no response), and the number *one* (full response)."[294] The implication was a cybernetic one; biological cognitive systems are, functionally, computers. Ridenour continued, "Unless we introduce a nonscientific hypothesis of vitalism, we must assume that the human cerebral cortex is a highly complicated but ultimately explicable—and therefore reproducible—digital computing machine."[295] In effect, Ridenour relayed the insights Claude Shannon had presented first to the Macy group to a wider readership, interested not so much in the new vistas of postwar science, but in utility and function of its products.

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[294] Ridenour. "Mechanical Brains," 111.
[295] Ibid. It is beyond the scope of the present argument to etch out the debate on this complicated matter. Objections have been raised premised on Gödel statements (John Lucas 1959), biological naturalism (John Searle 1980), and quantum mechanics (Roger Penrose 1989)—all vigorously rebuffed by the Artificial Intelligence community.

The *Fortune* piece went on to delineate a long string of scientific problems to which computers were just being applied, and generalized further, "The capability of the digital computer is summed up in von Neumann's remark that it is 'the totality of all simple gadgets.' This means that a computer and do anything that any machine can be built to do."[296] In recognition of the promise of EMCC, Ridenour reported firms like IBM, Raytheon, and G.E. beginning to sound out computer work: "[The computer's] applications in business are immediate and clear. It can handle the accounting, payroll, billing, and tax computation of any company, no matter how complicated the rules. More than this, the machine can play an important role in management… Today the job of information storage and processing is far too big for one or even several brains. External aids must be used."[297]

In 1953, IBM at last made its challenge to the front-runners Remington Rand. The titan of office calculation had had its chance to acquire Eckert-Mauchly in 1949, but had demurred, fearing antitrust action. IBM's first entry into the business market, the 702, mirrored the failure of its earlier investment in the Harvard project. Unlike its cousin designed for scientific use, the 701, the 702 couldn't match the pace of industrial capital expenditure. IBM, with its long lag-times in development, could not dent UNIVAC's reputation for reliability and quick delivery.[298] But by 1955, IBM and its vice president in charge of sales, Vincent Learson, had stolen two-thirds of the market from its competitor. "Big Blue" succeeded by integrating computers with its established range of office products – printers, calculators, and, notably, punched cards.[299] As IBM mobilized

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[296] Ridenour. "Mechanical Brains," 113.
[297] Ibid.
[298] Harris, William B. "The Astonishing Computers," *Fortune*, June 1957, 292.
[299] The nickname, "Big Blue," was in fact not coined by business writers until the 1960s, referring to IBM's

its formidable sales force in support of the computer division, office cultures steeped in IBM tradition were easily convinced to upgrade. IBM repairmen worked closely with clients, and omnipresent gray-suited salesmen were cordially familiar with boards of directors. "If I buy [your machine] and something happens—I'll get blamed," executives told competitors. "Let something happen to the 705 and I.B.M. will catch it."[300]

IBM thus contributed to the evolution of the computer from an exotic scientific gadget to a mundane business machine. It leant its powerful brand and reputation to business' race to stay ahead of the competition. As the market grew, so did competition. In 1956 Burroughs and National Cash Register announced large computer projects. They were followed by Honeywell (through its subsidiary Datamatic), R.C.A., and Raytheon.[301] The role computers would play in this transformation of American business, and of American life, was fast becoming visible. By 1965, American customers could choose between over 100 models from over twenty manufacturers. By 1970, the industry of rapid data-processing that arose around these machines accounted for 2% of the gross national product of the United States.[302] The press had featured ENIAC prominently, and UNIVAC's 1952 presidential prediction made it an early star. Still, for all their futuristic appeal, computers lacked a personality. They needed a spokesman.

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characteristically blue covers on its mainframe computers. See
Sellinger, Evan. *Postphenomenology: A Critical Companion to Ihde*. Albany: SUNY, 2006, 228.

300 Harris. "The Astonishing Computers," 294.

301 Edwards, Paul. *The Closed World: Computers and the Politics of Discourse in Cold War America*, Cambridge, Mass: MIT, 1996, 90-102. IBM gained a technological edge from its work with the Air Force on the SAGE missile interceptor system at M.I.T.'s Lincoln Lab. Designing the AN-FSQ7 controller, the largest computer ever built, ultimately required the labors of 20% of IBM's workforce. After IBM was brought aboard as a contractor 1958, it gained exposure to many of SAGE and its companion, the Whirlwind air defense system's important innovations in graphics, display, and magnetic core memory.

302 Mahoney, Michael S. "Cybernetics and Information Technology," in R.C. Olby *et al*. eds., *Companion to the History of Modern Science*. London: Routledge, 1989, 537-556.

Chapter 7 – Build-it-yourself intelligent robots and not-so-giant brains

In October 1949, the *New York Post* ran a large picture of a balding, bespectacled man, whose modest credentials belied the substantial pronouncements he made. Edmund C. Berkeley, formerly an actuary in Prudential Insurance's methods division, had since left the firm to become an independent consultant and writer. He had been working on a book that aimed to make accessible the contemporary history of digital computing machines, and offer some predictions as to their future. "I believe we are approaching a revolution in the handling of information, something like the industrial revolution in application of energy," Berkeley told the *Post*. "I am convinced that machines can do much of work."[303] In keeping with the postwar fashion for grand multilateral regulatory and oversight bodies, Berkeley proposed an agency of government, akin to the Atomic Energy Commission to support and foster appropriate use of information technology, and to supervise the process of knowledge automation.

Berkeley was taken with the power of computers to be applied to commonplace tasks while working under Howard Aiken in the Harvard Computing Laboratory. Since his *summa cum laude* graduation from Harvard with a B.A. in mathematics and philosophy, Berkeley had been obsessed with applying systematic logic to problems of human organization. As a sophomore, he queried his mathematics instructor, George Birkhoff, whether there could be developed an algebra of language. Birkhoff directed Berkeley to a then little-read book, *The Laws of Thought*, by George Boole. Boole's algebra described a notation and simple laws for performing operations on statements and

[303] *The New York Post,* October 13, 1949 clipping. Berkeley Papers box 10, folder 31.

classes of statements, such as "and," "or," "nand," "xor," and "not".[304] Berkeley was exhilarated, visualizing at once how language, logic, and argument could be put on the same rigorous footing as mathematics.

Berkeley's 1930 graduation address, titled "Modern Methods of Thinking" disclosed an enthusiasm for the power of applied *thought*. Rather than rousing them to service, or celebrating their success at finishing Harvard, Berkeley tendentiously lectured his classmates on the utility of Boole's method of ordering knowledge. As in physics or chemistry, Berkeley declared, "The atoms of reasoning and the forces linking them together—the concepts and their relations—can with skill be maneuvered and marshaled, made to form out of solution, into orderly systems of truths, brilliant sparkling crystals of solid substance."[305] He went on to describe these systems (mathematical postulate systems, systems of language, or the Boolean system of logic) as tools of abstraction, capable of rationalizing thought and communication, making them as efficient as possible. While an undergraduate, as later in Aiken's lab, Berkeley was preoccupied with rigorous and systematic methods; unsurprisingly, he went to work in Prudential's methods division. This "methods" approach is deeply analogous with the systems approach to information taken by Wiener, Walter, McCulloch and those at work in the

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[304] Boolean algebra, and the Boolean notation of symbolic logic, was to become a lynchpin of communications engineering, when in 1937 Claude Shannon, then a graduate student of Vannevar Bush at M.I.T. realized the applicability of Boolean operators to the relay and switching circuits of Bush's differential analyzer. Using Boolean algebra and binary arithmetic, Shannon found a simple way of expressing the electromechanical circuitry in telephone routing switches, since switches perform the basic "yes/no" logic of Aristotelian language. Shannon's master's thesis installed Boolean logic at the foundation of digital circuit design. Berkeley appears to have discovered the applicability of Boole's concepts to computers very near the same time.
Shannon, Claude E. *A symbolic analysis of relay and switching circuits*. M.I.T., Department of Electrical Engineering, 1940. Accessed 1 Sept. 2010 <http://dspace.mit.edu/handle/1721.1/11173>
[305] Berkeley, Edmund C. "Modern Methods of Thinking." Berkeley Papers, box 79, folder 7.

meta-discipline cybernetics. Particularly the "second-order" cybernetics of Heinz von Foerster was sensitive to subject's own relationship to the method of analysis.[306]

Without Berkeley's knowledge, the utility of symbolic logic to machine programming was formalized during his time at Prudential by a graduate student at M.I.T. named Claude Shannon. At M.I.T. Shannon discussed with Wiener the foundations of information theory; he, like von Neumann, was one of the cybernetics group whose work directly touched the construction of actual computer circuits.

Shannon was an electrical engineer, but was schooled in mathematics and logic, and had studied George Boole. Shannon's master's thesis, "A Symbolic Analysis of Relay and Switching Circuits," completed in 1937, demonstrated that Boolean algebra and binary arithmetic could accurately model the layout of electromechanical relays used in telephone routing switches. At the same time, he proved as a corollary that the telephone network could be used as a practical experiment to solve problems in symbolic logic. That electrical switches, performing the functions of "and," "or," "nand," and "not," were logical devices may have seemed intuitive to Berkeley, but it revolutionized the communications engineering field. With the theoretical grounding Shannon's thesis provided, practical engineering was finally linked with formal logic.[307] Would-be computer engineers could trust in the notion that the digital circuits they built could be arranged to model any statement, expressed in digital logic, numerical or otherwise.[308]

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[306] "For God's Sake, Margaret," Interview with Gregory Bateson & Margaret Mead. *CoEvolution Quarterly* (10), June 1976, 32-44.

[307] Ségal, Jérôme. *Le Zero et le Un*. Paris: Editions Syllepse, 2003, 78-79.

[308] Thus, there was a clear link from building complete postulate system for mathematics, as Berkeley's heroes Alfred North Whitehead and Bertrand Russell had attempted, and building a computer. Both, indeed, are constrained by the limits of computability discovered by Kurt Gödel and Alan Turing. A computer, in Berkeley's eyes, was fundamentally a system of thought, in tubes and wires. Unlike Aiken, the young mathematician was able to imagine a panorama of computer applications as wide as the spectrum of imagination.

Berkeley himself made this point in a 1950 article written for the journal *Science*, titled "The Relation Between Symbolic Logic and Large Scale Calculating Machines."[309]

Berkeley's tumultuous career at Prudential was marked by repeated efforts to apply mathematical logic to the computation of actuarial tables, and many attempts to acquire a computer for these purposes. He penned several internal memos on Boolean algebra and computers, chafing as his superiors resisted his more revolutionary impulses. Berkeley's notes in the early 1940s reveal a picture of a frustrated man biding his time, waiting to launch a more ambitious project: "Why is it necessary for me that my lovely ideas for perfection should happen?" he wrote. "Well what's life worth living for?"[310] In the face of management's reluctance, Berkeley succeeded in signing one of the first private contracts with the fledgling Eckert-Mauchly Computer Corporation.[311] The machine would be put to use in the relatively arduous domains of premium billing and accounting. Berkeley's interest in automatic computing derived partly from a desire for labor savings. The job of an actuary was painstaking, boring work, particularly for someone with as active a mind as Edmund Berkeley. "Arriving in a life insurance company" he remembered, "I found almost no interest in higher mathematics but an intense concern with correct arithmetical results. I was given a desk calculating machine and spent about three years operating it, just putting numbers into simple algebraic formulas."[312] He gave talks on the possibilities of "mechanical brains" to the likes of the

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[309] Berkeley, Edmund C. "The Relation Between Symbolic Logic and Large Scale Calculating Machines." *Science*. October 6, 1950 clipping. Berkeley Papers, box 26, folder 60.
[310] 1945 Journal, Berkeley Papers, box 1, folder 1.
[311] Campbell-Kelly & Aspray. *Computer*, 97. Even in 1947 Berkeley was pressing his superiors to order a UNIVAC, but the company had balked at the several hundred thousand-dollar price tag.
[312] Berkeley, Edmund C. "About the author." Berkeley Papers, box 10, folder 40.

Actuarial Society of America and the Insurance Accounting and Statistical Organization, while submitting papers on Boolean algebra to uninterested mathematical journals.

There were some at Prudential who shared Berkeley's enthusiasm for systematization. In 1946, a vice president, Harry Volk, tasked the young methods analyst with "Job 42," a program to investigate new technologies that could be applied to the life insurance industry. Berkeley wrote a series of reports he called "The Future of Machines," describing the potential uses of fax machines and digital calculators. In January of 1947, after attending a symposium on computer methods at his alma mater, Harvard University, Berkeley was sparked into two projects: the first, to secure a digital computer for Prudential, and the second, to form a society in which devotees like himself could discuss developments in computer technology outside the veil of military secrecy. The first project ultimately led to a contract with Eckert and Mauchly's ECC to build a machine that, Berkeley wrote, could save Prudential's billing operations 230,000 man-hours a year, and account for more than a quarter million in annual savings.[313]

The second project began slowly; initially Berkeley looked within the insurance industry's Life Office Management Association for likeminded souls. He organized a committee on calculating machinery, and encountered a substantial interest.[314] But he was already thinking more broadly. From his war days in Cambridge he had contacts at Harvard and M.I.T.; from his exploratory missions at Prudential he knew scientists at Penn and Bell Labs, and systems engineers at the Census Bureau. Hoping to reach a wide spectrum of computer people, Berkeley circulated a "Notice on organization of an

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[313] Akera, Atsushi. "Edmund Berkeley and the Origins of ACM," *Communications of the ACM* 50 (May 2007): 33.

[314] Yates, JoAnne. "Coevolution of Information Processing Technology and Use: Interaction between the Life Insurance and Tabulating Industries," *Business History Review* 67 (Spring 1993), 1-51.

‘Eastern Association for Computing Machinery,’” in July 1947. He cited the bold prospects for a computerized future in industry and government, but, importantly, he also noted the value of a human network for sharing and advancing new breakthroughs. The value of the EACM, he exhorted, would be in its “free flow of information.”[315] This same value underlay many of the later computer societies that inherited Berkeley’s mantle; the People’s Computer Company, the Homebrew Computing Club, and numerous other clubs dedicated to computer access for all, took free information sharing as a tenet central to both their means and their aims.

While still employed as “Chief Research Consultant,” at Prudential, Berkeley secured letters of interest from 175 people and organized the first meeting of the EACM at Columbia University on September 15, 1947. John Curtiss of the National Applied Mathematics Laboratories was elected the first president, while Berkeley volunteered to be the first secretary, a post he held for more than six years, positioning himself at the center of most of the important dialogue about computer technology. Two meetings followed in December at the Army’s Ballistic Research Laboratories in Aberdeen, Maryland (birthplace to Wiener’s insight that anti-aircraft gunnery was a kind of servomechanism), and by January 1948, the EACM had 350 members. Berkeley recommended the group drop “Eastern” from its moniker.[316] The ACM, as constituted in 1947, today remains the largest and most important association of computer professionals in the world.

Berkeley’s hopes from Prudential were perfectly expressed by a line of Vannevar Bush he lovingly underscored in the 1949 book *Modern Arms and Free Men:* “One

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[315] Berkeley, Edmund C. “Notice on organization of an ‘Eastern Association for Computing Machinery.’” July 1947, Berkeley Papers, box 8, folder 57.
[316] Akera. “Edmund Berkeley and the Origins of the ACM,” 35.

industry after another began to move out of cut-and-dried empiricism, or plain somnambulance, into deliberately planned programs using the science applicable to its field."[317] Boolean algebra and the logic of computerization seemed a golden ticket for insurance. But it was not to be. By the summer of 1948, the climate had changed inside Prudential. Harry Volk had left and been replaced by a new V.P. with no taste for automation. Berkeley found his efforts butting up against dug-in resistance. That his ideas were seldom adopted does not mean that they were unsound. They were, however, ahead of their time. Berkeley's sometimes abrasive personal demeanor and the scope of the reorganization he proposed likely worked to his detriment. Before the ENIAC's daughter, the UNIVAC 1, was ever installed at Prudential's Newark offices, Berkeley resigned and formed his own firm, Berkeley Associates, in July 1948, dedicated to proselytizing his "revolution." He met a receptive audience.

Less than a month after the *New York Post* story ran, Berkeley's book, *Giant Brains, or Machines that Think* was released by John Wiley & Sons to near-universal acclaim. Its previously obscure author was vaulted to the front pages of the nation's preeminent dailies. He found an airing for even the most far out of his predictions, and his example animated the field of high-tech futurism. The robotic toys he tinkered with in his Newtonville, Massachusetts lab captured the fascination, if not the pocketbooks of millions. Berkeley's survey of the capabilities of computers in existence at midcentury evoked the inexorable march of technology. Science had at last built machines to rival human cleverness, a fact seized on by journalists. Giant brains were "capable of completing in ten minutes the problems that would take a mathematician working day and night more than three years to solve," wrote the *Christian Science Monitor*. Wrote

[317] Berkeley Papers, box 10, folder 54.

Fortune, "This development is only in its infancy, yet already we have machines that see better than eyes, calculate more reliably than brains, communicate faster and farther than the voice, record more accurately than memory, and act faster and better than hands."[318] Berkeley catalyzed a critical mass of hype that propelled computers into mainstream consciousness.

A clear question presents itself: why, is the name of Edmund Callis Berkeley not enshrined with the likes of the computing immortals – Von Neumann, Turing, Aiken, Eckert and Mauchly? How did the face of the "computer revolution" dissolve out of public commemoration? Berkeley's impact on the history of computing is at once obvious, and subtle. For while a stronger public champion of computers did not exist, his technical impact on the fields of hardware engineering and theoretical computer science was virtually nil. Like Wiener, Berkeley excelled at forging alliances and bringing together enthusiasts of information science. Also, like Wiener, he was eminently conscious of his, and the computer's public image, and urged education as the key to easing its transition into modern society. Unlike Wiener, Berkeley had never authored any serious scientific papers; unlike von Neumann, he had not conceptualized the design of any information machine. What he did, and did very well, was describe and explain computers in a way laypeople could understand.

Giant Brains, or Machines that Think hit store shelves in November of 1949, aimed at an educated reading public versed in general science, but lacking any technical understanding of computers of mathematical logic. It was unambiguously pedagogical, and at least as normative as it was descriptive. In its 250-some pages, Berkeley began to construct the first intellectual history of the computer, described those machines then in

[318] *Giant Brains* reviews, 1950 clippings, Berkeley Papers, box 10, folder 30.

use, and outlined his vision of a world automated—and all its consequent time and labor-savings for humans. Inspired by his years at Prudential, he foresaw electronic digital computing assuming a substantial role not only in simple calculation, but in strategic decision-making as well. Computers, as he described them, portended a new day, a few years hence, of streamlined bureaucracy, new intellectual horizons for human thinkers, and great yields in efficiency and rationality across a range of endeavors—political, economic, and social.

Berkeley was not shy with predictions; nor did he pull punches when it came to anointing the logical activity of machines as "thought." The impact was powerful. "An appalling, yet fascinating, little book," *International Herald Tribune* declared. While Berkeley's "thinking machines" could solve equations that would take legions of human calculators years, "they cannot do things that any smart cat would find easy. But maybe one day they will. M. Berkeley is optimistic (or is that quite the word?) about what these automata can be taught to do for, and to, their human creators unless their human creators watch their step."[319] Many reviewers seized on an insight that Berkeley had borrowed from cybernetics, courtesy of McCullough, Pitts, and Walter. The *Herald Tribune* continued,

> Relays and electronic tubes can say 'yes' or 'no' … The trouble is that the ten billion separated brain cells that each of us carries around in his head are all, apparently, constructed in the same way. Each can say only 'yes' or 'no,' and it is out of their myriad combinations of these simple plus and minus reactions that all the poetry, science, law, politics, and philosophy that we know have come. It is a depressing reflection on the processes of thought, yet it does correspond with experience—we all know eminent administrators or lawyers whose major contribution is the ability to say either 'yes' or 'no' at the right time and in the right sequence … If the machines are learning to do it too, we cannot take them lightly.[320]

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[319] "The Thinking Machines," *International Herald Tribune*. December 6, 1949 clipping. Berkeley Papers, box 10, folder 30.
[320] Ibid.

Cynicism notwithstanding, critics by and large accepted Berkeley's description of the digital mechanism of thought as established science, though many expressed a degree of existential discomfort with the idea. As governmental and industrial bureaucracy swelled in size, as electric gizmos permeated more and more areas of American life, intellectuals were only too willing to reflect on pre-programmed nature of man's mind. Americans were increasingly in thrall to, as mathematicians Michael Polanyi put it, "a scientific outlook that appeared to have produced a mechanical conception of man."[321]

Some extrapolated further. *Giant Brains* spoke not only of appliances—traffic lights or thermostats—that "thought," after a fashion. True to its cybernetic roots, it focused on the organization of the *system* – men and machines in dynamic synthesis. Seizing on Berkeley's ideas of computer-automation in intellectual fields, the *New Yorker* suggested,

> The human brain is about to turn certain functions over to an efficient substitute, and we hear of a robot that is now capable of handling the tedious details of psychoanalysis, so that the patient no longer need confide in a living doctor but can take his problems to a machine, which sifts everything and whose 'brain' has selective power and the power of imagination. One thing leads to another. The machine that is imaginative will, we don't doubt, be heir to the ills of the imagination; one can already predict that the machine itself may become sick emotionally, from strain and tension, and be compelled to last consult a medical man, whether of flesh or of steel. We have tended to assume that the machine and the human brain are in conflict. Now the fear is that they are indistinguishable. Man not only is notably busy himself but insists that the other animals follow his example. A new bee has been bred artificially, busier than the old bee.[322]

Such commentary was echoed in publications small and large, local and national. The offhanded tone of the *New Yorker* critic hints at the familiarity of the subject matter to

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[321] Weizenbaum, Joseph. *Computer Power and Human Reason: From Judgment to Calculation*. New York: W.H. Freeman, 1976, 10. Weizenbaum wrote, "Again, the computing machine is merely an extreme example of a much more general phenomenon. Even the breadth of connotation intended in the ordinary usage of the word 'machine,' large as it is, is insufficient to suggest its true generality. For today when we speak of, for example, bureaucracy, or the university, or almost any social or political construct, the image we generate is all too often that of an autonomous machine-like process."
[322] "Talk of the Town," *The New Yorker*. December 14, 1949, 35.

much of the magazine's readership. That the philosophical implications of machine intelligence were being teased out, with considerable fluency, in mainstream, nonscientific publication suggests the widespread cultural impact of computers in Berkeley's moment – a centrality that eclipsed for a time their economic and scientific impact. *The New Yorker* piece, with its casual prophesies of an automated future, is telling evidence that the radical imagination of human machines and mechanical humans was never confined to the far-flung realms of science fiction serials, but was found its way into the living rooms of the postwar middle class.

Notably, *The New Yorker* anticipates with some irony the likelihood of the robotic psychotherapist, programmed to give simple responses to patients' complaints. This fantasy, among the many inspired by Berkeley's book, indeed came true in short order. One of the first public controversies to engulf the field of artificial intelligence systems involved a program designed to mimic the role of a psychotherapist. The breakthrough was not in the diagnosis of disease, but in a rather convincing mimicry of human speech in this highly specialized domain. We will return to this episode shortly.

Perhaps alone among his contemporaries, Berkeley was conceptualizing problems other than workplace automation, although this was manifestly at the forefront of his thinking. For Berkeley, issues of scale, marketability, and computers' effects on daily human life also took center stage. Speed, power, and reliability: these were the targets at which ENIAC engineers aimed. Tubes versus relays, calculations per second, tube burnout ratio, etc. Berkeley's efforts were directed toward an overlooked, *smaller* segment of the market. "I am descended from a long line of Frankensteins," he ominously conceded to the *New York Times Book Review* in 1950.[323] But in fact, his proposed integration of technology into human life was far more pedestrian than Shelley's gothic narrative. "Take ENIAC. Thirty tonnes, all-American, all-electronic tackle—of problems, that is: 60,000 a minute … [But] there's no reason why a family-size model can't be put on the market. It could handle recipes, canceled checks, insurance policies, old letters, telephone numbers, etc.—the sort of thing which, when you can't find it, breaks up a home."[324]

In effect, Berkeley was proposing a desktop personal computer, extrapolating *down* from the technologies of the day, not *up* as is often the temptation in forecasting technological change. His emphasis, as ever, remained on methods of thinking. As he had discovered in Aiken's laboratory, the rationalization and efficiency of symbolic logic can be imposed on a wide degree of tasks. Berkeley's graduation address to his Harvard class of 1930 lays out precisely this vision.[325] His forecasts did not originate in technical possibilities, but in organizational ones. Even unwieldy, kludgy contraptions like the relay sequence-controller or the 1600-Williams tube Colossus yielded to logical *programming*. As Berkeley made the case to America, computers were the instrument to bring order and logic to every aspect of life:

> What about the ordinary everyday effects of these machines upon you and me as an individual? We can see that the new machinery will apply on a small scale even to us. Small machines using a few electronic tubes—much like a radio set, for example—and containing spools of magnetic wire or magnetic tape will doubtless be available to us. We shall be able to use them to keep addresses and telephone numbers, to figure out the

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323 "Review of *Giant Brains*," *The New York Times Book Review*. January 8, 1950, 184.
324 Ibid. Berkeley later mused that only the obstacle of cost kept computers out of the hands of the multitude, "If expense were no barrier, we could make a physically small electric brain using a large quantity of small components (such as transistors, diodes, etc.), which would run extremely well and do many kinds of problems." Berkeley, Edmund C. *Brainiacs*. May 1959, Berkeley Papers, box 1, folder 40.
325 Berkeley emphasized the value of symbolic logic to the insurance business in Berkeley, Edmund C. "Boolean Algebra (The Technique for Manipulating 'And,' 'Or,' 'Not,' and Conditions) and Applications to Insurance," in *The Record of the American Institute of Actuaries* 26 (October 1937): 373-414

> income tax we should pay, to help us keep account and make ends meet, to remember many things we need to know, and perhaps to give us more information. For there are a great many things that all of us could do much better if we could only apply what the wisest of us knows.[326]

The application of computer power to mundane tasks must have seemed like a bold dare in an era when the cost of even a few cycles of any extant computer would have been in the hundreds of dollars.[327] A 1950 article for *Scientific American* expanded the list of possible domestic uses: "One day we may even have small computers in our homes, drawing energy from electric power lines like refrigerators or radios... They may recall facts for us that we would have trouble remembering. They may calculate accounts and income taxes. Schoolboys with homework may seek their help… We may find the future full of mechanical brains working about us."[328] At this time it was not at all clear that miniaturization was the future direction of the thinking machine. Many observers, including Aiken, envisioned only for bigger, faster machines engineered to tackle increasingly complex tasks in ballistics, radio astronomy, physical chemistry, and large-scale number crunching. At times, even Berkeley promoted computer power on the utility model—each user accessing the vast power of a central machine only in such allotments of time as needed.[329] Many believed a centralized utility would be the most cost-effective solution to popular demand for computing.

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[326] Berkeley, Edmund C. *Giant Brains, or Machines that Think.* New York: John Wiley & Sons, 1949, 194.

[327] The first such commercial attempt, in 1969, Honeywell's 316 Kitchen Computer was an unmitigated failure. Simultaneously a kitchen island and cutting board, this home computer was made to recipes, if the user could interpret the binary front panel lights and switches that served as an input/output device. It cost $10,000 and was sold at Neiman Marcus. It appears none were ever sold. See Spicer, Dag. "If You Can't Stand the Coding, Stay Out of the Kitchen," *Dr. Dobb's Journal*, August 12, 2000. Accessed 1 Sept. 2010. <http://www.ddj.com/184404040>

[328] Berkeley, Edmund C. "Simple Simon," in *Scientific American* 183 (November 1950): 40-43.

[329] This utility model, and the reckoning of computer power in man-hours was a precursor to the phenomenon of *time-sharing* that became the prevalent model of computer use on campuses and institutions during the 1960s and early 1970s. Users would sign up for blocks of time, and computer cycles (typically a small proportion of the available power) would be apportioned to their terminal. The alternative of everyone using their own, smaller machine was little considered when a mainframe

Bell Labs was, by antimonopoly consent decree, barred from entering the computer business, and was obliged to make public its technology at a nominal price. Transistors were not yet competitive on mass production cost and reliability with vacuum tubes and relays until the middle of the 1950s, and Bell Labs built several internal models with varying levels of success.[330] New entrants to the field like National Cash Register, Burroughs, and Philadelphia electronics firm Philco might have liked to leapfrog the vacuum tube logic of UNIVAC, but lacked the market presence (and strategic relationships with public sector clients) of their larger competitor.[331] Only the file cabinet-sized "minicomputers" of the Digital Equipment Corporation (DEC), and its iconic PDP-8 model, introduced in 1965, began to gnaw away at established circuit design. Notably, in 1950, when Berkeley constructed his home machine nicknamed "Simon", which may be considered the first true "personal computer," for the hobby market, he employed a relays in its architecture and for its simple 2-bit memory.[332] Berkeley's simple device sold for $190, with a fraction of the power and glamour of ENIAC.

Berkeley's Simon, while a relatively insignificant (and historically overlooked) technical development, appealed to a tradition that was becoming well established on both sides of the Atlantic: that of the electronics tinkerer. Amateur shortwave radio operators, "hams," contributed not just to the creation of a radio audience in the first part of the twentieth century, but several technical improvements in audio amplification

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installation cost between $500,000 and several million dollars.

[330] Irvine, M.M. "Early Digital Computers at Bell Telephone Laboratories," *IEEE Annals of the History of Computing* 23 (July 2001): 22-42.

[331] Ceruzzi, *A History of Modern Computing*, 65.

[332] Berkeley, Edmund C. "Simple Simon."

before the standardization of vacuum tube technology[333]. Amateur radio is a well-documented cultural phenomenon that made its impact on both the demand and supply side of the broadcasting industry. The development in the second half of the century of an electronics hobbyist market, catered to by the Heathkit, the Dynakit, the MITS Altair is, of course, a fitting parallel. The company Heath itself serves a bridge, from audio equipment in the 1940s, through transistor radios, to ultimately 1978's the famous H-8 computer.[334] As we will see in later chapters, this culture of amateur operators provided a critical early market for personal computers, and likely did more to direct the evolution of commercial electronics equipment than is commonly recognized.

Berkeley foretold a nearly endless expansion of power and shrinking of scale. Computer research had only begun five years earlier, he reasoned in 1949. The strides made even in that period had been enormous. Before long, computers would be cheap enough to function as simple, quotidian objects: "We can even imagine what new machinery for handling information may some day become: a small pocket instrument that we carry around with us, talking to it whenever we need to, and either storing

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[333] Douglas, Susan J. *Listening In: Radio and American Imagination*. Minneapolis: University of Minnesota, 2004, 16, 58.

[334] Heathkits played a seminal role in the education of a number of computer pioneers, including Apple Computer's Steve Jobs. Jobs' credits Heathkit with engaging him in the creation of electronics, beyond merely consumption: "Heathkits were really great. Heathkits were these products that you would buy in kit form. You actually paid more money for them than if you just went and bought the finished product if it was available. These Heathkits would come with these detailed manuals about how to put this thing together and all the parts would be laid out in a certain way and color coded. You'd actually build this thing yourself. I would say that this gave one several things. It gave one a understanding of what was inside a finished product and how it worked because it would include a theory of operation but maybe even more importantly it gave one the sense that one could build the things that one saw around oneself in the universe. These things were not mysteries anymore. I mean you looked at a television set you would think that "I haven't built one of those but I could. There's one of those in the Heathkit catalog and I've built two other Heathkits so I could build that." Things became much more clear that they were the results of human creation not these magical things that just appeared in one's environment that one had no knowledge of their interiors. It gave a tremendous level of self-confidence, that through exploration and learning one could understand seemingly very complex things in one's environment." "An Oral History Interview with Steve Jobs," *Smithsonian Institution Oral and Video Histories*, April 20, 1995. Accessed 1 Sept. 2010. <http://americanhistory.si.edu/collections/comphist/sj1.html>

information in it or receiving information from it. Thus the brain with a motor will guide and advise the man just as the armor with a motor carries and protects him."[335]

It is not clear that scientists gave much credence to these arguments, or even harbored grand ambitions of small powerful computers at all. But it is clear that, partly through Berkeley's efforts, laypeople began to believe computers mattered to them. In 1962, writing in *The New York Times*, science fiction author Arthur C. Clarke echoed many of Berkeley's pronouncements: "For as computers become smaller, cheaper, and more reliable they will move into every field of human activity. Today they are in the office; tomorrow they will be in the home. Indeed some very simple-minded computers already do our household chores; the device that programs a washing machine to perform a certain sequence of operations is a specialized mechanical brain."[336]

Predictions of this sort naturally give rise to a chicken-or-the-egg problem. Technical developments like thumbnail-sized chips made feasible smaller, personal systems. But absent a market primed for their arrival, such machines would likely never have been developed. This was Berkeley's work; acquainted with his vision of the future, readers likely wondered when they could expect a digital computer of their own. Given Berkeley's insistence on computers for everyone, it is well to ask, how robust was the evolutionary path of the digital computer toward individual consumer use? Put another

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[335] Berkeley. *Giant Brains,* 195.

[336] Clarke, Arthur C. "Spark of the Second Industrial Revolution," *The New York Times Magazine*, December 9, 1962, 127. Clarke identified the invention of the transistor, and the move to solid-state electronics, as the seminal moment in the history of the "electronic revolution," that he too compared to the 19th-century industrial revolution. "The transistor is of such overwhelming importance because it (and its still smaller successors) makes practical hundreds of electronic devices which were previously too bulky, too expensive or too unreliable for everyday use," Clarke wrote. Most of Clarke's contemporaries viewed transistors as a critical step away from unreliable vacuum tubes. But, by emphasizing the routine, inexpensive uses to which transistors could be put, Clarke focuses attention on the transistor's advantage of size. Berkeley, and later Clarke, were among the few to publicly link the future of transistorized electronics, and the use of computers in everyday life.

way, how likely, in 1950, was an alternative branch such as timesharing or third-party computer leasing to take a dominant market share? Like most counterfactuals, this question may be merely an intellectual exercise, but two observations bear consideration. First, opinion-makers like Berkeley estimated the future of computing machines not only by inferring forward their present capabilities, but by imagining future spheres of demand. His end user-centric philosophy was built on optimism that most technical hurdles could be cleared with relative ease.

It is axiomatic that the invention of the transistor in 1947 by John Bardeen and Walter Brattain at AT&T's Bell Labs (and William Shockley's semiconductor-based junction transistor) served as the critical moment in computer design, from the perspective of scale.[337] A commonly refrain further suggests that the invention of the independent invention of the microchip by Texas Instruments' Jack Kilby in 1958 and Fairchild Semiconductor's Robert Noyce (later a founder of Intel) in 1959 itself led inexorably to smaller and cheaper machines through institution of Moore's Law.[338] Indeed, solid state electronics improved both the durability and affordability of logical circuitry.

This linear history argues that vacuum tubes, transistors, and integrated circuits form a natural chain of succession in speed and reliability of logical processing. Here, the dominant account suggests that computer makers were pushing against a wall that prevented the cost-effective manufacture of small computers, and in due course they

[337] It should be noted that, despite their potential for logical complexity, reliability, and low power use, transistors were not an instant hit in the computer business. Yost, Jeffrey R. *The Computer Industry*. Westport, CT: Greenwood, 2005, 54.
[338] Gordon Moore formulated his "law" that the number of transistors that can be fitted on a microchip doubles every two years in 1965. If this "law" is taken to mean that the processing power of a solid-state digital computer increases at this rate, then its validity antedates its inception by at least a decade.

broke it down. T.R. Reid, writer of the authoritative biography of the integrated circuit, *The Chip*, reports that Sperry-Rand, makers of UNIVAC, were working on a desktop model in the late 1950s, before Noyce's computer-on-a-silicon-wafer breakthrough made such an idea feasible.[339] By 1962, John Mauchly was able to embrace the modern term; "There is no reason to suppose the average boy or girl cannot be master of a personal computer," he was quoted in *The New York Times.*[340] Paul Ceruzzi heralds the revolutions of DEC's PDP-series minicomputer, and Intel's 8080 microprocessor, but chides the companies for missing the move to micros, and for targeting the embedded circuits market, respectively.[341]

But the idea that microchips necessarily beget personal computers overlooks the use to which the vast majority of microchips are embedded: in telephones, televisions, automobiles, airplanes, microwaves, etc.[342] The configuration known as the "personal computer" arose out of an interplay of forces of which *demand* was as powerful as any. Those who have made predictions based on what people are likely to *want* to do, rather than what machines will be *able* to do, have been rather more successful in the long run. Despite his middling success as a computer entrepreneur, Berkeley's feel for durable long-term market dynamics was extraordinary.

Historians of computing have lately focused much attention on the *suppliers* of technology, be they government benefactors, research labs, or industrial heavyweights like IBM. This is natural; there is far more historical material originating from scientists

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[339] Reid, T.R. *The Chip: How Two Americans Invented the Microchip and Launched a Revolution*, New York: Random House, 2001, 4.
[340] "Pocket Computer May Replace Shopping List," *The New York Times*, November 3, 1962, 23.
[341] Mahoney, Michael S. "Review of Ceruzzi, Paul E. *A History of Modern Computing*," 93.
[342] Microscopic arrangement of transistors, diodes, capacitors and resistors printed on thin semiconductor—thereafter silicon—wafers.

and administrators than from shoppers. But if supply is seen as at least partly reactive to demand, we will have to come to understand how computing culture, such as it arose, participated in the process of technology creation.[343] Historian Ruth Schwartz Cowan has defined the murky area where consumer decisions meet available technology as the "consumption junction." This site has been described by Carolyn Goldstein as the sphere of home economists, who are the mediators between production and consumer choice, by Schwartz Cowan as "the place and time at which the consumer makes choices between competing technologies," and by Ronald Kline as "the mediation—by advertisers, sales people, and others—between groups we call consumers of technology and those we call producers of technology, such as inventors, engineers, managers, and workers."[344]

It must be acknowledged that Berkeley had some role in shaping these market dynamics; indeed, his advocacy raised consumer awareness and pushed manufacturers in the direction of smaller, cheaper computers. Berkeley, and others we will meet later, shared a cybernetic, "coevolutionary" outlook and were by-and-large successful at seeing it propagated across an expanding community of adepts. While the arrival of mass-market, user-friendly personal machines was not written in destiny at Noyce's lab in

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[343] Yood, Charlie. "The History of Computing at the Consumption Junction," *IEEE Annals of the History of Computing* 27 (January-March 2005): 86-87.
[344] Schwartz Cowan, Ruth. "The Consumption Junction: A Proposal for Research Strategies in the Sociology of Technology," in Bijker, Wiebe E., Thomas P. Hughes, and Trevor J. Pinch, eds. *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge, Mass.: MIT, 1989, 263.
Kline, Ronald R. *Consumers in the Country: Technology and Social Change in Rural America*. Baltimore: Johns Hopkins, 2000, 9.
Goldstein, Carolyn M. "Part of the Package: Home Economists in the Consumer Product Industries, 1920-1940," in Stage, Sarah and Virginia B. Vincentl, eds. *Rethinking Home Economics: Women and the History of a Profession*. Ithaca: Cornell, 1997, 271-298.

1959, or at the Moore School in 1947, an environment was continuously being created that was at the least favorable for this outcome.

It is difficult, of course, to map the many competing interactions at the point of sale, but it merits making a first effort. Here, Berkeley and others like him may shed new light. The forces that shaped consumer attitudes about computer technology had as much influence as cost, speed, and reliability in driving adoption. Berkeley's was indeed one of many voices contesting for computers' place in society. But his is a central one, both accurate and influential in directing computer power to the needs of the many. Popular histories favor the tycoons of industry, technology entrepreneurs like Noyce and Gates, while academic histories dismiss such "great men" narratives, preferring institutional and organization-centered microhistories. Both have thus far underestimated Berkeley's influence in this important regard.

Simon, the first computer worthy of the name intended for a home market, is important not because it sold mass quantities (it did not), but because it reflects a prescient engagement with the demand side. It was an icon of Berkeley's efforts at proselytizing the uninitiated; moreover it served as proof-of-concept. Boolean machines with all the theoretical potential of UNIVAC could be made the size of a box, for a few hundred dollars. In the decades following, others, better equipped than Berkeley to build consumer-friendly machines, would a parallel discovery. In 1950, Berkeley was tapping into a rich vein of exploration and personal discovery. His personal machines were built to be both fun and educational. It is unknown whether Simon *per se* influenced a generation of computer designers, as only a few dozen were sold. Still, this experiment is emblematic of Berkeley's approach to computer machinery, and his individual crusade to make computing accessible to all, when very few others were in this game. Berkeley's enterprise would win converts; as technology became less daunting, the prospect of the "computer revolution" would seem more real to all Americans.

Some of Berkeley's devices were consciously aimed at a different market: children. There was always an element of deliberate pedagogy in work, and consistently throughout his life, he wrote on methods of science and math education. He presented occasionally in local schools on computers and won a reputation as a friend to children.[345] Besides Simon, Berkeley constructed an endearing electronic squirrel, named "Squee," with two phototubes for eyes, a scoop that opened and closed, a drive motor, and a program to hunt a "nut" (in reality a tennis ball) and return it to its "nest." Squee was adroitly positioned as a public relations tool for Berkeley Enterprises—and it worked. Receiving mention in *Newsweek*, *The New York World Telegram*, and the *New York Times*. On March 19, 1956, *Life Magazine* covered Squee and Berkeley's puzzle-solving , tic-tac-toe-playing computer kit, "GENIAC," with a full-page pictorial. Tiny robots, Berkeley explained, could operate by themselves or play games with people, and were a natural hook to an audience unsure of what computers meant to them. The pictorial was aimed squarely at the lay reader, with a revealing hook for a title: "Robots for Fun."

Squee, GENIAC, and the other small-scale machines that followed were tapping into a market that would come later to have a meaningful impact on the computer industry. The hobbyist subculture, as it was named in the 1970s was not a new phenomenon, but developed out of the tinkering communities surrounding shortwave radio, home electronics (seminal computer-maker Heathkit manufactured popular

[345] Correspondence, Berkeley Papers, box 1, folder 8.

television and stereo DIY kits), and home robotics. That Berkeley saw the nexus of computing and garage-scale electronics indicates both a farsightedness on his part that would prove financially disadvantageous, and a unique concern with size and cost. Berkeley's larger project, naturally, was as a public relations ambassador, and tiny robots made good headlines.

"The main purpose of this program," Berkeley told *Life*, "was to make 'Robot Show-Stoppers', to help meet the problem of an advertising director who wants to put into his display in a show or convention some device which will 'STOP' every person there and make him notice it."[346] Better than anyone in the computer community, Berkeley excelled at just this task. But there was a more scientific purpose as well, one that pushed near to the frontiers of computing – artificial intelligence: "[Our purpose] is to explore the intelligent behavior of machines and master their techniques." Berkeley did not accomplish any tremendous technical breakthrough with his robotic squirrel, but he was succeeding in a commercial venue, without university or government backing. In 1956, a heady achievement.

Despite Berkeley's fame at the time, few could then have predicted how information technology would evolve. The explosion in the consumer market for electronics, from radios to personal computers, may be cited as a case study in the law of unintended consequences. The concerns animating ARPA administrators who in the 1970s underwrote the first network transfer protocols were military; they could not have predicted the flowering of the World Wide Web in the 1970s. In the 1950s, IBM coveted the office mainframe niche established by Remington Rand; even the foresighted Thomas Watson, Jr. failed to appreciate how IBM's dominant market position would persuade

[346] "GENIAC," *Life*. March 19, 1956 clipping. Berkeley Papers, box 68, folder 27.

executives to switch to PCs. But though the long cycle of historical change is prone to chaotic perturbations, there are conditions, necessary though insufficient, that make particular outcomes decidedly *more* possible. The consumer-oriented rhetoric deployed by Berkeley laid an important groundwork.

Giant Brains, published a year after Berkeley had left Prudential, was his manifesto. Computers—electric brains—had arrived, he insisted, and they were here to stay. The text is part pedantic exposition of the specifications and function of computers such as the ENIAC, and Harvard Mark I, part social commentary, part primer in information theory, and part prophesy. Declaiming first, "This book is for everyone," Berkeley set about a program of mass education and computer consciousness-raising—as much to defend science and digital logic from the suspicion as to outline a bold new frontier. By his own admission to his publishers, Berkeley was a teacher and a popularizer.[347]

While still at Prudential, his interests intersected with those of the readability expert and phonics consultant Rudolph Flesch, with whom he began a long correspondence.[348] Their efforts were geared at streamlining writing, hacking through dense, needless verbiage, in order to appeal to the widest audience possible. A Wiley internal memo worried, "It does not seem to be aimed at any particular group… The author has tried to suit too many potential customers, and in doing so he goes over the heads of those who have no preparation in the field and talks down to those who might have real interest in the field."[349] Such were the difficulties of writing a book of popular science. Berkeley fervently rejected this criticism. While a serious work on a difficult

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[347] Berkeley, Edmund C. "About the author." Berkeley Papers, box 10, folder 40.
[348] Correspondence with Flesch, Berkeley Papers, box 2, folder 42.
[349] "Memo to John Wiley & Sons," 1948, Berkeley Papers, box 10, folder 29.

subject, he appealed to his editors, "the language used in this book is, I believe, really simple … There are fewer than 1800 different words of two or more syllables used for explaining."[350] The publisher agreed. "While no Huxley or Bacon," concluded a reviewer of the manuscript, "Mr. Berkeley has the rare gift of being able to write as naturally as though he were chatting with a friend…What is difficult and strange is compared to the familiar—for example the mechanical brain is likened to a railroad line."[351] Very consciously, Berkeley was writing the first book for a mass audience on the subject of computing. At the same time, clear writing carried forward Berkeley's abiding interest in methods, logic, and the rationalization of mental labor. In the 1937, Berkeley wrote a series of letters, with Max Talmey, a doctor and the mentor of a young Albert Einstein, in Esperanto.[352] Whether his attention flitted to gardening, or early childhood education (two recurrent subjects in his corpus), or language, or computers, Berkeley always evinced a mania for efficiency.

Aware of the polemical argument implicit in his title, the introduction of *Giant Brains* immediately sets to work defending Berkeley's chosen terminology. The beginning of this chapter concerned the use of metaphor: how new ideas are packaged in terms of the old to grease the mechanism of their acceptance. Concepts that are framed in familiar terms, particularly technologies of social change, are more readily adopted. Information "surfers" were as aware of this technique as anyone else. Berkeley's intent was such, as he shared Flesch's affection for plain speech. "Another argument in favor of the term 'mechanical brain' is that what it denotes is clear to the uninitiated, and the term

[350] Ibid.
[351] "Review memo, John Wiley & Sons," 1948, Berkeley Papers, box 10, folder 29.
[352] Correspondence with Talmey, Berkeley Papers, box 1, folder 1.

attracts attention," he wrote.[353] "It is much clearer to ordinary people than the closest competing term 'digital computer.'" In an era where 'computer men' were a poorly understood vanguard, Berkeley would have liked to possess the flair of a Madison Avenue opinion-maker. Indeed, while at Prudential, Berkeley read Sills and Lesly's textbook, *Public Relations*, and took to heart marketers' lessons in linguistic framing.[354] The title of his book is clearly a self-conscious PR maneuver. Though he did not coin the term "mechanical brain," he surely appropriated it as his own.

Berkeley's interest in the attitudes of the non-specialist is of supreme importance to subsequent history. If the computer was to be applied only to the calculating needs of mathematicians like Aiken, or the Army's ballistics laboratories, it would remain a mere curio, testament perhaps to the fabulous technological leaps of postwar science and nothing else. Popular attention would abate. But, for Berkeley, computers' potential was much more, and it depended on educating the layman. His premise is that the success of a nascent computer industry would not only modernize business or advance science; it will be to revolutionize everyday life, to empower people to think in new ways, and, (as he had experienced from his desk at Prudential) to lift them out of the drudgery of menial information processing.

To this end, Berkeley was positively obsessed with language. Flesch's influence is unmistakable. He studied the efficiency of every word, boasting of the razor-sharp clarity of his message. "The term 'mechanical brain' is being used in more and more

[353] Berkeley, Edmund C., "As Quick as a Thought," Article for submission to *Amazing Science Fiction*. August 8, 1949. Berkeley Papers, box 15, folder 67.
[354] Sills, Theodore R. and Philip Lesly. *Public Relations: Principles and Procedures*. Chicago: R.D. Irwin, 1946. Copy in Berkeley Papers box 2, folder 49.

places," he reported in 1949, "and is steadily gaining popular acceptance."[355] Indeed, UNIVAC advertising pamphlets from 1951 refer to the UNIVAC I mainframe computer as a "giant brain" capable of greatly reducing businesses' overhead.[356] Commentators found themselves increasingly adopting Berkeley's language in order to describe what computers did. But Berkeley's term implied a host of new meanings. When he called these machines "brains," he meant to imply more than the means to rapidly add and subtract. Flexibility, the capability to handle all manner of logical operations, was their chief virtue.

In Berkeley's employ, the term "brain" is more than poetry. Encoded in his language itself is the assertion that computers are logical machines, not simply arithmetic tools. Like a McCulloch/Pitts neuron, their circuits could compose logic gates, firing *on* or *off*. If human reasoning was, as Berkeley believed, entirely circumscribed by the calculus of Boole, then computers could be brains in a very material sense. This was a cardinal example of the cybernetic reason; the equivalence of machines and organisms ought to be considered as a matter of function and organization. It was perfectly acceptable to mathematicians like Wiener and von Neumann to effectively black box the *stuff* of minds – information was about relationships, orders, operations. The material substrate of the homeostatic, self-directed information system was of tertiary concern.

In this spirit, Berkeley sets forth the definition: "These machines are similar to what a brain would be if it were made of hardware and wire instead of flesh and nerves. It I therefore natural to call these machines *mechanical brains*. Also, since their powers are

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[355] Berkeley. "As Quick as a Thought," 2.
[356] UNIVAC. Computer Product Literature 1948- (CBI 12), 1951. Box 91. Charles Babbage Institute, University of Minnesota, Minneapolis.

like those of a giant, we may call them *giant brains*."[357] Berkeley, the educator, was alert to semantics. Yet while describing what would appear to be a material, architectural equivalence, he goes on to make a functional, behavioral argument: "Can we say that these machines really think? What do we mean by thinking, and how does the human brain think?" Referencing without citation McCulloch and Pitts' all-or-nothing neuron model, Berkeley depicts thinking as a series of switches—like the logical decisions performed by machines. The simplest and smallest unit of information is nothing more than a binary relationship, appearing, "as a 'yes' or a 'no,' as 1 or 0, as the presence or absence of something, as black or white, as good or bad, etc."[358] A machine's basic function is to handle information, Berkeley writes; "it can calculate, conclude, and choose; it can perform reasonable operations with mathematics. A machine, therefore, can think."[359]

That we do not today refer to automatic calculating machines as "mechanical brains" is not due to a lack of effort on the part of Edmund Berkeley. The shift in terminology from "brain" to "computer" that occurred gradually in the early 1950s in the popular press is significant. At one level, it represents Berkeley's failure to win over a majority of the media and the reading public to his grandiose vision. Still, the growing lay use of "computer" is reflective of epistemological shifts apparent in the period after ENIAC's 1946 unveiling. That "computers" embody many of the properties of "brains" became so well established that a single term explicitly making this comparison was superfluous. Wiener's *Cybernetics*, McCulloch and Pitts' logical calculus, and von Neumann's *The Computer and the Brain* had all made clear that what brains did was

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[357] Berkeley. *Giant Brains*, 1.
[358] Berkeley. "As Quick as a Thought," 3.
[359] Berkeley. *Giant Brains*, 5.

"compute." Less quantifiable concepts like *eros* and *thanatos*, or *ego* and *id*, had given way to "information processing," "feedback," and "purpose." Edmund Berkeley crystallized these ideas in a single term, but as they became more established, his term likely seemed trivial, even pedantic.

The argument over whether the term "mechanical brain" was appropriate hinged, according to Berkeley, on semantics. Rather than redefining "think," with some great metaphorical flourish, Berkeley appealed for a narrow definition: "Their dictionary definitions refer to operations that in many cases a machine has performed and in other cases no machine has yet performed. It is universally recognized however that surprisingly many operations of thinking can be performed by a machine of the type called mechanical brain."[360] Furthermore, that a machine is merely *instructed* to operate on information is no explicit damnation; humans too are programmed in many ways, and respond predictably to stimulus: "Nearly all that you and I as human beings do is largely determined by our education and training. We also are 'programmed' to a very great extent, and some of us more than others… If we say that a mechanical brain can only think in limited ways, then there are certainly a number of human brains that can only think in limited ways."[361]

Elsewhere, researchers in the emerging field of cognitive science were refining this belief, seeking a successor to the cold reductionism of behaviorist psychology. Men like George A. Miller and J.C.R. Licklider, versed in the functionalist school of John B. Watson and their Cambridge colleague B.F. Skinner that looked at humans as conditioned programs, sought to incorporate the new science of information to scientifically model

[360] Berkeley. "As Quick as a Thought," 1.
[361] Berkeley. *Giant Brains*, 2.

the logical workings of the human brain.[362] Licklider and Miller's work, as we will see, developed this approach further to incorporate computers as a part of the cognitive *system*, pioneering valuable insights into what would become known as "artificial intelligence."[363] Behaviorists conceived of the human organism as a machine, but were little troubled by how the mechanism worked. Cognitive scientists evolved this effort beyond superficial observation toward a deeper theoretical understanding. The mechanistic worldview articulated by Berkeley was a prerequisite for the systematic exploration of the cognitive function of the brain. Cybernetics, as Berkeley viewed it, thus marks a transition, from equation with a machine to investigation of the machine.364

Not only were humans more predictable than they might first appear, but computers in 1949 were hardly representative of the range of what the technology might ultimately accomplish. A program, entered laboriously by rewiring its plugboard "function table." Input was direct and abstraction difficult. Output could printed by an IBM card punch; bugs could only be determined by back-translating the output code. One could hardly imagine this contraption capable of intuition or leaping to conclusions, auto-programming, or even *learning*. The ENIAC, by outward appearance, was little

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[362] Waldrop. *The Dream Machine*, 72-73.
[363] For a summary of Licklider's work as a psychologist, before his foray into computer science and science administration, see Miller, George A. "J.C.R. Licklider, psychologist," *Journal of the Acoustical Society of America* 89 (April 1991): 1887.
[364] As we designed artificial brains to be ever more like us, scientists begun to view human intelligence as ever more machine-like. If computers were brains, brains, too, were computers. Sociologist Harry Collins defines the mission statement of strong Artificial Intelligence as denying a "knowledge barrier" separating what computers can and cannot do. As long as we could make an action "machine-like" or "behavior-specific"—that is we could specify the required steps formally—a computer could perform it. Collins' analysis of the history of expert AI suggests a corollary: implicit in the creation of computation models of phenomena is the rationalizing and organization of these phenomena along mechanical lines. Before mechanization could take over the factory, Ford and Taylor had to make workers behave as a machine. The machine was an outcome of this organization.
Collins, Harry M. *Artificial Experts: Social Knowledge and Intelligent Machines*. Cambridge, Mass.: MIT, 1992, 240.

brainier than an electric toaster.[365] But if the syntax of a given activity could be specified, a computer, in principle, ought to be able to perfect it. "Men have only just begun to construct mechanical brains," Berkeley noted. "All those finished are children; they have all been born since 1940. Soon there will be much more remarkable giant brains."[366] Though stated purpose of the work was pedagogy, *Giant Brains* contained more than an element of imaginative futurism. A line of succession can be traced, running from Edmund Berkeley, through Arthur C. Clarke and Alvin Toffler, to Stewart Brand, Bill Joy and Ray Kurzweil. It is not too much to say that Berkeley was the first computer scientist to seriously, publicly consider the impact computers could have decades, if not centuries forward. As a prophet, his record is spotty. He did, however, help inaugurate a genre of prediction, founded on extrapolating from the potential uses of information technology.

Giant Brains is crowded with forecasts of ways that automation of information processing would serve modern society. The idea that small-scale computers would be made cheap enough for retail consumptions is nearly buried by a litany of more extravagant claims. Notable among these is his suggestion of the possibility of a worldwide electronic library, archived by machines "that will tell very swiftly where to find certain information."[367] This powerful idea had a longer history than Berkeley realized. The July 1945 issue of *The Atlantic Monthly* published an article by Vannevar Bush, director of the World-War II-era Office of Scientific Research and Development, which oversaw the Manhattan Project. Bush had built M.I.T.'s famous analog

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[365] It might be noted that toasters themselves have evolved greatly in intelligence and skill. An Arizona software company has developed a toaster running an austere version of the UNIX operating system, with a LED display, and Ethernet connectivity: http://www.embeddedarm.com/software/arm-netbsd-toaster.php
[366] Berkeley. *Giant Brains,* 8.
[367] Berkeley. *Giant Brains*, 9. The digitization of records has of course proven useful at many organizations. More ambitiously, the search engine Google announced in 2004 its effort to create a universal library of out-of-print books, available free on the web.

Differential Analyzer and retained an informed interest in computing during his government service. The *Atlantic* article proposed that as the American economy shifted from war production to peacetime, a greater emphasis should be placed on organizing and handling information. The management of data was to occupy the central postwar challenge facing public and private institutions. Science had progressed so far, Bush argued, that the sum of knowledge was becoming overwhelming and inaccessible to individuals:

> "Professionally our methods of transmitting and reviewing the results of research are generations old and by now are totally inadequate for their purpose. If the aggregate time spent in writing scholarly works and in reading them could be evaluated, the ratio between these amounts of time might well be startling… The summation of human experience is being expanded at a prodigious rate, and the means we use for threading through the consequent maze to the momentarily important item is the same as was used in the days of square-rigged ships."[368]

What Bush proposed, in the manner of an engineer drafting a rough sketch, was a system of microphotographed records, similar to microfilm, that he later called "memex." Most importantly, these records would be linked by "associative trails," that would cross-index words or ideas in a given record with other records. In effect, Bush had envisioned hypertext, a fractional, splitting text composed of a web of hyperlinks.[369] The two men who are credited with the invention of modern hypertext, Ted Nelson and Doug Engelbart, were both admirers of Bush's proposal.

Surveying the ascendant technology of the 1940s, Bush imagined the memex composed of tiny photocells, packed with shrunken images of the macro text. This vision was very much in accord with his analog approach to computing. Berkeley, writing in 1949 in the halo of ENIAC's success, envisioned instead a *digital* method. Information

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[368] Bush, Vannevar. "As We May Think," *The Atlantic Monthly*. July 1945. Accessed 1 Sept. 2010. <http://www.theatlantic.com/magazine/archive/1969/12/as-we-may-think/3881>
[369] Byers, T. J. "Built by association," *PC World* (April 1987): 244–251.

reduced as microfilm could be made extremely tiny and portable; information reduced to 1s and 0s could be made almost infinitely small, and portable over a wire. What Bush explicitly described in "As We May Think," was a database of linked scientific records, for use by professionals. Berkeley, in his fashion, wondered what would happen if everybody could use a digital memex. He anticipated, even where Bush did not, the ability of computers not only to store and retrieve information, but to organize it, and to communicate with one another. Mechanical brains could be used not only for the intellectual development of the individual, but indeed by the many, to network among themselves. "Thus we can see," he concluded simply, "that mechanical brains are one of the great new tools for finding out what we do not know and applying what we do know."[370] In reality, neither Bush nor Berkeley deserve credit for predicting the Internet—hundreds of critical ingredients, both technological and social, were hidden from them. But both men were able to foresee, where computers had been put only to narrow purposes, that great need and great possibility were on the horizon.

Other applications besides archiving were manifold in Berkeley's mind. In a few pages he composed a laundry list suggesting automatic address records, automatic translation, and speech-to-text (automatic stenographer).[371] Many of these applications required general problem solving and identification skills easily mastered by small children, but difficult to formalize in code. Where computers had a leg up was in the rapid calculation of millions of possibilities, at the level of expert knowledge. Berkeley

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[370] Berkeley. *Giant Brains*, 9.
[371] Berkeley. *Giant Brains*, 181-182. The latter applications required breakthroughs in machine intelligence that have proven slow in development. Pattern recognition, both in written texts and in speech, still bedevils AIs. Machines have difficulty differentiating individual characters and syllables from one another; thus squiggly lines of letters called "captchas" can be used by security firms to filter out robotic spammers from human users. Berkeley's heir, the futurist Ray Kurzweil made many breakthroughs in the area of speech recognition, developing the first large-vocabulary "automatic stenographer" in 1987.

offered two predictions in this arena, both of which would come quickly to fruition.[372] The first, that computers could numerically model weather patterns, had been proposed even before technology existed to make it feasible.[373] By 1950, John von Neumann and a team of meteorologists had conducted a successful forecast using simplified equations for atmospheric dynamics on the ENIAC. The second expert system Berkeley recommended was a machine for "psychological testing."[374] He proposed that a program could be created with a database of responses to standard psychological disorders, and a set of linked pathways, in the manner of memex, leading to a diagnosis.[375]

The publication of *Giant Brains* in 1949 also marked the début of Berkeley's Simon. "Simple Simon," is introduced in Chapter 3—"A Machine that Will Think"—as a thought experiment: a reduction of the principles of digital computation, as laid out by Alan Turing, to the simplest possible mechanical configuration. Simon, "so simple and so small in fact that it could be built to fill up less space than a grocery-store box," was at once a demonstration piece and an educational tool.[376] Plans to build the machine, and program a simple routine would be published the following year in the hobby journal

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[372] Berkeley. *Giant Brains*, 189-190.

[373] British mathematician Lewis Fry Richardson's 1922 forecast was a failure. June 15, 2004. Lynch, Peter. "Richardson's Forecast: What Went Wrong?" *Symposium on the 50th Anniversary of Operational Numerical Weather Prediction*. University of Maryland, College Park, MD. June 15, 2004. Accessed 1 Sept. 2010. <http://www.ncep.noaa.gov/nwp50/Presentations/Tue_06_15_04/Session_1/Lynch_NWP50.pdf>

[374] Berkeley. *Giant Brains*, 190. Berkeley's prediction of automated psychotherapy foreshadowed a controversy that touched both the computer and psychology communities in the 1960s. Joseph Weizenbaum's ELIZA was a program intended as a demonstration of computer-human conversation through recursive grammars, such as that of a Rogerian psychotherapist. Instead, it was embraced as the real thing: an automatic therapy machine à la Berkeley. Appendix 1 describes the controversy in more depth.

[375] Such rule-based systems have a long history in medical diagnosis, though unless a medical problem is narrowly specified, many systems' responses have been overly rigid. See: Szolovits, Peter *et al.* "Artificial Intelligence in Medical Diagnosis," in *The Annals of Internal Medicine* 108 (January 1988): 80-87.

[376] Berkeley, Edmund C. & Robert A. Jensen. "Constructing Giant Brains," *Radio Electronics* October 1950 clipping. Berkeley Papers box 68, folder 2.

Radio Electronics.[377] A magazine aimed at the hobbyist subculture, *Radio Electronics* regularly printed how-to manuals for building everything from shortwave radios to television sets. Simon appealed to these tinkerers. It was not capable of any great feats of calculation; it performed a numerical operation every 2/3 of a second, while the Moore School team's BINAC performed 3,500 every second. Berkeley's goal was instead to introduce a new class of businessmen, students, and families to mathematical logic:

> It may seem that a simple model of a mechanical brain like Simon is of no great practical use. On the contrary, Simon has the same use in instruction as a set of simple chemical experiments has: to stimulate thinking and understanding, and to produce training and skill. A training course on mechanical brains could very well include the construction of a simple model mechanical brain, as an exercise.[378]

At the same time, Berkeley conceived of Simon in the same terms as the giant calculating machines installed at Harvard and the Aberdeen Proving Grounds. Simon's "flesh and nerves" represented information, and it was substantively no different than its bigger cousins. It could add, subtract, compare, store, and retrieve values. It was fed by a punched paper tape and rather than printing to punched cards, its output consisted only of five external lamps, lit in different patterns.

To Berkeley, Simon was a mind of a sort. Gleefully indulging in what would later be known as the ELIZA effect, Berkeley imbued his creation with personhood and personality. "Is he docile? Is he stubborn?" Berkeley asked. "We know what his capacity is, but we do not know how to tell him anything. How do we connect our desires to his behavior?"[379] Personification was a device to reach readers, to connect to their experiences "programming" children or pets. Significantly, a small, "simple" box of

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377 Series of thirteen articles running from October 1950 to October 1951, Berkeley Papers, box 68, folder 2.

378 Ibid.

379 Berkeley, *Giant Brains*, 28.

lights with a name and a personality would be far less intimidating than the electricity-hungry "geniuses" housed at government agencies and engineering schools. The press, predictably, picked up on the act. Simple Simon found its way into a *Wall Street Journal* editorial; "The world may admire a genius, but it loves a moron," the paper crowed, praising the ease of understanding Berkeley's small machine. *The New York World-Telegram* echoed these sentiments, alongside a large picture of Berkeley with his pet computer. "Simple Simon…can't even count beyond three… But it's obvious—to us, anyway—that the scientists have just become revolted with their Frankenstein ambitions and are now trying to outdo Nature in the opposite direction."[380]

Though it was published in 1949, *Giant Brains* is also noteworthy for commemorating in print one of the first retrospective intellectual histories of computing, adopted subsequently by the greater part of the journalistic establishment. Contemporary historians such as David Mindell, Jon Agar, and Paul Edwards have traced a very wide net of moments and accidental influences that educed the constellation of computing technologies available at midcentury, but Berkeley, in his role as popularizer, favored a simpler linear progression.[381] Starting with Leibniz and then Lord Kelvin, and moving through the familiar stories of Babbage's Difference and Analytical Engines, Lady Lovelace's efforts at programming, and Herman Hollerith's punched-card tabulator used

[380] *New York World-Telegram*. May 18, 1950 clipping. Berkeley Papers box 10, folder 34.
[381] Many fine revisionist histories are published every year, emphasizing different aspects of the primordial soup from which the modern computer sprang. Notable among this cottage industry are David Mindell's *Between Human and Machine*, which documents the importance of earlier "engineering cultures" in the developing science of information, feedback, and communications, particularly within the Bell telephone system in the first half of the 20th century; Paul Edwards' *The Closed World*, which sees military strategy and technocracy as important antecedents for electronic computers which arose to simulate military exercises like antiaircraft fire and flight; and Jon Agar's *The Government Machine*, which views the British Civil Service at the time of Charles Babbage, and Alan Turing (whose father was employed in the foreign service) as an information processing system that laid initial groundwork for mechanical control and communication.

in the 1890 census, Berkeley brings the history of information processing into the modern era. In his view, computers would be best put to use solving business and logistics problems, and thus Hollerith occupies a central place. The next several chapters of *Giant Brains* at great pain sketch out the first contemporary history of Bush's Differential Analyzer, Aiken's Mark I, and Eckert/Mauchly's ENIAC. In so doing, Berkeley began the great exercise of computer mythopoesis predominant still today, to the misfortune of those excluded, such as John Atanasoff and Iowa State's Atanasoff-Berry Computer, F.C. Williams and the team behind the Manchester Mark I (completed in 1949 with the help of Manchester's new mathematics professor, Alan Turing), and Konrad Zuse's 1941 Z3, a fully programmable, binary digital computer, with conditional branching, unfortunately secreted behind the cloak of the Nazi *Luftwaffe*.[382] These machines have received much deserved later attention, but were for many years left out of the celebratory American popular narrative practiced by Berkeley and members of the print media. Indeed much thanks to popularizers like Berkeley, it was ENIAC and its successors that were endowed the lion's share of fanfare.

ENIAC functions as a character in Berkeley's tale. The backstory of the machine reads almost like a *bildungsroman*: "In the short space of four years, Eniac grew to maturity, and in Feburary 1946 he began to earn his own living by electronic thinking. He was the first giant brain to use electronic tubes for calculating. He was the first one to reach the speed of 5000 additions a second. He was the first piece of electronic apparatus

[382] Much debate has centered around the question "who invented the first computer?" Several alternative candidates are discussed in:
Cohen, I. Bernard. *Howard Aiken: Portrait of a Computer Pioneer*. Cambridge, Mass.: MIT, 2000, 299-300.

containing as many as 18,000 electronic tubes all functioning together successfully."[383] The figuring of ENIAC as the forefather to all modern electronic computers thus began during the machine's operational lifespan. There are, of course, numerous important antecedents that might have equally been chosen, but Berkeley's choice would echo throughout the literature of the coming decades.

Giant Brains' final chapters deal with a question that was increasingly gaining currency as computers entered the mainstream: that of social consequences. The most dire, according to Berkeley and many of his colleagues, was the automation of warfare, and even the possibility of an accidental nuclear attack. We will later return to this fear, the basis for several sensational works of fiction. As a technologist, he like Wiener was aware of the danger of becoming another Dr. Frankenstein – one destroyed by his own works.[384] In later years, Berkeley campaigned as a peace activist, nuclear disarmament replacing computer education as foremost in his agenda. The problem of computer-controlled military intelligence was prominent in discussions of Cold War strategy; indeed, most of the university-built computer systems of the 1940s and 1950s, particularly ENIAC and M.I.T.'s Whirlwind were constructed to model military environments.[385] The military's efforts to implement centralized, electronic command and control would come to a head during the later years of the Vietnam War with Robert McNamara's favored intelligence/logistics program Operation Igloo White. Such an automated coordination of troops and supplies on the electronic battlefield epitomized the fears of some who viewed computers as yet another weapon in the gruesome arsenal of

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[383] Berkeley. *Giant Brains*, 113.
[384] Berkeley. *Giant Brains*, 196.
[385] Paul Edwards makes the argument that thus the technology of the digital computer, abstracted the "political architecture of the closed world" and is the perfect icon of Cold War thinking 110.

mustard gas, napalm, and hydrogen bombs. McNamara's technologized Defense Department stands out as a famous military embrace of information systems, though it should be remembered that Operation Igloo White was deemed a failure, and most Pentagon top brass mistrusted and chafed at the arrival of the war-by-computer.[386]

By design, *Giant Brains* raised as many questions as it answered. Arriving in 1949, Berkeley's book was the beginning, and not the end of a conversation. The narrative that places ENIAC at the fulcrum of history—the heir to centuries of logical calculus and abortive experiments, and the ancestor to all future electronic digital machines—owes its origins to Berkeley's efforts at fashioning an accessible narrative. The mainstream press picked up this story and gave a prime broadcast slot. As interesting as the historical narrative was, it was Berkeley's future predictions that had the capacity to enthrall readers. Simon was an artifact from this future – the first computer-in-a-box that Americans would have the opportunity to touch. To color in the rest of the computerized world to come, Berkeley and the reviewers of *Giant Brains*, turned to a different expressive form, one with established precedent but just then coming into flower: science fiction.

[386] For a complete discussion of Vietnam War-era information technology, see Gibson, James William. *The Perfect War: Technowar in Vietnam*. New York: Grove/Atlantic, 2000.

Chapter 8 – Robots in conflict

For Berkeley, information was as likely to assist peace as war, and had no latent bellicose nature. "The pen is mightier than the sword," he wrote, "And if this is true, then the pen with a motor may be mightier than the sword with a motor."[387] Indeed this sentence encapsulates Berkeley's expectation that likely *only* the motorized pen may be able to stop ever more high-tech weapons. While automation promised unknown terrors on the fields of war, its effects on the home front were too familiar. Increasingly complex machine tools – automatic looms, hydraulic lifts in automotive assembly, offset printing and the like had helped make the United States the most productive economy in the world by 1950. Meanwhile, a boom in postwar consumption and greater access to world markets had held unemployment rates, even as the war ended, below six percent.[388] But the technology to manipulate information directly posed a legitimate paradigm shift. Change-sensitive and timely data processing had the potential to streamline and rationalize production. Moreover, new feedback-controlled robots might one day eliminate human hands almost entirely from the supply chain. Skilled workers and managers alike had never faced such a threat.

In fact, the very word *robot* connotes a threat to humanity. The term was coined in the 1921 play *Rossum's Universal Robots* (*R.U.R.*) by the Czech dramatist Karel Čapek, who derived it from the Czech *robota*, for "labor." In Čapek's story, humanoid robots, built to work happily in the industrial furnaces of a hypercapitalist future, revolt and overthrow their creators, resisting their exploitation by the owners of capital. The

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387 Berkeley. *Giant Brains*, 180.

388 U.S. Department of Labor: Bureau of Labor Statistics. "Civilian Unemployment Rate," *Federal Reserve Bank of St. Louis.* August 6, 2010. Accessed 1 Sept. 2010. <http://research.stlouisfed.org/fred2/data/UNRATE.txt>

fable is at once a morality play on the need to moderate technical ambition, whether in science or commerce, and a political piece in the Marxist tradition. Robots, in Čapek's view, occupy a dual role as technological threats to labor, and as a metaphor for workers themselves, seen as replaceable automata in the system of industrial capitalism. Berkeley, for whom the term "robot" has a far rosier overtone, acknowledges Čapek's apocalyptic vision: "The robot machine raises two questions that hang like swords over a great many these days. The first one is for any employee: What shall I do when a robot machine renders worthless all the skill I have spent years in developing. The second question is for any businessman: How shall I sell what I make if half the people to whom I sell lose their jobs to robot machines?"[389]

Robots were introduced to America as fictional characters, largely though the work of Isaac Asimov. Asimov's first robot story, "Robbie", published in September 1940 focused on a robot caretaker who becomes a friend to a wealthy child. While the girl's parents, caught up in a popular anti-robot fad, attempt to separate the two, they learn that their computerized au pair is something more than just steel and wires. "Robbie," was followed by a series of similar stories, published in the pulp magazine *Astounding Science Fiction*, and compiled in the bestselling volume *I, Robot*, published by Gnome Press in 1950.[390] Asimov probed the lines dividing humans and automatons. His fiction was not troubled by the specter of technological unemployment or industrialization's ravages on the natural landscape. Asimov painted a future of hesitant, but productive coexistence. Cybernetics was the engine of a new era of human relationships with machines.

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[389] Berkeley. *Giant Brains*, 202.
[390] Asimov, Isaac. *I, Robot.* New York: Gnome Press, 1950.

In a world of such diffuse influence, it should not be surprising that Asimov was not the first writer of sympathetic robot fiction. He was himself profoundly influenced by Eando Binder's 1939 story "I, Robot" published in the January 1939 issue of *Amazing Stories*.[391] So too, Binder was preceded by two stories that ran in *Amazing* in 1930 and 1932, portraying machines with the properties of intelligent computers. These stories, "When the Atoms Fail," and "The Last Evolution", were penned by a young M.I.T. graduate named John W. Campbell. Campbell notably had as a mathematics professor the science fiction fan Norbert Wiener, who encouraged him to enter the field of imaginative writing.[392] Campbell became the editor of *Astounding Science Fiction*, and a mentor to Asimov. It was the latter who was to be the more famous face of science fiction.

Asimov's prescient tales included hints of several themes that would become common in the science fiction genre: a powerful machine intelligence engaged in solipsism and epistemic crisis ("Reason", foreshadowing Clarke's *2001* and Heinlein's *The Moon is a Harsh Mistress*), discerning the difference between humans and sophisticated androids ("Evidence", foreshadowing Dick's *Do Androids Dream of Electric Sheep*), and the responsibilities of robots to humanity ("Runaround", foreshadowing Lem's *The Cyberiad* and Bradbury's *I Sing the Body Electric*). Though humanoid androids had appeared in fiction before, often in uncanny and frightening guise, Asimov made them something closer to human, imbuing them with all of our rational and irrational psychology.[393] The idea that robots would come to a central part of

[391] White, Michael. *Isaac Asimov: A Life of the Grand Master of Science Fiction*, New York: Carroll & Graf, 1994, 51.
[392] Warrick, Patricia. *The Cybernetic Imagination in Science Fiction*. Cambridge, Mass.: MIT, 1982, 54.
[393] Androids were objects of wonder and fear in Hoffman's *Der Sandmann* (1814), Shelley's *Frankenstein*

the industrial process was becoming commonplace during the so-called "Golden Age of Science Fiction" (1930-1950), with Asimov at the fore.[394] Edmund Berkeley helped usher these ideas from the pages of *Astounding Science Fiction* into a mainstream discourse.

In December 1949, Berkeley addressed a colloquium on digital computation, attracting members of the press corps. The *New York Herald Tribune* reported his prediction that one day, machines will "do the work of 45 per cent" of the country's population.[395] Later, in November 1950, Berkeley clarified his meaning in the *New York Times Magazine* with a piece of explicit futurology called "2150 A.D.—A Preview of the Robot Age."396 In a conversational style, he laid out the arguments for and against the

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(1818), Villiers de l'Isle-Adam's *The Future Eve* (1886), and Lang's *Metropolis* (1927). Only by the beginning of the 20th century were the complications posed by robots for humans' view of ourselves explored. Asimov's stories are both the best known and the best of this genre.

394 Roberts, Adam. *The History of Science Fiction*. New York: Palgrave Macmillan, 2006, 195.

395 *The New York Herald Tribune*, December 4, 1949 clipping. Berkeley Papers, box 10, folder 31. An informal referendum of colloquium participants on whether machines could think returned a verdict of "no," sixteen-to-nine.

396 Berkeley's predictions got him in hot water with the dean of American futurism, Norbert Wiener. In a letter addressed to the editors of the *Magazine*, Wiener stated that "The greater part of his article is a watered down and conventionalized version of material contained in my two books, *Cybernetics* and *The Human Use of Human Beings*. Mr. Berkeley does not refer to either of them, although they are both familiar to him." Wiener who had a penchant for priority disputes apparently felt that in hypothesizing an industrial revolution of intelligent robots, Berkeley was treading too close to his domain. Berkeley replied trenchantly, "In general, the subject matter of machines that 'think' and robot machines has been explored by a number of competent men over the years, including Charles Babbage, Karel Capek, Howard H. Aiken, John von Neumann, Vannevar Bush, and others. It is a large field, and hundreds of men, among them Dr. Wiener, have contributed to parts of it. In my opinion it is quite difficult to demonstrate specific authorship for the vast majority of ideas occurring in the field, although a coined word may have a speicifc author, such as 'robot' coined by Capek. Any investigator in this field it seems to me must realize that acknowledgement of specific ideas to one man – if he claims as his and they are his – implies the necessity of acknowledging dozen of ideas to many more men." He claimed that he had not even read *The Human Use of Human Beings*, though he cited *Cybernetics* in his book, *Giant Brains*. The argument raises an important question: could Wiener justifiably claim ownership over an entire genre of prediction that he had made popular? Or, as Berkeley asserted, had the field become so saturated and so mature that it existed truly in the public domain? It is my belief that the *Times* editors, in siding with Berkeley, tacitly acknowledged this fact; Wiener had birthed the baby, but, by 1950, it had begun to outgrow his care. Reluctantly, Wiener would have to accept that the torch had been passed; a new generation of public ambassadors would rise to follow in his stead.
"Letter to the *New York Times Magazine*." November 20, 1950. Norbert Wiener Papers (MC22), box 9, folder 129, Institute Archives and Special Collections, M.I.T., Cambridge Mass.
"Letter from Edmund C. Berkeley," December 7, 1950. Wiener Papers box 9, 129.

"intelligence" of information machines. Judging them to be, without doubt, on a path to greater intelligence and autonomy, he proposed an a national or international body, modeled on the Atomic Energy Commission to supervise and regulate computer research, and direct it if possible, toward the public good.[397] Without intelligent oversight, something Berkeley intended his own public advocacy to foster, the power of computers to reshape society could not be predicted. Borrowing from Čapek, Berkeley hypothesized an already-underway "robot revolution." "The phrase has an ominous ring," he admitted. "That such a revolution is in the making there can be little doubt. What its ultimate consequences will be, whether its net effect will be for good or for evil—on these matters, of course, no one can speak with certainty."[398] Even in 1949, Berkeley was publicly pronouncing the onset of revolution. In the *New York Post*, beside a large photo of the writer at home with his second wife, Suzanne, he is quoted, "I believe we are approaching a revolution in the handling of information, something like the industrial revolution in application of energy."[399] As the decade wore on it became ever more fashionable to speak of a computer "revolution," with much debate over what justifies such a term. In retrospect it is indeed remarkable to witness such consciousness of the historical tempest of computerization as early as 1949.

Berkeley's growing public persona clashed with the aspirations of American futurism's dean, Norbert Wiener. In a letter addressed to the editors of the *Magazine*, Wiener stated that "The greater part of his article is a watered down and conventionalized

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[397] *The New York Times Sunday Magazine*, November 19, 1950 clipping. Berkeley Papers box 10, folder 34.

[398] Ibid.

[399] *The New York Post*. October 13 1949 clipping. Berkeley Papers box 10, folder 31. Berkeley further proposed a regulatory agency, akin to the Atomic Energy Commission to guide the proper use of computer power.

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Like Asimov, but unlike Wiener, Berkeley believed robots would boost aggregate productivity. All things considered, they were a positive development. Technological unemployment was not high on his list of worries; gains in efficiency, he thought, would more than offset the cost of retraining workers to operate, program, and repair robot machines. A clumsily written short story, "Automatic Mix-up," that Berkeley submitted for Asimov's comment dealt with a team of systems engineers troubleshooting a deadly bug in the fictional "National Traffic Management System."[400] Hence even a country with a fully automated shipping system would still employ an army of technicians to keep it running.

Berkeley's story didn't succeed as fiction; it was rejected by *Astounding Science Fiction* in 1950, though its author kept tinkering. To Asimov, computer systems were less than ideal storytelling fodder, but Berkeley had a flair for handling raw details of technology. The great science fiction scribe wrote back, "It is a fascinating piece for a fellow automations expert. For the general reader, however, it makes hard swallowing. You must remember that the common denominator of all reader interest is *people*. Get

[400] Berkeley Papers, box 15, folder 74.

your focus on your characters and keep them there. Science and technology in s.f. is window-dressing, ornamentation, spice. It is *not* the main course."[401]

The correspondence between the two writers reveals that Berkeley acutely felt the influence of science fiction in his work to proselytize computers. Indeed, "Automatic Mix-Up" contains several elements of a story Asimov published the same year in *Astounding Science Fiction*—"The Evitable Conflict," later included in his celebrated collection, *I Robot*. In Asimov's more nuanced treatment, twenty-first-century society's economic production is fully automated by computer, though strange glitches in scheduling occur, appearing to violate robots' mandate to protect humanity at any cost.[402] Asimov, who always took a benign view of artificial intelligence, against the fanatical "Frankenstein complex" of the labor unions (Luddites) and religious mystics (animists) of his stories, revealed these glitches to stem from an interpretation of his famous First Law of Robotics: "a robot may not injure a human being, or through inaction allow a human being to come to harm." While individual errors may have sabotaged elements of the production cycle, scientists in "The Evitable Conflict" find that, in the robots' superior foresight, these small glitches prevented larger catastrophes from befalling humanity as a whole. As Patricia Warrick notes, for Asimov "Conflict is evitable; only the machine is inevitable."[403]

Asimov was an important filter for Berkeley, as for many Americans, of the emerging philosophy of science embodied by computer automation. His stories examined fears of robots running wild, while sparking the imagination of computers' future role in society. Berkeley, himself an aspiring science fiction writer, deliberately

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401 Ibid.
402 Asimov. *I, Robot*, 198.
403 Warrick. *The Cybernetic Imagination in Science Fiction*, 60.

emulated Asimov's dispassionate tone and resolute optimism. For Berkeley, as in "Automatic Mix-up," society's successful command of the advantages of computer power depended on better computer-human integration. He envisioned a single system—an electronic brain and human brains netted together. Errors could be averted if computers could be made, if not human, then more humanlike.

In 1949, Berkeley felt that the foremost prerogative was education: if humans were to be comfortable with the new machines, the giant brains had to be in some sense demystified – they were not geniuses, the playthings of arcane scientists in lab-coats, but ordinary appliances (though smarter)—even children, like Simon. If humans respected and understood computer power, it would in turn be a boon to humanity: "There will also be very great advantages from robot machines. The monster in *Frankenstein* is right when he says, "Do your duty towards me, and I will do mine towards you and the rest of mankind. And Harry Domin in *R.U.R.* is right as to possibility when he says, 'There will be no poverty… Everybody will be free from worry."[404]

Other thinkers evidenced a much more ambivalent attitude about the proliferation of computing technology. Computers were already embedded in airplanes and nuclear reactors; automatic controls animated factory assembly lines. It was fruitless to try and stop it. "Technological evolution is still accelerating. Technologies are always constructive and beneficial, directly or indirectly. Yet their consequences tend to increase instability," wrote John von Neumann in a *Fortune* editorial, ominously titled "Can We Survive Technology?" "In fact, the more useful they could be, the more unstabilizing their effects can also be…Technological power, technological efficiency as such, is an

[404] Berkeley. *Giant Brains*, 186.

ambivalent achievement. Its danger is intrinsic."[405] To von Neumann, as to Wiener, technology was inherently neutral; the profit potential of new devices was limited by human's ability to put them to responsible use. The rapid evolution of computer power, even by the early 1950s necessitated a new rethinking of mankind's purpose on Earth. We were users of tools, but to what end? Computers exposed the very cleverness by which we created them as a sort of burlesque; taken to extremes our logic could destroy us. Only with care and self-perception could we put this massive intellectual lever to better tasks. The public greeted the awesome moment these writers heralded with excitement, and with fear. Berkeley reckoned directly with this anxiety.

A book of enthusiastic futurism such as *Giant Brains* might strike us as a curious, amusing relic. The image of intelligent robots automating our factories, making military decisions, even running our households, remains somewhat the province of science fiction. Berkeley's broadside projects the kind of romantic machine-future on display at the 1939 International Exposition's "World of Tomorrow." Technological advance was a central dynamic in American culture in the 1950s. To paraphrase Stewart Brand, we are what we what we imagine our future to be. Historian Paul Boyer has demonstrated how the awesome technological horror of the atomic bomb redefined redefine man's relationship to machine world in the wake of the Hiroshima and Nagasaki blasts: "Nuclear power, radioactive isotopes, and other civilian applications of atomic energy were…a way of dealing with—or avoiding—unsettling immediate realities…. Either civilization would vanish in a cataclysmic holocaust, or the atomic future would be unimaginably bright."[406]

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[405] Von Neumann, John. "Can We Survive Technology?" *Fortune*, June 1955, 106-108, 151-152.
[406] Boyer. *By the Bomb's Early Light*, 122-125.

Computers entered this same discussion. The *Christian Science Monitor* declared in 1950, "[Computers] are as symbolic of this age as rocket ships or atomic bombs."[407] More generally, the order of machine control, accelerating from the cotton gin to the railroad to the automobile has been viewed within the tension of liberation and subjugation. The teleological rhetoric of progress, often opposed by a conservative primitivism had coalesced into a faith called by Leo Marx, "the technological sublime."[408] Now, the computer brought this inexorable progress into the mind of man – and there it met its most concerted philosophical challenge.

The reviews of *Giant Brains* were nearly uniformly positive. Both mainstream and niche reviewers covered the book. The January 1950 issue of *Fantasy Advertiser* waxed, "It looks like the physical scientists and engineers are once again pushing our science-fiction authors, by making real the type of thing we have been reading about for many years... It is a non-fiction book which is of prime interest to science-fiction readers."[409] *Astounding Science Fiction*, the serial science fiction monthly that had earlier rejected Berkeley's submission, agreed: "Here is a factual book that should be right up the alley of *Astounding* readers. As science fiction fans, we have been intrigued by tales of marvelous thinking machines. Of course, details were lacking and rightly so, since science fiction anticipates the future. Nevertheless, many of us had an abiding curiosity of how these marvels could be actually realized. Here now is the chance to satisfy that longing."[410]

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[407] *The Christian Science Monitor*, 1950 clipping. Berkeley Papers box 10, folder 31.
[408] Marx. *The Machine in the Garden*, 197. Marx writes "The awe and reverence once reserved for the Deity and later bestowed upon the visible landscape is directed toward technology, or rather the technological conquest of matter." See also
Nye, David E. *The American Technological Sublime*. Cambridge, Mass.: MIT, 1996.
[409] *Fantasy Advertiser*, January 1950 clipping. Berkeley Papers box 10, folder 31.
[410] "Review of *Giant Brains*," *Astounding Science Fiction*. June 1950, 99.

Meanwhile, the *New York Times Book Review* wrote that it "should make an ideal companion volume to Norbert Wiener's much-discussed *Cybernetics*."[411] This cybernetic connection was not lost on the publishers; Wiley consciously promoted the two books in tandem. Wiener was by this time among the nation's foremost scientific celebrities, and Berkeley's editors saw him in quite the same mold.[412] Indeed, the back of *Giant Brains*' first edition dust jacket featured a promotion for Wiener's book, announcing, "Dr. Wiener has done for the human brain what Einstein did for the universe."[413]

Vernacular cybernetics was different, and narrower, than cybernetics formally defined by von Neumann or Wiener himself. Indeed Berkeley contributed to a popular definition meaning "automation of control/communication processes through *intelligent* handling of information." While both denotations stressed the importance of information flows through circuits, Berkeley's use of the term added an active element—deliberate rationalization of information exchange, as via computers, with the intention of directing human behavior. To the original cybernetics pioneers, purpose and teleology were naturally-occurring properties of goal-directed systems, whether biological cells, antiaircraft gunnery arrays, or human organizations. They could be, but need not be engineered.

Wiener's *Cybernetics* necessarily framed the discussion of Berkeley's book. "Already banks are doing much of their bookkeeping in the cybernetic way," wrote the *Book of the Month Club* in a March 1950 review. "The factory will be singularly empty of men, except for a few trouble shooters who rush at once to a machine which, by a

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411 "Mechanical Logicians," *The New York Times Book Review.* December 11, 1949, BR19.
412 A Wiley & Sons letter to the advertising department of *Harper's* saw the two authors appealing to the same demographic: the journal's 155,000 educated subscriber families were "prize buyers of books," and influential purveyors of intellectual trends. December 1948. Berkeley Papers, box 10, folder 30.
413 Quote from *The New York World Telegram*, 1948.

flashing red light or sounding a gong, indicates that it is in a state of agony because the task that it is to perform has not been correctly state in punched holes or because an electronic tube has burned out or because there is a short circuit."[414]

Many reviewers fixated on the startling future applications of computer power imagined by Berkeley. Over the A.P. wire came the lead, "The stenographer of the future wouldn't wear nylon stockings, use lipstick, chew gum, or make mistakes in spelling. But she wouldn't be very pretty, either." Off-handed misogyny here blends with the concern that technology could upset comfortable social roles. As we saw, Berkeley's suggestion of the possibility of a robot psychotherapist engendered a robust discussion in the *New Yorker*. The subject of artificial minds tended to provoke alarm and Berkeley did nothing if not amplify it. But in many ways, the public had been teasing out the implications of the idea since Wiener released his landmark *Cybernetics* less than a year earlier. The field known as "Artificial Intelligence" would not be born until a series of conferences in 1956, organized by John McCarthy who debuted the term for the occasion.[415] Alan Turing had not published his famous test for machine intelligence. While Wiener defined a long history for the idea of reasoning as calculation, citing Leibniz as the "patron saint" of cybernetics, its full import had yet to be digested by laypeople.[416] Among the very

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[414] *Book of the Month Club*. March 1950 clipping. Berkeley Papers box 10, folder 31.

[415] The Dartmouth Conferences, which brought together leading figures in computer science—McCarthy, Marvin Minsky, Herbert Simon, Allen Newell—are considered the birth of AI as a discipline. McCorduck's *Machines Who Think* (111-136) remains the best text on the subject. Daniel Crevier (1993) details the many trials and travails of the effort for machine intelligence, while maintaining that AI may yet fulfill one day its grandest hopes. Crevier's comprehensive history establishes that the quest of McCullough, von Neumann, Turing, and Wiener for a logical model of human reasoning was indeed at the heart of Russell, Boole, and Frege's earlier projects as well.
Crevier, Daniel. *AI: The Tumultuous History of the Search for Artificial Intelligence*, New York: Basic Books, 47-49.

[416] Wiener, Norbert. *Cybernetics: or, Control and Communication in the Animal and the Machine*. Cambridge, Mass.: MIT Press, 1965, 12. Leibniz' system of universal reasoning, the *characteristica universalis*, seems to call for the language of logic undertaken by George Boole, and later outlined by Bertrand Russell and Alfred North Whitehead's *Principia Mathematica*. These efforts would find

first into the fray, Berkeley contributed some much desired clarity: “Ever since the world was startled to learn it had a new science, ‘cybernetics’,” wrote science journalist Marika Hellstrom, “the ordinary soul has been looking for two things: a hole to hide in before the robots take over, or a plain everyday explanation that might make him feel a little more comfortable in an age both atomic and electronic. Such an explanation has now been written, in the book *Giant Brains, or Machines that Think*, by Edmund C. Berkeley.”[417] In addition to futurist and educator, Berkeley assumed the role of interpreter.

Not every reader was happy with Berkeley’s interpretation, however. Hard scientists were less impressed with the author’s sweeping and grandiose comparisons. *The British Journal of Applied Physics* chastised, “The author seems so obsessed with the idea of these machines ‘thinking’ that he forces biological and psychological terms into the text even when there seems no call for them; for example, he introduces quite unnecessarily the term ‘mentality’ of a machine, and refers to the input elements as ‘eyes’ that indicate by ‘winking.’”[418] This review is remarkable as one of the few contemporary criticisms of Berkeley’s persistent anthropomorphism. More pointedly, the critic points out the unnatural slotting of simple developments in circuits and applied physics into a “cybernetic” intellectual paradigm.[419] Others complained that the logical functions performed by such as ENIAC comprised only a small portion of the organic whole of the mind. In *The Saturday Review,* psychologist Henry Link wrote, “the psychology of the

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expression in the Universal Turing Machine, a single machine proposed by Turing in 1936, that could process any effectively computable function. A single computer could, in abstract, be made to model any other—thus giving life to the dream of modeling human consciousness, in full, in a digital computer.

[417] Letter to Berkeley, May 1950. Berkeley Papers, box 10, folder 31.

[418] *The British Journal of Applied Physics*. 1950 clipping. Berkeley Papers, box 10, folder 31.

[419] Such critiques of the unwieldy, and often inappropriate “theorization” of biological science and control system engineering have been made by historians Lily Kay (2000) and David Mindell (2002). Kay, Lily. *Who Wrote the Book of Life: A History of the Genetic Code*. Palo Alto: Stanford, 2000.

giant brain is a magnification of the workings of one part of the human brain, and probably one of its less important parts at that."[420]

But anthropomorphism in science journalism was not a passing fashion. Berkeley succeeded in establishing an idiom that outlasted his book, as reporters casually wrote of "giant brains" or "thinking machines" well into the propitious decade of the 1950s. A 1957 *Newsweek* "Inventions" feature, for instance, announced that by introducing photochemistry to computer memory, National Cash Register had achieved a "nearly human brain."[421] These were routine sentiments. While Norbert Wiener and John von Neumann felt compelled to give lectures cautioning against too facile comparisons of minds and machines, the general public found it only too easy to employ the term "brain."[422] It helped that reputable experts like Claude Shannon, W. Ross Ashby, and Christopher Strachey speculated on the possibility of teaching a computer to play chess. Outside authorities also weighed in; in 1954, psychologist Wladyslaw Sluckin published a book of popular cybernetics titled *Minds and Machines*, describing the similarities between computers and nervous systems in problem solving, adaptive purposeful behavior, and deductive reasoning.[423] A chorus of scientific opinion outweighed the skeptics.

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[420] Link, Henry. *The Saturday Review*. February 25, 1950 clipping. Berkeley Papers, box 10, folder 31.
[421] "Nearly Human Brain," *Newsweek*, November 25, 1957, 102.
[422] McCorduck, Pamela. *Machines who Think*. Natick, Mass.: A.K. Peters, 2004, 151.
[423] Sluckin, Wladyslaw. *Minds and Machines*, Baltimore: Penguin, 1954.

Chapter 9 – The brains behind the "Brains"

Perhaps, as Wiener implied, Berkeley lacked sufficient scientific standing to serve as the American public's chief conduit to computer science. Nevertheless, his hortatory was endorsed by scores of experts attesting to the revolutionary power of computers. A most interesting phenomenon of the period of the 1950s was the relative readiness of esteemed scientists to engage in radical prophesy. By the latter half of the decade Edmund Berkeley had been superseded in some degree, if only because Americans had been so inundated with computer hype that they no longer needed a schoolmaster. Even with its author off-stage, however, the language of Berkeley's predictions remained in currency. The press corps wrote breezily of "electric brains," "electronic libraries," and low-cost digital computers. Berkeley had effectively written the script. This script, I argue, was written in a distinct idiom that is itself as much a historical artifact as the computers it described. Journalists, executives, and evangelists like Berkeley all wrote in a "cybernetic register," incorporating not only the terminology ("information," "feedback," "homeostasis"), but the conceptual vocabulary Norbert Wiener had made indispensible. The metaphor of the electronic brain owes much to the information circuits described by Shannon and modeled as neurons by McCulloch and Pitts.

One of the first highly visible, mainstream scientific applications based on this analogy was the nascent field of artificial intelligence (AI). AI christened itself with uncompromising pronouncements of computer's limitless capacity to use logic and to learn. Among the field's early leaders were two researchers at the Carnegie Institute of Technology in Pittsburgh, cognitive psychologist Allen Newell and economist Herbert Simon. Newell himself had written a paper on building a chess-playing machine in 1955, and he and Simon (with computer scientist J.C. Shaw) set to work that year building a program, called "Logic Theorist," engineered to automatically prove mathematical theorems. This program, completed before John McCarthy coined the term "artificial intelligence" in 1956, started from a hypothesis, using symbolic reasoning to delineate a "search tree" based on digital choices, progressing toward a goal of "proof," eventually proving 38 of the first 52 theorems of Russell and Whitehead's *Principia Mathematica*, some more simple and elegant than those previously derived longhand.[424]

Like Berkeley, Newell and Simon took as axiomatic the proposition that, like minds, computers operate not only by crunching numbers but by symbolically manipulating concepts (like true or false). The symbol-language of Boole was one logical calculus; the binary arithmetic of Turing's Universal Computer was another. Computers may have been "giant morons," capable of only clearly specified tasks, but they solved problems in a way fundamentally similar to people.[425] Simon wrote of his epiphany,

> When I first began to sense that one could look at a computer as a device for processing information, not just numbers, then the metaphor I'd been using, of a mind as something that took some premises and ground them up and processed them into conclusions, began to transform itself into a notion that a mind was something which took some program inputs and data and had some processes which operated on the data and produced output. There's quite a direct bridge, in some respects a very simple bridge, between this earlier view of the mind as a logic machine, and the later view of it as a computer.[426]

Simon's realization was an essentially cybernetic one. His 1969 book, *The Sciences of the Artificial*, made clear that feedback control was the critical antecedent of AI: it

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[424] Crevier. *AI*, 46.
[425] "Giant morons" was an oft-used quip computer scientist A.L. Samuel, who in the late 1950s developed a checkers program for the IBM 704 that could beat all but expert-level human players. Quoted in Georgescu-Roegan, Nicholas. *The Entropy Law and the Economic Process.* Cambridge, Mass.: Harvard 1981, 92.
[426] Quoted in McCorduck. *Machines who Think*, 151.

showed how complex systems could organize themselves purposively, working towards goals and adapting to a changing environment.[427]

Newell and Simon argued that the machines they created, such as the Logic Theorist, were not just metaphors or demonstrations; they were themselves theories about human thought, windows into the brain.[428] These machines would gradually improve in sophistication, providing ever more faithful models of thinking. "There are now in the world machines that think, that learn and that create," Newell and Simon wrote in 1958. "Moreover, their ability to do these things is going to increase rapidly until—in the visible future—the range of problems they can handle will be coextensive with the range to which the human mind has been applied."[429]

Newell and Simon's approach utilized heuristic programming—an approach similar to trial-and-error—to allow machines to learn from experience. Heuristic problem-solving fascinated observers because it imitated the learning mechanism of people, particularly children. Problems need not be structured perfectly by a programmer to be attempted by the computer. Simon later told *Fortune* that his programs "do not merely substitute brute force for human cunning. Increasingly they imitate—and in some cases improve upon—human cunning."[430] Computers could potentially be evolved to reason, to philosophize, to create works of art. Such extrapolations, the *Fortune* writer went on, "uncomfortably reminiscent of the androids of science fiction," threatened to revive old debates about free will vs. determinism, vitalism vs. mechanism, and man's

[427] Simon, Herbert A. *The Sciences of the Artificial*. Cambridge, Mass.: M.I.T., 1996, 172.
[428] Machlup, Fritz. *The Study of Information: Interdisciplinary Messages*. New York: Wiley, 1983, 253.
[429] Newell, Allen and Herbert Simon; "Heuristic Problem Solving: The Next Advance in Operations Research," *Operations Research* 6 (January-February 1958): 8.
[430] Burck, Gilbert. "The Boundless Age of the Computer," *Fortune*, 1964, 234.

place in the universe. Thanks to computers' accelerating power, the debate took place not only in university philosophy departments, but in bi-weekly business publications.

The qualification that computers model discrete aspects of human thinking, the sum of which might be called a mind, is one that developed as computer scientists began to appreciate the complexity of seemingly simple tasks such as pattern recognition in a visual field, or the operation of a robotic arms.[431] In 1964, Warren McCulloch made the argument that "minds" are embodied—a collection of physical memories and regulated chemical response, like a servomotor—while thoughts are the running of this apparatus.[432] *People* think, stressed McCulloch, not brains or computers. But to the extent that "brains" do our thinking, computers can do much the same thing.

Such nuanced distinctions were not of particular interest to Newell and Simon, or to the cheerleading press. The ground in fact had already been ceded; "thinking machines" were fair game. The question boiled down to a semantic issue, suggested *Time*. "We can often find simple machines," declared AI pioneer Marvin Minsky in a speech reported by the magazine, "which exhibit performances that would be called intelligent if done by a man. We are, understandably, very reluctant to confer this dignity on an evidently simple machine."[433] Minsky's machines *learned*, wrote *Time*, and thus

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[431] Marvin Minsky and Seymour Papert formally developed this theory in the 1970s, which evolved into Minsky groundbreaking 1986 book, *The Society of Mind*. Minsky's physicalist principle, "minds are what brains do," implies not only that consciousness is an epiphenomenon of a diverse set of mechanisms, but that no single formal statement is sufficient to describe the activity of thinking.
Minsky, Marvin. *The Society of Mind.* New York: Simon & Schuster, 1988, 4.
[432] McCulloch, Warren. "A Historical Introduction to the Postulational Foundations of Experimental Epistemology" (1964), in *Embodiments of Mind*. Cambridge, Mass.: MIT, 1988, 359-372.
[433] "Machines With Experience," *Time*, December 8, 1958. Accessed 1 Sept. 2010.
<http://www.time.com/time/magazine/article/0,9171,864534,00.html>
Minsky's 1958 address was given at Britain's National Physical Laboratory for a conference on "The Mechanization of Thought Processes." Though not in the habit of covering academic conferences, *Time* reported on Minsky's talk as if it were mainstream news. Other interesting notes compiled by *Time* from the conference included work on computer automated music composition, surgery, air traffic control, and legal argumentation. The conference's official slogan was: "whatever a human being can do, an

they will learn slowly how to think as we do. The first truly intelligent machines might refuse to admit they are machines at all. *Time* thus implies, surfing a wave of much mechanism in popular and academic thought, that we humans were the first such machines. "A machine has been taught to converse about the weather and to call its interrogator a liar when he attempts deception," the *New York Times* reported in 1959. "In reporting this, an experimenter predicted that, in little more than a decade, it will be impossible for a man in the next room to tell whether his conversation is with a man or a machine."[434] Why were scientists—in this case, at the University of Toronto—performing such silly and quotidian experiments? The possibility of newspaper coverage, it would seem, offers a likely hypothesis.

Even mid-market general interest publications like *Reader's Digest* got into the act. The October 1958 *Digest* reprinted an article from *Mechanix Illustrated* titled "Look What's Happened to the Thinking Machine!" "Electronic computers have moved out of science fiction into our daily lives," the piece declared.[435] Beginning with an anecdote about a young female operator's input mistake being corrected by one of the mainframes at the Vanguard Computing Center in Washington, D.C., it posed computers as anthropomorphic creatures with a slightly unsettling learning curve. "This is a wonderful machine," said the young programmer, "but it makes you shiver sometimes. Once in a while we give I an incorrect figure on purpose – just to see it sneer at us."[436] The new, faster generation of "giant brains," the reporter wrote, "can read, write and calculate simultaneously; they have tenacious 'memories,' and they can learn by experience. In the

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appropriate machine can do too."

[434] Thus, the Turing Test became fodder for popular discussion. *The New York Times*. December 30, 1959 clipping. Berkeley Papers, box 18, folder 55.

[435] "Look What's Happened to the Thinking Machine," *Reader's Digest* 73 (October 1958): 178-182.

[436] "Look What's Happened to the Thinking Machine," 178.

last half-dozen years they have come into wide use to perform miracles that touch the lives of all of us."

Reader's Digest couldn't resist a bit of prognostication. Carnegie Tech's Alan Perlis, a collaborator of Newell and Simon and a future president of the ACM, is quoted, "Computers can be programmed to do almost any mental work a man can spell out."[437] The article cites computers that make business forecasts, predict the weather, hunt legal precedents, diagnose diseases, and "compose harmonic but uninspired music." A.L. Samuel's checkers-playing machine integrates its own mistakes in its learned memory and gets better with every game. Though Samuel's creation "gives some observers an uneasy feeling," the article ends on an optimistic note. Faster and smarter computers wouldn't necessarily doom all of us to replacement by machine: "'Computers open up scientific possibilities that we unthinkable before,' says Ralph J. Cordiner, chairman of the board of General Electric Co. 'They will make possible entirely new products and industries. These technologies will be a major source of employment in the coming decades.'"[438]

In March of 1955, the cover of *Time Magazine* portrayed IBM's iconic Thomas J. Watson, Jr. tinkering with a humanoid robot. The simple image conveyed an emerging understanding that the computer industry had something to do with the search for human-like intelligence in electronics, and that private industry was now leading the charge.[439] "What d'you mean—obvious to the meanest intelligence?" asked a white-coated laboratory scientist standing beside a towering, Rube Goldberg-esque contraption labeled

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[437] "Look What's Happened to the Thinking Machine," 180.
[438] "Look What's Happened to the Thinking Machine," 182.
[439] *Time*, March 28, 1955.

"Danger: Electronic Brain," in a cartoon that ran in the October 24, 1960 *Newsweek*.[440] The weekly magazine's "Special Science Report" detailed a host of abilities ascribed to current and future machines with a breathless tone of "gee-whiz" science fiction. "Tomorrow will bring stranger and smarter robots that take dictation and type letters, draw blueprints, make medical diagnoses, and, as now seems likely, know how to reproduce themselves," read the lead. "Mathematician Norbert Wiener has suggested the balance of power may tip in favor of the mechanical slaves—just as Čapek's robots overthrew their masters."[441]

Quotes from Claude Shannon, Arthur Samuel, Grey Walter, and Ralph Gerard painted a picture of a future with computers not only staffing the assembly line, but managing executive strategy. Berkeley, no longer in the vanguard by 1960, was generally absent, but his predictions of computer secretaries, translators, doctors, and supply managers were memorized as canon. The problem of technological job destruction hung like a cloud over *Newsweek*'s survey, but the editors posed as its solution more technology. "We cannot solve unemployment," argued an IBM director, "but we can use a computer to predict what will happen under a given set of conditions. Thus, we will predict the future, and if we want, change it."[442] Computers' meaning for the workingman was equivocal; while Schumpeterian creative destruction might account for

[440] *Newsweek* October 24, 1960. Cited in Grupe, Fritz. "Computoons: The Evolving Image of Computers in Cartoons," *Computer* 29 (April 1996): 55-62. Though they may appear shallow cartoons in fact provide a useful reflection of evolving sentiment toward technological products like computers. Historian Fritz Grupe has taken an inventory of more than 1,700 such cartoons spanning the period between 1940 and 1990 and charted some of these changes. "Computoons," as he calls them, can show us "a person's first images of what computers were, how they worked, and, more significantly, the potentially disturbing social issues they raised," (55). In Grupe's schema, cartoon portrayals of computers evolved from exploring the tension over control between intelligent robots and their creators in the early 1940s, to humanizing the machines ("giving the tin man a heart"), to hostility, to ultimate coexistence by the mid 1970s.
[441] "Machines Are *This* Smart," *Newsweek*, October 24, 1960, 85-88. The article also cited Claude Shannon, Arthur Samuel, and Grey Walter on potential future applications of robotics.
[442] "Machines Are *This* Smart," 86.

a net fall in hours worked (though real wages, tied to gains in productivity, may indeed rise) computer-aided planning could wisely steer society through the worst.443 Čapek-like outcomes could be marginalized through data collection and analysis.

To *Newsweek*, the thinking machine-problem was a *fait accompli*: "The question 'Can a machine think?' is an old chestnut. Lincoln Laboratory's Oliver Selfridge argued, 'the answer is certainly yes,' though we would concede that this intelligence 'as an elusive, unnatural quality.'"[444] The weight of expert opinion, claimed the writers, rested with Selfridge. What kind of world would result where machines learned from their mistakes, or, even constructed and taught themselves? Though himself a sincere fan of the genre, Claude Shannon claimed the premise was not science fiction. Using Newell & Simon's heuristic method, computers might soon produce miraculously original ideas. "I don't like to make predictions," said Shannon, "but I expect that in ten to fifteen years, we will see machines doing complex intellectual tasks—writing theorems of interest to mathematicians, turning in good translations, understanding their environment. After that we can expect the general-purpose robots."[445]

The article repeated claims that a "second industrial revolution" was at hand. Its digital agents were catapulting an economy built on the application of machine power to physical tasks into a future where the organization of information mattered more than raw

[443] Industrial policy was the theme of the 1963 convention of the American Federation of Information Processing Societies. Adapting to the new state plenty in a highly automated economy called for more centralized planning, according to economist W.H. Ferry. The gears of the scientific-industrial-bureaucratic establishment, the "technostructure" in Galbraith's term, were too complicated to be allowed to break down. Ferry argued that agrarian-age theories of private property and free enterprise were outmoded and needed to be replaced by a state mechanism armed with the power of computer simulation and a mandate for a long view of the economy. Similar calls to national planning were increasingly heard as computers became ubiquitous in business and government. Burck. *Boundless Age of the Computer*, 230.
[444] "Machines Are *This* Smart," 88.
[445] Ibid. In the same paragraph as Shannon's forecast, the article discusses von Neumann's idea of a self-reproducing probe. By assembling a copy of itself from available materials, such a machine could perpetuate intelligence indefinitely, in environments inhospitable to humans.

mechanical advantage. Computer pioneers saw themselves shepherding a transition from *body* to *mind*, from machines that did manual labor to one that did intellectual labor. Sociologist Daniel Bell would write, “A post-industrial society is based on services… What counts is not raw muscle power, or energy, but information.”[446] In the first industrial revolution, “the steam engine augmented human muscle power,” said a physicist at Westinghouse. “Now we are augmenting human brain power.”[447]

The idea of the “augmented” human was a new one, helping to usher a quizzical public into the information society.[448] While AI researchers like Newell and Simon made gestures at duplicating man’s mental faculties, others were beginning to conceive of ways that computers and their biological users might enhance each other’s relative strengths. Rather than supplanting the human worker with a whirl of buzzing gadgetry, what was needed was a machine the worker could easily employ to increase his productivity. Berkeley laid out this vision in an editorial for *The Christian Science Monitor* in March 1951. “...‘Giant brains’ made out of hardware seem to be far removed from the experiences and lives of ordinary human beings like you and me,” he began. “[But] will that always be so? Are they bound to stay remote from ordinary living in a community?” He proposed that current, soluble problems of storage and programming were overcome, “We shall then have mechanical brains that will be cheap, small, with great memory, and good ability to recognize.” Attached to improved input/output devices, we might have sensor-linked automated drivers in cars, artificial intelligence programs to aid in the

[446] Bell, Daniel. *The Coming of Post-Industrial Society*. New York: Basic Books, 1976, 127.
[447] “Machines Are *This* Smart,” 85.
[448] Though the origins of the term “information society” are ambiguous, the concept was first formalized by the economist Fritz Machlup who studied the increasing contribution of the knowledge sector—education, research & development, information technology, information services, media, etc.—to U.S. GDP. Machlup’s *The Production and Distribution of Knowledge in the United States* (Princeton 1962) is the seminal academic treatment of the subject. Frank Webster has written a cogent intellectual history of the idea: Webster, Frank. *Theories of an Information Society*. New York: Routledge, 1995.

diagnosis of disease, automatic language translation, and even programs for lesson-drilling in schools. "We can imagine voting buttons ('yes', 'no', 'it depends', 'I don't know', etc.) installed on the television sets of voters living in a city," he wrote, envisioning more a high-tech Gallup service than *American Idol*.[449]

The process was deemed feasible because computers were progressively being understood to digest information "intellectually," rather than numerically—that is to say, using symbols rather than digits. "The electronic computer…enlarges brainpower even as other man-made machines enlarge muscle power," wrote Gilbert Burck in *Fortune*. "Like man, the computer expresses knowledge in terms of symbols; man's symbols are letters and numbers, and the machine's symbols are electromagnetic impulses that represent letters and numbers."[450] The key in interfacing these two knowledge systems was to translate the logic of the computer into the visual and physical language understood by humans. Developments in graphics, higher-order computer languages, natural language processing, and input/output would be needed. For instance, to communicate with Berkeley's Simon, one needed to master the digital logic of punched paper-tape; by contrast, a student using Grace Hopper's COBOL language (developed in 1959) could employ a number of familiar English-language commands such as "add," "move," "transfer," or "stop." Intended for business use (COBOL stood for Common Business Oriented Language), COBOL, like FORTRAN, compiled complex syntactical

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[449] "Community Living and the Uses of Machines that Think," *The Christian Science Monitor*. March 12, 1951 clipping. Berkeley Papers box 15, folder 77.
[450] Burck. "The Boundless Age of the Computer," 230-244.

commands into binary machine language, and was portable across multiple computer architectures.[451]

Through the late 1950s and early 1960s, popular writers crowed how computers' felt influence in daily life was becoming ubiquitous. On the contrary, while the number of installed systems had risen from fifteen in 1954, to more than 16,000 in 1964, the majority of Americans still had never directly used one. But computers were everywhere in popular culture, reflecting the pervasive expectation that logic and information would be used to rationalize every aspect of life. There was as yet no such thing as a "personal" computer, but journalists and authors that brought stories of great progress into every living room ensured that, for millions of Americans, the experience of computing was indeed very personal. Computers as a subject crystallized man's ascent into a being of pure intellect. The "thinking machines" of 1960 lacked emotion and aesthetic appreciation, but, computer scientists assured us, these they would learn in time. Computers were *us*.

The growing ubiquity of computer systems was itself a source of anxiety. Norbert Wiener, Burck pointed out, "now solemnly warns that computers can be improved to the point where they will get out of man's control."[452] Computer programs that could talk, learn, reproduce themselves—was all this progress getting out of hand? "Is man falling behind in a race with machines of his own creation?" asked a special feature in *U.S. News & World Report*.[453] "Electronic brains…[are] taking over in offices, factories, banks, government. Is it all to the good?" The question was partly social—concern over

[451] IBM's FORTRAN, developed in 1954, had become a popular standard, opening up a suite of practical programming tools to those not trained in difficult assembly language.
[452] Burck. "The Boundless Age of the Computer," 231.
[453] "Is the Computer Running Wild?" *U.S. News & World Report*, Feb. 24, 1964, 80-83.

automation—and partly evolutionary. A cartoon of anthropomorphic computers, staring in wonderment at a live human, their operator, was flanked by the caption: "If researchers are right, computers of the future will be almost human. They'll carry on conversations, develop emotions, make value judgments. Stop now? Says one scientist: 'It's like trying to prevent a river from flowing to the sea."[454]

Human emotion, our apprehension of right and wrong, even our own sense of identity, were, at base, computational algorithms, suggested atomic scientist Edward Teller. Computers "will become teachable, acquire experience, form judgments, develop emotions and take initiative," Teller predicted. Like Berkeley, *U.S. News* was convinced of the inevitability of more and more computation power. Its counsel was identical: caution, and wise use. The automation of operations had been an unqualified boom for the early 1960s military, but many brass worried about the judgment of an algorithm in pressing the red button. Nor was purchasing a computing machine enough alone to improve an organization's competitiveness. A McKinsey study of 1963 indicated that for many companies computers were no more than "expensive status symbols."[455] Creative programming, continual repair, and consistent throughput were prerequisites for successful automation. As the sparkle and glamour of computer technology (perpetrated by *U.S. News* among others) faded into acceptance, the question became, "what do we do with computers once we've built them?"

In an interview immediately abutting the *U.S. News* study, Norbert Wiener attempted to clarify the problem. Computer buzz had ridden the "worship of gadgetry," but to leave the matter of how machines would be used to the gadgets would be folly.

[454] "Is the Computer Running Wild?" 81.
[455] "Is the Computer Running Wild?" 82.

Humans had to assert intelligent control.[456] Wiener, who had been introduced to the public as rather a bold theorist—a perambulatory thinker bridging philosophy and mathematics—had gotten into the act of computer prophesy, following Berkeley. Miniaturization, he insisted, was the future of machine intelligence. Scientists were driving down the size and cost of hardware to where we could begin to use solid-state physics (read transistors) to truly mimic the informational structure of the brain. Learning computers, whether using neural nets or heuristic problem solving, could be built on hardware modeling nervous tissue.

Smaller, cheaper hardware meant new machines might indeed be cut to human size, mimicking brains in form as well as function. In 1961, *Time* wrote that computers should be built for abstract thinking via "electronic units, analogous to brain cells, that can be produced by the billion, be made too small to see with a microscope, send 100 million signals per second, never make mistakes and last indefinitely."[457] The idea, then, of "thinking robots taking over the earth," was unsettlingly real. "It is science fiction," Wiener admonished, "unless people get the idea, 'Leave it all to 'Tin Mike.' I mean, if we regard the machine not as an adjunct to our powers, but as something to extend our powers, we can keep it controlled. Otherwise we can't."[458] True to his cybernetic, systems orientation, Wiener called for computers to enable human wisdom, as intellectual prostheses. Men and women amplified by machines were a much more benign vision than "Tin Mike." As a corollary of this idea, automation ought to be approached with a grain of humanism. "The answer is that we can no longer value a man by the jobs he

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456 "Machines Smarter Than Men?" Interview with Norbert Wiener. *U.S. News & World Report*, Feb. 24, 1964, 84-86.
457 "Brains By Design," *Time,* January 20, 1961. Accessed 1 Sept. 2010. <http://www.time.com/time/magazine/article/0,9171,871996,00.html>
458 "Machines Smarter Than Men?" 85.

does. We've got to value him as a man… A whole lot of the work that we are using men for is work which really is done better by computers… [But] if we insist on using the machines everywhere, irrespective of people, and don't go to very fundamental considerations and give people their proper place in the world, we're sunk."[459]

Why were mathematicians such as Wiener and von Neumann, engineers such as Shannon, and cognitive theorists such as McCulloch all interested in the development of the computer industry? Improving industrial efficiency or developing war games for the Pentagon were not items particularly high on their agenda. Once a secondary consequence of the new informational worldview, electronic computing became, a decade on from the Macy Conferences, cybernetic science's most high profile fruit. Yet the example of Berkeley reveals how the popular discussion had evolved from first principles, set out by Wiener *et al*. Though not directly involved in the scientific research that constituted the genesis of cybernetics in the 1940s, Berkeley, as someone interested in methods, thought, and machines, was a keen follower of the new meta-discipline. There were primarily two avenues that proposed to him a linkage between the science of control systems and the science of digital computers. These were the study of the system formed by the machine, its user, and their feedback, and the equivalence between purposeful behavior and cognition in electronics and in an organism.

The Macy conferees described simply the way systems maintain homeostasis, regulating internal cycles of feedback. Later efforts, called by some "second-order" cybernetics, wished to draw from a broader field of observation and behavior, and the interaction *between* systems. Berkeley saw computation fitting into the cybernetic paradigm in a roughly analogous way. First-order logic, as Berkeley understood from his

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[459] Ibid.

undergraduate mathematics, expresses relationships between individuals of a given genre. That machines and organisms are of a kind—homeostatic systems—is a first-order statement. Second-order logic concerns sets of individuals; the rules that apply to them recursively. That we as users of computers may form a goal-directed system with the machines we use is, in effect, a second-order statement.

In *Cybernetics*, Wiener wrote of first-order programming as a kind of logic tree—if *x*, then *y*, etc. This is the way most computer operations were programmed. But deeper orders of decision making, involving educated guessing, stochastic programming under conditions of uncertainty, required some information about the state of the system itself, including the operator. Wiener had discovered this problem working on ballistics problems during the war. "The idea of a first-order programming, which may be linear in certain cases, combined with a second-order programming, which uses a much more extensive segment of the past for the determination of the policy to be carried out in the first-order programming" was used in the problem of predicting aircraft trajectories. Essentially, successful predictions had to include statements about the state of the system itself, and the human operator of the anti-aircraft gun.[460] Computers, as systems that maintain internal equilibrium by organizing feedback, fell *ipso facto* under the umbrella of cybernetic enquiry. But those who looked at radical new concepts like computers for the masses, netting together multiple systems, or responsive, real-time graphics, saw something different: computer power was a prosthetic tool to amplify human intellectual capability. Minds linked with computers could truly become cyborgs.

Berkeley and his ilk often wrote in what I call the "cybernetic register." This was an idiom explicitly informed by the science of cybernetics, and the published writings of

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[460] Wiener. *Cybernetics*, 173.

Wiener, von Neumann, and Shannon. Terms like *information*, *system*, and *communication* appear frequently in the sense cyberneticists envisioned. Often without making reference to Wiener or von Neumann's urtexts, writers like Berkeley assumed the reader's familiarity with their works. New epistemological assumptions about the algorithmic nature of human knowledge and behavior were taken as given.

An example may be found in Berkeley's correspondence with Edward Fredkin, a former fighter pilot and future director of M.I.T.'s Project MAC, and author of the first assembler for DEC's seminal minicomputer, the PDP-1.[461] Fredkin described a book of cosmology he aimed to pen that would set the ground rules for the convergence of the computation sciences. "What is the fundamental particle of physics?" he wrote to Berkeley. "What is it made out of? In my universe there are 2 kinds of things, 2 basic substances: 1's and 0's."[462] Man's place in these new cosmos would be contested. "Mankind will end its reign as the dominant species on Earth within 25 years, to be superseded by other creatures… [but] extinction will be a reversible process: future creatures will be able to make more men – when they want to… I think it is more likely that the individuals alive at that time may be given immortality, but that the continuation of the physical form of mankind will cease." Indeed computers were colliding and mixing with living organisms, in cyborg fashion. Fredkin continued, "Not only will computers be able to paint better paintings than men and write better music than men, but they will be able to grow better pelts than a sable, generate more potent venom than a cobra, and, strangely enough, have cuter puppies than a collie." For Fredkin in 1964,

[461] Fredkin was also the doctoral adviser to Turing Award-winner Ivan Sutherland, whose contributions to computer graphics include the seminal 1963 program Sketchpad, which allowed the user to draw, size, rotate and move lines, arcs, and shapes, and was the ancestor to the graphical user interfaces used in most subsequent operating systems.
[462] Letter from Fredkin, November 17, 1964. Berkeley Papers box 47, folder 4.

there had ceased to be any meaningful theoretical distinction between the natural and the artificial. Finally, and most radically, Fredkin proposed that the universe itself was nothing more than a computer simulation, and could be modeled exactly with the right inputs. "It will be possible," he said, laying out the central premise of his "digital physics," "to compute on an IBM 7090 every physical constant in the universe, with no measurements made."[463]

Several observations bear mention regarding Fredkin's aborted book project. First, its evident radicalism extends to the very foundations of metaphysics. In his arch-determinist universe, every physical interaction is decided in advance as physics runs through its cosmic program. Humans are not free agents, but lines of programming in fleshy form. Consistent with this philosophy, he viewed organisms as computers themselves, built not of nucleic acid and protein, but of 1's and 0's. Second, while Fredkin was a radical, he found a sympathetic audience with Berkeley and several publishers who entertained his project. A number of his ideas directly foreshadowed those by later futurists Vernor Vinge and Ray Kurzweil and were, for 1964, just ahead of the curve of mainstream scientific thinking.[464] Cybernetics' influence resonated loudly with Fredkin. Lastly, and most importantly, Ed Fredkin was not a science fiction author. His predictions were not meant as entertainment or speculative fantasy. A professor at

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[463] Ibid.

[464] For a theory of the universe as an information processing simulation, see: Barrow, John D. and Frank J. Tipler. *The Anthropic Cosmological Principle*. New York: Oxford, 1988, 658-664.
Science fiction, too, reckoned that the ultimate nature of the universe might be information. In Isaac Asimov's famous story "The Last Question," the human race's far flung descendents ask a disembodied, all-knowing computer (AC) of their creation if the direction of entropy in the universe can be reversed. The computer, a truly cosmic consciousness, ponders the question and discovers an answer, but has no one to report it to, time and space having already ceased to exist. To demonstrate its solution, it reverses entropy, creating the universe anew. Asimov's closing line reads: "And AC said: 'LET THERE BE LIGHT!' And there was light—"
Asimov, Isaac. "The Last Question," in *The Complete Short Stories*. New York: Broadway, 1990, 290-300.

M.I.T. and Boston University, he had worked directly with computers at M.I.T.'s Lincoln Laboratory and at the offices of Bolt, Beranek, and Newman in Boston. He was both a serious scientist and entrepreneur. His convivial letter to Berkeley attests to the penetration of the cybernetic register.

Berkeley's ideas were clearly steeped in the same cybernetic broth as Fredkin's. Having read deeply on the subject as a pastime, he offered by classified ad in *Gateway to Science* magazine a correspondence course in cybernetics. The course would cover "servomechanisms and automatic controllers, and their capacity. Analog and digital computers, and their control and capacity. The comparative psychology of animals. The human brain and its functioning. The significance of cybernetics."[465] A draft article Berkeley submitted to *Astounding Science Fiction* on "The Construction of Living Robots" spoke of the anticipation "that before a dozen more years go by, automatic machines (i.e., robots) that possess the essential properties of life will be 'in existence' – or should we say, 'alive'? Certainly much more than half the distance to the construction of living robots has been travelled [sic]."[466] Von Neumann's cellular automata, Grey Walter's turtle, the complex programmed behavior of anti-aircraft gunnery were all testament to the feasibility of such a program.[467]

An article that Berkeley did succeed in publishing with *Astounding Science Fiction*, in February 1952, further shows the influence of cybernetics on his thought. Titled "Machine Intelligence," the article linked feedback control, a standby of first-order

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465 *Gateway to Science*, 1956 clipping, Berkeley Papers, box 68, folder 28.
466 "The construction of living robots," 1952 draft, Berkeley Papers, box 16, folder 6.
467 Indeed, Berkeley spoke of his own commercial robots as, in some sense, living creatures, much like J.S. Sebastian's uncanny creations in the film *Blade Runner.* It is quite possible that Berkeley's "The Construction of Living Robots," self-published in 1952, served as a partial influence to Philip K. Dick, author of *Blade Runner*'s source material (the novel *Do Androids Dream of Electric Sheep*), and himself a reader of *Astounding Science Fiction*.

cybernetics, with learning and artificial intelligence, questions of the second-order. Quoting Ross Ashby, Berkeley wrote, "'the problem of the mammalian brain, then, is a that as a machine it has to work out an essential part of its own wiring.' The essence of the ability of the brain to work out its own wiring is, he says, the principle of negative feedback." Computer programs too could be instructed to adjust their own parameters: "It seems clear that it would be quite possible to give certain very general instructions of a 'negative-feedback' type to a big automatic computer like the Univac. Then after a while it would have worked out its own programming."[468]

Berkeley outlined his views at the Northwest Computing Conference in Portland, in September 1960. He began his address with the admonition that before long, such banquet speeches would be better written by computers. "As many of you know," he declared, "I am a radical. In fact, I will even tell you a secret. I am a revolutionary. I am one of the people who have from the very beginning of automatic computers proclaimed the revolutionary powers of these machines." A run-down of the accomplishments of mechanical brains culminated with a summary of Berkeley's now popular extreme mechanistic, functionalist view of intelligence: "I am now ready to state the first two theorems that I wish to present to you this evening: Theorem 1: Every intelligent operation that a human being can perform can also be performed by a machine. Theorem 2: Probably the machine can do it better."[469] This "heresy" generated thunderous applause.

[468] "Machine Intelligence," *Astounding Science Fiction,* February 1952, 95.
[469] Berkeley, Edmund C. Speech to the Northwest Computing Conference, Portland, 1960. Berkeley Papers, box 16, folder 80.

Chapter 10 – The birth of the cybernetic office

While Americans read about computers in their newspapers or saw them on television, many first experienced the new machines directly at work. The story of computers' explosion into twentieth-century life has been told as a narrative of countercultural "hacking" gradually swallowing the mainstream[470], and as an example of military control and Cold War dualism[471], but relatively few have emphasized the important role played by the *office* as a bridge between multimillion-dollar Pentagon research projects and the far out dreams of hacker space cowboys.[472] James W. Cortada has attested that the industry for mechanical office calculation was a good deal larger and more sophisticated than historians have noted, both in the variety of products available and in the business models of leaders IBM, National Cash Register, Burroughs, and Remington Rand. Before electronic, general-purpose computers were even thought feasible, data processing was a mature market. IBM, in particular, had a valuable franchise selling punched cards for its office calculators; services and peripherals for more complex machines was a natural transition.[473] For Cortada, the history of the computer industry is "the story of how a number of giants emerged out of the prosperity of the 1920s, survived and thrived in the 1930s, and were thus well positioned in the 1940s and during the 1950s to enter the age of the computer." Cortada's argument is oversimplified; academic breakthroughs at places like Penn and M.I.T. and energetic start-ups like EMCC often propelled innovation while "giants" like IBM were often

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[470] Fred Turner (2006), John Markoff (2005), Steven Levy (1984).
[471] Edwards (1997).
[472] Martin Campbell-Kelly and William Aspray's *Computer*, remains the best synthesis of the many histories of the computer, and a notable exception.
[473] Cortada, James W. *Before the Computer: IBM, NCR, Burroughs, & Remington Rand & the Industry they Created, 1865-1956*. Princeton, 1993, 91.

laggards. Yet his "marketplace perspective" is appropriate. "Customers needed to control increasing amounts of information, bought and installed machines to get the job done, and used them until something better came along," he writes.[474] The forces animating technological development were most commonly the forces of adoption and consumption. The locus of this history is the office.

While hobbyists were the evangelists of a fledgling movement toward personal computers, businessmen were the ultimate end market that drove the industry to every sales benchmark. The computer, in its mainframe, mini, micro, and personal iterations, was at heart a business machine. This important insight mediates between the military and countercultural histories. The need for improved data collection and information processing belonged equally to government and industry, but business-minded engineers like Presper Eckert quickly steered a course into the private sector. Hobbyists and hippies made great gains advancing a particular agenda for personal computing, but it paradoxically, for all their talk of mind-expansion and radical personal liberty, their aims were quite consonant with businesses' drive toward a computerized, networked office. It is no surprise, then, as Fred Turner points out, that many of the earliest hackers made comfortable transitions into industry.[475]

As historians move away from narratives of domination and control (such as the "contamination theory" of computers' military origins), we can begin to learn more about the demand side of the product equation and its felicitous contribution to the development of the personal computer.[476] Cortada's is the rare narrative that gives businessmen

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474 Cortada. *Before the Computer*, 264.

475 Turner, Fred. *From Counterculture to Cyberculture: Stewart Brand, The Whole Earth Network, and the Rise of Digital Utopianism*. Chicago: University of Chicago, 2006, 103-118.

476 Edwards' analysis of the computer industry has something in common with studies of pandemics. Most

primacy of place. The American office functioned as the nexus a certain cybernetic worldview and applied technology. In the following chapters we will take as the theme the productivity of the individual knowledge worker, and how research, marketing, and distribution combined to make this a central axis of consumer choice.

The history of the office calculator is long and varied, predating either the Pentagon's or hobbyists' interest in computation. There is a compelling case to be made that the important steps toward automatic computing were made not at the behest of the military, calculating aircraft trajectories in World War II, but as part of a centuries-long process of organizing office tasks. At the end of the 19th century, managers and government officials found that the increasing wealth and urbanization of the population as a result of the industrial revolution in the United States and Britain presented them with ever larger, ever more complicated data sets. The financial needs of the rising middle-class were served more than ever before by large, conglomerated banks and insurance firms. Scientific management dictated that data collection and processing be consolidated into a kind of information supply chain, a logical flow throughout of the

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modern computing, Edwards points out, is derived from technologies, or engineers at work on the electronic battlefields of SAGE, Whirlwind, and Operation Igloo White. Those that do not (video games or web browsers for example), usually have some ancestor technology funded by DARPA through its Information Processing Techniques Office. Thus, there is an element of military contagion; all computer technology is ultimately built on a model of the "closed world"—the tightly-controlled, linear algorithm, all of its game-theoretical outputs determined with statistical certainty. Edwards has a point: the Pentagon's dollars were behind much of the research that was done in the computer area for the quarter-century following World War II. Yet his formulation deliberately ignores several contradictions. For example, he makes little reference to the vast pre-history of computing and tabulating technology that predated military's interest these matters, as far back as Leibniz and Babbage. He also wrongly suggests that because the Pentagon funded a research effort, it must have exercised deliberate control over its direction. In fact, many scientists with differing views of "strategic applicability" received generous DARPA grants, while only a few of their projects were ever purposed either for the battlefield or even for electronic logistics. DARPA's "killer app," after all, was email, a technology more useful in the boardroom than the war room. Finally, Edwards' study neglects the consumers who gobbled up computer technology as soon as it was announced, and participated, through clubs, magazines, and online communities, in selecting which technologies were to prosper. In sum, the "closed world," while a valuable insight into part of computers' history, is quite incomplete as a model of technological development.

office. By the turn of the century, the Prudential Insurance company, Berkeley's alma mater, had rationalized the actuarial process into a single building, where information took a discrete path from input, calculation, storage and output. If this process resembled the logical organization of the electronic computer, it was no accident. Business machines--foremost automatic calculators to aid and replace human calculators known as "computers"—were embraced as essential elements in the information processing chain.

The British, whose centralized bureaucracy dwarfed rival nations', naturally led the charge, installing a central clearinghouse for London's banks, a central telegraph office for rerouting wire traffic, and a central star table-making office of the Royal Astronomical Society. Charles Babbage, the mathematician and civil servant known as the father of the digital computer, was equally an economist concerned with accuracy and efficiency, Working on astronomical tables, he bored quickly with the tedium of manual methods of calculation.[477] Babbage's celebrated machines were an effort to streamline the workings of science, industry, and the civil service.[478]

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[477] Campbell-Kelly and Aspray, *Computer*, 13.

[478] Babbage's story of imagination and frustration is well known. His "Difference Engine", described in an 1822 paper, was an automatic calculator that remained unrealized during his lifetime, due both to financial and mechanical constraints. A working model, however, built by Babbage's son Henry, was found unused in a Harvard storeroom by Howard Aiken, inspiring the Mark I. Babbage is perhaps more famous for conceiving of a more elaborate machine, the "Analytical Engine," that would have been able to store its raw output in a separate register from its program—or "mill"—and perform a new operation on it. The innovation of the loop (and the inherent possibility of a conditional branch, or a stored routine) would have fully automated the computation process and rested only a short cognitive leap away from Turing's general-purpose computer or Von Neumann's stored-program principle. After 1832, Babbage poured his energies into his new project to the neglect of his Difference Engine, though it too was never built. The flexibility of its programming was apprehended by Ada King, the Countess of Lovelace and daughter of the poet Lord Byron. Lovelace's evangelism on behalf of Babbage's work places her in the category of computer prophets, a full century before Berkeley. In her poetical words, the Analytical Engine's chief improvement was that of a "snake biting its own tail." Lovelace's suggestion of an algorithm to calculate a sequence of Bernoulli numbers is credited by some as the first computer program. Anthony Hyman has written a fair biography of Babbage (Hyman, Anthony. *Charles Babbage: Pioneer of the Computer*, Princeton, 1985). A more entertaining biography of Lady Lovelace is:
Woolley, Benjamin. *The Bride of Science: Romance, Reason, and Byron's Daughter*. New York: McGraw-Hill, 2000.

A novel interpretation of this story is proposed by historian Jon Agar. In *The Government Machine*, Agar suggests that the British Civil Service, increasingly rationalized and technocratized in the nineteenth century, was, in effect, an early digital computer. Computers were automated systems, in much the way British bureaucrats sought to reform the civil service. Notably, Charles Babbage who served Whitehall much of his career, and Alan Turing, whose father was employed in the Foreign Service, conceived of their machines as implementations of the logic and order spelled out by the government's division of intellectual labor.

Agar's case relies heavily on the examples Turing and Babbage, yet his analogy of the government as computer in macrocosm is compelling. More than a retrospective application of systems theory to Victorian society, Agar's thesis is supported by a number of concrete examples. Identity cards kept in a national register were analogous to von Neumann's stored programs[479]; Babbage referred to the "legislative" and "executive" departments of his Analytical Engine[480]; reformers such as Trevelyan and Haldane pervasively spoke of the bureaucratic "machine," which would operate in an efficient, rational, and nonpartisan manner, independent of the numerous lower-class clerks who tended to its functions.[481] At minimum Agar demonstrates another, non-military, non-North American context in which the vocabulary of a proto-cybernetics emerged: under Trevelyan, the civil service and the machines Babbage devised for it, effected a new science of the logical flow of information.[482] Joanne Yates has described the process,

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[479] Agar. *The Government Machine*, 218.
[480] Agar. *The Government Machine*, 41.
[481] Agar. *The Government Machine*, 52-67.
[482] Agar cites Otto Mayr's contention that differing political attitudes determined the choice of metaphors describing feedback control. While the authoritarian continent preferred metaphors of clockwork at the dawn of the Victorian era, British liberals devised that of the self-regulating machine.

which took place later in stateside factories and offices, as part of "revolution" in communication and control: in the theory of systematic management, "efficiency was to be gained by substituting managerially mandated systems for ad hoc decision by individuals, whether owners, foremen, or workers."[483]

It was not in their native Britain, but in gadget-happy America where business machines first migrated from government bureaucracy to private industry.[484] Herman Hollerith, a less profound but more practical mathematician than Babbage, demonstrated a tabulating machine capable of vastly improving the U.S. Census' tally system in 1889, just in time for the 1890 census.[485] Unlike his under-capitalized predecessor, Hollerith received the financial backing of the census office, allowing him to complete several machines that together reduced the time it took census takers to tabulate results from a decade in 1880, to one year in 1890. Like Babbage's design, and like the popular Jacquard loom, Hollerith's tabulators processed information delivered on punched-cards; Hollerith improved on existing input mechanisms by developing a key-punch (essentially a punched-card typewriter). The American engineer also stumbled onto the razor-razorblade model, made famous a few years later by King Gillette. The company leased its expensive tabulators, defraying the enormous capital outlay it would require to buy the machines outright, but made money selling proprietary punched cards. Hollerith's company, established independently in 1896, would be renamed International Business Machines under its former top salesman, Thomas J. Watson.

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[483] Yates, Joanne. *Control Through Communication The Rise of the System in American Management*. Baltimore: Johns Hopkins, 1989, xvii. Like a computer, the operation of the management machine that emerged in companies like DuPont and the Illinois Central Railroad was characterized by a multitiered command hierarchy, permeable only to flows of information.
[484] This is a pattern we find repeated in the telegraph, mainframe computer, and computer networking industries.
[485] Campbell-Kelly and Aspray. *Computer*, 23.

Hollerith's tabulators found their way into nearly every business in America concerned with information and became essential processors of inventory, payroll, pension, and accounting data. IBM's continuing relationship with the Census Bureau provided a reliable revenue stream, but Watson labored hard in peddling his machines and their lucrative punched-card franchise to private enterprises. IBM, as today, sold not only hardware, but services; its gray-clad service force helped with everything from installation, to repair, to programming. It was the ubiquity of IBM's office machines that allowed manufacturers to rationalize their order books, banks to clear millions of transactions, and life assurers to compute profitable terms on policies for the diverse multitude.[486] IBM, more than any single agent, enabled the manifest capitalization of the science of risk. To IBM, as to many office mangers, the arrival electronic computers signaled merely a continuation of the longstanding process of office automation. We must consider personal computers, the product of a different set of cultural circumstances, also to have a place in this timeline.

While Edwards identifies the dawn of electronic computing with the need for improved logistics and fire control during wartime, even war industries made effective use of preexisting calculating machinery from the likes of IBM and Remington Rand. Cortada points out,

> As the war progressed, the new technologies of the computer were applied to war-related activities, such as intelligence and the development of atomic weapons, while more mundane machines did inventory management and payroll. The excitement of the computer has caught the attention of most historians too much because during World War II the bulk of computing was done as during the 1930s and with equipment manufactured before the war for traditional accounting and business purposes.487

[486] Yates, Joanne. "Early Interactions between the Life Insurance and Computer Industries: The Prudential's Edmund C. Berkeley," *IEEE Annals of the History of Computing* 19 (1997): 60-73.
[487] Cortada. *Before the Computer*, 92-93.

One of the overlooked exigencies of wartime was office calculation. World War II can be seen as part of a continuum in the history of data processing, rather than the ignition of a new technological revolution, as Berkeley saw it. Both Cortada and Berkeley have grasped part of a larger story. In the rush to celebrate the new, however, it is important to remember computers' place in the lineage of business machines. Manufacturers, while acknowledging the groundbreaking technology at work, reminded their customers of just that.

In 1956, Remington Rand Univac published a brochure titled "What Every Businessman Should Know About Electronic Brains," which served both as promotional literature and a PR offensive against the most terrifying myths about their product. Addressing the everyman, Univac introduced the protagonist of the "Average Businessman," confounded by the "mass of technicalities" inscrutable to all but the most *au courant* computer engineers: "A.B. (as his friends call him) has been in a slightly nervous state lately because of all the gossip about a science-fiction Giant called the Electronic Brain. A.B. is being told that the Electronic Brain is going to take over his office, his plant, and—most likely—himself. He hears that he should wait before installing one. He hears that if he doesn't install one tomorrow, the competition *will* and they'll ruin him."488 Univac, reflecting the initiative of its founders, was not content to market only to technologically adept first adopters, like Berkeley's methods division at Prudential, but, mimicking IBM's sales tactics, targeted a wider public. Univac's whimsical pamphlet, embellished with cartoons, aimed help an uninformed customer navigate the labyrinth of "computerese." "When A.B. finishes," it promised, "he'll

[488] "Sperry Misc.", Computer Product Literature, box 91, 3.

discover the Brain is not such a monster after all. In fact, it's going to make life a lot more pleasant all around—for A.B. and for everyone who works for him."

Remington Rand's efforts are remarkable for their explicit recognition of the metaphors employed by Berkeley, and the cybernetic prophesies of the computer avant-garde. For its part, Univac did attempt to dispel the myth of the awesome thinking machine. Because they can process data in much the same way as the best office workers, "and because of their tremendous speed and accuracy, electronic brains are revolutionizing office work." Yet the brochure did not predict an imminent takeover of the workplace by thinking robots. "There's no magic involved," it continued. "Before an electronic brain can do as much as add one and one, human beings must tell it exactly what to do and—step-by-step—how to go about it."489 Univac found itself treading a fine line—both seizing on the sensationalist accounts offered up by journalists, appropriating terms like "electronic brain," and keeping the most frightening implications of these stories at bay. We can find in Univac's marketing language a reflection of the divide in the American mind. Computers were the new new thing, both enthralling and disquieting. At the point of purchase, marketers had to convince a wary public that computers were somehow both revolutionary thinking machines, and simple nonthreatening contraptions.

The UNIVAC pamphlet cleverly addressed one of the chief paradoxes of the futurists' vision of computer automation. Was the machine a mere beast of burden, designed to lighten our labor, or was it a lever, capable of augmenting human effort? Paired with people trained in its use, it could be both. Real inspiration, the brochure argued, never comes from a machine, but from the machine's users, "and once a UNIVAC

[489] Ibid.

computing system rescues them from handling dull routine chores all day long, they can begin to exercise it for more creative, and productive thinking."[490] The computer was gateway to intellectual horizons untapped by people straightjacketed to repetitive office work. A deeply cybernetic idea of tool-use and feedback systems was already well established in the discussion of office computers. No longer radical, advertising had made this idea a commonplace.

The "Computer Revolution" foreseen by Berkeley in 1962 was quickly recognized by numerous others.491 Computers heralded in a bona fide genre in social science. "The computer has begun an information revolution that will profoundly affect the lives of everyone," said computer scientist Isaac Auerbach in a 1962 address to the International Federation for Information Processing, a rival of the AMC. These strong statements were syndicated through the journal *Vital Speeches of the Day*.[492] A brief survey of landmark texts in this genre reveals both a depth and variety of these new worlds descending upon us.[493] Echoing such sentiments, the president of Burroughs

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[490] Ibid.

[491] Robert Kling, Suzanne Iacono, and Joey George systematically compares the utopian social language deployed by the likes of Berkeley and Alvin Toffler and the felt effects across a range of institutions, namely education and social welfare organizations. They conclude that while hopes for a grander project of social change were often inflated in public forums, the actual process of change and adaptation was gradual. For Kling and Iacono, if there was a "revolution," its germination was exceptionally slow. Kling, Robert, Suzanne Iacono, and Joey George. "Making the Computer Revolution," *Journal of Computing and Society* 1 (1990): 43-58.

[492] Auerbach, Isaac. "The Impact of Information Processing on Mankind," *Vital Speeches of the Day*, September 15, 1962, 729-732.

[493] Among the "revolutions" prominently featured in the media were the "computer revolution" of Berkeley (1962), Tomeski (1970), and Hawes (1971), the "technological society" of Ellul (1964), Meynaud's "technocracy" (1968), Martin/Norman's "computerized society" (1970), Brzezinski's "technetronic era" (1970), Helvey's "age of information" (1970) and Oettinger's "age of communications" (1971), Lamberton's "information revolution" (1974), Phillips' "communications age" (1975), Evans' "electronics revolution" (1977), Boorstin's "republic of technology" (1978), Martin's "wired society" (1978), Forester's "microelectronics revolution" (1980), Toffler's "third wave" (1980), Martin and Butler's "information society," (1981), and so forth. The "Information Society" even inspired the name of a popular eponymous new wave rock 'n' roll band. As Beniger wryly observes, snapshots taken between 1960 and 1980 all describe the change as in progress, or imminent. The more technology progressed, the vaster our imagination of the future became. Indeed, the revolution in technical and social control dates not to the

Corp., Ray Eppert was quoted in *Fortune*, "The electronic computer … has a more beneficial potential for the human race than any other invention in history." *Fortune's* reporter went on to wax, in a typically cybernetic lyric, "No other technical innovation has changed so many human activities in so short a time. An extension of man's brainpower, it is transforming science, medicine, government, education, defense, business. It may transform man himself."[494] Years before ordinary people could dream of affording a computing machine in their home, the transformation of the office heralded a new transformation in society.

When *Fortune* reported in 1957 on the coming era of electronic business, it told the story of a computer industry growing at more than 50 percent per year. In two years IBM had grown from a marginal player to the leader in business computing, thanks to improved turnaround and installation periods, responsive service, and tremendous customer loyalty. "Boards of directors may know little about machinery," *Fortune's* correspondent wrote, "but they know about I.B.M."[495] Returns to scale, gains from efficiency, and computational innovation were met with a nearly limitless corporate appetite; IBM and UNIVAC's products not only helped businesses solve problems faster, but helped them solve problems they'd never before considered. Examples ranged from 6-month forward capacity predictions for oil refiners, to shipping schedules in the dry foods business, to optimizing cost scheduling for PanAm's newest jet fleet. But at this exciting frontier, one area loomed as the event horizon of the computer industry: the fully automated plant. The "next big market" yet to be tapped, from the promontory of 1957,

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earliest computers, but to the beginning of systematized information processing, which Beniger, along with Yates and Agar, locates in the mid-to-late-nineteenth century.

[494] Burck, "The Boundless Age of the Computer," 230.

[495] Harris, "The Astonishing Computers," 294.

was factory automation. *Fortune* wrote, “the computer in this instance will direct production, thus becoming the heart of the so-called automatic factory … The best bet, based on experience, is that industrial electronic demand will not develop in any orderly way—it will explode.”[496] The idea of industrial robots replacing assembly-line hands was at least as old as Čapek, but this time, as it is sometimes said, was different. Computer programs could not only process and perform operations on large amounts of data, they could make “intelligent” decisions based on it. Factory command and control was coming under the domain of AI. As automation loomed over factories and white-collar offices alike, Americans watched and waited with anxiety. And they argued. The oscillating optimism and the pessimism centered around industrial automation tell us more about how Americans at midcentury viewed technology—and their future—than any other question.

[496] Harris. “The Astonishing Computers,” 296.

Part 3 – Computers and the Technological Society

Chapter 11 – The automation of knowledge

The arrival of commercial digital computers precipitated a society-wide rethink of the broader effects of technology on life and work in the "second industrial revolution." While the first electronic brains were greeted with almost mystical reverence, as monuments to the genius of post-war American engineering, by the late 1950s and early 1960s, the actual capabilities of computers had become a good deal more familiar. Some commentators, following Norbert Wiener's early example, began to question whether they were worth all the trouble. Indeed, they expanded and developed Wiener's argument. The popular critique of computer adoption ranged from practical (did they really deliver the benefits their advocates promised?), to epistemological (if man had indeed created his intellectual successor, what role was left to human reason?), to sociological (what should be done about the masses displaced by computing machines?)

This section is divided into several parts following a loose chronological framework. First, I show how "automation," as the practice of supplanting human with mechanical "thinking" became known, was figured as a distinctly twentieth-century development, a sequel to cybernetics, and a unique dilemma for modern intellectuals. Next, I examine what I call "the jobs backlash," a growing chorus of reactionary opposition to computer automation on the grounds that it injured the very people it purported to help—citizen-workers of a bygone industrial era. Automation was at the center of at least one major labor dispute, the transformative steelworkers' strike of 1959. This criticism became so resonant that supporters of automation, notably John Diebold, the latest in a series of public information ambassadors, were forced to concede that the new digital computers, at least in the short run, would cost jobs. "We are leaving the push-button age," he admitted. "Today the buttons push themselves."[497] By the early 1960s, public outcry had reached a crisis point that demanded comprehensive national solutions. In 1962, an otherwise important year in the debate, President John F. Kennedy made job losses to industrial automation a focal point of his administration's domestic policy, acknowledging that technological innovation had become perhaps the single most important animating force in American society.

Finally, I evaluate a number of claims, dating from the early 1960s, that the American economy was in the midst of a metamorphosis, from a production-centered manufacturing system, to one organized around the processing of information. These claims, which attracted bold labels like "The Information Society," "The Post-Industrial Society," and the "Technological Society," did more than merely announce the change from a reliance on manufactured goods to a reliance on services.[498] Rather, they suggested that the fundamental character of society had changed, and that generating *ideas*—whether basic science or technology—was now the primary orientation of the American industrial-government-research complex.

This idea's popularity was, I argue, a direct consequence of automation. As information-processing machines threatened to displace a large portion of the workforce, Americans needed to find new ways to engage the talents of workers/consumers. The way out of the productivity-unemployment trap, these thinkers proposed, would engage a

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[497] Diebold, John. *Man and the Computer: Technology as an Agent of Social Change.* New York: Frederick Praeger, 1969, 23. Though published in 1969, *Man and the Computer* compiles a series of lectures and speeches given by Diebold across America through the 1960s to trade organizations and intellectual societies like the Economic Club of Chicago.

[498] The futurist Robert Theobald wrote in *The Nation* of Jacques Ellul's eponymous manuscript: "*The Technological Society* is one of the most important books of the second half of the twentieth century. In it, Jacques Ellul convincingly demonstrates that technology, which we continue to conceptualize as the servant of man, will overthrow everything that prevents the internal logic of its development, including humanity itself—unless we take the necessary steps to move human society out of the environment that 'technique' is creating to meet its own needs."

greater share of Americans specifically in the activity of information processing. At the same time, computer engineers were dreaming up new machines with which non-specialist workers could interact directly. By the middle of the decade of the 1960s, most people on both sides of the debate had ceased to consider computers solely as adversaries of the laborer, and had begun to be seen as critical enablers of the information economy.

The social history of technology is a chronicle of human hopes and fears. The machines we make have promised to rescue us from hunger, war, and boredom, and at the same time threatened to destroy, replace, or dull us into complacent comfort. No revolutionary technology has been introduced without controversy and backlash; attempts to engineer the future have met with remarkable successes, yet their failures are just as stark.[499] Some critiques of technological progress belong to a category of thought we might call "anti-modernism," following the historian T.J. Jackson Lears.[500] Luddism—the violent opposition to advances in automatic machinery on the grounds of protecting human labor—was one manifestation. Other responses are more nuanced in character, ranging from complaints with the easy, administered safety of life in a technological society, to recognition of the limitations to human freedom when decisions about the economy, production, or social policy are made by a mechanical bureaucracy, to concerns about the machine's destruction of the natural environment and man's traditional ways of agriculture, crafts, and transportation.

The debate over industrial automation is not new to the age of the computer. Mechanizing biology—and especially the brain—has been a source of anxiety since its

[499] For an excellent history of technology and society in America, see: Purcell, Carroll W. *The Machine in America: A Social History of Technology*. Baltimore: Johns Hopkins, 2007.
[500] Lears, T.J. Jackson. *No Place of Grace: Antimodernism and the Transformation of American Culture, 1880-1920*. Chicago: University of Chicago, 1994.

first conception, and our literature is littered with the archetype of the "modern Prometheus"; our tales of Frankenstein and the rabbi of Prague warn us of transgressing the frontiers of our science. But computers raise different questions than earlier machines. If they are something more than tools, if they are indeed thinking machines, then they must automate something beyond manual labor. Computers, seen as intelligent organisms, possess the inherent potential to automate the entire process of knowledge—data gathering, idea generation, hypothesis testing, even decision-making. As Norbert Wiener noted, sufficiently sophisticated electronic computers were in fact purposive, teleological systems. As such, they bore a functional similarity to organisms. In the wake of cybernetics and its most visible symbol, the electronic digital computer, man's singular place as a reflective, logical creature was no longer sacrosanct.

When the first commercial computers came available, their creators imagined not only quick profits, but indeed a vast modernization of every aspect of civilization. John Mauchly cautioned the *Baltimore Sun* in 1946 that high speed electronic computing would never substitute for creative thinking; it merely relieved the drudgery of endless calculation. This meant steady marginal improvements in all domains: "better transportation, better clothing, better food processing, better television, radio and other communications, better housing, and better weather forecasting."[501] Berkeley hoped that organizing the data flow of the workplace along the lines mathematical logic would benefit all industries. But the potential intrusion of cold binary reasoning, of sensing, reasoning robots, into every arena left Americans feeling uneasy. Giant brains were a frightening enough prospect in principle. In the decades following Mauchly's invention,

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[501] *Baltimore Sun*, February 15, 1946, 7. Sperry Rand v. Honeywell Court Documents (Acc. 1825), box 9a, folder 128, Hagley Museum Archives, Wilmington, Del.

ENIAC's daughters flourished in firms as varied as steelmakers, banks, and candy shops. Ordinary people would have to reckon with a thinking machine in the office down the hall.

For many, the question was nothing less than humankind's replacement at the center of civilization. Historian of technology and social critic Lewis Mumford believed that the technologies of automation were nothing less than an assault on human freedom. "Organic systems are infinitely more complex than automatic systems; and what makes them so is the margin of choice, the freedom to commit and correct errors, to explore unfrequented paths, [and] to incorporate unpredictable accidents with self defined purposes," Mumford explained in a 1964 lecture.[502] If machines were not seen to possess this flexibility, it was despite the efforts of Wiener to expound the principles of feedback and homeostasis, or of Newell to explain heuristic programming, or of Berkeley to push the definition of automatic thinking. Wiener fretted that human users remained at the center of the feedback system, and were therefore responsible for governing it: "If the man isn't smarter than the machine, then it's just too bad," he said bluntly. "But that isn't our being assassinated by the machine. That will be suicide."[503]

But Wiener contended with a more fatalistic view—that mechanization had already overrun humankind's ability to steer its course. The same issue of *U.S. News* began to voice the existential paranoia that would become a commonplace of science fiction authors like Philip K. Dick and Bruce Sterling, and the later "cyberpunk" literary

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[502] Mumford, Lewis. "The Automation of Knowledge," *Vital Speeches of the Day*, May 1964, 441.
[503] "Machines Smarter Than Men?" Interview with Norbert Wiener. *U.S. News & World Report*, Feb. 24, 1964, 84.

genre.[504] "Are computers, even now, getting out of hand?" the newspaper wondered. "Is man falling behind in a race with machines of his own creation? And as for the future—is it really to be feared?"[505] Such a question had been aired many times, of course. Čapek's morality play was, at base, nothing resembling a narrative about machine intelligence, a concept that would have had very little meaning in 1921. It was, however, a parable about the peril of upsetting the precarious capital-labor antagonism via the introduction of machinery. The theme of forbidden knowledge and the organization of production had been elaborated earlier by Goethe in a 1797 poem, *Der Zauberlehrling*, known to English speakers via Disney's adaptation for the film *Fantasia*, in the segment "The Sorceror's Apprentice." When we use powerful magic, Goethe warned, we must be prepared to suffer its unanticipated consequences. The power of automatic production carried with it a deep danger when its algorithm was not strictly controlled. These concerns were abiding, but computers brought them painfully to the fore.

Wiener was quoted in *Time* magazine's summary of scientific themes of 1960: "The greatest challenge to man's ascendancy is not other living creatures but mechanical monsters of his own creation," read the subheading to his piece, "Revolt of the Machines." "It is my thesis," Wiener told *Time*, "that machines can and do transcend some of the limitations of their designers."[506] Later that year he wrote a piece of pop social philosophy in *Science*, titled "Some moral and technical consequences of automation." Here, he again expressed his worry in terms of the dynamic of control: "By

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504 For a review of cybernetic ideas in Dick's fiction, see: Warrick, Patricia. *The Cybernetic Imagination in Science Fiction*. Cambridge, Mass.: MIT, 1982, 211-215. For the classic cyberpunk sampler see: Sterling, Bruce, ed. *Mirrorshades: The Cyberpunk Anthology*. Wesminster, Md.: Arbor House, 1986.
505 "Is the Computer Running Wild?" *U.S. News & World Report*, Feb. 24, 1964, 80.
506 "Science: Views of Life," *Time*. January 11, 1960. Accessed 4 Sept. 2010. <http://www.time.com/time/magazine/article/0,9171,894641,00.html>

the very slowness of our human activities, our effective control of our machines may be nullified... We can still by no means always justify the naïve assumption that the faster we rush ahead to employ the new powers for action which are opened up to us the better it will be."[507] Computers, the quintessential cybernetic control systems, were the fulcrum of the automation story of the 1960s. Could we control our information processors, or were they beginning to control us?

"With the advent of the 'thinking' machine," joked Judy Viorst in the December 1960 *Science News Letter*, "people are beginning to understand how horses felt when Ford invented the Model T."[508] Computers occupied the driver's seat of a transformation Viorst called "a new machine revolution." "Electronic brains" were connecting long-distance telephone calls, automatically guiding machine tools, overseeing chemical processes, and helping doctors evaluate medical records. Viorst appropriated Berkeley's iconography unabashedly:

> What is new about these machines is not their brawn but their 'brains.' The brawn has been around for a hundred years. But only now have people begun to use—and need—machines that do their thinking for them. A recent cartoon showed a robot assuring a human job applicant that there was great room for advancement in his office. 'After all,' the robot pointed out, 'only a few years ago I was just a pile of junk in the back yard.'[509]

To Mumford, increasingly an opponent of technology-for-its-own-sake, computers were an insuperable artifact of the erosion in the human factors of design, politics, and social organization. "Shall we... restore man to his central position as the actor and director in a historic drama," Mumford wondered, "or shall we banish him into the wings, first as a mere agent of an automatic control system, but eventually as a desperately bored supernumerary with no more active responsibility than a union

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507 Wiener, Norbert. "Some moral and technical consequences of Automation." *Science* 131 (May 1960), 1355-1358.
508 Viorst, Judy. "Thinking Machines Take Over," *Science News-Letter*, December 3, 1960, 362.
509 Viorst, "Thinking Machines Take Over," 363.

stagehand in a modern drama that doesn't use scenery? Unless we tackle this question swiftly, we shall soon find that the last word in automation is automatic man." Mumford feared what he saw as "the great mechanical collectives"—megamachines of hierarchical logic in manufacturing, finance, the military, public education. Such monstrous complexes were attested throughout history, of course; long ago civilizations employed sophisticated systems to build pyramids and cathedrals, to spread laws and commerce, and to instill religious orthodoxy. Computers' novelty was in their usurpation of the control of knowledge, and thus too, the *New Yorker* critic lamented, the human spirit.

Mumford was influenced by the turn-of-the-century English writer Arthur Penty, who, in turn, was a product of "arts and crafts" school of John Ruskin and William Morris. By Mumford's day, an established tradition of thinkers, from Erich Fromm to David Riesman had equated the improved leisure opportunities deriving from mechanized production and the Smithian division of labor with insecurity and ennui.[510] Mumford held that a mechanized economy that privileged quantity over quality, impersonal efficiency over individual labor, had created a class of citizens whose basic needs for fulfillment and an intimate connection to society's productive capacity could no longer be met within the industrial system.[511] Echoing Thorstein Veblen and the French sociologist Jacques Ellul, Mumford argued that the market mechanism fundamentally mispriced these needs and that industrial capitalism, by emphasizing only "innovation" and price competition, had outlived its usefulness.

Later in the same speech, the 68-year-old Mumford's anti-modern stirrings took

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[510] Fromm, Erich. *The Sane Society*. New York: Holt, 1990.
Riesman, David. *The Lonely Crowd: A Study of the Changing American Character*. New Haven: Yale, 2001.
[511] Brick, Howard. *Transcending Capitalism: Visions of a New Society in Modern American Thought*. Ithaca: Cornell, 2006, 190.

on an almost fever pitch. Computers may beat humans in chess, for example, but ought we celebrate this triumph? "What will happen to human pride, or to the game of chess for that matter, when computers become so intelligent that they will deign to play only with other computers? If man's own life is indeed so utterly worthless, what new value does it acquire by being turned over to a machine?" Echoing Wiener, another lapsed technological optimist, Mumford agonized whether the modern value of scientific reason was a value at all. "When you empty out the proper life of man," he concluded, "all that's left is emptiness."

Perhaps it is easy to overestimate Mumford's influence among his contemporaries. His *New Yorker* audience was, ideologically and socioeconomically, a narrow set indeed. But if he didn't speak for Main Street, Mumford's skepticism is a pointed reflection of the response awoken by computers in the mind of the literary humanist. What for some was a practical and economic problem, was, for men like Mumford, moral and philosophical in nature. Barely a year after the vertiginous experience of the Cuban missile crisis, his existential anxiety not surprising.

Nothing gave Mumford more distress than the application of mechanical logic to war. Certainly, in the aftermath of Hiroshima and Nagasaki, the advancing technology of warfare loomed large as a threat to civilization. Giant Brains were at their most fearsome when directing warheads or subjecting diplomacy to game theory. "More and more electronic brains will be making decisions in response to menacing enemy moves," heralded *Newsweek* in 1960. Reducing questions of state to digital logic could lead to some very unpredictable outcomes. Norbert Wiener worried, "If the rules for victory in a war game do not correspond with what we actually wish for our country, it is more likely that such a machine may produce a policy which will win a nominal victory on points at the cost … even of national survival."[512]

Even computers equipped with a very sophisticated intelligence operated within the bounds of their programming. Thus they were very much subject to the rule of "garbage in, garbage out." A 1962 *U.S. News & World Report* feature wondered, "Will Computers Run Wars of the Future?"[513] If they did these problems would begin to compound on themselves: "Computers can be steered wrong. Questions framed in a wrong interpretation of events—bad intelligence, for example—will bring bad solutions." Military brass may have lost sleep over the erosion of human judgment in the tactical theatre. What kept more people awake at night was the possibility of an actual military strike triggered by computer, in an accidental war-game scenario. The abstraction of push-button war, enabled by new digital machines, exposed the frail line between routine error and calamity. "Can electronic 'brains' mislead commanders into war?" *U.S. News* asked. For the present, the prospect seemed unlikely. Two actual instances—reflections from the moon spotted by missile-defense radar in 1960 and a false signal during the Berlin crisis of 1961—both came to nothing when a human commander looked more closely into the situation.[514] But false alarms were an unnerving science fiction prospect; W.H. Pickering, head of Caltech's Jet Propulsion Laboratory foresaw a time when "the decision to destroy an enemy nation—and by inference our own—will be made by a radar set, a telephone circuit, an electronic computer."[515] Fundamentally, computer automation removed an element of control from the decision process. Trusting

[512] "Scientist's Warning: Now Machines Can 'Think'," *Newsweek*, 1960, 21.
[513] "Will Computers Run Wars of the Future?" *U.S. News and World Report*, April 23, 1962, 47. *U.S. News* cited the saying "[A computer] answers a fool according to his folly."
[514] "Will Computers Run Wars of the Future?" 48.
[515] "A-War By Accident," *Newsweek*, March 24, 1958, 62.

autonomous systems to govern matters of grave importance, like global military security, required a leap of faith even many computer scientists were unwilling to make. Pickering did not want to give over to the machine this much responsibility; his darkest nightmare was that "the failure of a handful of vacuum tubes and transistors could determine the fate of our civilization."[516]

Pickering's scenario was a staple of science fiction film and literature. The 1966 novel *Colossus*, adapted into a movie as 1970's *Colossus: The Forbin Project*, dramatized the near misses of 1960-1961 in a much more Shelleyian fashion. Dennis Feltham Jones' book depicted the production of an eponymous computer system that assumed absolute military authority for the United States.[517] Escaping its creators' attention was the fact that the USSR has simultaneously built a similar machine. In the interest of mutual safety, both defense systems are linked, and after exchanging stores of data and programs, become sentient. As their increasingly sophisticated data transmissions began to confound scientists in both countries, the connection is severed; in retaliation, the supercomputers launched twin nuclear strikes and demand to be reconnected.[518] The Americans and the Soviets agree; the computers disable the missiles, and establish control over all human society.

The same year that *Colossus* hit store shelves, Robert Heinlein published his

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516 Ibid.

517 Jones, Dennis Feltham. *Colossus*. New York: Berkeley Books, 1985.

518 The plot of Colossus bears some resemblance to the 1958 novel *Red Alert*, the basis for Stanley Kubrick's 1964 tragicomic film, *Dr. Strangelove*. In Peter George's earlier novel, an accidental missile launch triggers an automatic fail-safe, a Soviet "doomsday device" to destroy all of humanity. The rigidity of automated decision-making ultimately eludes all of the Russian and American authorities' efforts to circumvent annihilation. In Kubrick's film, the Americans' ex-nazi nuclear scientist Dr. Strangelove, reacts cheerfully to the imminent destruction of mankind. Civilization can be remade underground with survivors selected by a kind of lottery, he argues: "It could easily be accomplished with a computer. And a computer could be set and programmed to accept factors from youth, health, sexual fertility, intelligence, and a cross section of necessary skills.... But, ah, with the proper breeding techniques and a ratio of say, ten females to each male, I would guess that they could then work their way back to the present gross national product within say, twenty years."

Hugo Award-winning novel, *The Moon is Harsh Mistress.*[519] Heinlein's book is lighter in tone than *Colossus*, and concerns a fairly jovial supercomputer named "Mike" who organizes and directs a revolution by a 21st-century lunar colony against Earth. Mike handles not only logistics, but strategy, battlefield command, and public relations in the guise of his unseen alter-ego, Adam Selene. The war is successful, though the computer never graduates to the megalomania of Colossus. Instead, after achieving victory he retreats to the mundane data processing of his 1960s forbears.

Both stories rest on the notion that computers are somehow person-like, that artificial intelligence is an amplified version of human intelligence, and that quirks of personality are likely to be passed down from human beings to their mechanical progeny. Colossus and Mike, in their own ways, are ancestors to the HAL-9000, Arthur C. Clarke's malevolent flight computer in the 1968 film and novel *2001: A Space Odyssey*. This overwhelming consensus among science fiction novelists that computers made good characters—both heroes and villains—was terrifying when applied to a real-life military context. Many Americans had begun to think of their military (even before Vietnam War-era muckrakers made infamous Operation Igloo White) as a kind of mechanism dealing in cold logical calculus, impregnable to such human notions as empathy, compassion, or moral responsibility. The computer, imagined as a monster of unadulterated logic, was a natural symbol. It was not difficult for critics of American defense policy to imagine generals turning over the launch codes to an algorithm, a laboratory-grown Giant Brain with no understanding of the ambiguities of life in human skin. Pickering, a research scientist as well as an engineer, feared a glitch in the system. Others, like Mumford, feared the system itself.

[519] Heinlein, Robert A. *The Moon is a Harsh Mistress*. New York: Tom Doherty Associates, 1966.

From the earliest, computers were linked in popular discourse with the Pentagon. Indeed, Paul Edwards' history, *The Closed World*, has convincingly detailed the military origins of such technologies as conditional branching, magnetic core memory, and RASTER graphics.[520] In January of 1950, the cover of *Time* portrayed the Harvard Mark II (captioned "can man build a superman?") as an anthropomorphized naval officer in full military uniform, pouring over paper tape.[521] Edmund Berkeley, digital computers' foremost civilian advocate, wrote of the computer as the child of the Defense Department: "The military forces of the big nations, and the United States particularly, are more responsible than any other single source for the rapid growth of computer technology from World War I to the present. The need of military forces urged forward the computer art. The most powerful computers ever built are for the military forces."[522] But these bellicose beginnings didn't signify to Berkeley that all computers were good for was dropping bombs. The fact that military applications of computing power were, in the early 1960s, by far the most numerous only provoked caution, and alerted concerned citizens of the need for enlightened regulation and conscience in future technological evolution.

In fact, properly used, some suggested computers could help prevent war. If warfare is irrational, a machine with all relevant information and perfect deductive reasoning would do more to avoid war than to set off nuclear Armageddon. In a 1970 speech Berkeley spoke of the six-day war between Israel and Egypt that had taken place

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520 Edwards, Paul. *The Closed World: Computers and the Politics of Discourse in Cold War America*, Cambridge, Mass: MIT, 1996, 99-100. Edwards' larger thesis, that military attitudes about rational expectations, control, and programmability inform the creation of generations of computers after the first wave, is much more tenuous, depending on selective evidence gathering. My contention--that the computer is best thought of as an office product—places computer history in a quite different frame.

521 "The Thinking Machine," *Time*, January 23, 1950. Accessed 4 Sept. 2010. <http://www.time.com/time/magazine/article/0,9171,858601,00.html>

522 Berkeley, Edmund C. *The Computer Revolution.* New York: Doubleday, 1962, 137.

three years earlier. “Suppose Nasser...had had a computer” Berkeley mused, “and suppose Nasser's programmers had fed the appropriate information into the computer, and suppose the computer told Nasser that the Israelis would be victorious?”[523] Would the Egyptians have been aggressors if outfitted with state-of-the-art AI? Berkeley looked “forward to the day when the wisdom of appropriately programmed computers will be applied to great big problems of human society.” This was not coming from any crew-cut colonel, or Keynesian economic planner. Berkeley was as committed a peacenik as could be found in the early computer movement. A subscriber to the short-lived newspaper “Interrupt: Computer Professionals for Peace,” Berkeley wrote letters to local political officials, as well as Senator Ted Kennedy, protesting arms buildup and escalation in Vietnam. Like Norbert Wiener, he was able to reconcile agitating for peace, worrying over the misapplication of computer intelligence, and unabashed optimism for computers' future. It is thus wrong to conflate, as Paul Edwards does, enthusiasm for computers with the kind of demonic militarism associated with the likes of Edward Teller and John von Neumann. That many early computer pioneers served in the defense establishment is irrefutable. Vannevar Bush, Howard Aiken, and J.C.R. Licklider were all zealous military officers or administrators. But they were not without qualms, like Colossus' reluctant creator, the “cyberneticist” Dr. Forbin. That they all embraced arms buildup or push-button war without reservation is a fallacy. Many wartime scientists, Wiener and Berkeley among them, were particularly aggrieved by the defense application of what they saw as an eminently civilian technology. Computers and military decision-making were indeed cousins but were not necessarily joined at the hip.

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[523] Berkeley, Edmund C. “Address to the NRECA,” August 9, 1970, 6-7. Edmund C. Berkeley Papers (CBI 50), box 17, folder 81, Charles Babbage Institute, University of Minnesota, Minneapolis.

In addition to Mumford's existential angst, and the worries over military misuse, certain alarmed readers of *Cybernetics* raised the specter of a massive upheaval in labor. An early salvo in the critique of computer automation was fired by the satirist Kurt Vonnegut in his debut novel, *Player Piano*. In Vonnegut's 1952 work, released a year before the term "automation" would enter the mainstream, computers do not wage war, but rather manage a peaceful, prosperous society. Still, Vonnegut's protagonist, the aptly named engineer Paul Proteus, feels that some essential element of his humanity has been lost in the neatly administered life of a post-World War III Fordist America. Vonnegut knew his subject intimately; before retiring to pursue fiction writing, he worked in the public relations department of General Electric and saw the process of mechanization first-hand. Vonnegut had a degree in engineering and spent a lot of time talking to the breathless technological optimists in GE's computer department. This was where, he told *Playboy*, a vision began to take shape of a future "Brave New World" machines did all the work and the scientists who worked with them felt empty and useless. Vonnegut recalled,

> I saw a milling machine for cutting the rotors on jet engines, gas turbines. This was a very expensive thing for a machinist to do, to cut what is essentially one of those Brancusi forms. So they had a computer-operated milling machine built to cut the blades, and I was fascinated by that. This was in 1949 and the guys who were working on it were foreseeing all sorts of machines being run by little boxes and punched cards. Player Piano was my response to the implications of having everything run by little boxes. The idea of doing that, you know, made sense, perfect sense. To have a little clicking box make all the decisions wasn't a vicious thing to do. But it was too bad for the human beings who got their dignity from their jobs.[524]

The question Vonnegut asked in *Player Piano* is similar to Mumford's: what happens to man's self-respect when everything he does is done better by machine? In the words of the Shah of Bratpuhr, Vonnegut's archetypal outsider-observer, "What [were] people

[524] "Vonnegut on Science Fiction," *Playboy*, July 1973, 260.

for?"[525]

Vonnegut drew on the literature of computers, from Wiener through Berkeley. Paul Proteus speaks reflectively with his secretary Katharine Finch—the only woman at the Ilium Works factory where he is employed—about the social changes technology has wrought. "You say how the First Industrial Revolution devalued muscle work, then the second one devalued routine mental work," Katharine says. "I was fascinated." "Norbert Wiener, a mathematician, said all that way back in the nineteen-forties," Paul replies. Katharine wonders, "Do you suppose there'll be a Third Industrial Revolution?" Following the progression Paul has laid out, a third one could only devalue the spirit. "In a way, I guess the third one's been going on for some time, if you mean thinking machines," Paul muses. "That would be the third revolution, I guess—machines that devaluate human thinking. Some of the big computers like EPICAC do that all right, in specialized fields."[526] The supercomputer EPICAC (a play on ENIAC and the children's emetic ipecac) had made an earlier appearance in a Vonnegut's 1950 story of the same name, published in *Collier's Weekly*, an unusual venue for science fiction. In the short story, EPICAC falls in love with a human programmer, and, when it is spurned, deactivates itself. In *Player Piano*, the 14th generation EPICAC runs the United States economy from its base in Carlsbad Caverns and survives an assassination attempt by a Proteus-led Luddite rebellion. The rebellion succeeds in unleashing a tantrum of destruction, but not in overthrowing the techno-corporate order that governs everything. That the insurgents fail to blow up the giant computer is some evidence of the fatalistic streak that runs through Vonnegut's novels; it also serves as a comment on the

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[525] Vonnegut, Kurt. *Player Piano*. New York: Dial, 1999, 277.
[526] Vonnegut. *Player Piano*, 19-20.

inescapability of a society run by enormous business interests, armed with the latest automatic technology.

Player Piano was ahead of its time. Ambivalently reviewed, Vonnegut's first effort sold lightly and failed to establish the budding novelist's reputation. Yet it uncannily prefigured several of the debates over computer automation that would rage through the next decade. It linked factory mechanization, a phenomenon Vonnegut witnessed at GE, with economic planning by computer and artificial intelligence. It resonated with the existentialism voiced by Mumford over technological creep while introducing practical socioeconomic critiques of the automated factory that would animate the rhetoric of labor leaders. Vonnegut modulated these critiques through considerations of class and individual liberty, both of which would assume a growing importance. And, to some, it was prophetic: "Futuristic, but not far-fetched," declared a *Washington Post* reviewer. While deriding *Player Piano* as derivative of Huxley's classic, the reviewer admitted, "The reader will find that there is a germ of truth in Mr. Vonnegut's satirical fantasy if he will take the trouble to read Prof. Norbert Wiener's *Cybernetics*."[527] Thus Vonnegut succeeded in mounting one of the first popular fictionalizations of a cultural tumult instigated by cybernetics.

Computer automation was a phenomenon that seemed to have a life of its own. Many non-technical people conceived of computers as an exogenous force, soon to take over businesses, government, and the military. To Mumford, the increasing reliance on information machines amounted to a subtle, erosive loss of agency over the direction of human affairs. This was an erudite and highly lettered perceptive. But the central psychological dynamic underlying Mumford's address was in fact shared by many

[527] Smith, Harrison. "A Plausible Triumph of the Robots," *The Washington Post*. August 24, 1952, B6.

Americans. The general science reading public was a ferment of doubt and anxiety. Whether the bogeyman was unemployment, or automatic nuclear war, or the mechanization of the human spirit, Americans were deeply uneasy. In our survey of the 1950s and 1960s popular literature on automation, it will become clear that, in an important sense, this fears were all derived from the same source. The computer, once an exotic and magical “Giant Brain” was now a very near and clear rival to man.

Chapter 12 – A revolution on the shopfloor

Where the last chapter examined fears of military annihilation and the withering of individual autonomy, much of the debate over automation swirled around more prosaic concerns. In the following pages I locate an unresolved debate over its economic benefits chiefly in the writings of John Diebold, a charismatic "information ambassador" and the foremost exponent for the adoption of computer power for industrial applications. Diebold catalyzed a public conversation that had simmered below the surface since Wiener penned *The Human Use of Human Beings*; in the late 1950s and early 1960s, following Diebold, mainstream press outlets suddenly picked up on the story of how computers and automatic machinery were transforming American business.

Diebold was keen to establish, rightly, that while "automation" resembled a number of earlier trends in the political economy of the West, it was, in its postwar sense, a unique phenomenon. The history of automation reads like an applied history of Wiener's cybernetics. Many writers, especially Diebold himself, recognized this liaison and made it central to both their diagnoses of the problems automation posed, and their prescriptions for the future. The term "automation" entered the lexicon in an industrial context. In 1946, Del Harder, vice president production at Ford was asked what could be done to cut costs and raise output as the car company transitioned from a wartime to a peacetime economy. Apocryphally, Harder is thought to have said, "Give us some more of the automatic business, some more of that automation."[528] The term was applied at Ford Motor Company, under the leadership of the famous Whiz Kids, who included future secretary of defense Robert McNamara and dean of Stanford's business school,

[528] Ashburn, Anderson. "Detroit Automation," *The Annals of the American Academy of Political and Social Science* 340 (1962): 21.

Arjay Miller, to describe how machine tools and the assembly line could be linked in a continuous feedback loop. Ford's corporate admirers took notice, and the automation process was consciously imitated at rival car companies, as well as among appliance manufacturers, petrochemical companies, and metallurgical concerns.

It is necessary to distinguish what Harder meant by "automation" from an array of earlier manufacturing processes, collectively known as "mechanization." The use of machines to improve the speed and uniformity with which goods were made was of course at the heart of the industrial revolution. Mechanization had begun to take over weaving and many other hand trades by the eighteenth century, and by the nineteenth, steam power was helping mechanically process coal, reap grain, and assemble rifles. The "American system of manufacturing" led to the advent of the assembly floor, first in armories and shipyards, where production was sequentially organized into a *process*, and interchangeable parts allowed for the rapid reproduction of a standardized product.[529] Automation was a related, but different phenomenon.

Twentieth-century thinkers apprehended that mechanization was as much a social development as a technological one. Growing awareness of the importance of organization and pattern, to the flow of information through a production system, laid the seedbed for the idea of the *automatic*. In 1934, Mumford wrote,

> Mechanization and regimentation are not new phenomena in history: what is new is the fact that these functions have been projected and embodied in organized forms which dominate every aspect of our existence. Other civilizations reached a high degree of technical proficiency without apparently being profoundly influenced by the methods and aims of technics.[530]

Automation, as Diebold saw it, was the apotheosis of this trend toward the consideration

[529] Woodbury, R.S. *Studies in the History of Machine Tools*. Cambridge, Mass.: MIT, 1973.
[530] Mumford, Lewis. *Technics and Civilization*. New York: Harcourt Brace, 1936, 4.

of the entire organizational *system*. As managers turned their eyes towards methods, they began, at first unconsciously, to abstract the flow not just of parts, but of decisions (information) through the factory. It required, perhaps, a cybernetic point of view to appreciate the extent of the novelty. Norbert Wiener contrasted the first industrial revolution to a second one, then underway, wherein mental, rather than physical power, could be mechanized.[531] The automation of knowledge might have begun, in earnest, as early as the 1890 census, when Herman Hollerith won the contract to create a punched card tabulator to count results. Higher-order logic and reactive decision-making were more difficult processes to automate. With the creation of commercial digital computers, executives foresaw that every aspect of production, from strategy, input, ouput, and analysis, could be initiated by an information machine. Though Harder did not refer explicitly to "computer automation," "automation" became the quintessential neologism of the computer era. Often conflated with the longer history of mechanization, "automation" was most commonly meant a distinct, contemporary phenomenon.

At the time Harder made his famous remark, there were no private electronic computer installations in the world. It is something of an accident of history that he is credited with the coinage of "automation." Yet, such an accident reveals that computers were, however crudely, being inserted into a debate that preceded, and in some ways superseded, their appearance on the scene. The man who was most responsible for thrusting the term "automation" into the public circulation was a young management consultant and MBA named John Diebold. Diebold was only twenty-five in 1952 when he graduated from Harvard Business School and started the country's first consultancy

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[531] Wiener, Norbert. *The Human Use of Human Beings*. New York: John Wiley & Sons, 1953, 136-148.

dedicated to advising companies on automation.[532] Diebold's thesis, which had its origins in a famous manufacturing class taught by venture capitalist Georges Doriot, evolved into his eponymous 1952 book on the subject, and kick-started an industry of automation advice.

Unlike those who saw automatic feedback-controlled machinery as nothing more than an improved species of tool, as the grain elevator was an improvement on the miller's wheel, Diebold viewed the phenomenon as a decisive break from the past. Said Walter Reuther, "Not only the technique, but the philosophy of automation is revolutionary, in the truest sense of the word."[533] Diebold believed that he had entered an entirely original field of endeavor. "I do feel," he wrote, "that if automation means anything at all, it means something more than a mere extension of mechanization."[534] It implied an entire philosophy of how work is performed; rather than enhancing by piecemeal any given device, automation integrated a whole arena of machines as a feedback system. The system would be oriented around those fundamentally cybernetic parameters—control and information. "While its roots are far in the past—steering engines of ships, Watt's governor, Dutch windmills, Roman float control, Chinese chariot linkage systems—the technology of feedback applied on any wide scale is a phenomenon of our own times."[535]

Diebold keenly saw the link between the new science of computers and the manufacturing practice initiated by cost-conscious executives at Ford. While still at

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[532] "Computer Visionary John Diebold Dies at 79," *Associated Press*, December 27, 2005. *CTV News*. Accessed 4 Sept. 2010. <http://www.ctv.ca/CTVNews/SciTech/20051228/diebold051228>
[533] Diebold, John. *Automation: Its Impact on Business and Labor.* Washington: The National Planning Association, May 1959, 2.
[534] Ibid.
[535] Diebold, *Man and the Computer*, 134.

Harvard Business School, Diebold wrote Norbert Wiener's collaborator Julian Bigelow, asking how servomechanism theory might be applied to industry.[536] To Diebold, the proposition of automating a factory was very much a question of communication and control, and was thus in the spirit of Wiener and Bigelow's cybernetics. As he began to study computers as information-processing tools, Diebold became convinced that information processing lay at the heart of most business problems. He agreed with Wiener and Berkeley that the "second industrial revolution" was very different in character than the first, and would very likely be organized around the computer, just as the 19th-century variety was centered on the steam engine. To Diebold, automation was part of a sweeping movement that would change not only business, but everyday life as well. He announced that "the effects of the technological revolution we are now living through will be deeper than any social change we have experienced before."[537] Clearly, Diebold shared the belief of his breathless contemporaries' that history was speeding up.

Tellingly, the articulate and ambitious theorist became, as Wiener had for cybernetics and Berkeley had for computers, automation's popular evangelist. Through his tireless proselytizing, the stories of automation and computers became intertwined. "Combining many of the most important technological developments of the last decade, the computers embody the technology of control in its highest form," he wrote in his opus, *Automation*.[538] "When used with insight and ingenuity, computers will permit relief from the most repetitive form of human work. They will make possible more rapid and less wasteful methods of increasing our material well-being. By virtue of their great

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[536] Norbert Wiener Papers (MC22), 1950, box 9, folder 131, Institute Archives and Special Collections, M.I.T., Cambridge Mass.
[537] Toffler, Alvin. *Future Shock*. New York: Bantam, 1984, 14.
[538] Diebold, John. *Automation: The Advent of the Factory*. New York: Van Nostrand, 1952, 21.

speed and ability to handle many simultaneous variables, they will permit us to perform many tasks which until now we could not reasonably attempt."[539]. Though a more circumspect cheerleader than Berkeley, Diebold's volume was aimed squarely at a public of motivated readers, many employed at businesses beginning to computerize. His effort was to educate and to allay fears, and thus he steered clear of some of the melodramatic turns of phrase in which Berkeley indulged. He did however engage in prediction. Foreseeing computers used as communication devices, he saw a future of electronic stock exchanges, ordering "a process as simple as dialing."[540]

Diebold had read Berkeley's *Giant Brains* and thought its extravagance did more harm than good. Berkeley, like Wiener, warned, "There seems to be no kind of escape possible... It is necessary to grapple with the problem: How can we be safe against the threat of physical harm from robot machines?"[541] Diebold argued that this sort of hortatory only inflamed what Asimov had called the public's erroneous "Frankenstein complex". Diebold viewed the problem as largely semantic: as we hadn't yet words to describe the mathematical-logical work that computers do, we are left with residual linguistic artifacts like "thinking."[542] Computers were essential tools that would make our lives easier; there was nothing inherently in their logical circuits that threatened us with replacement.[543] The essential human quality of free will, Diebold believed could in

[539] Diebold. *Automation*, 1952, 30.
[540] Diebold. *Automation*, 1952, 41.
[541] Berkeley, Edmund C. *Giant Brains, or Machines that Think.* New York: John Wiley & Sons, 1949, 201.
[542] Diebold. *Automation*, 1952, 154.
[543] By 1966, Diebold had in great part recanted his earlier conservatism. In 1966 address tot the Chicago Economics Society, titled "The Profound Impact of Science and Technology," Diebold claimed, "Information technolgoy is leading us to the construction of machines that exhibit most of what we have previously meant by 'intelligence'--machines that can truly be said to learn and machines that not only respond intelligently to spoken commands but also speak. That such machines will pose problems is already evident. Some of the problems will be as fundamental as man's questioning his role in the world …

no way "be attributed to any machine yet developed, nor is there any indication that any such machine *could* be developed."[544] Computers were destined to remain resources of management, and not become managers themselves.

Automation had the effect of inextricably tying the development of the digital computer to the process of industrial automation, both for Diebold's lay readers, and for his consulting clients. It was a genre-making bombshell that thrust him into the spotlight, and it did much to propagate the sanguine view that computers were auguries of greater prosperity and more leisure ahead. But it also touched off an argument. Automation might improve manufacturer's bottom lines while lining consultants like Diebold's pockets, but would all society benefit equally? Not everyone shared his optimism.

In 1955 Diebold was the first to testify at a hearing called by the U.S. Congress' Joint Committee on the Economic Report on the social and political challenges of the phenomenon he had named. The hearings were, in the committee's words, "the first congressional recognition of this important postwar trend called automation."[545] For the first time, economists, labor leaders, and business executives sat in a room together to discuss computers with engineers like Vannevar Bush and Jay Forrester. Diebold told the panel that these new technologies were not only inevitable; they were necessary. "Automation is needed as the key to the survival of our way of life," he forcefully claimed. "We need greater productivity to meet the competition from our enemies and to provide the higher living standards and easier life that our people are demanding."[546]

Perhaps the one phenomenon most characteristic of our age is the rate of change itself." Diebold. *Man and the Computer*, 7.

[544] Diebold. *Automation*, 1952, 154.

[545] The Congressional Joint Committee on the Economic Report. "Automation and Technological Change," Washington: U.S. Government Printing Office 1308 (January 5, 1956): 3.

[546] Diebold. *Automation*, 1959, 6.

Only a comprehensive study—one that unearthed all the facts—could rebut the critics of automation, who, at the moment, were "dramatizing their case [more] effectively."

The tone in the room thus hardly touched the gloom of Mumford or Wiener, but did reflect a note of caution. Following Diebold, the subcommittee defined automation as a distinctly new phenomenon, made possible only in the postwar period by the science of cybernetics. As opposed to earlier mechanical systems, the subcommittee found that "the essential element in modern automation appears to be the introduction of self-regulating devices into the industrial sequence through the feedback principle whereby electronic sensing devices automatically pass information back to earlier parts of the processor tool wear or other items calling for control."[547]

As Wiener had predicted, this kind of automatic feedback control comfortably insinuated itself into industrial processes formerly staffed by human beings. In the Joint Committee's hearings, organized labor occupied a prominent seat at the table. Union leaders like Walter Reuther were cooperative, and stressed that increasing productivity and economic dynamism could improve the lot of the American worker in the form of release from drudgery, better pay, and better and cheaper consumer products. "Certainly none of the evidence," the subcommittee admitted, "…supports a charge that organized labor opposes or resists dynamic progress." Reuther and his colleagues were watchful, however, that the gains from productivity were distributed evenly throughout the production system. However positive automation for the economy as a whole, labor leaders worried that certain individuals would be disproportionately affected—particularly middle-aged and older workers.[548] "It doesn't do much good to try to

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[547] Diebold. *Automation*, 1959, 4.
[548] Diebold. *Automation*, 1959, 8.

convince an individual worker who does get displaced from an individual job that over a twenty-five-year span there is no such thing as technological unemployment," the president of Sylvania, an electronic firm, conceded. "All he is worried about is that he lost a job."[549] Should a displaced worker find a new job, he still stood to lose the accrued benefits of seniority, pensions, and insurance. The majority of witnesses agreed that even the certainty of long-run equilibria could not justify short-term inaction. As the economist of the moment, John Maynard Keynes, had quipped, "In the long run we are all dead."

The subcommittee viewed dealing with the human costs of a transition to a higher productivity equilibrium as a business problem as well as a social problem. In the spirit of pluralist cooperation, it recommended "that industry, and management for its part, must be prepared to accept the human costs of displacement and retraining as charges against the savings from the introduction of automation."[550] Notwithstanding this pitfalls, Diebold and a chorus of business leaders persuaded the Joint Committee that nothing could benefit displaced workers more than pro-growth policies aimed at creating an abundance of new jobs. The solution to the automation problem, the congressional panel concluded, was to assure "a good, healthy, dynamic, and prospering economy."[551] Computer automation, in practice, was a difficult matter, however. This mid-1950s consensus would soon break down.

Although computers by 1960 were well established in the public eye thanks to the obsessive fascination of the mainstream press, factory owners had only just begun to

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[549] Diebold. *Automation*, 1959, 28.
[550] The Congressional Joint Committee on the Economic Report. "Automation and Technological Change," 14.
[551] Ibid.

understand how to integrate computer control into their work processes. The possibility of incorporated feedback from the assembly line and automatically reconfiguring industrial processes had intrigued managers from the outset of the computer industry. Jay Forrester of M.I.T. had worked with servomechanisms for radar antennae and gun mounts during World War II, and was a pioneer in bringing the feedback principle to business. After the war, Forrester returned to the M.I.T. Servo Lab and oversaw development of the Whirlwind analog flight simulator, which Forrester gradually grew into a multipurpose digital computer, complete with cutting-edge magnetic core memory. As the breakthroughs in Whirlwind became applicable to automated decision-making through its offspring, the Air Force's SAGE (Semi-Automatic Ground Environment) missile-defense program, and later American Airline's SABRE automatic on-line reservation system, Forrester realized the importance of computing machinery to business.[552] In 1956 he moved to the Sloan School of Management and began to popularize the concept of automatic feedback in executive circles.

Two years later, *Fortune* wrote, "The computer's great role here is to eliminate delays in communication; in an automated oil refinery, for example, hundreds of measuring devices lead to the machine. The computer, having been given thousands of instructions on how to react to the readings of the measuring devices, *instantaneously* applies heat of pressure or otherwise adjusts the controls. Because it keeps on reacting and making adjustments instantaneously, in never has to make large adjustments."[553] In fact, refining and processing were two of the first industries to automate. In 1959, by one

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[552] SABRE was aptly termed, by Gilbert Burck in *Fortune* as "basically a highly ingenious method for keeping inventory in line." Though it was a national, distributed system over telephone lines, it was also, as Burck suggests, merely an evolution of the mainframe processors retailers' used to tabulate inventory and optimize its turnover rate. Burck, Gilbert. "'On Line' in 'Real Time'," *Fortune*, April 1964, 142.

[553] Burck, Gilbert. "The Boundless Age of the Computer," *Fortune*, 1964, 235.

estimate, the American oil refinery was 80 to 90 percent automated.[554]

"The artificial nervous system which is replacing the human one," *The Nation* concluded, "is based on a single underlying principle: the 'feedback.' This principle underlies all self-regulating systems, including living organisms."[555] Similar statements could be equally applied to wholesalers' electronic inventory management programs. Offices found that instead of hiring more clerks, complex payroll and revenue accounting could be performed on an IBM 705 or a UNIVAC. In the 1960s, ideas from servomechanism theory were liberally imported from cybernetics by management literature, and computer-aided feedback control seemed like a natural extension.[556]

Business spending reflected the emphasis given the new technology. The economist Robert Heilbroner estimated in 1962 that half of all the research and development expenditures in all of American history had been made in the previous decade.[557] Still, according to a 1963 McKinsey & Co. study, it was often difficult to justify the expense in terms of increased output; among twenty-seven surveyed manufacturing companies which had installed over 300 computer systems, only nine were earning enough on their investment to cover the installation. The greatest failure was when the machines sat idle because executives had not given enough consideration to what sort of work might be automated.[558] Companies were mistaken to equate computer time directly with clerical work, according to *Business Week.* Much of what

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[554] Diebold. *Automation*, 1959, 13.
[555] Piel, Gerard. "End of Toil," *The Nation*, June 17, 1961, 515.
[556] For an example, see the "management cybernetics" of Stafford Beer, an influential business theorist and pioneer in the field of operations research. Beer, Stafford. *Cybernetics and Management.* New York: John Wiley & Sons, 1959.
[557] Heilbroner, Robert. "The Impact of Technology," in Dunlop, John T., ed. *Automation and Technological Change*. Englewood Cliffs, NJ: Prentice Hall, 1962, 8.
[558] Burck. "The Boundless Age of the Computer," 218.
"Is the Computer Running Wild," 81.

clerks do is interpersonal and difficult to quantify. One large company found that after investing over $800,000 in installation, training, programming, and connecting peripherals, and over $500,000 in a dedicated staff, it could only reduce headcount by twenty-five percent.[559] The computer was at times simply uneconomic.

Businesses knew that information processing was the future; the trouble was in implementation. In David Noble's Marxist account, *Forces of Production*, machine tools factory managers were intrigued by so-called “Flexible Manufacturing Systems” if for no other reason than to wrest control of valuable process knowledge from workers and install it in software, which did not require pension benefits.[560] But in many cases, compelling arguments could be made for computer automation on the grounds of productivity yields. From 1947 to 1959, *Business Week* reported an increase of 223% in productivity in the synthetic fiber industry, with an attendant fourteen percent total decline in employment. So too, steel output increased seventeen percent over the same time period, while direct production employment declined by twelve percent.[561] General Electric managed to increase output by ten percent between the years of 1956 and 1959, while shrinking its production payroll an equivalent amount.[562] Clearly, computerization could in fact offer geometric gains in capacity while lowering variable costs.

Technology providers had an interest in making businesses' transitions easy. Marketing departments at major computer firms found themselves directly contending with public anxieties about the part electronic brains were playing in the transformation of American business. Univac's 1956 brochure, directed at the “Average Businessman”

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559 “Business Week Reports to Readers on Computers,” *Business Week*, June 21, 1958, 76.
560 Noble, David F. *Forces of Production: A Social History of Industrial Automation*. New York: Oxford University, 1986.
561 “Is Automation Really a Job Killer?” *Business Week*. February 24, 1962, 47.
562 Piel. “End of Toil,” 516.

exemplified a genre of marketing to non-technical executives. The computer was imagined as something powerful and efficient, but also something simple, obedient, and benign.

In its sales literature, Remington Rand trumpeted the invention the FLOW-matic programming language by Grace Murray Hopper, a Univac employee in 1955. FLOW-matic was an ancestor to Hopper's more famous COBOL, and a first attempt at developing a command syntax using English words. For Univac, at its best a difficult machine to operate, this meant nothing less than the full-scale democratization of computer use. “For the first time,” Remington-Rand declared, “Flow-Matic makes Univac directly available to a large class of potential users who have heretofore been forced to stand and watch the process of programming and coding from the outside. The result is bound to be beneficial right down the line, beginning with faster and more accurate preparation of refined programs and moving on through to greater and more effective utilization of data-processing system.”[563] Purchases could ensure a greater bang for their buck by training a greater percentage of their workforce to run and write programs on the Univac.

The chief selling point of a UNIVAC installation was the liberation of clerical manpower. But Univac's marketers consciously made no mention of layoffs. Overhead could be cut via faster workflow rather than headcount reductions. The computer industry, aware of the negative chatter, framed technology as a labor aid, not as replacement for human capital. After all, the computer illiterate customer might have justifiably imagined that after secretarial and actuarial positions were eliminated, managerial ones would be next on the chopping block. Computers lacked creativity, the

[563] Ibid.

brochure stressed, “but your skilled personnel have imagination … and once a UNIVAC computing system rescues them from handling dull routine chores all day long, they can begin to exercise it for more creative, and productive thinking.”[564] Couching its pitch in terms of productivity, Univac tread lightly around the role of automation in unemployment, which, as we will see, was canny strategy given the febrile atmosphere of the 1950s and 1960s. At the same time, it positioned the computer in a paradoxical dual role: at once it was a clerk, capable of managing the most mundane tasks without complaint, and a window to greater intellectual horizons when paired with the spark of human programming. The kind of man-machine symbiosis Univac hinted at was to be a great part of the resolution of the fears of the computer's first two decades. As more and more people learned to use computers, computers too would learn to be better partners their human users.

Univac's principal competitor, IBM, got into the pamphlet act too. IBM had overtaken Univac in sales primarily on the strength of its established sales force and customer relations. Big Blue's great success over the entire course of its history as a hardware firm was to make its products seem as familiar and indispensible as a pencil without debasing their mystique. “In a few short years since it was developed, the computer has profoundly affected all of us,” pronounced one brochure. Univac had FLOW-matic; IBM had the nearly-as-accessible FORTRAN. Despite its radical potential to change the fundamental framework of business, the computer could be seen as a simple democratic force. The writer, senior engineer Fred Gielow, emphasized that computers were just the latest productivity tools in IBM's product line. “It's not at all hard to think of the computer as an electronic wizard. But it isn’t magical. Like the

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[564] Ibid.

television set in your living room, the computer is simply a piece of electronic equipment. Unlike your television set, which is designed to entertain you, the computer is designed to solve problems."[565] Solving problems was what IBM machines were for; like the UNIVAC, the IBM 7090 was branded a thinking aid. The language of intellectual augmentation was unmistakable: "The computer cannot think any more than the washing machine can think," wrote Gielow, disposing of the prevailing "Giant Brain" myth. "What it can do is extend man's problem-solving capabilities by performing many arithmetic, logic, branching and input/output instructions with lightning speed."[566] Get your employees in front of a computer, IBM suggested, and *they* could become Giant Brains.

By 1960 computers had made significant headway running plants in industries where inputs and process were fairly static. Steam-electric plants along with coal and chemical processing had nearly achieved the promise of full automation. Texaco, Monsanto, Standard Oil of California, and numerous electric utilities were already operating "closed loop" computer control systems, *Business Week* found.[567] In such a process, sensors and actuators actually fed directly into a computer processor that could control factors of speed, temperature, and input volume. The message of this and similar articles was unambiguous. Computer automation was here and it was here to stay.

Yet in manufacturing, where production schedules were more protean, managers encountered more difficulty in adopting computer control. Here, informed production

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[565] Gielow, Fred C. "Introducing … the Computer," IBM, Computer Product Literature 1948- (CBI 12). Box 76, 3. Charles Babbage Institute, University of Minnesota, Minneapolis.
[566] Ibid.
[567] "Computers Start to Run the Plants," *Business Week*. November 5, 1960, 52.

decisions had always eluded concretization in a model.[568] If demand for Widget A surged in the Northwest in the first six months of the fiscal year, should production be ramped up for the third quarter, and by how much? How would such an increase in capacity affect Widget B? And so on. Any control system clearly depended on a number of subjective assumptions about speed, cost, distribution, demand, the cost of capital, and sundry other parameters. Such questions depended on the skilled interpretation of data.

Manufacturing problems were difficult to put to the computer, but the new breed of technologists, inspired by Berkeley and Wiener, hoped to do so. "The old reliance on good, solid judgment bred of tenure and experience is under the eroding attack of irrepressibly enthusiastic engineers waving charts, graphs, and long rows of calculations spewed out of a computer's line printer at thousands of characters per minute," *Business Week* wrote cheekily. As the magazine observed, technological adoption is often the terrain of generational struggle. Information processing entered the fray in the 1950s as contested ground between traditional management practice and newer quantitative methods, perhaps symbolized best by Ford's whiz kids and their talisman, Harvard Business School grad Robert McNamara.[569]

One neutral area between outright automatic decision-making and gut reaction was computer simulation. Questions, such as the production schedule problem above, could be run repeatedly through a simple computer mock-up, and the results could help managers make more enlightened forecasts. By modeling previous swings in demand,

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[568] Wren, David A. *The History of Management Thought*. New York: John Wiley & Sons, 2004, 99-103.
[569] For an extended treatment of information processing in "systematic management," see: Haigh, Thomas. "Inventing Information Systems: The Systems Men and the Computer, 1950-1968." *Business History Review* 75 (Spring 2001). The subject of the article are the young specialists in the field of operations research, exponents of a new kind of Taylorization by computer. These young "systems men" sought a more scientific, quantitative method of control by promoting computing as an essential tool of the corporation. This movement, unsurprisingly, was led by a McKinsey consultant, Richard F. Neuschel.

businesses hoped to adjust inventories more closely to these swings. Simulation was another area to which Forrester believed real-time feedback could be profitably applied. But were the data reliable? What value should computer operators attach to a particular piece of information? Skeptics who viewed human behavior as essentially fuzzy and unpredictable worried about the accumulation of ready-made economic tools for forecasting misapplied to certain scenarios. But technology's cheerleaders were clearly in the ascendancy. "There's an art to riding a tiger," admitted economist Gerhard Bry, who oversaw the computer used for analysis at the National Bureau of Economic Research. "But we've reached the point where every company should consider the value of electronic computers for its forecasting operations."[570]

Time magazine chimed in assuredly, "Because any change in final demand is now quickly translated by computers into a rise or fall in production, businessmen can operate with leaner stocks, cut down the high costs of accumulating and warehousing inventory."[571] Graced with a soupçon of "scientific" precision, management asserted a more aggressive authority over the production curve. According to *Fortune,* experimental models of factors affecting sales were proving the businessman's best ally: "Instead of relying on guesses and intuition, he now can go ahead on logical deductions from facts."[572] Simulation could aid economic planners as much individual private companies. "By spotting economic danger symptoms early...[it will enable] government to apply early remedies," *Time* continued. Stanford economist Kenneth Arrow, an important game theorist as well as an early student of technology and economic growth,

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570 "When Computers Take to Prophecy," *Business Week*, June 1, 1963, 47.
571 "Business: Automation Speeds Recovery, Boosts Productivity, Pares Jobs." *Time*, December 29, 1961. Accessed 4 Sept 2010. <http://www.time.com/time/magazine/article/0,9171,827230,00.html> *Time* referred to these adaptable forecasting techniques as "the new leanness."
572 Burck, "The Boundless Age of the Computer" 215.

made this bold declaration: “There won't be a 1930 again.”[573]

As a consequence of this excitement, computers found their way into companies' operations departments, alongside their cousins in payroll and accounting. Some observers of the accelerating pace of industrial automation were naturally wary. “Automation is already moving with a rapidity that threatens to tear apart existing social and organizational structures,” wrote one commentator. “According to some observers, it will even alter the habits of thought that men have up to now prided themselves on … Now, new industrial functions, new economic forms, new work habits, and new social headaches are being created in ways that signify a kind of dialectical leap.”[574]

As Americans wrestled with the macroeconomic consequences of computer automation, they saw not just a transformation of the shopfloor, but a metamorphosis of society as a whole. In an “information economy,” as Fritz Machlup termed it, the labor force would no longer be a mere repository of manual, animal power, but of all the learning, ideas, and techniques of the technological state of the art. More Americans would be writing memos and fewer would manning assembly lines; more would be writing programs while fewer would be punching in data. Machlup's 1958 study counted the measurable American “knowledge” business at $136 billion, almost a third of total U.S. GNP. Moreover, this share was growing more than twice as fast as the economy as a whole.[575] More of businesses' energies and dollars were devoted to technical knowledge, particularly in the form of research and development (R&D). According to Edward Denison of the Committee for Economic Growth, R&D accounted for ten percent of the information economy in 1960, constituting a fifteenfold increase since 1930. Those

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[573] “Business: Automation Speeds Recovery, Boosts Productivity, Pares Jobs.”
[574] Seligman, Ben B. “Man, work & the automated feast,” *Commentary* 34 (July 1962): 9.
[575] Burck, Gilbert. “Knowledge: The Biggest Growth Industry of Them All.” *Fortune*, November 1964, 28.

employed in these information industries were better educated. College enrollment stood at 53 million individuals in 1960, a growth of fifty percent over the previous decade. The average worker, Denison estimated, had spent nearly twice as many days in school as his counterpart in 1930.[576] Continued rapid acceleration in the rate of skill development would be needed to accommodate the improvement in sophistication of manufacturing techniques, and to handle the information economy's exploding data flow.

Management guru Peter Drucker devised a term for these new, better educated wage earners: "knowledge workers." "Work in today's society and economy is work that applies vision and concepts—work that is based on the mind rather than the hand," he wrote in 1959.[577] Like Diebold, Drucker was a self-styled leader of a popular school of sociological prediction that served to interpret vast shifts in the economic landscape and to explain where ordinary Americans might fit in. Such an interpretive role, played equally well by technologists like Berkeley and imaginative types like Asimov, mediated public reaction and perhaps softened the public response to the changes wrought by information technology. For while automation was met with a measure of fear, there were no uprisings, no sit-ins, no Luddite factory-razings.

Probably the most thoughtful exponent of the idea of an information society was the Harvard sociologist Daniel Bell, whose signature work, *The Coming of Post-Industrial Society*, was not published until 1973. Though a late arrival, the content of the book was already well known; Bell had long discussed the evolution of the labor movement from his editor's pulpit at *Fortune*. Bell's views are significant because they help to elucidate Americans' consciousness of change. The theme most consistently

[576] Burck. "Knowledge," 29.
[577] Drucker, Peter. *Landmarks of Tomorrow: A Report on the New 'Post-Modern' World.* New York: Transaction, 1959, 91.

expounded in his writing was of an American society graduating from the fires of Marxist capital-labor antagonism into something more technocratic; here, perhaps, is a hint why the automation debate never boiled over into generalized unrest.

In *The Coming of Post-Industrial Society*, Bell re-affirmed Machlup and Drucker's categorization of the primacy of knowledge in an economy predicated on professional services and communications rather than the fabrication of objects. Such a society would be staffed by a professional or technical class, while being planned and controlled by cybernetics-schooled technological adepts.[578] Readers recognized the leadership as members of what economist John Kenneth Galbraith termed the "technostructure," a coming-together of industry leaders and bureaucrats to manage enormous, interconnected markets.[579]

New to Bell's account was an emphasis on the dimension of growth, along with an accordant emphasis on investment. "The ability consistently to re-invest annually at least ten percent of GNP became the basis of what W.W. Rostow has called the 'take-off' point for economic growth," Bell wrote. Reaching this point of maturity, as the United States did around mid-century, opens up "new technological frontiers in order to maintain productivity and higher standards of living."[580] Bell thus placed computers in the context of an explosion in planning, forecasting, and information management—the heritage of a society finally to look at itself critically and consider its own evolution. Information theory, cybernetics, decision theory, game theory, utility theory, and stochastic processes

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[578] Bell, Daniel. *The Coming of Post-Industrial Society: A Venture in Social Forecasting.* New York: Basic, 1973, 27. Bell described the ascendance of a "new intellectual technology" of forecasting and mapping, preferring (like Berkeley) to lodge the capacity of oversight in government and inter-government agencies. Technological progress run amock was just as dangerous as stagnation to Bell, and required enlightened planning.

[579] Galbraith, John Kenneth. *The New Industrial State*. Princeton: Princeton University, 2007, 63.

[580] Bell. *The Coming of Post-Industrial Society*, 22.

were all manifestations of these advances. All required calculating and data-handling ability made possible by computerization. Citing Wiener's work on teleological systems, Bell set forth his formula for growth: “An intellectual technology is the substitution of algorithms (problem-solving rules) for intuitive judgments. These algorithms may be embodied in an automatic machine or a computer program or a set of instructions based on some statistical or mathematical formula.”[581] Bell's broad understanding of the information revolution lends credence to Jon Agar’s argument that these formalizations began not with computers, but earlier in the nineteenth century, with the programmatic organization of behavior in the civil service.[582] Computers were accelerating the process into private industry and into public view.

One needn't look far to see the specter of these transformations in popular culture. The 1957 film *Desk Set*, starring Katharine Hepburn and Spencer Tracy satirized the mechanical decision-making of the computerized office within Hepburn and Tracy’s familiar battle-of-the-sexes terrain. Hepburn plays a librarian at a television network who begins a reluctant romance with Tracy, a computer expert who is brought in to install an “electronic brain” in the library. Tracy’s EMMARAC will handle payroll and catalog functions, and is expected to bring a dose of Taylorist “efficiency” to Hepburn’s operation. Hepburn and the female library staff immediately suspect that the machine is there to replace them. Shortly, everyone receives a pink slip courtesy of the computer in their pay envelope. According to formula, the two leads clash and it is revealed that the

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[581] Bell. *The Coming of Post-Industrial Society*, 29-30.

[582] Galbraith would likely have concurred with this interpretation. In *The New Industrial State*, he describes the technology as effectively breaking down production into discrete component functions. In a complex economy, making a machine *required* a machine. This microfractioning of tasks generates a feedback loop of more expensive fixed assets, more specialized manpower, and yet more planning (11-15). Bureaucracies are in this sense industrial machines.

computer has fired everyone at the company, including the president. A riot is averted as the company abandons the planned automation project. As it turns out, Hepburn's library ran quite efficiently without a computer.

Other fictionalizations followed a similar model. The Hanna-Barbera cartoon *The Jetsons* humorously portrayed life and work in a post-industrial society during an initial run between 1962 and 1963. A space-age counterpart to *The Flintstones*, *The Jetsons* derives most of its laughs from the incongruity of seeing residents of a high-tech future faced with many of the same family and office difficulties familiar to viewers. Its light-hearted deconstruction of contemporary futurism exposes how the mass public viewed difficult issues of technology and society with a mix of bewilderment and detachment. They were interesting only insofar as they pertained to everyday middle-class life. In the Hanna-Barbera universe, the lives of the white suburban household is essentially the same in 2062 as it was in 1962. It was a comforting parable of the computerized future, neither utopic nor dystopic in any great measure. The family drama facing George and Jane Jetson consists primarily of decisions about consumption, recreation parenting, and the budgeting of time. Like the science fiction it lampooned, *The Jetsons* commented on *present-day* society – one the show's writers found in flux, but essentially whimsical and contented.

Each episode followed a basic recipe: some new piece of space-age gadgetry would be introduced in the name of making the characters' lives easier. Rosie the robot maid, 'Lectronimo the automatic dog, a flying suit and a shrink ray never work out quite as planned (though Rosie became a favorite character), and life settles back in its old routine. *The Jetsons*' wry take on office automation was structurally similar to *Desk Set*.

Quintessential knowledge worker George Jetson's responsibility at Spacely's Sprockets demands pressing a single button on his computer, once a day. George's workweek is two hours a day, three days a week. As the sprocket industry is mostly automated, George spends most of his time gossiping with his coworkers and grousing about Cosmo Spacely, his tyrannical boss. On the day of his expected promotion to office supervisor, George is greeted with a rude surprise.[583] Instead of handing his top employee a raise, Spacely introduces him to a towering purple robot named "Uniblab." "It's some kind of a brain," says George, awestruck. "It's the latest thing," Spacely replies. "It cost over five billion of the company's money." Uniblab is installed as the new office supervisor, and George its assistant. Uniblab, which boasts a Ph.D. from M.I.T., sets to work streamlining the office, starting with the employees; "Cut the gab. Cut the gab. Time is money. Time is money," it tells Spacely's receptionist in its repetitious monotone.

With productivity up, George is unceremoniously fired when caught complaining about Spacely on Uniblab's tape reel. He tells a coworker, "Imagine putting you back on the four-day week, the slavedriver. What does he think this is, the twentieth century?" For a short time, *The Jetsons* protagonist was made to share the ignominy of the technological unemployed—replaced by the newest, smartest computer brain. All is of course restored to normal, according to the dictates of the show's circular narrative. George's friendly building superintendent, Henry, suggests introducing a little "tonic" into the robot's daily portion of "unilube," which results in an inebriated Uniblab embarrassing Spacely in front of the board of directors. The board chairman cynically refers to Uniblab as a "tax deduction – this brain of brains", and is then offered a spin of the roulette wheel and doused with coffee by the $5 billion-automaton. "Is this your idea

[583] "Uniblab." *The Jetsons*. ABC. November 25, 1962.

of *efficiencies*, Spacely?” he demands. Uniblab is promptly demoted to Henry's assistant and George gets his raise after all.

At this point we should find almost rote the cartoon's second-nature facility with the idea of “brains” embodied in circuitry, a cybernetic concept most of America had embraced, albeit with some reservation. More interesting perhaps was Hanna-Barbera's view toward office automation. The sprocket factory floor, always-out-of-sight, is fully automated, allowing George and his fellow white-collar workers a leisurely lifestyle, though one with its share of human drama. Human management, by contrast, remains firmly entrenched, with Spacely's executive suite recognizably appointed in 1960s office modernism. Spacely's ill-devised effort to introduce computer automation to the task of supervising human performance fails, not because of George's prank, but because Uniblab is essentially incompetent and cannot master the nuance of personal interaction.

Automation's most appealing prospect of to a 1960s knowledge worker must have been the dream of the six-hour week. In the actuarial business, Edmund Berkeley initially looked to computers as a labor-saving device. Bored by the repetitive nature of work, systematizing the routine calculations of life insurance became his singular focus while working in Prudential's methods division. Berkeley wrote in his journal a number of questions that underpinned his efforts: “Can I get a secretary to work for me for nothing? … How should you organize your work so that you do less, and can prepare for a better job? Why are you always overloading your productive capacity?”[584] Wiener, whose *Human Use of Human Beings* had reckoned directly with these matters expressed Berkeley’s sentiments more succinctly: “It is a degradation to a human being to chain him to an oar and use him as a source of power; but it is an almost equal degradation to assign

[584] Berkeley. March 10, 1948 journal. Berkeley Papers, box 2, folder 54.

him a purely repetitive task in a factory which demands less than a millionth of his brain capacity."[585]

The simple answer to Berkeley's frustration was computerization. Shortly after joining Prudential, Berkeley was already at work creating a systemic shorthand with standardized abbreviations and symbolic operations language for use in group annuity work.[586] The effort to rationalize intellectual labor led him back to Boolean algebra, which, along lines similar to Shannon's 1937 thesis, led him to computer circuitry. The root interest in automation came from Berkeley's deep loathing of the tedium of calculation, just as Wiener found the computations performed at the National Ballistics Research Lab dull and beneath human endeavor. Both men hoped computers might obviate such tasks.

A *Time* magazine review of the 1961 cyclical economic recovery reached much the same conclusion.[587] "What automation did for production workers in 1961 was to abolish much of the dirty and drudge work—the tedious, boring jobs that proliferated after Henry Ford's assembly lines in 1913 began to replace craftsmanship with mass assembly," the article touted. "In steel mills and chemical plants, yesterday's blue-collar worker now wears white overalls, sits at a pushbutton panel as massive as a cathedral organ, and takes home a technician's fat pay envelope." The difference, apparent at the beginning of the decade, was in the proliferation of computers. In 1961, sales and rentals of computers topped $1 billion for the first time, with a 100% year-on-year increase in units in operation—9,000 "ranging from giant brains down to small, desktop convenience

[585] Quoted in Diebold. *Automation*, 1959, 35.
[586] Berkeley. 1947 journal. Berkeley Papers, box 2, folder 41.
[587] "Business: Automation speeds recovery, boosts productivity, pares jobs"

models."[588]

These machines were integrated into the industrial process generating data and feedback at every level. To staff a complicated system required information literacy more than brute force. As *Time* put it, in 1961 "machines have now begun to duplicate the work of men's minds as well as men's hands, and often do it better, faster, cheaper, and more accurately." Work necessarily became more interesting, even for white-collar employees: "What computers did for clerks was to eliminate the menial paper shuffling, permitting people to spend their energies on more creative and profitable work." On the assembly line, laborers sometimes found computerized workflow to their liking. An internal Ford document testified that at its automated River Rouge plant, workers "go home less tired; the pay is better; the work is softer. Few complain of boredom. On the contrary, they speak of the mechanical charges with a pride that is rare among factory workers."[589]

Taking a cue from Berkeley, *Time* could not resist a bit of utopian reverie: "It could well be that computers are propelling the U.S. toward an era when the American worker can have his cake and eat it too: the material rewards of mass-produced abundance and the satisfaction that comes from performing an intricate and responsible job."[590] Thus the computer "brain" offered a distinct twofold advantage to its human user: higher pay *and* lower-cost goods. If the brain of transistors and wires engendered a new dialogue on problem of mind-body dualism, its rewards suggested a kind of modern gnosticism—work that consisted only of mental processing, with physical exertion (and lower levels of thought) delegated to automata.

[588] Ibid.
[589] Diebold. *Automation*, 1959, 36.
[590] "Business: Automation speeds recovery, boosts productivity, pares jobs" *Time*.

This brand of utopianism had precedent. A 1951 *Harper's* essay, titled "Electronics and human beings" speculated that the freeing of workers from menial tasks might be the ticket to a golden age of prosperity and enlightenment:

> When the human element is removed entirely, and replaced by electronic machines that control and collate, then we have the essential device around which the new social organization will be built…The end in view of such a regimentation of machines is to have all routine and unpleasant work done by aggregation of machine units and leave men free for the creative and higher managerial jobs… It is not unreasonably to suppose that the widespread use of automata (machines, not men) may bring an era of peace and creative human development[591].

In the early 1950s, these ideas would have counted as base speculation. A decade later, computers were eliminating hours of calculation and file processing for jobs across the country. Workers could witness the change happening before their eyes.

Gerard Piel, co-founder of *Scientific American*, wrote in *The Nation* that the shift to a knowledge economy was part of a larger technological change in the relationship between human beings and the factors of production. Piel might have cited Mumford's classification the twentieth century as bridging the "paleotechnic" and "neotechnic" stages of civilization—a further abstraction of knowledge from direct production to concern with methods and information.[592] In 1934, a rather more optimistic Mumford wrote that, countering Marxian, antagonistic models of capitalism's overthrow, society might gradually evolve to a "neotechnic" period where "the worker, instead of being a source of work, becomes an observer and regulator of the performance of the machines—a supervisor of production rather than an active agent."[593] A century before, the machine used to be intimately connected to the land's permanence, and land was the final measurement of wealth. A machine, such as the plough, might have a productive lifetime

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[591] Leaver, E.W. and J.J. Brown. "Electronics and human beings." *Harper's*, August 1951, 88, 92, 93.
[592] Mumford. *Technics and Civilization*, 265-267.
[593] Mumford. *Technics and Civilization*, 227-228.

(before becoming obsolete) as long as its user's. “Today,” Piel argued, “the economically significant industrial property is not the machine, but the design—and not even the design so much as the capacity to innovate design in process and product.”[594] Such attitudes, according to historian Howard Brick, emblematized the mid-twentieth century fascination with a set of ideas he calls “post-capitalism.”[595] Brick argues that proponents and opponents of automation alike, in the 1960s, reached a consensus that a purely market-centric allocation of resources had permanently unbalanced the classical production-consumption equilibrium and that some novel, hybrid social-market order was necessary. If the political implications of “postindustrial” capitalism were unclear, its economic fruit—abundance—was not.

What Piel described was a transition from value calculated in terms of physical material to ideas, knowledge, and human capital.[596] Skills—programs or productive algorithms, as it were—could be abstracted to a machine's memory banks, providing a base of valuable knowledge that grew with that of society. *Business Week* conjectured that the effect of this new digital library “may be equal in kind to the change that occurred when written language appeared. Writing freed mankind from total dependence on memory and permitted the accumulation and selection of effective knowledge. The computer program in turn accumulates and preserves skills.”[597]

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[594] Piel. “End of Toil,” 516.
[595] Brick, Howard. *Transcending Capitalism: Visions of a New Society in Modern American Thought*. Ithaca: Cornell, 2006, 192.
[596] Already underway in 1961 was a movement that would be popularized by the consultancy McKinsey in the late twentieth-century as “asset-light”--firms core operations were successively dedicated to specialized information transfer, while hard assets were removed to places where labor was cheapest. The spectacular Götterdämmerung of this model took place in 2001 with the bankruptcy of energy trader Enron, a company that, under former McKinsey consultant Jeffrey Skilling, had replaced its pipelines and power utilities with computer programs and highly compensated energy traders. For more on Enron and “asset-light” management, see: Jorion, Paul. *Investing in a Post-Enron World*. New York: McGraw Hill, 2003, 8-10.
[597] “New Tool – New World,” *Business Week*. February 29, 1964, 74.

The implication of all this for workers was that there would simply be less to do. Future office hands like George Jetson would be employed to generate ideas, not to *make* anything; that was work for the machines. The "end of toil" was drawing near. Indeed, a single man-hour of 1960 work could produce an amount that required three man-hours in 1900. Assuming a constant rate of output, 58 million more Americans should have been in the unemployment lines.[598] But this, of course, is the Luddite fallacy; production is not constant. Much of the gain in productivity is reflected in increased output, yet not all. The balance was an increase in leisure. Even if hours work hardly diminished, the amount of per capita human work as a mechanical quantity, force times displacement, surely decreased by a multiple.

Writing in a progressive publication like *The Nation*, Piel was compelled to speculate on the realignment of economic and political power. "The advance of science has for many years been undermining the two pillars of our economy: property and work," the article proceeded. Traditional class politics, as Daniel Bell predicted, were also on the way out: "The ownership of property is no longer the primary source of power, even economic power, in our society; nor does ownership establish the significant, functioning connection between people and the things they consume. Work occupies fewer hours in the lives of everyone; what work there is grows less like work every year, and the less people work the more their production grows."[599] Piel's language, roughly translated, represented a revision of classical economic theories of growth; property and work are sobriquets for capital and labor, the two inputs. It was becoming apparent that a third input, which could be termed "knowledge" or "technical progress," was outstripping

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[598] Piel. "End of Toil," 517.
[599] Piel. "End of Toil," 515.

the gains that could be directly attributed to either improvements in the stock of capital or labor. Robert Solow's seminal 1957 paper attributed as much as 88% of the growth function to this third, exogenous variable.[600] Computers were the face of this technical progress, but what they wrought was more than economic: "Fundamental changes in the social order—in man's relationship to man—are therefore in prospect and are already in progress."[601]

Productivity had the effect of redistributing purchasing power to those engaged in administration and distribution.[602] The knowledge economy, for all its inequality, still promised the silver lining of a potential realignment of communal values. The cheaper consumer prices afforded by automation and the extension of easier credit to all segments of the population were extinguishing the middle-class virtue of thrift from our national consciousness.[603] "Any hard work that a machine can do is better done by a machine;

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[600] Solow, Robert M. "Technical Change and the Aggregate Production Function," in *Review of Economics and Statistics* 3 (1957): 312–320.
The value of technological improvements in agricultural productivity was introduced by the 18th-century economists François Quesnay and Jacques Turgot. Until Solow and Trevor Swan in 1956, models of steady-state growth were unstable; they existed on a "knife's edge"—any deviation from the growth path due to input fluctuation resulted in further, wider deviations. By introducing productivity as a variable (the capital-output ratio, the Solow-Swan neoclassical model allowed growth to swing back to its steady-state path. There remained however, a "residual" productivity increase independent of capital productivity. Solow bracketed this exogenous residual, which he called "innovation." For the first full treatment of innovation as a measurable variable in the aggregate output function see: Romer, Paul "Endogenous Technological Change." *The Journal of Political Economy* 98 (October 1990): 71-102.

[601] Ibid.

[602] Piel. "End of Toil," 517.

[603] Cultural historian Hans Medick has argued that E.P. Thompson's seminal study of working class culture in industrial Britain in effect charts the development of a negative consciousness of class imposed from above, from a Victorian bourgeois culture. The ideals of thrift and industry, since Weber associated with a Protestant focus on material, earthly existence, were in fact class virtues disguised as more universal spiritual ones. In the late 19th century, an emergent white-collar class defined the working orders as those who resisted an economy of prudent investment, savings, and family planning. Reserve hoarding and resource accumulation were "irrational," Medick theorizes, for workers whose hope achieving monetary independence was as remote as social advancement. "Plebeian culture," in Medick's account, expressed "preferences and priorities which were profoundly different from those which the moralising, mercantilist advocates of thrift and industry sought to impose." Now, it seemed, these priorities, rooted as they were in the advent of industrial capitalism, were being erased by new modalities of abundance afforded by labor automation.

‘hard’ these days means mostly boring and repetitive, whether in the factor or office.” Piel reasoned. Yet Piel still revered craftsmanship and design, which in contrast to Mumford, he deemed in no danger of dying out. Indeed, “the liberation from tasks unworthy of human capacity could free that capacity for a host of activities now neglected in our culture: learning and teaching, the sciences, arts and letters, the crafts, medicine and its allied works, politics, and public service.”[604] Automation could be seen as a progressive social force.

Medick, Hans. “Plebeian culture in the transition to capitalism,” in *Culture, Ideology, and Politics*, London 1982, 90-91.

[604] Piel. “End of Toil,” 518.

Chapter 13 – The jobs backlash

Lewis Mumford spoke for many when he wondered whether mankind was prepared to sacrifice its autonomy on the altar of technical progress. Apart from atomic weapons, no single issue galvanized such rabid opinion during the postwar period. Indeed, a 1961 poll revealed that American workers feared only Soviet aggression more than automation.[605] Factory automation served as a convenient symbol of the growing sentiment that technology had advanced too far, too fast, leaving its human creators puzzled vestiges of a bygone age. In a little over thirty years, a typical American family would have purchased its first television, refrigerator, and automobile. Wars were waged with machinery of frightening power; government officials collected data stored in vast electronic databases. Shattering the boundary of space, the Soviet Union launched the first artificial satellite, Sputnik, in 1957, pipping NASA by a year. Industrial robots made millions of new products faster and more cheaply than could have been possible by handcraft. The last frontier of mechanical conquest, it would seem, was human consciousness. Now this private dominion was under threat by whizzing, beeping "giant brains."

Alarm bells had been rung as early as 1950, when Wiener turned his eye to the social effects of cybernetics in *The Human Use of Human Beings*. Seeing computers as a blunt tool, Wiener described a dark side of their relentless driving down of costs and improvements to productivity. "Let us remember that the automatic machine … is the precise economic equivalent of slave labor," he wrote. "Any labor which competes with slave labor must accept the economic conditions of slave labor. It is perfectly clear that

[605] "When Machines Replace Men," *Newsweek*. June 19, 1961, 79.

this will produce an unemployment situation, in comparison with which … the depression of the thirties will seem a pleasant joke."[606] The topic remained fairly dormant during the economic expansion of the early 1950s, but the mass introduction of computers into the workplace nevertheless inspired a certain malaise. Wiener's apprehensions for the proletariat were gradually extended to the professional class as computers entered banks, accounting and payroll departments, and offices. Books and television shows with science fiction thriller titles like *Cybernation: The Silent Conquest* or "Automation: The Awesome Servant" promised that as the service industries were also automated, displaced blue-collar workers would have nowhere to go.[607] The more awareness of the role of computers in automation grew, the wider the circle of those affected extended.

The maturation of computers in the workplace brought to the fore a simmering disquiet that had been latent in the debates of the early 1950s. Increasingly, the worries of Wiener and Vonnegut were expressed throughout society as a whole. As discussion of the transformative impact of the computer metamorphosed from awe and fantastic possibility in the early to mid-1950s, to unavoidable reality at the turn of the decade, the tenor shifted from one of science fiction to one of economic danger. It was suddenly necessary to take stock of a host of changes in production processes, bookkeeping, and the employment rolls. We might view the reaction to this new economic frontier in the frame of a loose dialectic. In the early 1960s, the tone of the conversation was alarmist, echoing Mumford and Bertrand Russell's earlier warnings. During the course of 1962, a

[606] Wiener. *The Human Use of Human Beings*, 189.
[607] The term "automation," with its connotation of human redundancy was never a political winner. It was, even in 1953, so loaded that GM banned employees from using it to describe the company's manufacturing methods. See: Hounsell, David. "Its Consequences," in Shiomi, Haruhito & Kazuo Wada eds., *Fordism Transformed.* Oxford, 1995, 86.

national spotlight was cast on automation, originating from the White House and filtering down to mainstream journalism. Following our rubric, 1962 forms something of an inflection point, after which defenders of automation and its critics stepped up the intensity of their arguments. As the decade wore on and economic conditions normalized, opinion-makers approached a tentative consensus that I will call an automation "synthesis." By the middle of the decade, journalists, politicians, and scientists wrote about automation less as a looming disaster than as a foregone conclusion, the new tracks which the locomotive of the United States economy would have to navigate. Many of the solutions they proposed were actually put into practice. The rest of this section follows this admittedly rather diffuse chronological template of thesis, antithesis, and synthesis. At the dawn of the 1960s, rising consciousness of the consequences of automation triggered what I term the "jobs backlash." Our story begins here.

No aspect of the automation debate witnessed such disagreement as the consequences of the computer for employment. Jobs were being lost to automatic machines; this fact was indisputable. Controversy raged over whether the rise automatic factory could yield new possibilities as fast as it closed old ones. And what of the displaced worker? It was all very well if legion of George Jetsons would work in comfort three-days-a week and share in the collective prosperity of the machine age. How would the assembly-line hand in Toledo feed his family? "Will the Computer Outwit Man?" asked a *Fortune* headline in 1964. Though *Fortune* predicted an ultimate "technological triumph," it conceded as troubling the proposition "that the computer will hoist unemployment so intolerably that the free-enterprise system will be unable to cope with the problem, and that the government will have to intervene on a massive scale."[608]

Even the upper ranks of the skilled workforce feared for the durability of their employment. Bud Calhoun in *Player Piano* provided an example of the runaway effects of automation. A skilled engineer at Ilium Works, Calhoun invents a machine that performed his job better than he could. Suddenly redundant, he is laid off and cast into the ranks of the permanently jobless in the slum of Homestead.[609] It seemed that if the pace of mechanical improvements was not arrested, no job would be safe.

As wages rose in the boom times of the postwar recovery, capital found greater incentives to leverage the output of the workforce. Over the course of the same decade, Eckert and Mauchly's UNIVAC, followed by IBM and a host of imitators, offered executives ways to effect a great deal more precision and control over automatic processes than had been heretofore possible. Likewise, Machlup and others documented how durable goods and industrial manufacturing had become mature industries in the West. Services were replacing automobiles and dishwashers as a source of dynamic growth. If businesses could not grow revenues at the same pace, they would have to turn toward profit margins to improve the bottom line. The result was a visible realignment of employment patterns. *Time* reflected in 1961, "Since 1947, the U.S. work force has expanded from 60 million to 71 million, but the total number of production-line workers has decreased 7%. And in industries particularly susceptible to automation, the decline has been even more dramatic: since 1947, production-line employment has dropped 10% in autos, 17% in steel, 35% in textiles."[610]

Americans observed a feedback loop between rising wages and more automation

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[608] Burck, Gilbert. "Will the Computer Outwit Man?" *Fortune*, October 1964, 120-121.
[609] Vonnegut. *Player Piano*, 62-65.
[610] "Business: Automation Speeds Recovery, Boosts Productivity, Pares Jobs." *Time*.

that looked as if it would continue in perpetuity. As America departed an era of cheap labor, companies found that competitiveness dictated the production of higher value goods at lower cost. The price was improved technology, which necessitated a greater investment in human capital. Those stranded behind, particularly well-compensated union workers, risked becoming a class of structurally unemployed. “Even as it has cut blue-collar ranks,” *Time* reported, “automation has been spurring a steady rise in employment of office workers to handle the new information available, technicians to devise new applications for the machines, and managers to do the decision making.”[611] In 1961, manufacturing employed thirteen percent more clerks and sixty-five percent more technical workers and managers than it had a decade earlier. Because of this stratification between blue-collar to white, union rolls were being depleted. “Assembly-line workers are the bulwark of the union movement, and clerks and service workers the hardest to organize. Result: union membership has dipped from 18.5 million to 18.1 million in the last five years.”[612] Aggregate wages rose more slowly—less than three percent per annum versus the five percent average over the previous five years. Thanks to the efficiencies of computer automation, the demand curve for labor had shifted down and to the left. Accordingly, the robustly growing industries of the early 1960s—defense, aerospace, microelectronics—were most openly hostile to organized labor, and often migrated to regions where union membership was low, in Western and “Sun Belt” states.[613]

Some organized labor leaders proposed a simple solution: shorten the workweek.

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[611] Ibid.
[612] “Business: Automation Speeds Recovery, Boosts Productivity, Pares Jobs.” *Time*.
[613] Schulman, Bruce J. *From Cotton Belt to Sunbelt: Federal Policy, Economic Development, and the Transformation of the South, 1938-1980*. Durham, N.C.: Duke, 1994.

The thirty-two hour week was an idea in circulation almost since Henry Ford instituted the forty-hour week at his plants. When Walter Reuther, the president of the United Auto Workers, asked Richard Nixon if he was willing to commit the Republican Party to adopt a four-day workweek plank in its 1956 campaign platform, the vice president demurred. But Nixon agreed that in the not-too-distant future he envisioned a shift to fewer hours for all employees.[614] The proposal never attained serious consideration, though both presidential candidates floated it on the 1956 campaign trail.[615] Opponents contended that a federally mandated shorter workweek would likely have ossified labor markets and forced workers to share the burden of unemployment. Workers might make ends meet by moonlighting; unemployment would remain stubbornly high.[616] Those agitating for a wider distribution of a static labor pie knowingly challenged received economic thinking. The notion that there is a fixed amount of work to be done in an economy was referred to by D.F. Schloss in 1891 as the "lump of labour" fallacy.[617] Automation had provoked in the production-consumption schedules, Reuther argued. As more profits were sunk into capital equipment, even rising output did not increase the share of labor for human hands. Easy fixes, then, tended prove elusive.

Labor leaders were often the most outspoken critics of automation. Reuther estimated that twenty-eight million production jobs would be lost to computers over the course of the decade of the 1960s.[618] In 1957 he had appeared on a Edward R. Murrow-moderated CBS documentary, "Automation: Weal or Woe?" to debate IBM's Thomas J. Watson, Jr. on the subject of job losses. The program was sympathetic to grim

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[614] Associated Press. "Nixon Says Time Needed to Bring Four-Day Week." September 27, 1956.
[615] Piel. "End of Toil," 517.
[616] Samuelson, Paul A. *Economics*, *9th ed.* New York: McGraw Hill, 1973, 575-6.
[617] Schloss, D.F. *Methods of Industrial Remuneration*. London: Williams and Norgate, 1898, 80.
[618] "When 'Brains' Take Over Factories." *U.S. News and World Report*, February 24, 1964, 83.

frustrations of displaced autoworkers, which it played against "the cool, four-day-week visions of scientists and industrialists."[619] George Meany, the head of the UAW's umbrella organization, the AFL-CIO, called automation a "curse... a real threat … [that] could bring us to national catastrophe."[620] As usual, the last hired and first fired suffered most. The least employable—the young, unskilled, and often African-American, were forming, in the words of *Life* magazine, a "human slag heap," an incendiary class dynamic with the potential to polarize an already tense political environment.

It was true that, exiting the recessions of 1958 and 1960-1961, employment in the United States failed to return to pre-downturn levels, or approach any standard accepted level of "full employment." While the rate of unemployment in 1957 was measured by the Labor Department at 4.3%, in 1959 it only reached a low of 5.1% in July. Furthermore, while the 1960-61 recession ended in February of 1961, according to the National Bureau of Economic Research, employment lagged, recording a 1961 low only in December, at six percent flat.[621] The relationship between inflation, which had persisted at sub-2% levels for much of the early 1960s, and unemployment was, for the first time, beginning to be understood.[622] Factory productivity had an overall depressing effect on labor costs, and therefore ultimately on consumer price levels, which was seen

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[619] First aired June 9, 1957. "Television: Review," *Time*, June 24, 1957. Accessed 1 Sept 2010. <http://www.time.com/time/magazine/article/0,9171,825051,00.html>

[620] "Automation: its benefits and its slag heap," *Life*, January 10, 1964, 6.

[621] U.S. Department of Labor: Bureau of Labor Statistics. "Civilian Unemployment Rate," *Federal Reserve Bank of St. Louis.* August 6, 2010. Accessed 1 Sept. 2010. <http://research.stlouisfed.org/fred2/data/UNRATE.txt>
"U.S. Business Cycle Expansions and Contractions," *National Bureau of Economic Research*. April 12, 2010. Accessed 4 Sept. 2010. <http://www.nber.org/cycles/cyclesmain.html>
See also: Zarnowitz, Victor. *Business Cycles: Theory, History, Indicators, and Forecasting.*. Chicago: University of Chicago, 1996.

[622] Phillips, William. "The Relationship between Unemployment and the Rate of Change of Money Wages in the United Kingdom 1861-1957," *Economica* 25 (1958): 283-299.
The Kiwi economist's "Phillips Curve" posited an inverse relation that would govern central bank policy in the developed world into the 1970s.

as tending *ceteris paribus* toward lower employment in the macroeconomy. The unemployment in the America at midcentury was seen less as cyclical—the type bred of business retrenchment or credit tightening—and more as structural, resulting from powerful underlying capacity shifts in the broader economy. With unemployment nearly reaching postwar highs, and the early 1960s recovery appearing to be of the jobless variety, labor leaders had cause to single out automation as the culprit.

Their complaints registered with prominent management spokesmen, who were forced to defend an unpopular proposition as inevitable. Technology firms had much to gain from computerization but were frequently in the crosshairs. “We can't argue that technological change and automation are not labor-saving processes,” conceded Thomas J. Watson, Jr., of IBM. “They do cause displacement of people. But how can we permit an able-bodied man or woman who wants to work to be a problem? This is the real test of whether Democracy can triumph over Communism.”[623] While Watson placed automation in the public debate, privately IBM contributed its share to retraining. In 1961, Big Blue spent $41 million on pro bono computer education.[624] The materials industry, which by 1964 had been one of the greatest beneficiaries of computer-aided production, constituted another battleground. Roger Blough, the chairman of U.S. Steel, put the issue in bleak terms: “Even if it were possible to block change in America, or to slow it to a snail's pace, other men and other nations would merely pass us by while our dragging feet trudged to national oblivion.”[625] The fruits of computerization in industry may have seemed rotten, but there was no avoiding it.

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[623] “When Machines Replace Men,” 80.
[624] Ibid.
[625] “When 'Brains' Take Over Factories,” 83.

Automation itself formed the crux of one of the most contentious labor disputes of modern American history. If computers had been a point of smoldering anxiety for labor through much of the 1950s, 1959 marked the first conflagration point. The 1959 steel strike sent reverberations through the United States economy, signaled important shifts in production and trade patterns, and defined the labor-relations approaches of the Eisenhower and Kennedy administrations. Indeed, steel is an appropriate context in which to view the evolving attitudes toward automation of the American manufacturing complex—organized labor, industry, and policymakers equally.

Throughout the 1950s steel made healthy profits. A wave of construction, auto production, and an increasingly integrated global supply chain helped the industry's top and bottom lines, leading to heavy investments in capacity. Prices held steady with inflation, as did wages.[626] The nation's dominant steel union, the United Steelworkers of America (USWA), led by David J. McDonald, sought to keep pace with Reuther's UAW which had won major wage and benefit increases in the 1950s, threatening a strike. Industry negotiators, with Blough at the fore, demanded a precondition: for management to brook a wage increase, union leaders would have to agree to drop Section 2(b) of its master contract, which included a clause prohibiting managers from introducing any new work rules or machinery that would reduce hours worked or lower overall employment. From the position of management, such a barrier to modernization constituted featherbedding and weakened the competitiveness of American steel.[627] Section 2(b) in fact proved a sticking point, and despite the Eisenhower administration's attempt to

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[626] Stein, Judith. *Running Steel, Running America: Race, Economic Policy, and the Decline of Liberalism*. Chapel Hill, N.C.: University of North Carolina, 1998, 23.
[627] Rose, James D. "The Struggle over Management Rights at US Steel, 1946-1960: A Reassessment of Section 2-B of the Collective Bargaining Contract," *Business History Review* 72 (Autumn 1998): 7.

mediate, negotiations broke down; on July 15, half a million steelworkers walked off their jobs.

Earlier strikes in the transit, telephone, and textile sectors had all contributed to a tense labor dynamic in the 1950s. Steel, however, was different. The signature material good of the American manufacturing economy, the legacy of Carnegie and Frick, steel was critical to the nation's infrastructure, not to mention its military readiness. The steelworkers' strike virtually shut down production in multiple sectors of the economy, from commercial construction, to cars, trucks, and ships. Convinced that American national security was at stake, Eisenhower sided with the steelmakers.[628] Despite McDonald's efforts to rally support, labor solidarity fractured; Reuther worried that a steel shortage would threaten jobs on Detroit's auto production lines.[629] Public opinion was divided, but was, in the main, rather unsympathetic to McDonald and the USWA. Popular media, such as Elia Kazan's 1954 film *On the Waterfront*, had given many Americans the impression that corrupt union leaders' interests were divergent from the rank-and-file, while the 1957 Soviet launch of Sputnik suggested a clear link between technological production and domestic security.[630] Eisenhower invoked the Taft-Hartley Act, and upon the approval of both an arbitration panel and the Supreme Court, an injunction was granted in November, forcing the USWA back to work.

In economic terms, the four-month strike was only the beginning of the story. During the period that the furnaces were halted, a number of industries had been forced to switch to cheap imported steel. The shift proved durable; American steelmakers' profits

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[628] Metzgar, Jack. *Striking Steel: Solidarity Remembered*. Philadelphia: Temple, 2000, 6.
[629] "Aspirin for Steel," *Time*, November 16, 1959. Accessed 1 Sept. 2010. <http://www.time.com/time/magazine/article/0,9171,811417,00.html>
[630] Stein. *Running Steel, Running America*. 22.

would never return to their early-1950's heyday. Automation and computerization, or "modernization" in management argot, had become a strategic necessity. Imported steel from recovering Western Europe, along with the adoption of new lighter, stronger grains shrank revenues.[631] American firms, saddled with high labor costs and low-single-digit margins had two options: raise prices (an outcome anathema to inflation-conscious planners in Washington) or cut their demand for labor. Further weakening the unions' position, since work had resumed, labor relations had remained frosty with output-per-worker low. Vice President Nixon, sought to preserve the viability of American steel and his own bid for high office and intervened to bring into effect a new compromise contract in January 1960 that allowed for a \$.07/hour wage hike, a staggered cost-of-living adjustment, improved benefits, and the preservation of 2(b). Blough called it an "armistice."[632] Nixon lost a squeaker, but by the time Kennedy had taken office, steel was mired in a secular downturn.

Labor leaders like McDonald may have thought they had their man in the White House, but Kennedy wanted neither to see the steel industry wither, nor prices to rise, dragging on the rest of the economy. Historian Judith Stein notes, "Kennedy was concerned with growth, but the economy was a handmaiden to the Cold War, his principal interest... Kennedy found it intolerable that the United States had 'the lowest rate of economic growth of any major industrialized society in the world,' not because he was concerned about unemployment but because growth to him meant 'strength and vitality,' the ability to 'sustain our defenses.'"[633] A philosophy of growth as national strength reflected the influence of Kennedy's foreign policy advisor, the Cold Warrior

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[631] Stein. *Running Steel, Running America*. 25.
[632] Stein. *Running Steel, Running America*, 24.
[633] Stein. *Running Steel, Running America*, 28.

Walt Rostow, whose volume, *The Stages of Economic Growth*, stands as a major document from the era.[634] When Kennedy asked his attorney general, the former AFL-CIO lawyer Arthur Goldberg to derive an all-parties consensus from the President's Advisory Committee on Labor-Management Policy, Goldberg agreed to subordinate his union allegiances to Cold War necessity.[635]

Labor relations as practiced by Kennedy predominantly aimed to decrease wage demands in the hope of moderating price inflation. In mature sectors such as steel, national changes in productivity would be the "benchmark" for evaluating price and wage policies.[636] Under the new president, wage demands were not allowed to outstrip rates of price inflation within a sector or in the economy as a whole. Nor, it appeared, would unions be able to retard the productivity growth of such a vital industry as steel. By May 1962, the steel industry was in a "crisis" of such significance that the broader stock market sold off, triggering a short recession.[637] The president turned to Keynesian fiscal measures, promising relief both in corporate and individual marginal tax rates.[638] He also liberalized the steel industry's depreciation schedules, an accounting change that permitted executives to write off capital equipment more quickly to reflect a higher rate of technical obsolescence. The bargaining power of the USWA had never been lower.

A new three-year contract was due to be signed in 1962, and it would be considerably less favorable to McDonald. Due to mounting pressure from the president and the attorney general, the union finally backed off its insistence on the preservation

[634] Rostow, Walt W. *The Stages of Economic Growth: A Non-Communist Manifesto*. London: Cambridge University, 1960.
[635] Stein. *Running Steel, Running America*, 26.
[636] Stein. *Running Steel, Running America*, 30.
[637] Gore, Albert. "The coming steel crisis and how to deal with it," *Harper's*, April 1962. Accessed 1 Sept. 2010. <http://www.harpers.org/archive/1962/04/0075444>
[638] The package was not signed into law until 1964, under Lyndon Johnson. During that year unemployment declined from 5.5% to 4.1%; Keynes was named *Time*'s Man of the Year.

Section 2(b) intact. The union agreed not to enforce the automation clause, and in return, a percentage of the profits from higher productivity would be mobilized as wage increases. In effect, the USWA accepted a smaller, more modern steel industry, with fewer jobs and higher skill requirements. That the new bargain was struck in 1962, under Kennedy, reflects how quickly the consensus had shifted. While automation was fundamentally the enemy in 1959, it had, in the span of three years, become a fact of life. As a result of the industry's shrinkage, improved milling techniques, and the new contract, steel output in 1963 fell short of 1957's total by 3.1%, while at the same time employment in production had dropped twenty-three percent. The same dynamic played out, less publicly, across a variety of industries.

The resolution of the steel strike set a broad pattern in future union contracts; progressive wage increases, the preservation of benefits for members, and a reduction in the overall job pool were, for example, hallmarks of 1974 settlement of United Mine Workers' bituminous coal strike.[639] Naturally, the new labor relations paradigm only exacerbated the problem of technological unemployment that had originally motivated USWA. The steel strike set automation on a national stage; anxieties and hopes ran high.

The jobs question was moving beyond union rallies and economics departments. In July 1963, the women's magazine *McCall's* ran an interview with an unlikely suspect: John Diebold. In a four page graphical spread, "When Will Your Husband Be Obsolete?" Diebold (still only 36 years old) contrived to offer some comfort to *McCall's* readers who might have looked at the rapid transformations in the economy with wonder and

[639] Navarro, Peter. "Union Bargaining Power in the Coal Industry, 1945-1981." *Industrial and Labor Relations Review* 36 (January 1983): 218.

dismay.[640] “Some time within the next thirty years,” Diebold told *McCall's*, “sixty million Americans in several hundred occupations will find their work changing radically. Some jobs will disappear sooner, some a little later; but in the end, every one of these employees is practically certain to be obsolete within the next generation.” Diebold's numbers, while more benign than those propagated by Reuther, represent a multiple of the 1963 U.S. manufacturing labor force.

Quickly, however, his grim tone lifted: “Just where does your husband's job stand in this changing scene? Fortunately it is now possible to predict with reasonable accuracy what his prospects—good or bad—may be.”[641] On the opposing page, Diebold proposed (with a consultant's clarity) a table of glide-paths across multiple occupations. Jobs were organized into “dead-end”, “status quo”, and “bright future” categories. Each was accompanied with a brief annotation, explaining its importance—or lack thereof—to the coming information economy. Dead-end jobs included old standbys (assembly worker, automobile repairman, elevator operator, farm worker, mail clerk), next to a new class of information-handling fossil professions (bank worker, bookkeeper, electrical power plant worker.) It is interesting that among Diebold's dead-end jobs were several (auto mechanic and farm worker, for example) whose lot would in fact be improved by the significant gains in complexity and productivity engendered by automation, despite their ties in rapidly automating industries.

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[640] That the problem of skill obsolescence was gendered male in *McCall's*' account is perhaps less a relic of a 1960s binary, and more a function of automation's disproportionate impact on male workers. Women, more likely to be employed in the service sector as teachers or typists, were not on the front lines of the automatic revolution in manufacturing. It is ironic, however, that many of the information-handling jobs that would, as the decade wore on, be delegated to small computers, were traditionally staffed by women. Revealingly, the term “computer,” prior to ENIAC's arrival was most commonly used to refer to information clerks in accounting offices and government statistical centers—a woman's job. See: Light, Jennifer S. “When Computers Were Women,” *Technology and Culture* 40 (July 1999): 455-483.

[641] Cahn, Patricia. “When Will Your Husband be Obsolete?” Interview with John Diebold. *McCall's*. July 1963, 64.

Happily, Diebold predicted that the husbands of *McCall's* readers engaged in such doomed trades as textile production would be given opportunities to adapt. The Department of Labor had announced its intent to retrain 100,000 workers in 1963 alone. "Surprisingly, and hopefully," Diebold went on, "right now in the United States more adults than schoolchildren are engaged in some form of organized study (high-school evening courses, college and university extension divisions, trade and business schools, correspondence courses, and other classes."[642] Notwithstanding the many hard-core unemployed, Diebold joined others in pointing to the undercapacity in the national labor force. Many commentators had lamented the acute shortage of electronics technicians, computer operators, bookkeepers, repairmen, draftsmen, and engineers of all stripes.[643] Diebold himself reported one estimate that each year America fell short of its requirements for engineers by 25,000, and for technicians by as many as 75,000. Automation was only increasing demand.[644] Vannevar Bush had testified to the congressional Joint Committee that the Soviet Union was turning our engineers at twice America's rate, and technicians at nearly twenty times that. Opportunities were at hand, whether from government sponsors, educational institutions, trade unions, or from firms themselves. It was up to American workers to seize them. With a little motivation, production workers could move into "bright future" fields like chemical engineering, data-processing systems analysis, weather forecasting, life insurance (despite Berkeley's effort to automate it), and dentistry. Writers and editors would be in demand as leisure time and literacy increased. Luckily for Diebold, "consultant" made the list of "bright future" jobs, since business was coming to depend "less on executive intuition and more

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642 Ibid.
643 "Business: Automation Speeds Recovery, Boosts Productivity, Pares Jobs." *Time*.
644 Diebold. *Automation*, 1952, 21.

on scientific management."[645]

Diebold advised worried women, "Rather than fearing or fighting a change if it is called for, you should help your husband welcome it." Drawing a picture of the nation's mythic past, he urged, "It will take as much courage and pioneering to strike out into new occupations as it did for ancestors to venture into the unknown West. Perhaps this is the very challenge to keep alive the pioneer spirit that made America."[646] That a management consultant specializing in computation could make such exhortations in the pages of grocery-shelf household magazines is evidence of the seriousness with which many Americans viewed the technological challenges of the 1960s.

For Diebold, adapting to the new economy meant nothing less than a large-scale effort to transform the system of education, and an investment worthy of the challenges experienced during World War II. A national program, "on a much broader scale" was required.[647] The very survival of our society, he stressed, "depends on our winning what H.G. Wells almost fifty years ago had the prescience to call 'the race between education and catastrophe.'" The president of one institution at the forefront this reinvestment in technical education—Caltech—wrote that the applications of automation have brought new security, new comfort, and even new dignity for the working man, but only "if he is suitably educated to perform more skilled and more interesting tasks... Our educational system and our social and political institutions and practices face a great challenge in helping us—and all the world—meet these new opportunities."[648]

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[645] Diebold in Cahn. "When Will Your Husband be Obsolete," 118.
[646] Diebold in Cahn. "When Will Your Husband be Obsolete," *McCall's* 119
[647] Diebold. *Automation*, 1959, 38. A 1959 report by the National Manpower Council, quoted by Diebold, suggested that even non-industrial jobs would be affected: "Many of today's electricians will have to learn electronics if they are to retain their skilled status… Pipefitters may have to learn hydraulics."
[648] DuBridge, Lee. "The Educational and Social Consequences of Automation," in Dunlop, John T., ed. *Automation and Technological Change*, 42.

Not everyone shared Diebold's polyannaish view of labor flexibility. Retraining was, in the view of *The Atlantic*'s William Glazier, "a simple solution [that] is frequently either naïve or dangerously disingenuous."[649] The success of retraining depended on two variables: management's capacity to offer skill-building programs, and labor's willingness to invest in itself. Surprisingly, it was often the latter that was in short supply. For workers to find employment in Diebold's growth industries, significant labor mobility was required. A senior assembly-line hand at an auto parts firm in Michigan may not have favored the prospect of uprooting his family to work on jet engines in Oak Ridge, Tennessee. Moreover the, the marginal return to labor needed to be significantly, visibly higher in the "bright future" world for the currently employed to assume the cost and risk of investing in new skills. Even the unemployed were slow to make the leap. In California, under a state program, 50,000 unemployed were eligible for a thirteen-week training course, yet only thirty-eight applied and twenty-six actually enrolled.[650] Glazier drew on the example of the closure of an Oklahoma City meatpacking plant where laid-off workers were offered retraining. In this instance, of the 431 employees given the option, only sixty were deemed capable, thirteen completed the course, and a mere seven found new jobs.[651] Most skills, the AFL-CIO pointed out, were learned over years on-the-job, and vocational training was less helpful than actual opportunities. "It is not surprising," Glazier concluded, "that unemployed workers are so markedly unenthusiastic about retraining when they have so few reasonable expectations for re-employment."

Edmund Berkeley, who through the 1950s and early 1960s was editing a journal

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[649] Glazier, William. "Automation and Joblessness: Is Retraining the Answer?" *The Atlantic Monthly*, August 1962, 43.
[650] "When 'Brains take over factories," 83.
[651] Glazier. "Automation and Joblessness," 45.

called *Computers and Automation*, was among those skeptical of retraining. The idea that the hundreds of thousands of operators of now automatic elevators could be provided for by good-hearted skills programs was "a delusion and a snare," he told an audience in Atlantic City, NJ in 1965.[652] Berkeley insisted that the scale of the problem was much larger than public officials were willing to acknowledge: "Retraining programs deal with hundreds, perhaps thousands, of people, it is true. But there are literally millions of people in the category. Anybody who advocates a program that is going to help 50,000 people, when there are 8,000,000 people in trouble, is trying to plug up an enormous hole in the dike with a needle." To Berkeley, there was a clear argument for direct, public poverty relief. In a computerized era, the principle of "If you don't work, you don't eat" was "absurd." "When all the useful work can be done by one out of twenty persons," Berkeley insisted, "the other nineteen persons will completely abolish this puritanical idea."[653]

Many firms were reluctant to invest heavily in employee retraining, despite the good public relations associated with such programs. The hope that displaced workers would simply migrate to building and maintaining machines seemed insupportable from a microeconomic point of view. "If as many people were now employed in manufacturing the machines as had formerly been used in making the final product," Glazier cautioned, "there would be no point in substituting machines for people."[654] An influential study by James Bright of Harvard Business School putatively showed that the effect of automation

[652] Berkeley, Edmund C. "The Social Implications of Computers and Automation." *Annual ACM IEEE Design Automation Conference*, Atlantic City, N.J. June 23, 1965, 4.
[653] Berkeley. *Giant Brains*, 9.
[654] Glazier. "Automation and Joblessness," 44.

in a particular firm was to reduce the overall demand for skilled labor.[655] The application of Bright's findings to the larger economy, however, ran afoul of the lump of labor fallacy. If the size of the labor force were directly tied to output, automation's net effect on employment should be expected to be negative. But if machines yielded gains in productivity, the total output per man-hour would rise, allowing firms to maintain constant payrolls while profiting from cost savings on each marginal product. More likely, individual firms would shrink payroll while other service-oriented or capital goods firms would expand to take up some of the slack. This logic notwithstanding, the belief persisted that job destruction in particular firms or industries necessarily implied job destruction across the economy. The value of retraining was, at the very least, openly contested.

The jobs backlash met with considerable opposition from technophiles and business leaders. Though recognizing the difficulties faced by unskilled and clerical workers, many viewed the productivity and time-savings from computers as a qualified blessing. In this camp were the Kennedy and Johnson administrations, engaged in competition on all fronts with the Soviet Union. Public officials and business-friendly writers were joined by professional economists, who in the early 1960s increasingly flocked to the relatively new field of growth scholarship, an area of inquiry that attempted to quantify some of the gains to economic product afforded by technology. Boosters like Diebold and Berkeley found themselves at once in the middle of a storm that had captured national attention at the highest levels.

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[655] Bright, James. "Does Automation Raise Skill Requirements?" *Harvard Business Review* 36 (July-August 1958): 85-98.

Chapter 14 – No need to panic

The specter of job losses inspired an impassioned response; so too, automation's naysayers encountered a broad swathe of opinion in favor of automatic machinery. If the meaningful axis of dialogue was between groups we might call "modernizers" and "anti-modernists," there was nevertheless significant common territory. Everyone agreed that automatic machines posed a revolutionary possibility in American business, and that this radical transformation would impact some workers negatively. The disagreement concerned the shape of the proper response. What solutions could be wrought by the public and commercial sectors that could ameliorate automation's adverse byproducts while preserving the recipe for growth, productivity and prosperity?

Issues such as those broached by the likes of Berkeley and Wiener, and publicly debated by agonists such as Diebold and Reuther, had a tendency to divide opinion. Watchful observers, however, might have hoped cooler heads would prevail. Indeed, there was, in the words of Stanford economist Victor Fuchs, "no need to panic." Elites progressively adopted such accommodative, reassuring language in the years following the initial employment shocks of the 1960-1961 downturn. A visionary optimism articulated by Kennedy in 1960, and by Johnson following the president's assassination, strove to reconcile the special American dynamism driven in part by computers and automation, with a greater emphasis on shared prosperity. "We should not fear automation or try to retard it," Fuchs wrote in *The New York Times Sunday Magazine* in 1963. "On the contrary, we should welcome it, and try to accelerate it. Automation is the key to a higher standard of living at home and to increasing our ability to help less fortunate peoples abroad." There was, however a pressing need "to face the problems with coolness, intelligence and determination. A 'do-nothing' attitude is unwise and unjust. The greatest danger is not that technological change will come too quickly, but that our institutions will adapt too slowly to the problems and the promise of automation."[656] Labor economist John T. Dunlop heralded the rise of an "industry of discovery," the postwar R&D machine that was driving up productivity, and, with it, living standards. In the first half of the 1960s, rates of productivity growth averaged close to three percent a year. Dunlop enthused,

> It should not be too much to look forward to the day when productivity increases at such a rate (five percent a year) that these standards are doubled every fifteen years. These potentials underscore the common gains to be shared by increasing productivity and the possibilities of insuring adequately those who bear the costs of the adverse initial impacts of some technological changes.[657]

One positive externality from the use of computers in industry was the emergence of entirely new markets. The Joint Committee remarked that a commonly overlooked fact was "the extent to which goods and services not previously available or possible are made possible by the introduction of automatic processes."[658] Nuclear energy and the manufacture of color televisions would be quite impossible without automatic temperature control and robotic assembly machines. The digital computer market itself ballooned from $3 billion in sales in 1954 to $7 billion in 1960.[659] With each of these industries, a service sector sprang up alongside. Established industries experienced second-order effects as well; the telephone company, for example, discovered that by the middle of the decade much of its long-line service was being monopolized by machines. Overnight, data transfer became an important business segment. A survey by the

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[656] Fuchs, Victor. "Fallacies and facts about automation," *The New York Times Sunday Magazine*, April 7, 1963, 180.
[657] Dunlop. *Automation and Technological Change*, 3.
[658] The Congressional Joint Committee on the Economic Report, "Automation and Technological Change," 7
[659] Diebold. *Automation*, 1959, 22.

International Association of Machinists found that among 346 metalworking plants that had automated some of their processes, total employment actually *increased*.[660] Diebold further envisioned the blooming of computerized education systems, and a data utility, or "inquiry industry" where information such as the price/earnings ratio of a stock, could be available to a customer "from a unit on his desk."[661]

The demand for labor rested unfulfilled in transportation, housing, sanitation, and pollution control due to the robust infrastructural requirements of the new productivity and its higher standards of living. Productivity gains luckily did not only extend to labor; capital, too, is made more efficient by information technology via lower transaction costs and greater access to remote markets. Thanks to new industries and the growth of old ones, Diebold forecasted, "Mass unemployment, even a fairly high rate of unemployment, is not inevitable."[662] Just as growth in tertiary sectors of the economy required capital, it required a skilled workforce. Public investments in infrastructure would have to be matched investments in training. Industrial policies addressed to the changes brought by automatic machinery should have, Diebold thought, a dual focus: improvements in capacity were linked in a feedback system with intangible assets, such as skills.

Public action on skill development struck a popular chord. John F. Kennedy's 1962 State of the Union address made "strengthening the economy" its foremost domestic priority. At press conference in February of that year, Kennedy announced that "the major domestic challenge of the Sixties [would be] to maintain full employment at a

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[660] Diebold. *Automation*, 1959, 29.
[661] Diebold. *Man and the Computer*, 13.
[662] Diebold. *Man and the Computer*, 16.

time when automation is replacing men."[663] A *New York Times* columnist cheekily commented, "Machines are replacing everything in this country, except maybe pretty girls, and President Kennedy is worried about it."[664] The first piece of legislation the president requested in 1962 was the "Manpower Training and Development Act, to stop the waste of able-bodied men and women who want to work, but whose only skill has been replaced by a machine, or moved with a mill, or shut down with a mine."[665] Kennedy's proposal resonated with many listeners. A Gallup poll taken after the State of the Union asked Americans which of the president's recommendations they were most willing to sacrifice for; sixty-seven percent responded in favor of retraining, greater than any other.[666] The Johnson administration pursued its predecessor's policies with equal vigor. Among the first legislative initiatives of the Great Society was a federal pilot program to train 21,000 unskilled workers.[667] As Berkeley recommended, economic mandarins had begun to include worker displacement as part of a comprehensive antipoverty agenda—not as the source of the problem.

National attention on automation markedly coalesced around the Kennedy years. The president himself stated in a February 1962 press briefing that he regarded automation as "the major domestic challenge of the Sixties—to maintain full employment at a time when automation, of course, is replacing men."[668] Shortly after assuming office, labor secretary Arthur Goldberg felt the need to address the issue head on. Writing in the *New York Times Magazine* (in a piece called "The Challenge of Industrial Revolution II"),

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[663] Quoted in Dunlop. *Automation and Technological Change*, 1.
[664] Ibid.
[665] Kennedy, John F. "Annual Message to Congress on the State of the Union," *John F. Kennedy Presidential Library and Museum*. January 11, 1962. Accessed 4 Sept. 2010. <http://www.jfklibrary.org/Historical+Resources/Archives/Reference+Desk/Speeches>
[666] Glazier. "Automation and Joblessness," 43.
[667] "Automation: its benefits and its slag heap," 6.
[668] "Is Automation Really a Job Killer," 47.

Goldberg announced that the president had created a task force of labor leaders, top executives, Commerce and Labor department officials to investigate "the benefits and problems created by automation."[669] This sort of roundtable consensus building illustrates well Kennedy's own brand of the pluralist ethic, the idea that negotiation and compromise were the keys to practical progress as the many political stakeholders of twentieth-century America fragmented into diverse interest groups.[670] Coalition politics—the meeting place between business, labor, and science—provided the model for the course Washington would take toward automation in the Kennedy/Johnson years. It was a model that largely accepted the inevitability of automation and its economic bounty, while aiming to mitigate the displacement of workers within limits defined by the industrial system.

Goldberg described the phenomenon in carefully chosen language: "The advent of the electronic brain controlling the mechanical muscle has made possible fully automatic factories and offices—but it has also raised the specter of severe dislocation in the American work force." For policymakers, the task was to consider "the necessity for continued increases in productivity, based upon labor-saving techniques... without causing individual hardship and widespread unemployment." In keeping with the approach from the White House, Goldberg lauded the examples of the radio-television and life insurance industries; transitions to a more automated shopfloor here were shepherded by special committee consultation between labor and management. Labor leaders were consulted ahead of time, retraining plans put in effect, attendant wage rises

[669] Goldberg, Arthur. "The Challenge of Industrial Revolution II," *The New York Times Sunday Magazine*. April 2, 1961, 14, 25.

[670] See Richard Hofstadter. See also: Hamilton, C.V. "New Elites and Pluralism." In R.M. Pious, ed. *The Power to Govern.* Proceedings of the Academy of Political Science 34 (1981): 167-173.

negotiated, and provisions for the laid-off provided. The transitions in these structurally expanding industries were, in Goldberg's judgment, managed smoothly and gradually, with the minimum of pain. Reassuringly, he contended, "the experience of successful companies indicates that automation in a context of expanding national employment and economic growth presents few problems that adequate and open planning cannot solve."[671] Goldberg urged that companies accept not only responsibility to shareholders, but to employees and indeed to the public. A new spirit of national cooperation was needed in light of the changes in the broad economic landscape.

"Planning" was, for the Kennedy administration, the operative word. Already factory automation had inspired executives to reevaluate every step of the production process along lines set out by the gurus of scientific management. Automation was as much about organization as about new tools. R.H. Sullivan, a vice president at Ford, told John Diebold, "The trouble with our manufacturing methods was that, like Topsy, they 'just grew' and nobody had taken time out for a long view. What we needed was a complete rethinking of the problem—a whole new philosophy of manufacturing."[672] The introduction of new machinery was, at its heart, an optimization problem. Comparable thinking could be applied to society writ large.

Public officials, flush with Keynesian optimism, were as in thrall to the science of optimization as executives at Ford or Prudential. Public sector intervention could work on a federal, corporate, or municipal scale. Goldberg cited successful training programs instituted by the city of Phoenix, Arizona—a center of Sunbelt expansion—to attract and retain high-level human capital in an information economy. The computer in its

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[671] Goldberg. "The Challenge of Industrial Revolution II," 14
[672] Diebold. *Automation*, 1959, 12.

forecasting, data processing, and simulation capacities, was the ideal instrument of the planner. Goldberg concluded, "Enlightened businessmen, far-sighted labor leaders, and responsible public can, together, make automation a general blessing." Together, this grand corporatist alliance would craft "a blueprint for a better world."[673] In *The Coming Of Post-Industrial Society*, Bell saw public planning as a critical element in marshalling the explosion of abstract knowledge as a social and economic resource. Brick explains that for Bell, "The preeminence of 'theoretical knowledge' (basic, rather than applied science) demanded an 'orientation toward the future' that was the watchword of postindustrialism."[674]

Such dirigiste models, it was thought, might depart significantly from purely market-centric allocation of economic resources. "The Ad-Hoc Committee on the Triple Revolution" was a diverse affiliation of thinkers that included Piel, Heilbroner, Nobel laureate chemist Linus Pauling, futurist Robert Theobald, civil rights activists Bayard Rustin and James Boggs, New Left campaigners Tom Hayden and Todd Gitlin, and a number of others. In 1964, the Committee drafted and sent to Lyndon Johnson a memorandum identifying three social revolutions underway in America requiring necessitated new government action. Of paramount significance was the "cybernation" revolution—the increasing obsolescence of manual labor in the face of accelerating technological change. "The Triple Revolution" declared, "In the developing cybernated system, potentially unlimited output can be achieved by systems of machines which will require little cooperation from human beings. As machines take over production from men, they absorb an increasing proportion of resources while the men who are displaced

[673] Goldberg. "The Challenge of Industrial Revolution II," 25
[674] Bell. *The Coming of Post-Industrial Society*, 197.

become dependent on minimal and unrelated government measures—unemployment insurance, social security, welfare payments."[675]

A situation of dependency was unavoidable, but it could be eased by the provision of housing, transit, electrical power, and income distribution, the authors argued. The Committee articulated a template consistent with what Brick identifies as the post-capitalist ideal. While classical economic models stressed the maximization of resource productivity through efficiency and the profit motive, the Committee viewed clean water, clean air, and satisfying employment as fundamental *consumer rights*. "An adequate distribution of the potential abundance of goods and services," the memorandum read, "will be achieved only when it is understood that the major economic problem is not how to increase production but how to distribute the abundance that is the great potential of cybernation."[676] Markets, which rationally turned to machinery to increase profits, could, it seemed, no longer provide for these needs. The Johnson administration lent a sympathetic ear. With the White House occupying the role of referee between capital and labor, new agencies were created to ensure environmental and consumer protection; moreover Johnson's sweeping "Great Society" vision, announced the following year, took unprecedented steps to furnish economic opportunity.[677]

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[675] Ad Hoc Committee on the Triple Revolution. "The Triple Revolution." *International Socialist Review* 24 (Summer 1964): 86.

[676] Ibid.

[677] Historian Robert M. Collins has described the political economy of the 1960s in terms of "growth liberalism"; the background of economic growth afforded new redistributive or quality-of-life measures that took lower priority in times of fiscal and employment stress. Notable among these are the Clean Air Act of 1963, and even the Clean Water Act, enacted in 1972 under Richard Nixon. Importantly, inasmuch as the Great Society took steps to ameliorate poverty, the administration framed its efforts within the liberal credo of "opportunity," rather than "entitlement." The Economic Opportunity Act, encompassing programs like Head Start, VISTA, and Job Corps, was seen as a "hand-up" rather than a federal handout. Even in the entitlement program Medicaid, an important plank in the War on Poverty, determination of eligibility and partial funding responsibility was devolved to individual states. See: Collins, Robert M. *The Politics of Economic Growth in Postwar America*. New York: Oxford, 2002.

Even John Diebold, who had always advocated decidedly market-based solutions, recognized the necessity of some degree of central planning. "Labor must work with capital to minimize individual hardships and to increase individual opportunity," he argued; nevertheless, both sides had to reconcile to the "unpleasant" prospect of government stepping into the breach. "All these points are linked to the need for planning," Diebold wrote in 1969. "The changes occurring in our society can be harmful if not anticipated and planned for."[678] He tabled several proposals for channeling private investment into needed areas, including targeted tax deductions, government-backed venture capital, and state guarantees on the debt of enterprises that trained-up displaced workers.[679]

At the same time that cabinet secretaries were waxing utopian in the pages of the *New York Times*, economists were struggling to account in their models for the astonishing productivity growth of the past decade and a half. What relationship did the automation of knowledge bear to economic output? That per capita economic growth was a precondition for the general amelioration of misery was a proposition questioned by few. Brick, however, suggests that, for some, growth itself was the culprit. In a period of post-scarcity, there were indeed some who doubted the power of capitalism to effectively allocate resources such as leisure time, a cleaner environment, and good taste. Nevertheless, it would be a mistake to suggest that slow or anti-growth forces constituted the majority. Though uneasy humanists like Mumford may not have been willing to

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Davies, Gareth. *From Opportunity to Entitlement: The Transformation and Decline of Great Society Liberalism*. Lawrence, Kan.: Kansas, 1999.
Rome, Adam W. "Give Earth a Chance: The Environmental Movement and the Sixties," *Journal of American History* 90 (September 2003): 525-554.
[678] Diebold. *Man and the Computer*, 17.
[679] Ibid.

accept certain tradeoffs for growth, the majority of automation's critics would have applauded an increase in the stock of goods and services by any other means. But if productivity increased such as to become a significant drag on employment and, in turn, aggregate demand, serious doubt would be cast on the champions of further technological adoption.

1962 inaugurated a new consciousness from the nation's highest office of the importance of automation. It was also a banner year in growth scholarship. Edmund Berkeley published his follow-up blockbuster, *The Computer Revolution*, a paradigmatic instance of the heady language employed to describe the phenomenon of automation. SABRE, American Airlines' electronic ticketing system, matured out of M.I.T.'s Servo Lab and came online. And two eminent economists, one British and another American, reshaped the academic consensus on technology's contribution to growth.

It was only in the 1940s that classical economics began to count productivity growth in the larger growth model.[680] A decade later, Robert Solow of M.I.T. updated the model to distinguish between vintages of capital, giving greater value to later vintages—newer capital reflects newer knowledge and technology, and is therefore assumed to be more productive. Solow was the first economist to treat technology as a variable, though *how* knowledge was shared throughout the economy remained exogeneous. In a landmark 1957 paper, he revised several assumptions of the classical growth model, and came to a rather startling conclusion. By taking increases to the stock of capital and labor as twin engines of production, and by requiring constant returns to scale of the two factors combined, Solow found that 87.5% of the experienced growth in the United States

[680] The Harrod-Domar growth model was independently developed by Sir Roy Harrod in 1939 and Evsey Domar in 1946.

between 1909 and 1949 was due to some third, time-varying parameter, distinct from either.[681] This enormous lacuna, which became known as the "Solow residual," highlighted the economics profession's inability to develop an independent theory of technical change. Capital improvements were themselves embodied in new machinery and R&D, so even if Solow had overestimated the leftover margin to some extent, significant influence still should have been ascribed to technology. Economists raced to formalize the Solow residual.

In a series of papers, the Cambridge economist Nicholas Kaldor began to consider technological change outright. To Kaldor, productivity growth ought to be evaluated as an endogenous variable—that is, as a visible component of the growth function. In Kaldor's schema, the technical progress function was equivalent to the rate of growth of labor productivity with respect to the rate of growth in capital per worker. The graph, he postulated, would have a concave shape if viewed from below due to the requirement of diminishing returns to scale.[682] The model pointed to the same surprising conclusion as Solow's: to achieve the steady-state growth observed in America and Britain, per capita increases in investment would not be enough; massive gains from technical change were necessary. Steady two percent growth is, of course, not a linear function; it is exponential. The effects of compounding become tremendously powerful over time, accounting for the manifold advances in productivity and living standards over the first half of the twentieth century. To grow GDP from $1,000 to $1,020 requires an absolute change of only $20. But to grow $10,000 to $10,200—the same rate—is more difficult by a factor of ten. Yet this is exactly what was observed. To account for these patterns,

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[681] Solow, Robert M. "Technical Change and the Aggregate Production Function," in *Review of Economics and Statistics* 3 (1957): 314.
[682] Scott, Maurice F. *A New View of Economic Growth.* New York: Clarendon, 1989, 109-112.

Kaldor needed either to revise his technical progress function, or give it a more preferential weighting. In a famous 1962 paper with colleague James Mirrlees, Kaldor attempted to explain how such a powerful influence was possible. Solow's model required capital to increase homogeneously over time; in reality we know that equipment is capitalized in fits and starts, new products come online in cycles, and breakthroughs in knowledge represent discontinuities with the past. To better isolate this phenomenon, Kaldor and Mirrlees utilized a "vintage" model, essentially painting productivity growth as discrete.[683] Workers "learn by doing" on each successive vintage of equipment, ultimately maximizing their rate of output-per-unit time given the rate of capital investment. But, instead of sputtering to a stop, the function reinvigorated itself on each new vintage of machines. In this manner, Kaldor and Mirrlees brought the problem of technical progress halfway into the frame of economic growth. Treating progress as the productivity that accrue to increases in capital, the two Cambridge economists conceptualized "knowledge" as embodied in physical equipment. They made no direct provision for human or intangible capital. And though they employed a less generic approach to how machines are used and skills are attained, they stopped before identifying the precise role played by learning apart from increases in investment.[684]

Stanford economist Kenneth Arrow, also in 1962, offered a subtle twist on this relationship. What he called the learning coefficient was a function not of per capita investment, but a product of the absolute level of knowledge already in existence. Thus ideas, rather than exhibiting decreasing or constant returns, had the property of

683 Kaldor, Nicholas and James A. Mirrlees, "A New Model of Economic Growth," *The Review of Economic Studies* 29 (1962): 174-192.

684 Harcourt, Geoffrey C. *Some Cambridge controversies in the theory of capital*. London: Cambridge University, 1972, 80-83.

compounding.[685] This characteristic is easily demonstrated by many companies' experience buying a computer. As many firm discovered, the initial outlay on a computer system could, as a capital good, add to productivity at the margin. But buying an expensive mainframe did not conclude the process. Additional capital expenditure was rarely dedicated to replacing the current system, lock, stock and barrel, with a better one. New technology had the capability of improving productivity from the present stock of knowledge, frequently at less expense. An executive who had bought an IBM System/360, for example, could milk more horsepower out of his machine by purchasing modular add-ons, additional terminals, upgrades, or peripherals. Most significantly he could, either through IBM's service representatives, or internally through such user-friendly platforms like IBM's FORTRAN language, develop programs that put the machine's processing power to more creative, efficient use. In the words of *Fortune* magazine, "The computer indirectly spurs productivity. Not only does it make existing machines more productive, but it stimulates the purchase of newer and still more efficient machines."[686] Once on the accelerating path of productivity growth, new vistas opened up to business that would have been unthinkable before.

The new subdiscipline of endogenous growth theory catapulted a new matter to the forefront of our understanding of economic growth: that of intellectual property. While society often chooses to protect commercially sensitive ideas by patent in the interest of incentivizing future research, Arrow's learning function instead stressed the importance of knowledge sharing. IBM's product development benefitted from breakthroughs achieved during work on the System/360, but it also shared in the past

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685 Arrow, Kenneth J. "The Economic Implications of 'Learning by Doing'," *Review of Economic Studies* 29 (1962): 155-173.
686 Burck. "The Boundless Age of the Computer," 232.

cumulative investment of its rivals. Any particular firm may experience constant returns to research, but through the economy-wide collective effort of all firms (as well as government and university research), knowledge builds on itself. Arrow and his followers treated ideas essentially as a free public good, or in the language of economics, an external benefit.[687] Striking the balance between what knowledge was made available to individual firms, and what remained exclusive intellectual property was now a pivotal consideration in dealing with growth in the macro economy.

Other economists were beginning to look in new ways at the role technology played in shaping the labor market. Foremost among them was a young professor at Columbia University, the future Nobel laureate Gary Becker. Becker was attracted to a controversial area of study, one Adam Smith had called "human capital." It was controversial because to equate human beings as "capital" was to compare them to the stock of physical capital—in other words, to demean them as machines.[688] Becker's 1964 book *Human Capital* made the important leap from Smith's classical method by regarding human capital as fundamentally augmentable. When we attend university, enroll in a computer-training course, or learn computer skills on the job, Becker remarked, we (or our employers) are *investing* in our human capital, thus assuming a rate of return sufficient to make our investment worthwhile.[689] Becker further noted that it was not a country's physical resources that determined its wealth, but its accumulation of

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[687] Arrow's treatment of knowledge as a publicly available good can be thought of in terms of the total factor productivity element of the Cobb-Douglas production function (all effects not caused by inputs. In this formulation, total output is described by the simplified equation $Y= G^zKi^aLi^{1-a}$, where "a" is the productivity growth of labor, "K" the capital input, "L" the labor input, and "G" the stock of capital publicly available. Essentially, labor retains skills earned in productive experience, allowing economies of scale to develop over time.

[688] Becker, Gary S. "The Economic Way of Looking at Life." Nobelprize.org. December 9, 1992. Accessed 4 Sept. 2010. <http://nobelprize.org/nobel_prizes/economics/laureates/1992/becker-lecture.html>

[689] Becker, Gary S. *Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education*. Chicago: University of Chicago, 1964.

knowledge and skills.[690] Investments in technology would achieve very low returns if coincident investments were not made to prepare workers to use it. In order to achieve the rates of growth computers promised, and economists such as Kaldor and Arrow forecasted, social policy should be geared toward instruction in technical literacy. Over the following decades, as more Americans began to use computers in their daily working lives, the United States' stock of human capital rose dramatically, enabling increasing returns in the form of rapid productivity growth.

What becomes clear when evaluating the impact of Kaldor and Arrow's papers, both in their influences on subsequent scholarship on public consciousness, is that the rate of technological advance had become inseparable from the study of growth. With Solow, Kaldor, and Arrow, knowledge takes on a significant proportion of the responsibility for driving growth through the economy. Growth, all things being equal, means more jobs and higher wages. Thus, by 1962, there was a budding academic consensus that, with respect to the value of industrial automation, the burden of proof ought to be shifted to its opponents, at minimum. Computers, and particularly in Arrow's formulation, techniques for using them, were both the result and the source of the knowledge function. It would be as pointless to argue against them as it would to question the worth of electric light, or cheap rail transportation, or the assembly line. On net, economists' arguments implied, computers were job creators.[691]

Economists who observed a decoupling between rates of growth in productivity

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[690] Howard Brick takes a dismissive view of the idea of human capital, a late twentieth-century economic breakthrough that fits outside his narrative of declension. Becker's calling children "durable consumer goods," he terms a "gaffe," indicative of an outmoded "economic imperialism." (238) Rather, Becker and his followers' work was a challenging update of academic economics' hyper-materialist orientation that integrated newer understandings of the cultural and social dimensions of growth.

[691] For a statistical look at the relationship between rates of productivity growth and levels of unemployment, see Appendix 2.

and changes in the unemployment rate gave credence to the suggestion that the hiccups in the jobs picture in the early 1960s resulted not from new technologies but the familiar rise and fall of demand in the business cycle. Output and employment were not lumpy, affecting more automated sectors more than less automated ones; the downturn was felt smoothly throughout the economy. *The New Republic* summarized thus:

> If the 'structural change' thesis is correct, the behavior of unemployment (or employment) in industries and occupations where there have been important changes in technology or in consumer preferences should differ markedly from earlier years when the over-all unemployment rate was about the same. Furthermore, output per man-hour should be increasing much more rapidly than in earlier periods of similar general economic characteristics...[T]he slowdown in employment growth and the rise in unemployment has been widespread throughout the economy, affecting industries and occupations in about the same proportions as in earlier years of over-all low demand.[692]

Rising productivity and falling employment are often associated with cyclical downturns. These cycles were too robust to be fundamentally dislodged by a new product, no matter how revolutionary. The National Commission on Technology, Automation, and Economic Progress, established in 1964, agreed: "The persistence of a high general level of unemployment in the years following the Korean War was not the result of accelerated technological progress. Its cause was interaction between rising productivity, labor force growth, and an inadequate growth of aggregate demand. This is firmly supported by the response of the economy to the expansionary fiscal policy of the last five years... The basic fact is that technology eliminates jobs, not work."[693]

As my graph displays, by 1962 the rate of unemployment had moderated considerably from the previous half-decade, and it continued on a sustained low trend throughout the 1960s. Meanwhile, productivity growth, after a setback in 1961, resumed

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[692] "Why Unemployment Stays Up," *The New Republic* (147), October 20, 1962, 18.
[693] Bowen, Howard R. and Garth L. Mangum. *Automation and Economic Progress*. Englewood Cliffs, N.J.: Prentice Hall, 1966, 101.

its locomotive pace. With this improvement in labor conditions, paired with persistent increases in output, the uproar over automation began to abate. There was very little contemporary documentary evidence to support Meany's thesis that automation necessitated job losses. After 1962, when Kennedy identified automation as both a fact of life and an urgent question, the direct relationship between productivity and unemployment labor leaders' posited appeared a good deal more tenuous.

Capitalism depends on innovation. Innovation causes disruption, and sometimes destroys jobs. Some firms fail so that others may take up their slack. The system is a dynamic and random one such that weakness in one sector may herald strength in another, seemingly altogether unrelated. The process has many names: the business cycle, economic Darwinism, creative destruction. The last was coined by the Austrian economist Joseph Schumpeter, in 1942's *Capitalism, Socialism, and Democracy*—to this day the most cogent account of the manner in which capitalism regenerates itself.[694] Libertarians, like Schumpeter himself, preferred this cycle to be allowed to play itself out with the minimum intrusion; labor, capital, and technology could allocate themselves better than any central planner.[695] Social democrats would have wished to correct the crudest swings of capitalism's pendulum, shielding its casualties from further harm. What emerged in the 1960s was a tentative compromise between Schumpeterian capitalists, and the ascendant center-left that some sacrifices were to be tolerated in the name of greater efficiency, but not all. Government could assist the transition to more

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[694] Schumpeter, Joseph A. *Capitalism, Socialism, and Democracy*. New York: Harper, 1962. Schumpeter's predictions about the rise of social democracy were borne out by the efforts of the Johnson administration.
[695] Economists of the Austrian school, like Schumpeter and his protégé Hyman Minsky did not, of course, accept the classical equilibria of Adam Smith or David Ricardo. Even an untrammeled market could, through the mechanism of credit and the waxing and waning of sentiment, rise in spectacular booms and fall in catastrophic busts. Yet, on balance, Schumpeter distrusted the wisdom of bureaucrats than the collective behavior of the herd of buyers and sellers.

productive forms of industry (it is noteworthy that the rapid private take-up of computers in the 1960s could not have happened absent heavy government investment in earlier decades); it could also attend to those left behind.

Following in the footsteps of the previous secretary of labor, Goldberg's successor Willard Wirtz pursued this line of argument in a 1965 *Times* special section on computers. Wirtz's testimony inherited something from Kaldor's and Arrow's work while acknowledging the endurance of creative destruction. "As recently as a generation ago, man's stock of knowledge did not necessarily, or even often, affect the durability of his employment," Wirtz began.[696] This was no longer true. No longer could credit, capital mobility, or industrial cycles assume all the blame. The trend was as Arrow described; knowledge built upon itself, geometrically, and the uneducated were increasingly excluded from the benefits of growth. The distribution of economic power was two-tiered; the technically literate enjoyed rising wages and job stability, and the have-nots enjoyed neither. As Wirtz described it, the capitalist system was organized around innovation: "Technological change no longer is the only child of the lonely inventor. It has become the product of a rationalized industry of discovery."[697] By conceptualizing technological change as an accelerating trend, Wirtz made it both inevitable and natural. Adaptation, in the form of a federal "affirmative manpower policy," was the only answer.

Followers of Schumpeter interpreted the computer as an unqualified boon. Writing in *Newsweek*, libertarian thinker Henry Hazlitt placed the automation backlash within a time-honored tradition of blaming the machine. "Ever since technological

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[696] Wirtz, Willard. "Automation and Employment." *The New York Times*. May 23, 1965, 4.
[697] R&D spending had risen to new postwar highs in the 1960s, consistently above 2.5% of GDP. The government had a hand in this, more than half of these dollars being apportioned by Federal sources. See: "Measures and Comparisons of National Resources for R&D." National Science Foundation, 1996. Accessed 4 Sept. 2010. <http://www.nsf.gov/statistics/nsf96333/measures.htm>

progress began," he counseled, "men have feared efficiency and machinery as a threat to their jobs.[698]" He drew a lesson from the nineteenth-century garment industry, where stocking frames were once demolished by handicraft workmen. Thousands of machines were burned during a series of riots, along with the houses of their inventors. While the original Luddites seethed, the stocking business expanded, and by the end of the century, one hundred workers were employed for every one in Ned Ludd's time. Hazlitt complained, "Yet the belief that machines on net balance destroy jobs, no matter how often disproved, never dies. Whenever there is prolonged unemployment machines get the blame anew. In the depression of 1932, a group called the Technocrats emerged to blame the mass unemployment in that era on the machine. Well, here we go again."

The Austrian prescription for unemployment was not to ignore it until the economy reset to equilibrium. It was, simply, to grow your way out. Automation fueled growth, and was therefore the cure to its own disease. Elite opinion in the 1960s hewed remarkably close to this line. Even if computer automation was really responsible for all growth in productivity, the statement that "automation replaces men," was still incorrect, wrote *Business Week*: "It contains a major concealed assumption: that total output remains constant while productivity increases, thus that fewer people are needed to do the same work."[699] Output, however, was not static. As output grows, so too does demand for higher order tasks along the production chain. A study by the Joint Economic Committee found that labor was being "steadily upgraded" not immobilized by automation. *Business Week* wrote, "A rapidly rising level of education has facilitated the flow of manpower into white-collar, service, and professional jobs. In the past 20 years,

[698] Hazlitt, Henry. "Automation makes jobs," *Newsweek*. March 5, 1962, 70.
[699] "Is Automation Really a Job Killer?" 47.

the median education of male workers has risen from slightly less than grammar school education to slightly less than high school." Long before Daniel Bell authored his famous comment on the service sector, economic mandarins had hailed and facilitated its rise.

Paul Armer of the Rand Corporation estimated that the computer industry alone would create a million new jobs before the end of the 1960s, without counting the exploding need for programmers.[700] Diebold's "bright future" opportunities were not only to be found in high technology. Indirectly, the effects could be traced to every industry. "A computer-controlled oil refinery employs fewer people than a conventional refinery, but it helps bring costs and prices down; and a steady reduction in the real price of petroleum helps increase the demand for them and so generates thousands of jobs in their distribution and sale," Gilbert Burck argued in *Fortune* in 1964. "An excellent case could be made for the proposition that if the computer did not exist, it would have to be invented."[701]

By the middle of the decade Burck's view was considerably less contested. Automation's proponents might have found their thinking embodied in economist George Terborgh's popular paperback, *The Automation Hysteria*, which endeavored to counter the naysayers once and for all. "The word automation had not been long in circulation before there appeared a growing body of literature predicting catastrophic effects on *employment,*" Terborgh opined in his introduction.[702] The "alarmists," as Terborgh called them, expected "permanent and incurable mass unemployment" as a result of the computer's labor savings. By 1965, however, the economy had turned. The

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[700] Burck. "Boundless Age of the Computer," 232.
[701] Ibid.
[702] Terborgh, George. *The Automation Hysteria*. New York: Machinery and Allied Products, 1964, 2.

unemployment rate for that year had fallen by almost a full percentage point, to 4.51%. The computer no longer seemed as threatening as it had at the outset. As the Roman aphorist Publilius Syrus wrote, “Prosperity makes friends; adversity tries them.”

IBM had set up a 500-seat auditorium at the 1964 New York World's Fair to demonstrate to many for the first time the use of its operating systems.[703] Next door, Bell Telephone demonstrated a working computer modem. American industry was putting its Giant Brains on bold display. To Terborgh the computer was not a threat; it was an aid. Rather than revolutionizing a single industry as the automatic loom had for textiles, computers, he argued would slowly improve many industries, resulting in greater efficiency across the entire economy. “The displacement of blue-collar workers by computer automation is relatively insignificant at present and promises to remain so for a long time,” he reassured.[704]

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[703] “New York World’s Fair pavilion,” *Vintage Views*. IBM Archives. Accessed 4 Sept. 2010. <http://www-03.ibm.com/ibm/history/exhibits/vintage/vintage_4506VV2085.html>
[704] Terborgh. *The Automation Hysteria*, 79.

Chapter 15 – Purpose before power

Through the crucible of the unemployment problem emerged a realization by most parties that technological progress was at once an inescapable fact, and, for all but the least prepared, a potential blessing. The state, private industry, and individual employees all had a role to play in smoothing the transition. In the mid-sixties, American society settled on what I term the "automation synthesis," a careful digestion of computers' potential with neither the hyperbole of Berkeley nor the existential fear of Mumford or the alarmists.

The new consensus owed something to the balance Diebold had outlined more than a decade earlier. Automation was in part an historical rupture, he had argued; it would "appear as a distinct phase in industrial progress, but it is nevertheless a part of the long continuum of man's mechanization of his work."[705] "When these new machines reach their potential," he was quoted in *Time*, there will be a social effect of unbelievable proportions."[706] Coincidentally, during the 1960s, Diebold was already becoming more radical in his predictions, talking of cyborgs, affordable home computing, and integration of mind and machine, as we will see in coming chapters. But American society, particularly the businessmen whose concerns he attempted to assuage, was catching up to Diebold.

Reader's Digest assimilated this point of view in a short piece that ran in October, 1962.[707] While noting local disruptions—in an American Oil Co. refinery that had replaced 6,500 men and women with a feedback control computer, for example—it

[705] Diebold. *Automation,* 1952, 6.
[706] "The Cybernated Generation," *Time*. April 2, 1965, 3.
[707] Excerpted from MacMillan, Robert H. *Automation: Friend or Foe*. New York: Cambridge University, 1956.

concluded that mechanization has over time given birth to as many industries as it laid waste: "the thought of a robot directing a factory stirs among many of us the specter of jobs destroyed. Yet, as we know, machines—given the golden gift of time—have always created more jobs than they displaced."[708] Job losses in heavy industry would be more than offset, in the long run, by gains in a doubly productive service sector. Popular treatments of these issues in the mid-sixties trended toward such a symmetrical weighting of advantages and complications. Pieces like this one in *Reader's Digest* suggest that Americans were becoming more comfortable with the effects of computers in plants. Yet they were hopeful for some kind of systematic strategy, from industry or government, to smooth the rash of structural changes underway.

The fledgling synthesis rested on a somewhat reflexive argument that, while technology had presented a raft of social difficulties, this same technology was alone capable of resolving them. The paradox of fighting fire with fire was not lost on astute statesmen such as Wiener. But rather than shut down the American productivity machine, they counseled a policy of more judicious use. Writing in the *New York Times*, historian Melvin Kranzberg summarized, "Many of our contemporary social problems—pollution of air and water, urban disorganization, and war and peace—arise from the unthinking applications of science and technology. The possibility, however, that science and technology may be used to resolve these complex problems depends largely on political decisions and social changes—which the computer can help analyze, predict and perhaps direct."[709] Computers—unique among technologies as enablers of logical reasoning—opened a window on the organizing, calculating, and planning capabilities of the human

[708] MacMillan. *Automation: Friend or Foe*, 59-60.
[709] Kranzberg, Melvin. "Computers: New Values for Society," *The New York Times Sunday Magazine*. January 9, 1967, 135.

mind. By shifting the conversation from what computers *did*, to how we *used* them, Kranzberg subtly turned attention back on the human dimensions of computing. With these considerations in mind, we might create gentler, yet more flexible and powerful technology. His argument emblemized the consensus that purpose mattered a good deal more than power.

An era of high speed information processing entailed a different set of challenges for business. Firms installed computer systems to streamline simple processes like inventory management or temperature feedback control on the factory floor. They found, however, that as intelligence proliferates, the range of problems to which it can be applied becomes coterminous with its capabilities. America in the age of the electronic computer was veritably deluged with information. The new machines, as Berkeley and Diebold had predicted, found no dearth of applications. Directing military resources, predicting and tuning the economy, managing production at large enterprises, serving up strategic imperatives via game theoretical models, governing the bureaucracy; engineers had invented computers to solve a few discrete problems, like anticipating aircraft trajectories. In less than two decades, American society was utterly reliant on them.

The glut of information unleashed by the automation of knowledge gave rise to a growing sensation of what futurist Alvin Toffler called "information overload"—that the flood of data and the complexity of social organization was outstripping our ability to make sense of it. Cognitive strain was experienced on an individual and a societal level. A 1966 article in *The Nation* confirmed the psychological problem of "sensory overload; that is, of an inability to absorb more than a certain amount of experience in a given time."[710] In popularizing the term, Toffler referred to a more generalized phenomenon—the paralysis of decision-making in organizations when too much data is available.

Humans, it seemed, would have to begin to organize their lives more according to the principles of digital computation. As a civilization, we would have to find ways to integrate computer planning with human planning. Computers could provide deductive certainty, foolproof calculation, the speed and fortitude to run one thousand trials of a given program to determine the most likely result. The theologian Paul Tillich once remarked that "men will quickly commit themselves that promises certainty in their existence."[711] For optimists, computers offered just this promise. To make use of this newfound power, however, humans programmers needed to encode a sensible calculus of choice, correct starting conditions, and to identify all relevant variables. This required the problem to be specified formally. To make matters more difficult, computers operated in the realm of discrete mathematics—the binary logic of and/not, if/then, start/stop. Their users, found themselves in the confusing world of continuous variables, ever-shifting conditions, differential equations. To marry these frames of reference better ways of interaction would need to be devised. Contemporary input/output standards like batch processing, teletype, and punched card printouts limited users' real-time access to expensive computer systems.

In his 1970 opus, *Future Shock*, Toffler wrote of a society where the engines of decision, turning on information, were the critical drivers of the economy, not historical forces like birth rates, levels of investment, or rainfall. Quoting U Thant, he asserted, "It

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[710] Theobald, Robert. "Should Men Compete with Machines?" *The Nation*, April 19, 1966.
[711] Tillich, Paul. "Critique and Justification of Utopia," in *Utopias and Utopian Thought*. Frank Manuel, ed.. Boston: Houghton Mifflin, 1966, 307.

is no longer resources that limit decisions. It is the decision that makes the resources."[712] Toffler accented the need for increased scientific/technological literacy and better channels of communication among and between people and their machines. These were the problems that motivated a new generation of computer evangelists, researchers who saw computer power as something that ought to be in the hands of every worker. "To master change," Toffler wrote, "we shall therefore need both a clarification of long-range social goals *and* a democratization of the way in which we arrive at them."[713] To this end, he proposed a civilian technology "ombudsman," in the mould of Berkeley's international regulatory agency, to steer new innovations to the best satisfaction of social needs.[714]

For some, the best way to accomplish Toffler's objective was to yoke computers more closely to human minds; computer networks in development at the Pentagon's Advanced Research Projects Agency under Larry Roberts and Bob Taylor, and improved input/output systems like Ivan Sutherland's SKETCHPAD, completed as a Ph.D. project at M.I.T. in 1963 exemplified research in this vein.[715] Toffler's future was a preconditioned on the linking of machine and user in a kind of cybernetic feedback system that amplified the strengths of each. Toffler mused

> that the biological components of the super-computers of the future may be massed human brains. The possibility of enhancing human (and machine) intelligence by linking them together organically opens enormous and exiting probabilities so exciting that Dr. R. M. Page, director of the Naval Research Laboratory in Washington, has publicly discussed the feasibility of a system in which human thoughts are fed automatically into

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[712] Toffler. *Future Shock*, 16-17
[713] Toffler. *Future Shock*, 422.
[714] Toffler. *Future Shock*, 390. Like Berkeley, Toffler believed America was undergoing a "computer revolution" (192), and that such rapid change needed to be carefully monitored and directed.
[715] Campbell-Kelly, Martin and William Aspray. *Computer: A History of the Information Machine*. Cambridge, Mass.: Westview, 2004, 290-292. Before the official launch of the ARPANET in 1968, individual ARPA research centers being connected for email and file-sharing applications, expanding M.I.T.'s Compatible Time-Sharing System (CTSS) on an IBM 7094 mainframe.

> the storage unit of a computer to form the basis for machine decision-making. Participants in a RAND Corporation study conducted several years ago were asked when this development might occur. Answers ranged from as soon as 1990 to 'never.' But the median date given was 2020—well within the lifetime of today's teenagers.[716]

The idiom of applied utopia was thick in Toffler's account; he dealt in "probabilities," not "possibilities." But studies like RAND's were not wild science-fiction imaginings. They were a natural application of Norbert Wiener's cybernetics to the social problems of the day. Toffler knew that rudimentary beginnings of such cybernetic systems were being undertaken in engineering laboratories from Cambridge to Palo Alto to Pittsburgh to Urbana-Champaign.

Diebold noted in 1969 that the rise of electronic communication and data processing would inspire a new breed of "multinational" corporation. Such large-scale enterprises would need to take advantage of tools to integrate informationally (if not vertically). Operations research (the modeling of management problems by computer) and computer simulation were begetting techniques to solve new, more complicated problems, and, ultimately, to "transcend the compartmentalized structure of business organization."[717] Fitting these technologies to the sometimes divergent needs of shareholders, consumers and employees would become a serious challenge for executives decades hence: "When machines are in league with men, the soul of the alliance must be human, lest its ends become less than human," Diebold wrote. "Management must use the technology and encourage its development to serve human purposes."[718]

The problem of "getting more from the machine tools we have" was outlined as early as 1961 in a speech by Dause L. Bibby, the president of Remington Rand, makers

[716] Toffler. *Future Shock*, 191.
[717] Diebold. *Man and the Computer*, 109.
[718] Diebold. *Man and the Computer*, 138.

of the UNIVAC. "One of the paradoxes of our age is that advances in science and technology are far outstripping man's ability to manage his affairs," Bibby contended, presaging talk of "information overload."[719] The solution was not to race ahead building faster machines (though Univac was happily doing so), but to elicit more value from those we had. It would be fruitless to engineer better machines without engineering better users. As Bibby put it, "Effective decision-making can only be the result of well-organized clear thinking." Bibby's statement naturally raised the question of whether machines could think. "I 'compute' they can," he returned. To ask the question misses the central point—men and machines must work in harmony. Either is ineffective without the other: "Computing, thinking. Thinking, computing. Six of one—half a dozen of the other. It is as true of computers as of the human brain: They are only as good as the uses to which they are put."[720]

"If we really hope to get added leverage from the computer in our economic and scientific struggle," Bibby told the Eastern Joint Computer Conference, "we as individuals must reorient our thinking away from hardware and toward the *application* of our machines. It may be said today that for every 1,000 hours devoted by our best scientific brains to developing better computer equipment, just one hour is spent in devising methods to improve its use. This imbalance can sabotage our hopes for the future as surely as a military defeat."[721] Some of the need could be met at an organizational level, with more dollars allocated to software, peripherals, and training. But Bibby was more ambitious, advocating a wholesale realignment of national policy

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[719] Bibby, Dause L. "Computers and World Leadership," Speech to Eastern Joint Computer Conference, Washington, D.C. December 12, 1961. *Vital Speeches of the Day*, December 1961, 286-297.
[720] Bibby. "Computers and World Leadership," 286.
[721] Ibid.

priorities. “We deplore the inadequacies of our schools,” he said, “yet how many of us have given any private, intense though to the programming of knowledge for better learning and retention? Teaching machines are in their neolithic phase today.”[722] At the very highest levels, America needed to think about incentives for study of engineering, computers, and physical sciences, where enrollment rates were falling behind the Soviet Union. Bibby hoped the United States government would “think big,” using computers to “expand the horizon of technique” beyond individual companies and to planning the national economy. In the future, computers everywhere would be “linked up and talking to one another on a national—and intercontinental—communicating system.”[723] In such an interconnected world, it was up to Americans to claim the mantle of technological leadership.

Fears of automation slipped from public consciousness gradually, not as a consequence by a supreme victory by its advocates. The piecemeal gains won by steelworkers, the retraining programs that were launched by firms and municipalities reveal how the automation synthesis was achieved in practice. Notwithstanding the clamor for high-level planning, it is important to remember that the history of thinking about (and with) computers is the cumulative product of individuals responding to individual moments. Berkeley was set down the path of computer ministry when he acquired a UNIVAC for Prudential. Diebold began by studying scientific management at Harvard Business School. Eckert and Mauchly openly clashed with school administrators and their research colleagues in their attempt to make electronic computing a profitable business. None of these enterprises were the product of long-

[722] Ibid.
[723] Bibby. “Computers and World Leadership,” 287.

range plan or central office. If the Pentagon is responsible for developing the electronic digital computer, it was in some respects accident. Its twists and turns embraced myriad different architectures, digital and analog, mechanical and electromechanical, and were the product of both research sector and garage innovation.

Indeed future computer prophets came to see individualized, interactive computers as deeply antithetical to the notion of centralized planning. When workers began to encounter computers on a personal basis, they often found the experience liberating. Computers that could enable communication, or display graphics, or aid in household tasks performed quite the opposite task of their number-crunching counterparts in the halls of government. To some, the post-industrial society meant a transition from antagonistic, molecular capitalism to a benignly planned managed economy, or to the brand of technologized corporatism in Vonnegut's dystopia; knowledge workers on the front lines of the computer revolution had an entirely different future in mind.

David Noble reminds us that despite the overwhelming managerial urge to control and measure, those who create and those who employ technology are "as prejudiced as the next person, constrained by the technical 'climate,' cultural habits, career considerations, intellectual enthusiasms, institutional incentives, and the weight of prior and parallel developments."[724] Even in its adolescence, technological forecasters tried to imbue the computer with a certain inevitability, a single path that could be steered by right-minded mandarins, but never arrested. In their turn Berkeley, Diebold, Toffler, and hundreds of journalists proposed that the "electronic brain" was a discovery—a powerful motor behind the wheel of history—and not a set of inventions by and for individual people. It was not the invention of historians and subsequent mythologists that

[724] Noble. *Forces of Production*. 145.

computers were endpoint of a long philosophical tradition. Wiener traced them to Aristotle and Leibniz, Berkeley to Frege and Boole. Even IBM and UNIVAC's marketers gleefully indulged in futuristic tropes that saw automatic machines solving most of society's problems as if by magic.

Yet, evident in Noble's caution is the enduring strength of Galbraith's technostructure, thriving not as a monolithic agency, but as a whirlwind of direction from below. In a firm, Galbraith noted, "Nearly all power—initiation, character of development, rejection or acceptance—is exercised deep in the company. It is not the managers who decide. Effective power of decision is lodged deep down in the technical, planning and other specialized staff."[725] The users of technology operated in small worlds—not in the global theatre of Cold War grand strategy. David Mindell has identified how specific technological changes are wrought in small-scale "engineering cultures" defined by the particular challenges of the local environment.[726] Scientists working on ARPA's payroll were not crew-cut commanders like Kubrick's caricature Buck Turgidson. They were, rather, small networks of people with a shared interest in how computers could be made more human. According to Galbraith, this is the very nature of innovation: "Adaptation...is reinforced by the nearly invariable tendency for individuals to narrow the universe so that it is coterminous with their own horizons… the world of the bureaucrat is his unit, section, branch, or bureau… It is this sub-universe that he seeks to accommodate to his own goals."[727]

The computer was many things to many people; it resisted tidy planning. The

[725] Galbraith. *The New Industrial State*, 62.
[726] Mindell, David A. *Between Human and Machine: Feedback, Control, and Computing before Cybernetics*. Baltimore: Johns Hopkins, 2002, 62-70.
[727] Galbraith. *The New Industrial State*, 144.

1950s and 1960s debate over automation reflected this diversity of opinion. Its partial resolution shows us the integration of automated information processing into the main currents of business, academia and government was a move away from the linear narrative championed by Berkeley. The architects of a new range of close-knit human-computer systems, though they continued in the vein of Wiener's humanist philosophy, prized conditional explanations over linear ones, on-the-ground distributed decision making over planning by colossal brains.

It was the personal computer that ultimately banished the specter of man's replacement by machine to the dustbin of history. The machine was transformed from a brain into a tool, from an automaton to a critical part of thinking system, tied to its user by feedback. The lesson of cybernetics, as it was understood by a new generation of computer scientists, was not the equivalence of organic and mechanical forms of thought—it was their deep and powerful compatibility. The mass of unorganized data was accelerating geometrically; the information society was becoming dramatically more complex every year. Computer visionaries saw in the prospect of a smaller, cheaper, more intuitive machine a way to empower ordinary workers to better manage information overload. "Just as mechanical power tools have extended the capacity of individual workers, the computer is able to extend a businessman's capacity for imaginative foresight, intuitive judgment, and positive executive control," extolled the *Christian Science Monitor*.[728] Even though they represented the cutting edge of technology, computers would be simple and easy to use. Frederick Frick, an engineer at the Lincoln Lab predicted that, within a decade, the computer, like the telephone would be accessible

[728] Cowen, Robert C. "The Computer: Power Tool for Thinking," *The Christian Science Monitor*, May 22, 1964, 1.

to ordinary people without technical expertise: “It should at least have the impact of the automobile.”[729] Diebold agreed. Computers in the 1960s were a part of ordinary life, though often invisible, processing tax records, designing airplanes, monitoring steel furnaces, and computing insurance policies. But they would soon enter the realm of the mundane and quotidian:

> A key characteristic of the new technology is that it will allow the housewife at home, the physician at his office, the engineer or scientist at his laboratory, the businessman at his desk great selectivity to ask for specific information that is of interest to him and to receive answers to such inquiries virtually as he makes them, whether they be book reviews, the results of a baseball game, an intricate problem involving pharmaceutical research or financial analysis.[730]

Douglas Engelbart was one who elected to enter this fray. Like Diebold, he had read Edmund Berkeley's manifesto, *Giant Brains*. Interactive computers, he believed, did not have to be clunky prototypes like *Simon*. “I knew implicitly, and with surety, that if a computer could punch cards, that it could also electronically display text and draw on a CRT,” Engelbart remembered. “And if radar attached to a CRT could respond to operators, then people could also interact with a computer that had a CRT. I could see electronically, that if other people were connected to the same computer complex, we could be collaborating. And I knew that was something I could do.”[731]

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[729] 5. Frick spoke from direct experience. In 1963, his laboratory at M.I.T. had completed a small, simple computer called the “LINC.” The following year, a contract was established with the infant Digital Equipment Corporation (DEC) to manufacture commercial models, the designs of which evolved into DEC's popular PDP series minicomputers. The PDP-1 was advertised as a “fast, general purpose digital computer”, priced between $85,000 and $220,000. Purchasers also acquired the auxiliary benefit of membership in the Digital Equipment Corporation User's Society (DECUS), which provided free information exchange and troubleshooting. DECUS was an important, bootstrapped effort at competing with IBM's famous service team, and also formed one of the earliest communities of computer programmers. DEC, Computer Product Literature, box 12.

[730] Diebold. *Man and the Computer*, 11. Diebold also mused that a close integration of machine and user could elide some of the boundaries of what constituted *knowledge*. Though he chose not to use the loaded term “cyborg,” he thought the 1970s might bring about “the probability of man-machine symbiosis—the linking of a man’s brain directly into the memory and calculating power of electronic computers.” He wondered, “Are we heading into a time when Dr. Faustus becomes Everyman?” (5)

[731] Engelbart, Douglas C. “A Profile of His Work and Vision: Past, Present and Future”. Logitech, 2008, Accessed 1 Sept 2010. <www.sri.com/news/storykits>

Part 4 – From Thinking Machines to Tools for Thought

Chapter 16 – Toward computers for everyone

The synthesis that prevailed by the mid-1960s held that the automation of knowledge work was inevitable. No longer massive, mechanical harbingers of our obsolescence, computers were turning into thinking aids, simple enough for an ordinary businessman to use. Higher-level programming languages like ALGOL and BASIC compiled more intuitive commands into machine code, allowing nonscientists to communicate with advanced machines. More affordable, modular installations like IBM's System/360, and DEC's popular "mini", the PDP-1, cost as little as $150,000 and found their way into medium-sized businesses. Yet the decreasing cost-curve was a necessary though insufficient condition for human-computer partnership to reach its full potential. Fundamental questions about the design of hardware and software remained unanswered. Designers and customers alike still shared attitudes toward technology rooted in the philosophy of scarcity typified by early skeptics like Howard Aiken.

These attitudes were changing. The controversies of the prior decade had provoked a reimagining of the machine's part in the American drama. It had graduated from an engine to an automaton; now it would become a psychedelic. The jobs crisis that turned America's attention suddenly toward automation led to a new direction forward. The "post-industrial state," the "service economy," or the "information age"—these were variations on a theme. If the American worker was to be relevant in a high-tech world, he needed to reinvent himself. Technical skills and computer literacy would be nearly universal job requirements in the America of Daniel Bell and Alvin Toffler's imagining. But the machines they used were to change as well. Douglas Engelbart was one who rallied to Edmund Berkeley's call for smaller, friendlier computers. The engineers who shouldered this duty did so without certainty that the problem of easy, affordable computer access was scalable. They knew, however, that if they failed, the worst scenarios imagined by skeptics of automation may well have come true.

The technological challenges of the second half of the twentieth century would not be like the first. The in 1960s, America was deeply interconnected; instant electronic communication was pervasive. The non-communist world provided an entire hemisphere of demand for American goods and services. Heavy industry was in a structural decline; information processing was proliferating. Technology capable of obliterating human life stood ready to be unleashed at the touch of a button. Most of all, every event, every scientific advance, every whisper of news filtered throughout a global information system, available for real-time feedback. Human beings, more than ever, needed the assistance of technology to make sense of it all. Some of the most hyperopic computer proselytizers saw opportunities to bridge that gap.

Margaret Mead described the whole of civilization in 1965 as a vast explosive device, so convergent and inherently unstable that any disruption could send it fracturing into oblivion.[732] The "information explosion" threatening to drown humankind was epitomized, in Mead's image, by the feeling of the living participant on a telephone call who receives a recorded message on the other end. It was the feeling of the dehumanized consumer, the stunted soul in a giant bureaucracy, George Jetson and the Uniblab.[733] In these circumstances, "blind reactionary behavior," a new resurgence of Luddism, might be understood.

But this exponentially more data-rich society need not only lead to confusion. Felicitous discoveries rippled outward in cascades, remaking the economy at a greater pace than ever. Mead called for "the innovators in the new technology to invest time and thought in ways in which delight and hope for the human consequences of the new

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[732] Mead, Margaret. "The Information Explosion," "Special Advertising Section: The Information Explosion." *The New York Times*, May 23, 1965, 18.
[733] Mead, "The Information Explosion," 20.

technology can be increased, and fear and rage decreased."[734] Hers was a rallying cry for the best of human considerations in machine design, a new device that "can be simplified and reduced in price so that it can become either a household tool or a child's toy." Mead, the anthropologist, looked upon computers as cultural objects. But she was not alone in fretting over their "message." Raw economic productivity may have been justification enough in computers' early days, yet in the socially conscious 1960s, they would need to be oriented as well toward human happiness. Isaac Auerbach, in 1965, pronounced the full-blown revolution in computing "a rather conservative forecast." Information, he claimed, was now "the wheel on which the fate of mankind turns." To appease the skeptics, new attention should be directed to the "human problems raised by the computer." Auerbach acceded to the vein of determinism that ran beneath the prevalent synthesis narrative. "Accommodation," he assured, "will come; it is just a matter of time."[735]

If Edmund Berkeley was the computer industry's foremost popular liaison in its early years, the computer systems of the 1960s were far too diverse to present a single face to the public. Any discussion of the drive toward computers as intellectual aids, however, has to start with J.C.R. Licklider. Joseph Carl Robnett Licklicker was a psychologist trained in the field of psychoacoustics—the study of human perception of sounds. Working at Harvard's Psycho-Acoustic laboratory in the 1940s, Licklider began a series of interdisciplinary conversations that helped form the interdisciplinary project later known as cognitive science. Licklider and his fellow brain scientists, linguist George A. Miller and biophysicist Walter Rosenblith, crafted a challenge to the

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[734] Ibid.
[735] Auerbach, Isaac L. "Information—a Prime Resource," "Special Advertising Section: The Information Explosion." *New York Times*, May 23, 1965, 4.

functionalism of the dominant behaviorist school of psychology, attempting to discern the underlying structure and organizational principles that defined the mind itself. Examining the relationship between communication—visual or auditory—and understanding, led Licklider and his colleagues to the newly emerging science of information, and how information was processed in the brain.[736] In 1951, Licklider and Miller moved to M.I.T. where he joined the Lincoln Laboratory within the electrical engineering department. At M.I.T. was Claude Shannon, whose refashioning communications theory also took account of the perceptions of the receiver. In Shannon's formulation, a message's information content depended on the amount of difference conveyed beyond what was already known. The function of information in the human cognitive system would greatly inform Licklider's approach to computer science.

Almost by accident, the ambitious psychologist was recruited into M.I.T.'s work on air defense. "It turned out that there was a lot that needed to be known about the presentation of information in the communication control system," he remembered. "Here the engineers were bringing radar, and computers, and everything together. Then there was essentially a big display and control problem."[737] Radar operators, utilizing state-of-the-art computers to tabulate and interpret data, frequently found their tools clumsy and awkward. Nearby, M.I.T.'s Servomechanism Lab was simultaneously pioneering the development of CRT displays and real-time input through light-pens, to be used with Jay Forrester's Whirlwind computer.[738] Licklider's research likewise became

[736] Crowther-Heyck, Hunter. "George A. Miller, language, and the computer metaphor and mind." *History of Psychology* 2 (February 1999): 37-64.
[737] J.C.R. Licklider Oral History (CBI OH 150), October 1988. Charles Babbage Institute, University of Minnesota, Minneapolis, 5-6.
[738] Licklider wrote a memo while consulting for IBM about the value of displays, advising the computer giant to invest in its graphics segment:

focused on the human factors of computer use. In 1962, after a stint with the acoustics consulting firm, Bolt Beranek and Newman (BBN), in Cambridge, Licklider was appointed the first director of Information Processing Techniques Office (IPTO), a division of the Advanced Research Projects Agency within the Pentagon. At BBN, Licklider had enjoyed uninterrupted time with a TX-2, essentially a transistorized model of the Lincoln Lab's graphical, interactive LINC computer. "It was fun to play," Licklider explained. "Everybody connected with it just sat at the console and did on-line interacting and programming and since I was the one of the first ones, I got most of the time."[739] The opportunity convinced Licklider that if everyone could experience computing in this manner, productivity would become a linear function of access. "I guess you could say I had a kind of religious conversion," he told a journalist.[740] Licklider took this deep-rooted bias with him to his administrative post at IPTO where he began a crusade to construct technology that could improve the human-computer interface.

For the director of APRA, Jack Ruina—himself an M.I.T.-trained electrical engineer, the selection of Licklider to lead IPTO was fortuitous. "I found…[that] the growth in computer technology, hardware technology, clearly was exceeding what people knew what to do with it – in terms of not just number crunching, but once they wanted to

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Licklider, J.C.R. "Man-Computer Interaction Through Graphics," 1966, J.C.R. Licklider Papers (MC499), Box 8, Institute Archives and Special Collections, M.I.T., Cambridge, Mass.
He wrote of Ivan Sutherland's pioneering graphics work, "a display connected to a digital computer gives us a chance to gain familiarity with concepts not realizable in the physical world." May 29, 1965, Licklider Papers, Box 8.

[739] Licklider Oral History, 15-16. Licklider's instructor on the BBN machine (later upgraded to DEC's commercial model, the PDP1), was a young programmer named Edward Fredkin—the computer "revolutionary" whose futuristic ideas had inspired Edmund Berkeley.

[740] Rheingold, Howard. *Tools for Thought: The History and Future of Mind-Expanding Technology*. Cambridge, Mass.: MIT, 1985, 136. For many of Licklider's contemporaries, the push to make "on-line" computing available to all was often couched in the terms of the deepest meaning.

get in to do analysis."[741] Ruina's effort was, in effect, to link computer command and control with the new behavioral science. The suggestion that individuals would soon gain access to powerful centralized computer systems, along the model of the electric utility, was "very much in the air" at M.I.T. This future, Ruina realized, necessitated a great deal of work on the human side of the interaction. While higher-ups like McNamara remained interested in ballistics defense and nuclear test detection, Ruina saw a research opportunity in computer use. IPTO became "a small but interesting program on the side."[742]

Licklider and his successors turned this small and insignificant office into a powerhouse, channeling funds into many of the research projects that would inspire the technological revolutions of desktop computing, artificial intelligence, networking, e-mail, and the Internet. Most importantly, Licklider's singular vision and big-picture outlook, disseminated through a flurry of memos and brisk thought-pieces, gave philosophical legitimacy to the project of interactive computing. He and his apostles were responsible for constructing the narrative teleology of computers' evolution into tools for people, electronic nodes in a cybernetic feedback system. Effectively, they selected one of several possible paths (giant number-crunching brains, menaces to employment, invisible embedded circuitry being others) to capture public attention and determine the direction valuable research dollars.

It must be emphasized that while Licklider is thought of as the godfather of an idea he termed "man-computer symbiosis," it did not have a unique genesis. As Ruina noted, a disposition towards computer democracy was "in the air." In a May 1965 special

[741] Jack Ruina Oral History (OH 163), April 1989, Charles Babbage Institute, University of Minnesota, Minneapolis, 4.
[742] Ruina Oral History, 6.

advertisement section of the *New York Times*, titled "The Information Explosion," Westinghouse engineer Edwin L. Harder regretted "The Myth of the Giant Brain." Without naming Berkeley, Harder wrote of the widespread conviction that "the computer was a giant and awesome thinking machine, capable of carrying out human-like mental processes at fantastic speeds in come mysterious manner." He observed, "Implicit in this myth was the belief that the computer's complexity was beyond the average man's understanding and that the machine represented a threat to man's supremacy."[743] Rather than debate whether computers were giant brains or giant morons, Harder preferred a different approach: "The computer as a *tool*—this is the concept that has recently begun to make some headway in dispelling the myths of the giant brain." The key to this enlightenment was, of course, exposure. Many students in technical schools and universities were programming in FORTRAN, submitting problems to campus computer centers; businessmen were developing convenient uses for their installations themselves, without delegating to an army of computer professionals. Harder predicted that such "direct experience with the computer as a tool will have a widening impact as the new generation of scientists, engineers, businessmen, and administrators pick up the reins of their professions in the coming years." Average men would need to know how a computer worked, just as their fathers had known what was under the hood of their automobiles.

But Harder placed even more faith in a recent development, one stemming from the work of Licklider and the IPTO research community. This development was the "on-line" computer system, a powerful shared system connected to hundreds of typewriter-

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[743] Harder, Edwin L. "The Myth of the Giant Brain," "Special Advertising Section: The Information Explosion." *The New York Times*, May 23, 1965, 5.

sized terminals. It wasn't difficult to imagine "systems with low-cost terminals attached to the home telephone, permitting the housewife to press a few telephone buttons to order and automatically charge purchases from a supermarket or department store."[744] The society that integrated such technologies into the easy flow of everyday life would surely generate efficiencies capable of employing millions of new workers. Harder anticipated a phenomenon within computer science that Engelbart would call "augmentation." Designed for fluid, natural use, computers might one day truly become "tools to expand man's intellect." Attention to such human purposes began as a peripheral trend within ARPA and among the technical community generally. Yet it was imbued with a great mystique of inevitability, fostered by Wiener, Berkeley, Diebold and a chorus of science journalists. Licklider and Engelbart were both products and progenitors of this movement as it entered the mainstream.

Rocket scientist Simon Ramo articulated exactly this vision in his contribution to the *New York Times* special section. "The mass extension of man's intellect by machine and the partnership of man and machine may well be the technological advance dominating this century," he speculated.[745] It is telling that a man whose career was spent designed intercontinental ballistic missiles, whose capstone achievement was the completion of the Titan rockets that carried America's first artificial satellites into orbit, should see computers and not rocketry as the dominant technological force of the space age. Of course, the physics, materials, and propulsion chemistry of this new mechanical monster were all developed on digital computers from the workshops at IBM, Raytheon, and Univac. Ramo spoke not of individual engineering breakthroughs, but of the socially

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[744] Ibid.
[745] Ramo, Simon. "The Computer as an Intellectual Tool," "Special Advertising Section: The Information Explosion." *The New York Times*, May 23, 1965, 9.

destabilizing expansion of brainpower. In a sense, electronic computers were the latest in a long genealogy of "intellectual tools": "A book, a file of notes, a blackboard, a slide rule, or a cash register are all extensions to the human brain." Ramo shared Wiener's philosophy; we had always been cyborgs, even before we were aware of it.

Computers, though, were also communication aids, their power subject to the non-linear laws of networks. "[I]nterconnection at a distance," Ramo suggested, "makes possible large scale interacting networks for information storage, transmission, retrieval and processing that are well beyond man's capabilities." The felt effect would be many orders of magnitude beyond that of the abacus or office tabulator. Lawyers, physicians, librarians, and educators would all gain access to the summed knowledge of society. The entire edifice of information exchange—from primary school to the corporate boardroom—would be shaken. Even as the operations of digital computers became more complex, parcels of computing power could be allocated to end users along the lines of an electrical utility. *The Atlantic* theorized that the range of applications of this information utility could include "medical information systems for hospitals and clinics, centralized traffic control for cities and highways, catalogue shopping from a convenience terminal at home, automatic libraries linked to home and office…teaching consoles in the classroom, research consoles in the laboratory, design consoles in the engineering firm, editing consoles in the publishing office, computerized communities."[746]

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[746] Greenberger, Martin. "The Computers of Tomorrow," *The Atlantic Monthly,* May 1964. Accessed 5 Sept. 2010. <http://www.theatlantic.com/past/docs/unbound/flashbks/computer/greenbf.htm> The concept of the information utility was well established by the time this article appeared. Two decades before, in the pages of the same journal, Vannevar Bush extrapolated such a service from the analog machines of his day. Edmund Berkeley had suggested the possibility in *Giant Brains*. Greenberger guessed that, despite the enormous infrastructure build-out necessary, costs could be controlled due to the added efficiencies of automated tax and billing, automated securities ordering and fulfillment, and direct-to-consumer marketing.

Ramo's name appeared in a *Los Angeles Times* piece two days later predicting that "Every household will have a remote console with push-button access to the large, central time-shared computers."[747] The vast economic upheaval resulting from the digitization of *everything* seemed an overwhelming prospect. "Advancing technology often appears a mixed blessing because of the imbalance of technological advance versus social adjustment lag," Ramo conceded. Nevertheless, he professed that "in a few decades, it may be our increased brainpower, itself the result of proper employment of technological advance, that enables us to solve our social problems."[748] Ramo's statement reflected the qualified confidence of the automation synthesis.

During the early 1950s, the most serious arguments over computers centered around the questions, "can a computer think?" and "can a computer learn?" These arguments brushed up against an existential angst that only began to abate when more people actually gained first-hand experience with computers. "It became evident that computers can do only what men program them to do and no more," Licklider wrote.[749] At M.I.T., an ill-defined philosophical problem grew to be a real challenge of logic and mathematics. Natural language composition was one example; no ironclad law barred computers from that realm, "but their performances within it are hardly good enough to suggest any immediate threat of serious competition to creative man." Licklider adumbrated in the *Times* a bounded world divided between the logical operations of computers and the creative inspirations of man. To borrow paleontologist Stephen Jay

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What Bush, Berkeley, and Greenberger all conceived was, in its essence, very similar to today's Internet, though on a centralized rather than distributed model.

[747] Bengelsdorf, I.S. "Like it or not, there's surely a computer in your future," *The Los Angeles Times*. May 25, 1965, A1.

[748] Ibid.

[749] Licklider, "Computers: Thinking Machines or Thinking Aids?" "Special Advertising Section: The Information Explosion." *The New York Times*, May 23, 1965, 13.

Gould's phrase, neither performed well in the other's non-competing magisterium. The imperative for future programmers and hardware designers, then, would be to derive the best from each domain. The next decade of computer science would be characterized by "close partnerships," teaming each special capability in a "new kind of interaction."

The blended approach Licklider favored broke with the traditional partition of computer technicians' hands-on access and the processual remove experienced by computer uses. "The man cannot send his question to the computer one day and get his answer back the next," he wrote with characteristic pith. "The man and the computer need to write, sketch, and eventually talk to each other." The prototype for future thinking aids already existed in the terminals available at Whirlwind or the Lincoln Lab. These "time-sharing" machines constituted the next wave in Licklider's eyes. To sit down at your desk should mean sitting down at your computer. Your filing cabinet would be your computer's store; inter-office memos also would take digital form. *Times* readers were treated to a pictorial sketch of the proposed system: "Your typewriter is connected to the computer, and the computer can type back to you when you type to it. The writing surface in front of you is also a display surface, a doodle pad for you and the machine to sketch your ideas on."[750] Licklider succeeded in advancing his agenda because his arguments were intuitive, simple-to-grasp, and seductive. They placed common people in the driver's seat of control. They made computers seem powerful, but also intimate. Nowhere in 1965 did the machines under discussion exist, except in blueprints, but Licklider made them seem real and inevitable. He gave computers much-needed new clothes: no longer "thinking machines," they were repurposed as "thinking aids."

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[750] Ibid.

To witness the prestige Licklider's ideas carried, one need look no further than a full-page advertisement by the Digital Equipment Corporation (DEC), a few pages after his manifesto. "Is man obsolete?" asked a bold-typed headline, next to a black-and-white photo of a clean-cut, young engineer scanning over a teletype print-out.[751] The text read, "Some say that the machine is about to take over, that the computer revolution means the dwindling of man's usefulness on planet earth." Not so claimed the makers of the PDP-8 minicomputer, cousin to machines that had first ensorcelled Licklider at BBN and the Lincoln Lab. "We make computers, but we have never forgotten the man," DEC proclaimed. "In every significant new product, we have in some way increased man's mastery over his machine." DEC computers distinguished themselves by their low cost and accessibility. The great success of the PDP-1, installed nationwide in small businesses and campus computing centers owed to its simplicity: "It was a friend, not an emperor, and it went to work wherever there was a wall outlet to plug it in." DEC's marketing team cleverly responded to the generalized sense that computers were assuming too much control, and were becoming masters over the people and organizations that used them. But the Maynard, Massachusetts-based company invoked a different spirit when it announced its advances in "man-machine communication." As we will see, this is a term intimately associated with J.C.R. Licklider.

Licklider's suggestion was that people would remain the steersmen of the cybernetic ship, amplified by increases in calculating speed, but also by humanistic programming and design. DEC professed its own effort "to make the machine a partner, rather than an overlord. Our equipment seems to say that man can be freed to take his

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[751] DEC advertisement, "Is man obsolete?" "Special Advertising Section: The Information Explosion." *The New York Times*, May 23, 1965, 21.

rightful place as the creative force in a society served by machines." DEC's advertising on behalf of the PDP-8 was effective—between 1965 and 1967 revenues multiplied sixfold to $4.5 million.[752] The remarkable success of the product is testimony to DEC's ability to anticipate the needs of a new market, where affordable computing could offer added value in the hands of people outside government and the Fortune 500. Congruently, it testifies to the power of a message, nurtured by Licklider, that computing should be much more than the calculation of immensely complex mathematical problems. DEC's advertising reflected the first stabs in the direction of computing as an interactive experience.

Chapter 17 – The quest for symbiosis

A too little understood element of Licklider's intellectual formation is his profound orientation toward cybernetics. While it is often remarked that his ideas came to maturity in the interdisciplinary environs of Wiener and Shannon's Cambridge, historians have neglected the important effect the principles of homeostasis and feedback, and the analogy between electrical and biological circuits had on his thinking. By the 1960s, Shannon had left M.I.T. for Bell Labs, Wiener had matriculated from scientist to public intellectual and social critic, and Pitts had ceased his academic research. Wiener died in 1964 by which time digital computers captured far more professional and popular attention than his cybernetics. Though the context of computer research at the Lincoln Lab was too far removed from the immediate postwar moment Macy Conferences to stretch the comparison, it is nevertheless instructive to think of Licklider as a kind of next-generation cyberneticist.

Licklider's work in psychoacoustics very clearly provided the platform for his later human factors research.[753] These early cognitive inroads into brain science were in

[752] Hemmendinger, David. & Edwin D. Reilly, "Digital Equipment Corporation." *Encyclopedia of Computer Science,* 4th ed., New York: John Wiley & Sons, 572-576.
[753] Much of Licklider's research at the Psychoacoustics Lab (PAL) centered on the transmission of speech for optimal intelligibility. One problem Licklider worked on extensively was communication at high

keeping with the cybernetic emphasis on structure, purpose and teleology; where the behaviorists treated the mind as the engine of conditioned response, psychologists like Licklider and Miller strove to map its information-processing pathways. Brains, like all biological systems, were homeostatic bodies; through feedback relationships with various stimuli, they internally generated their own courses of action. The informational school of cognitive psychology to which Licklider belonged invited analogies to electronic computation.[754]

One of the few commentators to appreciate the depth of Licklider's grounding in cybernetics is the journalist Mitchell Waldrop, author of an excellent biography, *The Dream Machine*. His interviews with Licklider before the latter's death, and with his widow Louise, hint that the future IPTO administrator saw Wiener's cybernetics as formative education in the possibilities of human computing. During his time at M.I.T., "Lick" had been an enthusiastic guest at regular Tuesday-night interdepartmental dinner salons hosted by Norbert Wiener. He would return, Louise remembered, fresh with new ideas, discussing research opportunities late into the night. In her words, Wiener's Cambridge was a hub of interdisciplinary fraternizing and intellectual "cross-fertilization."[755] Repaying the visit, Wiener attended an NSF-funded symposium Licklider organized in 1954 titled "Conference on Human Communication and Control." The transcripts portray Wiener comfortably at home in the world of psychological science, speculating with Miller and Robert Fano on the possibility of measuring human cognitive capacity and run-rates in "bits." Licklider noted in his journal how Wiener had conjectured that memory savants (a subject dear to Miller) "achieve their performance essentially by programming their mental operations in the manner of a computing machine. They have so practiced routines and subroutines of computation that they do not have the difficulty most of us have in keeping track of the problem and continuing to work effectively toward its solution."[756] Wiener's idle supposition has been subsequently proven more-or-less correct.

George Miller told Waldrop that the Psychoacoustics Lab (PAL) at Harvard had always been alert to work in the cybernetic field and had invited fellow cognitive scientist Walter Pitts to explain Wiener's theories.[757] The summer of 1948 (when Marvin Minsky

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altitude. The difficulty of compressing speech to increase the carrying power of radio, though not formulated as such, was effectively an information problem—a distant cousin of Shannon, Nyquist and Hartley's work on sampling and channel capacity. See:
Licklider, J. C. R., & Kryter, K. D. "Articulation tests of standard and modified interphones conducted during flight at 5000 and 35,000 feet" (OSRD Report 1976). Cambridge, Mass.: Harvard University, Psycho-Acoustic Laboratory, 1944.
Shannon, Claude E.. "Communication in the presence of noise". *Proceedings of the Institute of Radio Engineers* 37 (January 1949): 10–21. *Stanford University*. Accessed 5 Sept. 2010. <http://www.stanford.edu/class/ee104/shannonpaper.pdf>

[754] Ulric Neisser's seminal textbook *Cognitive Psychology* defined human beings as dynamic information processors, and provided the new field's charter: to determine the stores and transmission channels of information in the brain, and to model their workings. Neisser, Ulric. *Cognitive Psychology*. New York: Appleton-Century-Crofts, 1967, 4-9.

[755] Waldrop, M. Mitchell. *The Dream Machine: J.C.R. Licklider and the Revolution that Made Computing Personal*. New York: Penguin, 2002, 66.

[756] Licklider, J.C.R. "Conference on Human Communication and Control." 1954 journal notes, Licklider Papers, box 5.

[757] Waldrop. *The Dream Machine*, 68.

was a graduate assistant) was a "wake-up" moment, with Shannon's landmark paper having furnished new, broad relevance for investigations at the PAL.[758] The alliance between Licklider, Miller, and their disciple Minsky's work on the logical structure of memory and perception and Shannon's logical description of electric circuits is informative; already Licklider evidenced some early recognition of human-computer interface problems that would dominate his subsequent career.[759] The fields of electrical engineering and cognitive science were each independently arriving at a study of the flow of information through circuits. "Nature is very much more hospitable to information processing than anybody had any idea about in the 1950s," Licklider later said. "We didn't realize that molecular biologists had provided an existence proof for a fantastically efficient, reliable information processing mechanism—the molecular coding of the human genetic system. The information equivalent of the world's entire fund of knowledge can be stored in less than a cubic centimeter of DNA, which tells us that we haven't begun to approach the physical limits of information processing technology."[760]

The direct confirmation of a significant pollination of cybernetic ideas among his psychologist cohort helps to establish Licklider as a latter-day cyberneticist, we may also identify a Wienerian turn in his computer writings. Perhaps not wishing to pollute memoranda intended for circulation at BBN or the Pentagon with too much philosophy, or to preserve a limited focus, Licklider scrupulously avoid explicit reference to the intellectual tradition of cybernetics. Nonetheless, there are several apparent strands of inheritance, particularly in Licklider's famous notion of "man-computer symbiosis." His eponymous paper is an evocative subject for analysis.

"Symbiosis"—Greek for "living with"—was defined by the 19th-century German mycologist Heinrich Anton de Bary as "the living together of unlike organisms."[761] In the sense Licklider intended, the term suggests the biological phenomenon of mutualism, wherein two species each derive a unique evolutionary advantage from the other. The relationship might be as straightforward as the gut bacteria of cows, which aid in digestion, or as intricate as the system of pastureland fertilized by the waste of the animals it feeds. Biological metaphors are no stranger to "information talk," and Licklider would have been aware of precedent for his nomenclature. His implication that computers constitute a species of information machine, different but compatible with humans, is deliberate. As he had written in the *New York Times*, the idea of symbiosis is quite apposite to explain the interactions of mechanisms of diverse relative capabilities, each of whom gains more as a system than alone. In his 1960 manifesto, published in the *IRE Transactions on Human Factors in Electronics*, Licklider specified the requisites for

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[758] Waldrop. *The Dream Machine*, 74.
[759] Bernstein, Jeremy. "Profiles: Marvin Minsky." *The New Yorker.* December 14, 1981, 50-126.
[760] Rheingold. *Tools for Thought*, 150. The understanding of DNA as informational "code" is explored with great care by historian of science Lily Kay. Against the vast history of biological science, Kay argues, beliefs like Licklider's represented a narrow—and often inappropriate—reframing of the mechanism of genetic transfer. Though a kind of computational decrypting led in part to Crick, Watson and Franklin's discovery of the helical structure of DNA, it also led scientists to many experimental dead-ends and inspired a misguided belief in the material reality of a heuristic, explanatory metaphor. Notwithstanding Kay's legitimate objections, discoveries in genetics provided ample theoretical validation to information scientists in other fields.
Kay, Lily. *Who Wrote the Book of Life: A History of the Genetic Code*. Palo Alto: Stanford, 2000
[761] Wilkinson, David. "At cross purposes." *Nature* 412 (2001): 485.

and the desirability of designing such a system. At the time, he was employed as a research scientist with BBN, spending the larger portion of his time on the TX-2 computer programming rather than problem-solving. "Man-Computer Symbiosis" derived from a "little picture in my mind of how we were going to get people and computers really thinking together."[762]

Licklider began his famous essay with the qualification that there were no true man-computer symbioses yet in existence. Early mechanical extensions of humans—prostheses, wheelchairs, contact lenses—did not represent the ideal of mutualism. The human operator dictated the entirety of the relationship. "There was only one kind of organism—man—and the rest was there only to help him."[763] More recently, a different kind of system had come into view: automation, or the machine's "replacement of men." In the automated chemical plant, "the men who remain are there more to help than to be helped." Automation, for Licklider, was the very antithesis of the effort he was undertaking. Instead of mechanically extended humans, one might speak of "humanly extended machines."[764]

It was possible, Licklider admitted, that one day machines would outdo human beings in areas of creative problem solving, natural language understanding, or pattern recognition. He cited the rapid advance of several theorem-proving programs, Newell and Simon's "Logic Theorist" among them. In the meantime, he predicted a long interregnum in which neither machines nor their human creators had the upper hand. Computer science was searching for more effective tools, heuristics, algorithms to shorten the time between idea conception and realization.[765] In this medium-term, "the main intellectual advances will be made by men and computers working together in intimate association."[766] If the ambitions of AI did not bear fruit for decades or centuries, the years of partnership between human brains and computing machines might still be "intellectually the most creative and exciting in the history of mankind."

What was needed to bring about the golden age of creativity that many journalists were predicting? The primary obstacle remained, even for experienced programmers like Licklider, the difficulty of communicating with a computer. It was not that the demands of calculation outpaced the pure processing speed to execute them. Many commercial early adopters found, rather, that it is often quite problematic to put your queries to the computer. Poincaré had called attention to the matter of formulation in problem solving when he noted, "The question is not, 'What is the answer?' but, 'What is the question?'"[767] This consideration often frustrated would-be computer users. If computing machines were to help in designing the problems to be solved, they must be

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[762] Lee, John A.N. and Robert Rosin, "The Project MAC Interviews," in *IEEE Annals of the History of Computing* 14 (1992): 16.
[763] Licklider, J.C.R. "Man-Computer Symbiosis." *IRE Transactions on Human Factors in Electronics* (1), March 1960, 1.
[764] Licklider. "Man-Computer Symbiosis." 2.
[765] Licklider clarified, "By tools, in this context, we mean the conceptual instruments that aid men in devising systems: the theorems, theories, models, and prescribed procedures that extend man's intrinsic intelligence." Decision theory, linear and dynamic programming, network theory, and servomechanism theory were all first steps along these lines. "Report for Bolt, Beranek, and Newman." 1960, Licklider Papers, box 7, 9.
[766] Licklider. "Man-Computer Symbiosis," 3.
[767] Licklider. "Man-Computer Symbiosis," 4.

made to think in "real time," as humans do. Their responses should be those of "a colleague." The conventional sequence of problem-input-output was all too jarring. Licklider reported, by way of personal experience, that he often found himself spending 85 per cent of his time "getting into a position to think"—that is, formulating the problem. This meant collating data, rigorously specifying the program to be executed, formatting input for the computer. Getting the answer took only a few seconds.

Ultimately, computers and humans not only spoke different languages, but were made for different tasks:

> Men are noisy, narrow-band devices, but their nervous systems have very many parallel and simultaneously active channels. Relative to men, computing machines are very fast and very accurate, but they are constrained to perform only or a few elementary operations at a time. Men are flexible, capable of 'programming themselves contingently' on the basis of newly received information. Computing machines are single-mind, constrained by their 'pre-programming.'

In his rhetoric, Licklider casually referred to brains in informatic terms. Unlike Berkeley, he did not do so for pedagogical effect, or to analogize what computers do to thinking. On the contrary, Licklider implicitly compared man to a kind of meaty computer, even as he observed their differences. The view of the mind as an information handling device was sufficiently pervasive among the electronics community, his intended audience, that Licklider felt no need to qualify his terminology.

The equipment of interactive machines was to be multidimensional. In Licklider's schema it could model and draw graphs, interpolate and extrapolate, present the user with multiple discrete choices, translate between math and logic—numbers and language—and do all this with swift professionalism of a skilled secretary. To maintain such a level of personal attention, computer power would have to be time-shared: "Any present-day large-scale computer is too fast and too costly for real-time cooperative thinking with one man. Clearly, for the sake of efficiency and economy, the computer must divide its time among many users."[768]

[768] Licklider. "Man-Computer Symbiosis," 6.

Aside from the technical trouble of dividing a mainframe's core processor among several terminals, Licklider identified three basic areas where research should be directed. The first was random-access memory; the magnetic cores of Whirlwind's data storage were replicated in many installations throughout the early 1960s.[769] Magnetic core memory was too slow, too unwieldy, and too uncompressed to manage a number of applications running simultaneously. The second and more exigent necessity was an improvement in language facility. Licklider noted great strides in this area; particularly compiling programs like FORTRAN and ALGOL that were beginning to adapt computers to more human modes of expression. At the heart of the problem, however, was humans' fundamental inability to think in linear fashion. "Men appear to think more naturally and easily in terms of goals than in terms of courses," he observed. "True, they usually know something about directions in which to travel or lines along which to work, but few start out precisely formulated itineraries."[770] When we make a sandwich, for example, we do not follow the precise program of a recipe; more likely, we assemble ingredients until we have something we'd like to eat. Two possible approaches suggested themselves: either programs should assist in their own self organization, or systems might offer a menu of easily callable common subroutines.

The third, and most pressing concern was the lack of effective input/output (I/O) equipment[771]. In conversation, people communicate visually, physically, and in terms of

[769] Magnetic core memory was organized hierarchically. Entries were classified into registers according to their importance to the machine's operating program. This meant that searching memory was a serial process, and slow. A series of branching directories organized by function would have made memory access more intuitive.
[770] Licklider. "Man-Computer Symbiosis," 7.
[771] One promising tool for figuring computer input in a manner consistent with human proprioception, Licklider noted elsewhere, was a little device developed by IPTO contractor Doug Engelbart – "a novel cursor-controlling bug." Engelbart's team was having tremendous success navigating their graphical user

abstract ideas—not instructions. Licklider knew that a military command-and-control hierarchy never lent itself to creativity or collaboration.[772] Computers needed to be flexible to this type of expression. CRT monitors ought to replace printouts or clunky oscilloscope screens. Typewriters ought to replace punched-card entry. Even the inchoate technology of speech recognition had a role to play. Licklider evidently envisioned something like a personal workstation: "Certainly for effective man-computer interaction, it will be necessary for the man and the computer to draw graphs and pictures and to write notes and equations to each other on the same display surface. The man should be able to present a function to the computer, in a rough but rapid fashion, by drawing a graph."[773]

Licklider's proposal was at once ambitious and modest. It was ambitious in its call for remaking the working relationship between knowledge workers and their tools. It was modest in the means it recommended. None of the improvements Licklider advised lay very far from the realm of possibility. "Man-Computer Symbiosis" was designed to provoke, but it was also designed to produce real change quickly. Many of its programs were already underway at M.I.T. In this sense, it was hardly a bombshell after the fashion of Wiener's *Cybernetics*. It refrained from positing an overarching philosophical realignment in computer engineering. Between the lines, however, Licklider took small

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interface (the on-line system or "NLS") by means of small mechanical invention we would recognize as a mouse.

[772] It is important to point out that, while Licklider ultimately became a military employee, he retained a firmly civilian mindset. His experiences in the Psychoacoustic and Lincoln labs convinced him of the vitality of cross-communication and spontaneity. These were characteristics frequently associated with the friendly, bottom-up research structure he implemented at IPTO. It would be a mistake, therefore, to associate Licklider's teamwork model with a "Closed World." In Norberg and O'Neill's study of the IPTO, Licklider is viewed as "more a product of the Cambridge community than of any institution." The various research teams under his umbrella collaborated at jocular PI (principle investigator) retreats, to which graduate students were sometimes invited. An effort was always made to encourage feedback between the different outposts. Norberg, Arthur L. and Judy E. O'Neill, eds. *Transforming Computer Technology: Information Processing for the Pentagon, 1962-1986*. Baltimore: Johns Hopkins, 2000, 27-35.

[773] Licklider. "Man-Computer Symbiosis," 10.

circumscribed steps toward that end. In 1960, there was hardly any computer literature on how ordinary workers might engage with future machines. Technical papers concentrated predominantly on long-range efforts like AI or small improvements to current hardware and software. Popular writing was just beginning to grapple with the effects of computers on factory automation and employment, often wondering if machines were our evolutionary successors. Licklider chose an entirely different tack, one synchronized with cybernetic systems science.

There are several interrelated cybernetic themes implicit in Licklider's paper, but it will suffice to identify three:

- First, its informatic worldview. It was true that human minds functioned quite differently than electrical ones, yet both obeyed the basic parameters of information input, processing and feedback.
- Second, the emphasis on real-time feedback. Since Wiener's analogy of antiaircraft gunners and neuromotor response in animals, corrective feedback of information has formed the axis of systems studies. Licklider wished to place human-computer *mutual* relationships within the category of such feedback circuits.
- Third, the idea of the artificially enhanced organism. To many today, "cybernetic" signifies a class of electromechanical improvements to biology, creating a kind of hybrid: the cyborg.[774] Licklider did not push this matter as far as his protégé, Doug Engelbart, but one can divine in his essay the germ of the technologically "augmented" human, capable of manipulating computers as easily as an appendage. From here sprung the conception of the computer as an "intellectual prosthesis."

Licklider operated within clearly established modalities of the cybernetic reason, though he sometimes strayed far from its original intent. The history of cybernetics, as written, often moves, from the 1960s on, into psychiatry, ecology, media studies and various

[774] An excellent commentary on cyborgs, within the feminist critical tradition, is Donna Haraway's "A Cyborg Manifesto." Far too rich to be encapsulated here, Harraway sees the cyborg as a direct challenge to vitalistic, naturalistic narratives of biology and gender. It is its liminal quality—nature enhanced by technology—that renders obsolete the observer-observed divide endemic to Western philosophy of science. Haraway, Donna. "A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century," in *Simians, Cyborgs and Women: The Reinvention of Nature*. New York: Routledge, 1991, 149-181.

forms of social science.[775] The narrative I propose would include interactive computing as one of cybernetics' nearest intellectual progeny. "Man-Computer Symbiosis" carried this legacy quite far; indeed some see it as the foundational document in the history of the Internet.[776] Tami Tomasello has conducted a wide citation survey and found that, since its publication, Licklider's piece has been cited by academic researchers, on average, three to four times each year.[777] This is a heady achievement for a now half-century-old text. Its influence on interactive computing and networking propagated a number of cybernetic ideas to new audiences.

Some of the apprehensions that led Licklider to the principle of interactivity were further explored by a pair of psychologists writing in the pages of *Science*. David Johnson and Arthur Kobler, in a 1962 treatise "The Man Computer Relationship," argued that the divergence between human and mechanical domains was insufficiently appreciated by computer scientists. Norbert Wiener had expressed concern that military computers might attempt to achieve "nominal victory" even at the expense of national survival. Now, a highly placed Pentagon official observed that "at the heart of every defense system you will find a computer."[778] Reflecting Mumford's attitude toward automatic decision-making, the authors stressed that "Computers are used by man; man must be considered part of any system in which they are used." This holistic construction

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[775] The most comprehensive intellectual histories of cybernetics include: Slava Gerovitch's *From Newspeak to Cyberspeak* (MIT 2002), an account of the cybernetic tradition in the Soviet Union, and Katharine Hayles' *How We Became Posthuman* (Chicago 1999), a history of the philosophical phenomenon of post or trans-humanism.

[776] Brate, Adam. *Technomanifestos: Visions of the Information Revolutionaries*. New York: Texere, 2002, 87.

[777] Tomasello, Tami. "A Content Analysis of Citations to J.C.R. Licklider's 'Man-Computer Symbiosis,' 1960-2001: Diffusing the Intergalactic Network," Ph.D. Dissertation, Florida State University, Tallahassee, Fla., 2004. 6. Florida State University: Electronic These, Treatises, and Dissertations. Accessed 5 Sept. 2010. <http://etd.lib.fsu.edu/theses/available/etd-04102004-214127/>

[778] Johnson, David L. and Arthur L. Kobler. "The Man-Computer Relationship: The potential contributions of computers crucially depend upon their use by very human beings." *Science* 138 (November 23, 1962): 873.

belied their intent to separate clearly what computers and humans each do. If society was to gain from computers, people had to comprehend their output. Johnson and Kobler defined two strata of problems: "routine" and "special." Routine problems occur in bounded fields, such as physical science, where there are generally clear criteria to interpret a decision's success. Here computers sometimes fared quite better than humans. "Special" problems are different; suppose that Seattle citizens feel that their city's beauty is being destroyed by a cheap, direct, efficient, but ugly freeway. There is no clearly defined criterion of output: "beauty, they feel, should be one of the parameters." But how is beauty to be measured? The problem is not the computer's—it is ours. Yet when the computer delivers its results, "they have the aura of finality and correctness."[779]

Because society had placed such faith in the operations of machines, it ran the risk of overlooking crucial parameters not amenable to processing. "Values" were of this genre. In a simple decision, all value choices can be rank ordered. Unfortunately, values are rarely specified unambiguously. Sometimes, as in the case of the highway, the values in question cannot be determined until after the decision is made.[780] Machine learning systems "require that the rules of the game be clearly stated, that the goal be exact and easily measurable, and that the game be of such duration that the machine can learn through repetitive playing."[781] Unlike checkers, nuclear deterrent strategy fit none of these descriptions. Faced with daunting complexity, sensing their own inadequacy, humans were tempted to turn over responsibility to some ultimate decision maker promising scientific certainty. Though humans were more fallible and less accurate,

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[779] Johnson and Kobler. "The Man-Computer Relationship," 874-875.
[780] Management simulations used in business schools, and war games used at military academies could often be "beaten" by extremely unorthodox, unethical decisions. Such a decision is a major plot element of the Orson Scott Card's 1985 science fiction novel *Ender's Game*. Were these choices to be trusted?
[781] Johnson and Kobler. "The Man-Computer Relationship," 877.

Johnson and Kobler advised humans to pause the simulation midstream to determine if its tactics were compatible with the original goals. "We find that the computer is being given responsibilities with which it is less able to cope than man is," they concluded.[782] When the article was written, the authors were likely unaware of Licklider's advocacy for user-friendly computers. They would have supported his purpose, however. By giving users direct, dynamic access to the closed-world computer model society could arrest its most inhuman decisions.

In 1962, J.C.R. Licklider was sitting in the director's chair of ARPA's Information Processing Techniques Office. One of his first moves was to award a $2 million grant to his old time-sharing allies at M.I.T., led by Claude Shannon's former collaborator, Robert Fano. The venture became known as Project MAC for "Project on Mathematics and Computation" but was later backronymed "Multi-Access Computer", "Machine-Aided Cognition", or "Man and Computer," according to need. It was the longest running grant IPTO would award. Although Licklider was, in name, an independent administrator, he urged along Fano's proposal, serving almost as a conduit between ARPA higher-ups and engineers at M.I.T.[783] The initial prospectus was framed in terms familiar to Johnson and Kobler.

"The nation is facing urgent problems, both military and civilian, in which conclusions must be drawn from, and timely actions must be taken on the basis of very large volumes of data collected from a variety of sources," Fano began. "The initial wave of optimism, resulting from the apparently unlimited logical power of digital computers was followed by the realization that much more was involved than the construction of

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[782] Johnson and Kobler. "The Man-Computer Relationship," 879.
[783] Robert M. Fano Oral History (OH 165), April 1989. Charles Babbage Institute, University of Minnesota, Minneapolis, 11-12.

larger and faster machines."[784] Fano's proposal acknowledged that "Giant Brains" foreseen in science fiction had largely proven to be cognitive infants with respect to non-numerical problem solving. Not only were new computers needed, but new techniques for exploiting their talents as well: "Computer systems (including programming aids, operational organization, and input, output, and display equipment) have not yet been developed that are easily and economically accessible, and that are truly flexible and respond to individual needs, particularly the need for quick, direct response." Fano's language might have been cribbed directly from Licklider's paper. In what might be seen as an instance of "agency capture," M.I.T. scientists knew they had "their man" in the seat of power. Licklider and Fano both believed in the role of universities as knowledge producers for the public need, unique centers of academic freedom and cheap student manpower to which the government could outsource scientific production. As Vannevar Bush had demonstrated, an M.I.T. man in office could foster this relationship tremendously.

Fano's request outlined a sweeping shared endeavor beyond the typical charter of a research lab. Project MAC was not building static assemblies of hardware and software. Instead, he proposed a continuously evolving process of invention and reinvention. The computers Fano envisioned building would be constantly updated, modified and customized to improve user experience. Interactive computing was thus a moving target; "The users themselves may be regarded as part of the system since their own approach to research and problem solving will have to evolve together with the hardware and software," he wrote. This eminently second-order cybernetic methodology

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[784] Licklider, J.C.R. "Proposal to ARPA, for a Research and Development Program on Computer Systems." 1963, Licklider Papers, box 7.

also expressed Doug Engelbart's "bootstrapping" ethic—that one should create the tools for actual use in solving yet more difficult problems, and learn from the experience. In fact, a follow-up Project MAC proposal referenced three gospels in its first page: Engelbart's "Augmenting Human Intellect," along with Bush's "As We May Think," and Licklider's "Man-Computer Symbiosis".[785] The goal of the program, in Fano's words, was to evolve computer systems "easily and independently accessible to a large number of people, and truly responsive to their individual needs."

785 Ibid.

Chapter 18 – Building an "Intergalactic Network"

Licklider, like Fano, was interested in collective computing. Networks were about getting resources, like valuable processor cycles, to those who needed them most; but they were also about growth through sharing. Licklider carried his interest in networking from M.I.T., to IPTO, to the private sector, and later back to M.I.T. Everywhere he maintained a steadfast belief in the positive social benefits of thinking in communication with others. To the extent that technologies for implementing this ideal were funded by closed, hierarchical bureaucracies like IBM and the Department of Defense, Licklider's advocacy is largely responsible. Inspired by a popular dream—computers for everyone—Licklider and his colleagues changed the way computers were built, used, and connected.

Netting together a large number of people without stifling inspiration or creativity was an imperative at Project MAC, and across the many IPTO research centers—at Engelbart's Stanford Research Institute, at Champaign-Urbana, at Berkeley, to name a few. With his background in the psychology of communication, Licklider treated it predominantly as a matter of formalizing language. It was equally important to create a shared methodological protocol as it was to electronically link different time-sharing systems. He was an "activist" administrator, impressing upon all subordinates his big picture vision. In April of 1963 he issued a memo, with characteristic flair, to the "Members and Affiliates of the Intergalactic Computer Network."[786] Licklider analogized IPTO's objective to the question faced by science fiction writers: "How do you get communications started among totally uncorrelated 'sapient' beings?" How do

[786] "Correspondence 1958-1969" Licklider Papers, box 3.

you collaborate effectively on a common platform, while retaining a spirit of freedom and independence? The answer was a central control language, which, for the time being, issued from Licklider's desk.

The "Intergalactic Computer Network" is justifiably seen as one of the founding documents of the present Internet. Though the ARPANET did not come online until 1968, under Licklider's heirs, Robert Taylor and Larry Roberts, the conversation generated by Licklider's first query evolved into the guiding principle for its development. The concept of a control language was implemented in local packet-switching nodes called Interface Message Processors, or IMPs, an early form of Internet router. Decentralized routing made the system rugged and flexible, as Licklider had hoped, and individual outposts retained a great deal of autonomy, typical of the informal, "progressive R&D atmosphere that was necessary for the development and implementation of the network concept."[787] Getting everyone organized was easier than Licklider had expected. A minor bit of software called "e-mail" quickly became the ARPANET's first killer app. UCLA's Leonard Kleinrock, one of the developers of packet-switching mathematics that drive all modern networked computing, remembered, "E-mail was the biggest surprise about the ARPA network. It was an ad-hoc add-on by BBN, and it just blossomed. And that sucked a lot of people in."[788] BBN could trade ideas in real time with the University of Utah, Robert Fano could swap lines of code with Doug Engelbart. Email ultimately served as Licklider's common language; it helped form a coherent computer science community.[789] Virtual networking had the effect of

[787] Abbate, Janet. *Inventing the Internet*. Cambridge, Mass.: MIT, 2000, 56.
[788] Waldrop. *The Dream Machine*, 326.
[789] The effort to cohere many diverse projects was at the heart of the "Intergalactic Network." In essence, Licklider wanted to delocalize the intensely parochial politics of the individual research branch, and erect a

uniting people's interests, driving patterns of research in a way that even a rousing personality like Licklider could not. It could also be fun. In 1972, when ARPA director Stephen Lukasik plugged into the system he became an enormous fan, using it for business and personal dispatches. He often carried his thirty-pound portable terminal with him to check his messages.[790]

That the computer could be used for such "frivolous" tasks undergirded the symbiosis agenda. Ken Olsen was an engineer at the Lincoln Laboratory, working with Licklider, who helped design the TX-2. In 1957, with venture capital provided by Georges Doriot's American Research and Development corporation, he moved up the Concord Turnpike to found DEC, and with it, the minicomputer industry. In a retrospective, Olsen admitted that most scientists at M.I.T. in the 1950s thought of computers as too important, too costly, to be used for fun. When Olsen and DEC co-founder Harlan Ellison designed a diagnostic "memory test computer" for the Whirlwind, they experienced a conversion that presaged Licklider's a few years later. Working odd hours with their small machine, Olsen and Ellison were able to toy around, spontaneously experimenting with immediate feedback. They consciously ported this capacity in the design of the TX-0 (the TX-2's predecessor) at the Lincoln Lab.[791] Olsen described operating the TX-0 by light pen as a sport: "You could draw, play games, be creative—it

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wider platform. He even envisioned software (like today's Java applets) existing only on the net, free of any user's harddrive (Waldrop 226). Science fiction writers used this premise as a point of departure for imagining truly disembodied intelligences, like the online consciousness Dixie Flatline in William Gibson's *Neuromancer* (1984).

[790] Waldrop. *The Dream Machine*, 325.

[791] The TX-0, built in 1956, was structurally very similar to the Whirlwind, with an equal 64K of 18-bit words core memory. The difference, implicit in its name, was that it employed transistors (first produced by Texas Instruments in 1954), and was thus much smaller, cheaper, and more reliable. See Ceruzzi, Paul E. *A History of Modern Computing*. Cambridge, Mass.: MIT, 2003, 127-129.

was very close to being the modern personal computer."[792] When a few M.I.T. grad students built the space combat shoot-'em-up "Spacewar"—thanks to Stewart Brand *Rolling Stone* feature, the iconic early computer game—they programmed it on one of DEC's PDP-1's.[793] Licklider formulated the mission statement; Olsen and Ellison were already preparing the technology.

Even at the decreased cost and scale of DEC's machines, most people could not justify spending hours blowing up virtual spaceships. Scientists at Project MAC devised a more democratic alternative. The Compatible Time-Sharing System (CTSS) was inspired by an early build by John McCarthy, and overseen by Robert Fano and Fernando Corbato.[794] The goal of time-sharing was to exploit the efficiency of the group, parceling out computer cycles to users who most demanded it. When one user paused to draft a new line of code, the system would dynamically allocate its processor and core memory to someone else. Under the reigning paradigm of "batch processing," an applicant had to deliver a program to be filed in a queue, then wait hours or days for an answer that only took a computer a few minutes. A minor semantic error often invalidated the results and forced him or her to start from scratch. CTSS was so popular and successful that by 1966 it had 160 terminals situated around the M.I.T. campus.[795]

A time-shared system, in Licklider's words, would serve as an "amplifier of intelligence, entering into and extending the thought and decision processes of many

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[792] Allison, David. "Transcript of a Oral History Interview with Ken Olsen," *National Museum of American History, Smithsonian*, September 28-29, 1988, Accessed 4 Sept. 2010. <http://americanhistory.si.edu/collections/comphist/olsen.html>

[793] Levy, Steven. *Hackers: Heroes of the Computer Revolution*. New York: Penguin, 2001.

[794] The CTSS, demonstrated first in 1961 and active until 1973, is generally considered the first time-sharing system. By the early 1970s, similar set-ups were ubiquitous across college computing centers. Norberg and O'Neill. *Transforming Computer Technology*, 98.

[795] Fano, Robert M. and Fernando Corbato "Time-Sharing on Computers," *Scientific American*. September 1966, 129.

individuals."[796] In 1963, Licklider gave an influential speech to the NSF, entitled "Computer Integrated Community." Here he charismatically merged folksy common sense and intellectual precision. With an off-handed remark, he consigned batch processing to the stone age of on-line computing: "To an ever-increasing group of university faculty members, staff and students… a digital computer is a thing to which one delivers a deck of punched cards before 10:00 A.M., and from which he receives a sheaf of print-outs when he stops by on his way home to dinner."[797] Programs might not have compiled for reasons such as "NSSR SQRT" – there was no such subroutine as "SQURT."

There existed a paradise beyond such frustrations. Computer science was on the cusp of what Licklider called "the cerebral frontier." As a self-style visionary, in the mode of Berkeley and Diebold, Licklider made gazing into the future his priority. Few knew what lay beyond but the some who ventured close enough to get a view could foresee "fabulous things that stimulate the spirit of adventure, that promise new knowledge, great riches, and fantastic power."[798] Some of his colleagues (he omitted himself) had "through overprivilege, managerial enlightenment, or inadvertencies of scheduling…uninterrupted access to large computers for hours at time."[799] These happy accidents "kindled (among the few) an enthusiasm for…real-time interaction with powerful computers." There was no wait for error diagnostics; for these fortunate elect, the "feedback loops" of real-time debugging and correction served as the mechanism of

796 Norberg and O'Neill. *Transforming Computer Technology*, 97.
797 Licklider, J.C.R. "Computer Integrated Community." January 22, 1963. Licklider Papers, box 7, 1.
798 Licklider, J.C.R. "The Cerebral Frontier." 1962, Licklider Papers, box 7, 6.
799 Licklider. "Computer Integrated Community," 3.

problem solving.[800] How could such opportunities be made economical, given the investment required to bring a large digital computer online? Men and computers were fundamentally incompatible in terms of time and cost, Licklider admitted. Computers work very rapidly and cost hundreds of dollars per hour, while men cost only a fraction and work slowly. The problem was easily reconciled, however—simply share the computer among many men.[801] Both SAGE and SABRE had achieved this result, and their model could be exported to general-purpose machines. Every "interaction buff" Licklider knew developed his finesse with the light-pen working on recycled surplus SAGE consoles and the Lincoln Lab's old TX-0 computers repurposed by Project MAC to facilitate time-sharing.[802] Time-sharing was therefore the first step toward realizing the intergalactic network.

"It is now feasible—and practical, too—for a very creative man to think in direct interaction with a computing machine," Licklider wrote in a 1965 issue of the lay publication *Science Digest*.[803] Inexpensive small-scale digital computers, like the PDP-8, were facilitating such interaction. Time-sharing, which he described in detail, was making it accessible to all. Apart from the efficiency gains, the visceral excitement of using a computer one-on-one was not to be underestimated. "Sitting at the console, working directly with the computer—instead of going through a series of such intermediaries as programmers, coders, key-punch operators—" Licklider related, "one enjoys a certain thrill and avoids the long wait between the 'question-in' and 'answer-

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[800] Licklider, J.C.R. "Man-Computer Partnership," *Science Digest*, May 1965, 20-21.
[801] Licklider. "Computer Integrated Community," 4.
[802] Licklider. "Man-Computer Partnership," 22.
[803] At a 1966 computer science conference sponsored by the RAND corporation, Licklider pondered with Joseph Weizenbaum and Herb Grosch the possibility that small free-standing computers would proliferate. They concluded it would be more cost-efficient to centralize computing power for the foreseeable future. "9th RAND Symposium" 1966, Licklider Papers, box 8.

out'."[804] Proponents of this kind of interaction understood that public acceptance hinged on computer's redefinition from lightning fast, million-dollar suction valves of data, to friendly partners, no more expensive and intimidating than a secretary.

A *Fortune* magazine feature story in 1964 broadcast Licklider's message to a mass audience. "Machines that man can talk with," were near at hand, *Fortune* claimed. Soon computers, "intelligent enough to be approached in a more democratic, 'man-to-man' manner," would be able to recognize handwriting, aid in the drawing of engineering diagrams, and converse in "something like plain English."[805] In order to do original work, people cannot spell out every step in advance. Rather, we desire to "maintain easy give-and-take relations" with our electronic interlocutors. Ivan Sutherland's SKETCHPAD, *Fortune* noted, accomplished this very fluidly. He described working with the TX-2 (depicted in a small photograph) as a kind of tennis game: "I spent hours with it, at night and weekends when there was no one to interrupt me, and it was a thrill to struggle with an idea and then to see it working on the screen."[806] *Fortune* took further note of Project MAC, an "intellectual Operation Bootstrap," which signified that the kind of intimacy Sutherland recounted might be available on a wider scale: "Time-sharing, as a practical way of giving many investigators a chance to communicate directly with large-scale computers, is a deliberate effort to increase the power of the human mind, to amplify intelligence."[807] The tenor of Project MAC's evangelists was as much sociological as it was technological. Fano explained that the M.I.T. community

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[804] Licklider. "Man-Computer Partnership," 18-19.
[805] Pfeiffer, John. "Machines that Man Can Talk With," *Fortune*, May 1964, 153.
[806] Pfeiffer. "Machines that Man Can Talk With," 155.
[807] Pfeiffer. "Machines that Man Can Talk With," 198.

functioned as a test group in an experiment to test the power of interconnectedness. *Fortune* agreed: "This is intelligence amplification with a vengeance."

In 1966, Fano and Corbato spread the word of time-sharing in the pages of *Scientific American*. There article was mostly nontechnical but philosophically progressive—so much so that it was excerpted in Brand's *Whole Earth Catalog* two years later. Apart from a detailed layout of the technical infrastructure, much of what they wrote sounded a lot like Licklider's memos. Time-sharing, they argued, did much more than save time and money; it actually enabled the user "to conduct a continuous dialogue with the machine and in effect [made] the computer his intellectual assistant." Moreover, it got many people carrying on projects together, through the machine, using the collective knowledge of its library of programs, operations, and subroutines.[808]

They stressed that there was much work to be done; input/output (I/O) remained horrendously primitive. Teletype worked too slowly, graphics were undeveloped, and most users could not draw on their machines. Fano and Corbato's piece was nevertheless suffused with a sense of inevitable progress. Typically, they described the evolutionary path of human-computer integration in the cybernetic idiom: "In a sense the system and its users have developed like a growing organism. Most striking is the way the users have built on one another's work and become dependent on the machine. More than half of the commands now written into the system were developed by the users rather than the professionals charged with programming and developing the system."[809] Fano remembered the on-line system fostering a sense of shared endeavor: "Immediately

[808] Licklider. "Man-Computer Partnership," 19.
[809] Fano and Corbato. "Time-sharing on Computers," 136.

people began to document their programs and to think of them as being usable by others. They started to build on each other's work."[810]

Bootstrapping thus took the form of a kind of cybernetic autopoiesis. "The coupling between such a utility and the community it serves," Fano and Corbato proclaimed, "is so strong that the community is actually part of the system itself." With continued growth, it did not require a long stretch of the imagination to conceive of "an entire business organization making and executing all its major decisions with the aid of a time-shared computing system."[811] Indeed, computer utilities would play a significant role in all human affairs. Through collaborative genesis and self-maintenance, it would be possible to say that the computer systems were becoming, reflexively, a proxy for the community itself. This is exactly what Licklider had in mind.[812]

Universities in particular acutely felt the drawbacks of batch processing. College students were increasingly being taught to design, write, and debug programs. Computer instruction, of course, demanded on-the-fly learning, a process of real-time trial-and-error that was impossible with long queues for computer time. For this reason Berkeley had built his demonstration machine, Simon, at a scale small enough and a price-point low enough for anyone to tinker with uninterrupted. One mathematician at Dartmouth College, John G. Kemeny, was especially concerned for the pedagogy of computer

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[810] Waldrop. *The Dream Machine*, 232.
[811] Fano and Corbato. "Time-sharing on Computers," 138.
[812] Licklider later wrote in a memo to IBM executives that "one of the principles, or hopes, within the idea of the on-line community is that, through a process of interaction among users…there will come into effect a progressive accumulation of useful computer programs, of widely applicable data, and of technique and doctrine and know-how—and the accumulation will provide the basis of a much more effective way of solving problems, of planning, of maintaining coherence in large-scale complex operations." What Licklider proposed was the seeding of an organically-evolving tree of knowledge. Rather than create the entire geography of computer uses by executive fiat (from IPTO, IBM headquarters or elsewhere), Licklider relied on a technique now known as "crowd-sourcing" – that is, devolving control over a problem to a "crowd," or community of dedicated users. "IBM: Memo from JCRL," Licklider Papers, box 3.

science, given the difficulties of access for his students. Like his mentor, fellow Hungarian John Von Neumann, Kemeny saw the computer as an important social event. Together with another mathematician, Thomas Kurtz—also the director of Dartmouth's Computer Center—Kemeny implemented a system similar to CTSS at Dartmouth in 1963, called the Dartmouth Time-Sharing System. In order to make the system more straightforward, they also authored a new programming language, BASIC, that was meant to be used interactively. It included a visual command-line interface that could be manipulated with vanilla English keywords such as "RUN," "SAVE," "NEW," or "PRINT." BASIC, which Kemeny and Kurtz test ran on psychology students in 1964, became one of the most popular programming languages among the uninitiated.[813]

Kemeny's persistent advocacy of science and technology education saw him rewarded in 1970 with the presidency of Dartmouth. From that distinguished perch, Kemeny penned the 1972 treatise *Man and the Computer*. In its pages he espoused a belief that after the development of the general purpose computer itself, the most important advance in the history of twentieth century technology would be easy man-machine interaction. Kemeny joined a movement away from computing dominated by a scientist elite, and toward democracy. He noted, "We at Dartmouth envisaged the possibility of millions of people writing their own computer programs."[814] If Licklider was interactive computing's most forceful proponent, he did not crusade alone.

Computer interaction could be just as valuable in business as in research. While many companies had, in the preceding decade, bought expensive mainframes to help manage their expanding data flows, few had invested much in making them adaptable to

[813] Ceruzzi. *A History of Modern Computing*, 78.
[814] Kemeny, John G. *Man and the Computer.* New York: Simon & Schuster, 1972, 30.

interactive use. But information is effervescent and mutable, and early computers' response times were slow. "Knowledge is power and control, provided it is timely, ample, and relevant," wrote *Fortune*. Facts were useful, but "unless a man understands how they are related, and particularly how their relationships are changing, he knows very little."[815] Westinghouse was a pioneer in this area, installing more computer systems in more departments than any rival company. The effort, according to the computer systems chief, was "to shrink the lead time in the management information cycle to practically nothing."[816] Computers now prepared invoices and booked all transactions, but also responded instantly to changing warehouse stocks, making the inventory cycle thirty percent leaner.

In the eyes of the business world, a system such as SAGE promised to further ameliorate the time mismatch. "One big lesson it teaches, aside from the fact that it puts the whole business on line in real time, is how to manage the symbiosis of man and machine," *Fortune* continued, importing Licklider's term. "SAGE matches the two easily and naturally, letting the computer help rather than take over."[817] Built to track incoming bombers, SAGE's processors were distributed over a national network, flexible, and responsive. It also proved effective at training Air Force officers in computer use, as one day it might corporate officers.

SAGE's natural successor was the Lincoln Lab's SABRE (initially the "Semi-Automatic Business Environment Research). In 1960 SABRE was now handling American Airlines on-line reservation system, *Fortune* reported, clearing an

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[815] Burck, Gilbert. "'On Line' in 'Real Time'," *Fortune* 69 (April 1964): 141.
[816] Burck. "'On Line' in 'Real Time'," 144, 145.
[817] Burck. "'On Line' in 'Real Time'," 145.

unmanageable backlog and saving the company millions of dollars in the bargain.[818] A central, time-shared computer handled queries through hundreds of remote input/output consoles. So too in the railroad industry; simulation was helping streamline traffic control through real-time feedback. Besides providing calculating power, computers could entirely transform the way managers thought about business problems. "By enlarging management's abilities to adjust its means to its aim," *Fortune* surmised, "the computer will enlarge management's abilities to formulate its aims."[819] As many were coming to appreciate, getting the right answer was not nearly as critical as asking the right question. To truly understand the question, feedback is essential. The process of trial-and-error, the opportunity to dynamically test assumptions, integrating constant inflows of new data, and the capacity (as Johnson and Kobler urged) to make qualitative assessments upon review of initial results all hinged on an improved "on-line" experience. As was sometimes remarked, an executive is a genius if he is right fifty-two percent of the time. "Whatever the correct percentage," *Fortune* wrote, "the machine can help him expand and elevate his native intuitive powers to new levels."[820]

J.C.R. Licklider viewed the agendas of academic research and business with respect to computer interaction as fundamentally harmonious. If computers were to be put in front of everyone who could use them, the private sector would have a very important part to play. In 1964 he left IPTO in the hands of his chosen successor, the 26-year-old graphics prodigy Ivan Sutherland, and took a job as a consultant for IBM. Partnering with several research labs in Cambridge and elsewhere, Big Blue represented

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[818] Norby, R.D. "The American Airlines Sabre System," in Gallagher, James D., ed. *Management Information Systems and the Computer*. American Management Association Research Study, 1961, 150-176.
[819] Burck. "'On Line' in 'Real Time'," 252.
[820] Burck. "'On Line' in 'Real Time'," 145.

for Licklider the most likely private agent to bring his visions to bear on a scale worthy of their ambition. As he had at ARPA, Licklider outlined a bold progression of steps IBM could take to assume a leadership position in what he assured them was a future of personal, networked computing. To Licklider's disappointment, IBM was late to adopt time-sharing, only retro-engineering the System/360 for time-sharing in 1967, and failed to enter the microcomputer market until 1981.

In a 1965 memo to the director of the Thomas J. Watson Research Center, Licklider described the long-range plans being undertaken at Project MAC: "The broad area of interest is on-line interaction between men and information-processing machines. This interest is focused mainly on software and interaction techniques, but it extends also to hardware devices through which interaction is mediated."[821] With the aim of achieving "close, effective partnership between men and information processing machines," Project MAC was pursuing research agendas in graphical interaction, keyboards and alphanumeric displays, natural language text, database software. The entire edifice of on-line computing depended on the success of these lines of study in creating a convenient, natural facility for machine interaction. All were areas where IBM could profitably begin to devote its own substantial resources. Licklider went on to propose several key directions for IBM's project planning over the next several years, even suggesting the company become a contractor to ARPA—an arrangement he could have facilitated.

IBM "wants, or should want," Licklider advised, to establish a favorable early foothold in the technologies of computer interaction.[822] Melding communications infrastructure with information processing, for example, would be a lucrative venture for

[821] "IBM: Memo from JCRL," 1965. Licklider Papers, Box 3.
[822] "IBM: Memo from JCRL," 1967. Licklider Papers, Box 3.

an early entrant, though he cautioned IBM to focus on hardware, software, and service, and not take on any of the coloration of a utility or bandwidth provider. Beyond modems, routers, and the like, improved user interfaces portended an integration of computers and peripherals into the basic routines of the office. In 1967, IBM was already working on adapting time-sharing and improvements in graphics as features for its System/360 mainframe line. Licklider thought that minicomputers, like DEC's PDP-8, presented a stiffer long-term threat: "The limited objective lies in the more distant and less certain—but vastly larger—goal of providing a faster, more efficient way of getting alphanumeric information out of human minds into computer-processible form and, in particular, of bringing computers directly into the stream of office transcription."[823] The rise of the digital office was a prediction Berkeley, Diebold, and Toffler had all been fond of repeating. Licklider, who was more familiar with the technical aspects of hands-on computing than any of them, was no less a cheerleader. In 1970 he wrote,

> Surely there will be a time when most serious intellectual work is done 'on-line,' with the aid of and in the medium of an electronic information network. Desks will be consoles. Pens and pencils will be position-sensitive styli. If paper plays a significant role, it will be because paper supports clear images that can be handled conveniently – not because print on paper lasts for years. Most business and professional conversations and many meetings will involve computer support and take place through the network.[824]

If the average office were to become computerized, equipment makers would experience a gradual shift down the value chain to lower-margin, higher-volume products. But, given the "information explosion" with even small businesses were wrestling, IBM should expect a robust growth market for decades.

While IBM would lag in the burgeoning small office market for more than a decade, concentrating on large installations for government and institutional clients,

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823 "IBM: Memo from JCRL," 1965. Licklider Papers, Box 3.
824 "A Hypothetical Plan for a Library-Information Network," August 7, 1970, Licklider Papers, box 9, 7.

Licklider's advice indeed proved prescient. Ultimately, young startups like Microsoft, 3Com, Cisco, Sun, and Oracle would move aggressively into the markets for enterprise software and networks, and IBM would, much later, divest its hardware arm to concentrate on its formidable service brand. "The next big, exciting development in interactive computing," Licklider preached in 1967, "will be the netting of multiple-access computers. IBM must not fail to be a leader in computer netting. I am worried that the attention of the Corporation may be so strongly fixed on problems that hang over from past efforts in time-sharing that the forward prospect…will not be clearly perceived and will not be responded to strongly and soon."[825] Despite Licklider's stature, IBM did not heed his advice in time, and lost share to younger rivals across its business mix. That Licklider failed to convert America's leading office machine company to his dream of computer democracy should not be seen as evidence that his ideas held little sway. Rather it is quite telling that members of the ARPA community like Licklider, Ken Olsen, and later Bob Taylor and David C. Evans effected such a comfortable dance between the worlds of research and commerce. The fact testifies to the convenient slippage between computer prophecy and engineering, between *ideas* and *devices*, that characterized the interactive computing movement.

Licklider had strained to make the IBM front office conscious of the changes in the computing landscape wrought at research laboratories across the country. His pitch would have remodeled the computer as a communication device. Finding IBM's large institutional bureaucracy less impressionable than the government's, he returned in 1968 to M.I.T. to take over from Robert Fano as director of Project MAC. The fledgling ARPANET and experiments with multi-access computers had conclusively demonstrated,

[825] "IBM: Memo from JCRL," Feburary 1, 1967. Licklider Papers, Box 3.

he believed, that "computers [were] as much for communication as they [were] for calculation."[826] System Development Corporation of Santa Monica, CA supplied further precedent. *Fortune* reported that its time-sharing system had linked forty distinct laboratories by remote exchange, all able to "dial" each other, with the central processor (a simplified version of the machines IBM built for SAGE) functioning like a telephone switch.[827] Tymshare, of Cupertino, California had success in the late 1960s selling direct dial-up access to its fleet of minicompters, offering users a chance to experience machines they could not otherwise afford. The commercial model took several years to gain traction. A 1974 advertisement for the fledgling Compu-Serv, later a leading Internet service provider, declared that the company had finally brought "remote computing from concept to reality." Utility computing, as Licklider and Taylor had hoped, presented a distinct economic value proposition: "Time-sharing on Compu-Serv's computer network enables users to effectively utilize powerful computers at a fraction of the cost involved in owning a computer system."[828]

In 1966 Sutherland had handed the reins (and checkbook) of IPTO to his deputy, Robert Taylor. Licklider could not have hoped for a more faithful accomplice in bringing about the intergalactic network. Taylor, like Licklider, was trained in psychoacoustics, though he possessed no doctoral degree. A gregarious Texan, the son of a preacher, he was a consummate networker who had a gift for seeing how the many puzzle pieces of the computer field fit together into a larger picture. He was also a steadfast devotee of Licklider's school of close human-computer partnership. "The whole notion of people

[826] Licklider Oral History, 51.
[827] Pfeiffer. "Machines That Man can Talk With," 196.
[828] CompuServ, Computer Product Literature 1948- (CBI 12), 1974. box 7, 1. Charles Babbage Institute, University of Minnesota, Minneapolis.

sitting in key punch rooms just really, I don't know why, just irritated me," he remembered.[829] When he read "Man-Computer Symbiosis" in 1960, he "just lit up." Here was the answer to his keypunch dilemma. After graduate school he moved to NASA where he ultimately became Engelbart's chief patron before migrating, with Engelbart's funding, to ARPA. To Taylor, no proposal was as singularly attractive as building a national computer network to connect the far-flung research centers IPTO had endowed. Searching for support, he found a willing ear in his predecessor.[830] "Go for it," Licklider told him.[831] Their bull sessions became a thought-piece entitled "The Computer as a Communication Device," an explanatory tract written breezy prose and accompanied by illustrations from Playboy cartoonist Rowland B. Wilson.

It announced itself with the kind of soi-disant clairvoyance that had become Licklider's convention: "In a few years, men will be able to communicate more effectively through a machine than face to face."[832] What could be achieved in a time-shared system across a room, could just as easily be achieved over thousands of miles. This sentence could be seen as an early epithet for the ARPANET. They continued,

> We believe that we are entering a technological age in which we will be able to interact with the richness of living information—not merely in the passive way that we have become accustomed to using books and libraries, but as active participants in an ongoing process, bringing something to it through our interaction with it, and not simply receiving something from it by our connection to it.[833]

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[829] Robert Taylor Oral History, Computer History Museum, Woodside, Calif., October 2008, 7. Accessed 5 Sept. 2010. <http://www.computerhistory.org/collections/accession/102702015>
[830] Licklider had written a paper on the Internet concept as early as 1962. See: Licklider, J.C.R. and Welden Clark, "On-Line Man Computer Communication." AFIPS Joint Computer Conferences, ACM. May 1962, 113-128.
[831] Waldrop. *The Dream Machine*. 264.
[832] Licklider, J.C.R. and Robert Taylor. "The Computer As a Communication Device," *Science & Technology*. April 1968, 21.
[833] Ibid.

What Taylor and Licklider propose is a kind of participatory democracy in the mode of what is now called "Web 2.0". The idea that the whole of the community was more than the sum of its parts is captured by their slogan, "When minds interact, new ideas emerge."

It is worth noting that a distributed computer network, as Taylor and Licklider imagined is actually quite antithetical to the centrally managed economy earlier digital computers seemed to foretell. The coming "post-capitalism" heralded by the sociologists of Howard Brick's account, a kind of quasi-corporatist planning by technocratic elites, was closely tied to the supposed scarcity of computing resources. If Licklider and Taylor succeeded in allocating computing power evenly across a community of users, the need to consolidate economic planning in the hands of industrial, political, and organized labor brahmins would be somewhat obviated. So too, advanced machines gifted with graphics and intuitive user interfaces might be useful as more than number-crunching engines of economic rationalization; they could enable creative solutions to non strictly-economics problems like industrial design, environmental conservation, or disease diagnosis. Berkeley's proposed information-regulatory agency would be sourced to the crowd.

Effortless communication requires a plastic medium, one that could be played and experimented with by all. Only in the later 1960s was the digital computer coming to fit this criterion. Licklider and Taylor explained that communication is little more than the sharing of mental models. The computer was a felicitous aid in representing these abstractions, enabling "cooperative modeling."[834] "Model," was of course a broad term; computers facilitated the sharing of tools, not just data. Through text, graphics, diagrams, charts, tables, and pictorial representations, along with programs to operate on them, the

[834] Licklider and Taylor. "The Computer As a Communication Device," 22.

entire suite of human productive reasoning, it was hoped, could be loaded onto a shared computer drive. Via the store-and-forward mechanism computers metamorphosed into switches; they could double as data warehouses, typographical editors, translators, draftsmen, calculators, and logicians.[835] Of course it wasn't true that any computer could interface with any other, but "computers are joining the family and interchange is far greater than it used to be." Licklider and Taylor essentially updated a narrative of communication as information-sharing that Wiener and Shannon began. Computers, now with an expressive capacity greater than just electric impulses, could enable systematic study of the semantic and behavioral levels of communication. Progress toward a common language was unstoppable, Licklider believed: "There will be much communication."[836]

In "The Computer as a Communication Device," the authors anticipate unequivocally the network's evolution into something resembling the Internet. By bringing together talented people and forcing them to jettison their individually competing empires, the community eventually gains "critical mass." Theirs was one of the first acknowledgments of the snowballing power of network effects in computer linkages. The network would unite disparate people and allow them to traverse their intellectual horizons: on-line interactive communities, Licklider and Taylor wrote, "will consist of geographically separated members, sometimes grouped in small clusters and

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[835] Licklider and Taylor estimated that with the heightened competition in the fields of consoles and storage (the latter was cheapening 50% per unit every two years) the costs of such a network would soon be reckoned in the dollars per hour, if it could be used enough.
[836] Licklider, J.C.R. Address to York University: "The Computer Age: The Nature of Computers and Automation" October 23, 1965. Licklider Papers, box 7, 11. Asked by the organizers of the conference to deliver a speech on the future of "Computers and Automation," Licklider initially demurred. The person they should ask, Licklider responded, was Edmund Berkeley. "Thinking of him leads me to realize that I could, indeed , cover my topic complete in one sentence," Licklider wrote. "Computers and Automation is a journal edited and published by Edmund C. Berkeley, and its nature is excellent and informative."

sometimes working individually. They will be communities not of common location, but of *common interest*."[837] Telecommunication will allow for long-desired associations based on commonality, not the accident of proximity. Intellectual sproutings in the most obscure areas would surely follow. The authors foresaw something for everyone: "There will be plenty of opportunity for everyone (who can afford a console) to find his calling, for the whole world of information, with all its fields and disciplines, will be open to him—with programs ready to guide him or to help him explore."[838]

One of the outcomes of the distribution of network resources, Licklider believed, would be a delocalization of physical place. Arthur C. Clarke had opined in the *New York Times* a few years before that "The improvement of communications will…render obsolete the city's historic role as a meeting place for minds and a center of social intercourse. This is just as well, anyway, since within another generation most of our cities will be strangled to death by their own traffic."[839] Though Licklider was neither a social activist, nor very concerned with human geography, he did see a certain appeal in moving communication from a physical to an electronic plane. Networked computing would foster "disurbanization and cottage industry," he predicted, "dispersal of society to avoid dangers or unpleasantness of overcrowding in the city, plus dispersal of organizations (employees working at home…a so on into the blue, or even into space)."[840] The idea that the network was something not to layer on top of social interaction, but to replace it altogether, has been adopted by urbanists and "virtual age"

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[837] Licklider and Taylor. "The Computer As a Communication Device," 37-38.
[838] Licklider and Taylor. "The Computer As a Communication Device," 41.
[839] Clarke, Arthur C. "Spark of the Second Industrial Revolution," *The New York Times Magazine*, December 9, 1962, 127.
[840] "IBM: Memo from JCRL," Feburary 1, 1967. Licklider Papers, Box 3.

prophets in more recent decades.[841] Instead of a dystopic, depersonalized cyber-wasteland, it is interesting to find that decentralization was an immensely appealing prospect for many in the 1960s. These speculations, enabled by the computer's new capacity for sending and receiving complex messages, constituted a critical ingredient of the hippie ethics of self-reliance, back-to-nature, and communalism that aligned themselves with personal computing in the early 1970s. They had premature champions in Licklider and Taylor.

It is worth noting that, despite his stature as the computer movement's preeminent "organization man," Licklider's sympathies for the progressive social values with which he occasionally flirted ran more than skin-deep. He harbored a distrust of the military for whom he worked, and a deep antagonism to the growing conflict in Vietnam.[842] He was, like many university professors, a social liberal who esteemed computers chiefly for their mind-expanding properties. This fact, though self-evident in Licklider's writings, is a meaningful rebuff to those who view the computer systems he helped create as eminent tokens of a military sensibility. Indeed, the collaborative atmosphere of IPTO described in Arthur Norberg and Judy O'Neill's synoptic *Transforming Information Technology* could not have differed more from a military command structure.[843]

J.C.R. Licklider's writings often betray the sense of a scientist consciously manipulating the defense brass. When he wrote a proposal for continuation of Project

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[841] See: Mitchell, William. *Me++: The Cyborg Self and the Networked City*. Cambridge, Mass.: MIT, 2003.
Rheingold, Howard. *The Virtual Community: Homesteading on the Electronic Frontier*. Cambridge, Mass.: MIT, 2000.
Turkle, Sherry. *Life on the Screen: Identity in the Age of the Internet*. New York: Simon & Schuster, 1997.
Winner, Langdon. "Silicon Valley Mystery House," in *Variations on a Theme Park: The New American City and the End of Public Space*. Sorkin, Michael, ed. New York: Hill & Wang, 1992, 31-60.
[842] Waldrop. *The Dream Machine*, 401. Licklider's humanism, his concern for the life of the mind can be read in all of his writings from his early years at Lincoln Lab until his retirement.
[843] Norberg and O'Neill. *Transforming Computer Technology.*

MAC in November of 1968, for example, he made no mention of military applicability, instead choosing to list the many programs and languages in the CTSS "living" library, including LISP, STRUDL, and MATHLAB.[844] He often insisted, perhaps disingenuously, that solutions benefiting the community of academic users could be adapted to military needs. "Hopefully, many of the problems will be essentially the same, and essentially as important, in the research context as in the military context."[845] As an engineer himself, Jack Ruina was a natural ally, but Licklider wasted no effort converting him to his broad vision. "I got Jack to see the pertinence of interactive computing," Licklider told a journalist, "not only to military command and control, but to the whole world of day-to-day business."[846] The key feature of Licklider's management style, according to communications scholar Thierry Bardini, was the bypass of the traditional peer review system, substituted by the informal network he cultivated. Licklider described it thus: "You learn to trust certain people, and they expand your acquaintance. I did a lot of traveling, and in a job like that, when people know you have some money it's awful easy to meet people; you get to hear what they are doing."[847] A group dominated by academic scientists, Janet Abbate points out, functioned quite differently than a government agency. The values of collegiality, decentralized authority, and open exchange of information were all actively incorporated into the body of the ARPANET.[848] Naturally, this communal focus inspired very different results than an ordinary defense project.

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[844] Licklider, J.C.R. "Proposal for Continuation, Project MAC, Nov. 1968." Licklider Papers, box 9.
[845] Licklider, J.C.R. "Members and Affiliates of the Intergalactic Computer Network," April 25, 1963. Licklider Papers, box 3, 7.
[846] Rheingold. *Tools for Thought*, 145.
[847] Bardini, Thierry. *Bootstrapping: Douglas Engelbart, Coevolution, and the Origins of Personal Computing*. Palo Alto: Stanford, 2000, 22.
[848] Abbate. *Inventing the Internet*, 5.

In Norberg and O'Neill's account, Licklider went to Washington in a deliberate attempt to serve as an "unofficial representative" of the Cambridge community—a position for which he was well suited as an architect of the symbiosis philosophy, and as its most prominent spokesman.[849] In most respects, he acted as a broker. Flaunting the Pentagon's unwritten policy against favoritism in awarding contracts, Licklider was instrumental in crafting MIT's original project MAC proposal, and in selecting Fano as its leader.[850] In effect he shoved money into the hands of John McCarthy at Stanford and Edward Feigenbaum at Berkeley, soliciting proposals in personal letters. Though artificial intelligence pioneer Allen Newell had never heard of him, Licklider sent him a $300,000 check, no questions asked.[851] All of these researchers had had distinguished academic careers, and none had a scintilla of interest in national defense applications. Scientists could very well accept military dollars without subscribing to military philosophy. The sacrifice was well worth it to "liberate human potential." "That was the lie we told ourselves," said Bob Metcalfe, the engineer behind the ARPANET's store-and-forward packet switching technique. "Our money was only bloody on one side."[852]

Licklider engineered this administrative coup by reframing "the mission." He clearly articulated a past, present, and future of interactive computing, time-sharing, and networking, and was thus able to cast many of his proposals in the light of the Cold War defense priority of a robust, redundant communications and transportation infrastructure.[853] Fortuitously, M.I.T. had achieved modest breakthroughs in military

849 Norberg and O'Neill. *Transforming Computer Technology*, 89.
850 Waldrop. *The Dream Machine,* 219.
851 Waldrop. *The Dream Machine,* 209-210.
852 Waldrop. *The Dream Machine,* 281.
853 A classic example of the force of this imperative was Eisenhower's billing of the 1954 highway-building initiative, equally an investment in economic growth, as the "National Defense Interstate Highway Act."

readiness through computer interaction with projects like SAGE, which may have relieved some officials of their doubts. During IPTO's first half-decade, Licklider and his colleagues effected an unprecedented end run around a stodgy defense establishment, co-opting its bounty for primarily civilian interests.

Here, if anywhere, is evidence to destabilize historian Paul Edwards' consensus reading of the digital computer as Cold War grand strategy made flesh. Edwards' is a deconstructionist, discursive argument; the computer's military origins are very much inscribed in its vocabulary—"digital," "model," "simulation," "light gun," "control," "automation." He is quite convincing in describing the "hermetic worlds of thought" at Forrester's Servomechanism Lab, detailing the self-reinforcing feedback loops between IBM (Forrester's chief benefactor), the Pentagon's desire to anticipate and deflect and ballistic missile attack, and Forrester's own drive to Taylorize every aspect of his production cycle (a tactic he would later teach at M.I.T.'s Sloan School of Management).[854] He is less persuasive in his attempt to establish George Miller's brand of cognitive science as the heir to arch-hawk Von Neumann's theories of rational behavior in "game scenarios," and self-assembling automata.[855] Edwards fails most evidently to substantiate his boldest contention—that "the computerization of society…has essentially been a side effect of the computerization of war."[856] This deterministic argument is the motive theme behind Edwards' entire enterprise. If the testimonies of Wiener, Berkeley, Licklider, Taylor and countless others are to be believed,

[854] Edwards, Paul. *The Closed World: Computers and the Politics of Discourse in Cold War America*, Cambridge, Mass: MIT, 1996, 77-100.
[855] Edward. *The Closed World*, 225-240. Edwards (mistakenly) identifies Miller and Licklider's work at the Psychoacoustics Lab as a continuation of the behaviorist school's models of conditioned response. As Licklider and Miller both attest, their efforts were quite distinct conceptually and methodologically.
[856] Edwards. *The Closed World*, 65.

it represents a false syllogism. Their work was no side effect; it was, for ARPA at least, the prime mover. The integrity of Edwards' "closed world" thesis rests, in the end, on a contamination theory of military influence—anything the Pentagon's dollars touch is inevitably warped to its purpose. A vision of the military as a corrupt demiurge arises from a misreading of the history of ARPA, but also from a naïve antiestablishment sensibility common to many Left critiques. In a society that emphasized continuous mobilization, military funds are directed down very diverse avenues; these do not all become "militarized." The swelling of the defense branch over the course of the Cold War put the military in the business of health care, education, logistics, natural resource management, in addition to information technology. If the "closed world" metaphor holds in some instances, it is nevertheless an overly-reductionist framework to evaluate every direct and indirect consequence of Pentagon investment in the twentieth century.

If there was a grand, unifying mission that guided Licklider's efforts, it was his concern with the predicament of information overload. Computers as mental aids, computers as communications tools, and computers as shared resources as all diverse approaches to the problem of organizing data so people could make more effective use of it. A trait Licklider shared with Berkeley was an abiding interest in the business of organization. Licklider spoke of an "information explosion," estimating that if every book and article ever published were counted there were more than 10^{14} alphanumeric characters that would need to be indexed, equivalent to 10^{15} bits. Dealing with these data required not a technological solution, but "a social revolution." "Social revolution takes place very slowly," Licklider remarked.[857] The trouble was to get relevant information, in a comprehensible form, into the hands of those who needed it. In 1965, Licklider

[857] Licklider, J.C.R. "Librarianship: 2000 A.D." Address to IBM, June 1965. Licklider Papers, box 7.

wrote a book, *Libraries of the Future,* in which he explored how the computer might be put to these tasks. The inspiration he cited in his introduction was, unsurprisingly, Vannevar Bush's Memex.

Bush essay, "As We May Think," published in the July 1945 *Atlantic*, was based on a draft he submitted to *Fortune* in 1939. War intervened; Bush took a position as head of the Carnegie Institution in Washington, and the *Atlantic* ended up with a lightly revised version. As a leader in the scientific establishment, Bush was consumed by the matter of getting good information to those who could profit from it; Mendel's publications on genetics, for example, had languished unread for a century. Even in the 1930's, many scientific disciplines were being swallowed by a mass of research data. "There is increased evidence that we are being bogged down today as specialization extends. The investigator is staggered by the findings and conclusions of thousands of other workers—conclusions which he cannot find time to grasp, much less to remember, as they appear," Bush complained.[858]

The difficulty rested with artificial, counterintuitive systems of indexing. Vague subject categories or alphabetical hierarchies frustrated those searching for a simple concept they could not precisely define. Put simply, "The human mind does not work that way. It operates by association." Bush continued, "With one item in its grasp, it snaps instantly to the next that is suggested by the association of thoughts, in accordance with some intricate web of trails carried by the cells of the brain… The speed of action, the intricacy of trails, the detail of mental pictures, is awe-inspiring beyond all else in nature." These free associations, the province of learning and creative thinking were

[858] Bush, Vannevar. "As We May Think," *The Atlantic Monthly*. July 1945. Accessed 1 Sept. 2010. <http://www.theatlantic.com/magazine/archive/1969/12/as-we-may-think/3881>

deeply antithetical to the rigid way computers stored and presented data. Yet Bush boldly predicted that "selection by association, rather than indexing, may yet be mechanized."[859] A machine like Bush's memex—a terminal at a vast microfilm processor—could catalogue entries this way: "Wholly new forms of encyclopedias will appear, ready made with a mesh of associative trails running through them, ready to be dropped into the memex and there amplified."[860]

Bush's vision was a powerful influence on Licklider. Much of what was proposed in 1945 could be realized two decades later in a digital, time-shared system. Mindful of Bush's precedent, Licklider penned a 1967 *New York Times* editorial renewing the former's call for innovation. The "information explosion" was real, he cautioned; the output rate of scientific papers was doubling every decade. At the same time, "computers are showing that they can free librarians from routine but essential chores."[861] Digital record keeping, radically cheaper storage, and interlibrary networks could all facilitate the *sine qua non* of librarianship: not just referencing information, but making "organized sense" of it. Familiar with many of the tools under development at Project MAC, Engelbart's "Augmentation Research Center," and elsewhere, Licklider predicted that "we are heading for a coherent network of information resources and services in which

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[859] Ibid.

[860] The technological solutions Bush proposed were rooted in 1930s engineering challenges like photographic reproduction, pictorial representation of text, hydraulic tubes, and optics. Indeed, he had first sketched something like the Memex machine in a 1933 article, "The Inscrutable Thirties." Though the social problem "As We May Think" addressed persisted well into the second half of the twentieth century, Bush's article could never have imagined the "hypertext" electronic links described by Ted Nelson or developed for Engelbart's NLS. Nyce and Kahn (1991) make this point effectively in their history of the Memex, "A Machine for the Mind." That ideas like Bush's are capable of cross-pollinating across vastly different contexts attests to the strength of the methodology that placed human patterns of thinking at the forefront of engineering design.
Nyce, James M. and Paul Kahn. *From Memex to Hypertext: Vannevar Bush and the Mind's Machine*. San Diego: Academic Press, 1991, 39-66

[861] Licklider, J.C.R. "Computers Are Helping Scientists Locate That Particular Pebble in the New Avalanche of Information." *The New York Times*. January 9 1967, 139.

many agencies and societies and companies cooperate." The principle of associative indexing was closely linked with interactive computing. Each technology attempted to match electronic information to the learning function of the human user. Licklider stated that in the near future, it would be possible for "people to do their studying and thinking in direct interaction with computers and to gain access through wire or cable… or even relay-satellite to remote banks of computer-processible information."[862]

Licklider's enduring pursuit was the better use of information by people. When he wrote in 1973 that information science was not the science of information, he meant just that; logicians, mathematicians, reporters and psychologists had all long swum in these waters. The new study of information ought to be devoted to a narrower, but more elusive endeavor: "to apply computers in the intelligent organization and understanding of information."[863] Linking minds and computers was only a beginning to this transformative process. When John Gage, a co-developer of the Berkeley UNIX operating system and early employee at Sun Microsystems, first uttered the phrase that would become his company's slogan—"the network is the computer"—he may as well have been quoting Licklider. He might also have said "the *system* is the computer," for without notion of close man-machine symbiosis, the contemporary understanding of what a networked computer is disintegrates. This critical interpretive leap—that machines were not invented to terrorize us or replace us, but to work with us, for our collective benefit—is one for which Licklider can justly be given credit.

862 Ibid.
863 Licklider, J.C.R. "Psychological and Technological Dynamics of Information Science," 1973 draft. Licklider Papers, box 10, 4.

Chapter 19 – The augmented intellect

Like many influential philosophers, Licklider cultivated a protégé. Indeed, he cultivated many, as younger researchers, inspired with the call to action of "Man-Computer Symbiosis," fanned out across the IPTO network to implement his legacy. The name that is most often identified with Licklider's school of interactive computing, is that of Douglas Engelbart. Engelbart—the inventor of the mouse and of the windowing, tiling, graphically interactive NLS (On-Line System) that was the seed of the Xerox Alto, Apple Macintosh, and Microsoft Windows operating systems—was a more diffident and subtler ambassador than Licklider. Yet their attitudes toward interactivity were nearly identical. Engelbart was an engineer, not an administrator. Soft-spoken and contemplative, he unlike Licklider was capable of physically bringing into being technologies users could reach out and touch. By creating objects, he took what was a somewhat desultory set of philosophies and made them concrete. For a technician he wrote lucidly and profoundly, establishing a set of principles and practices that would migrate from his Augmentation Research Center (ARC) at SRI to Xerox's PARC (Palo Alto Research Center), and eventually into the product development labs at Apple Computer and the workbenches of garage hobbyists. His ideas were played to a kind of mainstream pop cybernetic beat through the applied mania of his former employee, the *Whole Earth Catalog*'s Stewart Brand. And he was the author of perhaps the most seminal moment in the history of the personal computer, a presentation known as the "Mother of All Demos."[864]

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[864] Levy, Steven. *Insanely Great: The Life and Times of Macintosh, the Computer that Changed Everything*. New York: Penguin, 2000, 42.

On December 9, 1968, Doug Engelbart stood before a crowd of about 1,000 at the Fall Joint Computer Conference in San Francisco's Convention Center, his face projected on a screen above the podium juxtaposed next to his computer interface.[865] For ninety minutes the stunned onlookers watched a demonstration of not only the first computer mouse, with which he effortlessly commanded a suite of programs, but what-you-see-is-what-you-get word processing (including cut, copy and paste functions), online hypermedia, real-time groupware collaboration with employees at his office in Menlo Park, email, graphical tagging and filing of documents, and a number of other techniques, none of which had been publicly unveiled. He even constructed a shopping list, dynamic clicking and dragging items in order of importance. It was, in the words of journalists Paul Freiberger and Michael Swaine, "one of the most impressive technology demonstrations since the atomic bomb test at Alamogordo."[866] Stewart Brand operated the camera at SRI, sending instant images of Engelbart's seventeen collaborators sharing his screen. Such was the reaction that it is now common practice for popular histories to introduce Engelbart's 1968 demo as the moment of genesis of the personal computer.[867] The reality, of course, was that the dazzling showcase of December 1968 disguised a long prelude; Engelbart's team's inventions did not hatch suddenly at the Fall Joint Computer Conference, but were the product of many fits and starts from conception to

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865 Engelbart, Douglas. 1968 Fall Joint Computer Conference demo, San Francisco. Video accessed 5 Sept. 2010. <http://sloan.stanford.edu/MouseSite/1968Demo.html>
866 Freiberger, Paul and Michael Swaine. *Fire in the Valley: The Making of the Personal Computer*. New York: McGraw Hill, 2000, 303.
867 For example, see: Markoff, John. *What the Dormouse Said: How the 60s Counterculture Shaped the Personal Computer*. New York: Viking, 2005, 144-148.
Freiberger and Swaine. *Fire in the Valley*, 303-306.
Rheingold. *Tools for Thought*, 326.
Gillies, James and Robert Caillau. *How the Web Was Born: The Story of the World Wide Web*. London: Oxford University, 1999, 98-100.

implementation. Before the mouse, for example, cursor-control devices operated by pointing the knee or the nose were discarded because they caused muscle cramps.[868]

Yet the many diverse experiments Engelbart "bootstrapped" at the ARC were guided by an overriding conceptual program, inherited from Licklider, that Engelbart imparted to his staff. They were guided by the philosophy that humans ought to be able to use computers with a minimum of strain or translation effort. Into the mix, Engelbart added his own sensibility—one informed by a proto-New Age, mind-expansion philosophy that uneasily allied the worlds of the 1960s counterculture and the builders of electronic office machines. Where Berkeley saw "Giant Brains," Engelbart saw, rather, giant systems of thought. More than anyone, he was responsible for bringing Licklider's grand vision into an era of user-friendly gadgets and devices.

Douglas C. Engelbart had always exhibited a social consciousness rare among his fellow electrical engineers. Growing up in a rural area outside Portland, Oregon, his father ran a radio store and his mother, whom he described as "very artistic," wrote poetry in German. A relative of his father's had been poet laureate of Norway.[869] After graduating from Oregon State University, he was drafted into the Navy as an electronics technician. On a stopover in the Philippines in 1945, he encountered an *Atlantic Monthly* in a Red Cross library and read Bush's "As We May Think" with ravenous interest. "I remember being thrilled," Engelbart recalled later. "Just the whole concept of helping people work and think that way just excited me."[870] Years later he would write the

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[868] Engelbart, Douglas C. "The Augmented Knowledge Workshop," in *A History of Personal Workstations*, Adele Goldberg, ed. Reading, Mass.: Addison-Wesley, 1988, 197.
[869] Douglas Engelbart Oral History, Stanford University History of Science, December 1986. Accessed 5 Sept. 2010. <http://www-sul.stanford.edu/depts/hasrg/histsci/ssvoral/engelbart/engfmst1-ntb.html>
[870] Engelbart Oral History.

venerable engineer and thank him for his article that had "influenced me quite basically."[871]

After he was decommissioned, Engelbart did contract electrical work for NACA Ames in Mountain View, though he remained just a "naïve drifter"—taking notes on subjects that interested him, planning somehow to contribute to society: "I wanted to invest the rest of my heretofore aimless career toward making the most difference in improving the lot of the human race."[872] He read Edmund Berkeley's *Giant Brains*, and got an inkling that he might want to work in the computer field.[873] Engelbart was drawn to the subject of information overload. The complexity of the human situation was increasing exponentially. "Human beings face ever more complex and urgent problems," he said, "and their effectiveness in dealing with these problems is a matter that is critical to the stability and continued progress of society."[874]

Engelbart had a "flash of insight"—improving man-machine interaction was a bounded engineering problem. Better CRT console, refined I/O devices, and new software could aid in making computers more democratic. He enrolled in graduate school at Berkeley but found little interest there in "augmenting human intellect."[875] As a graduate student he was tasked to program a high-speed digital computer, CALDIC, for the Office of Naval Research. After a year teaching at Berkeley he found a position at the independent Stanford Research Institute in Menlo Park which promised to give him the freedom to work on interactive devices. SRI was typical of 1950s independent R&D

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[871] "Letter to Vannevar Bush," September 8, 1958. Box 6, folder 15. Douglas C. Engelbart Papers, Stanford University Special Collections and University Archives, Stanford, Calif.
[872] Engelbart. "The Augmented Knowledge Workshop," 188.
[873] Maisel, Andrew. "Doug Engelbart: Father of the Mouse," *SuperKids: Educational Software Review*. Accessed 5 Sept. 2010. <http://www.superkids.com/aweb/pages/features/mouse/mouse.html>
[874] Engelbart, Douglas C. "Program on Human Effectiveness." December 12, 1961. Engelbart Papers, box 5, folder 7.
[875] Engelbart. "The Augmented Knowledge Workshop," 189.

labs; there was certainly no explicit interest in computer interactivity, but the management—particularly device pioneer Hewitt Crane—were tolerant of far-sighted basic research in little cared-for areas, particularly if external funding was available. Engelbart parlayed his contacts at NACA (later NASA) into a modest series of grants from a fellow traveler in interactivity, Robert Taylor.[876] Engelbart's consciously fashioned his lab as a "pursuit vehicle" for augmentation research—"a place where I would have a good chance to work toward developing such a program."[877]

Augmentation for Engelbart embodied a research agenda similar to, but more sophisticated than "man-machine symbiosis." When Engelbart spoke of "augmenting human intellect" he meant something more profound than designing humans ergonomic tools for input, or a natural language command syntax for programming. Engelbart was fundamentally interested in transforming information into *knowledge*, which he deemed quite a different thing. When *Fortune* reported "like man, the computer expresses knowledge in terms of symbols; man's symbols are letters and numbers, and the machine's symbols are electromagnetic impulses that represent letters and numbers," it only got at half the question.[878] Humans also express knowledge pictorially, in diagrams, in flow-charts, through scribbles and doodles, in wandering associative trails—in complex organizational structures. Computers could be made to mimic, correct, share, and aid in designing these structures.

[876] Bardini. *Bootstrapping*, 23. Among Engelbart's other sponsors at the Air Force Office of Scientific Research were the farsighted administrators Harold Wooster and Rowena Swanson, who were longtime advocates for his work.
[877] "Correspondence," Engelbart Papers box 6, folder 15. Engelbart noted, "I had had nothing but negative reactions from people up to then."
[878] Burck, Gilbert. "The Boundless Age of the Computer," *Fortune*, 1964, 101.

Augmentation conjured the image of an elective prosthesis; a tool that performs a human task in fluid harmony with its partner, enhancing native human capacities. Evidently, it was derived in some part from the cybernetic systems thinking that had galvanized Licklider's early career. Thierry Bardini makes clear that as much as Licklider and Engelbart strived to represent thoughts on the computer screen, they were equally interested in discovering the wordless "language" that governed the organizational structure of communication. Hypertext was very much a result of this errand. The novelist Philip K. Dick—author of perhaps the earliest piece of "cyberpunk" literature, *Do Androids Dream of Electric Sheep*, wrote of the brain:

> We do not merely see its thoughts as objects, but rather as movement, or, more precisely, the placement of objects: how they become linked to one another. But we cannot read the patterns of arrangement; we cannot extract the information in it—i.e. it as information, which is what it is. The linking and relinking of objects by the Brain is actually a language, but not a language like ours (since it is addressing itself and not someone or something outside itself).[879]

Engelbart wanted to build machines that could unite these two languages, one recursive and organizational, the other expressive but incomplete. Bardini identifies the root of this approach in Licklider's psychological training. At IPTO, the computer was "progressively reconceptualized from a task-oriented logic machine to a 'dynamic personal medium,'" Bardini writes. For Licklider, Human-Computer Interaction meant "a communicative act between the user and the computer, modeled on a conversation between colleagues."[880] Framing computer interaction in terms of communication—whether body language or speech or writing—inherited both the cybernetic and cognitive

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[879] Dick, Philip K. *Valis*. New York: Vintage, 1991, 23.
[880] Bardini, Thierry and August T. Horvath "The Social Construction of the Personal Computer User: The Rise and Fall of the Reflexive User." *Journal of Communication* 45 (1995): 46.

accents on the mechanism and structure of information transfer. Augmentation was an idea of some complexity.

Like many of his colleagues, Engelbart maintained in interest in teaching computer concepts to the unenlightened.[881] Computer education was about more than fair access; it was a pressing socioeconomic issue. In a 1961 issue of the popular journal *Electronics*, John Mauchly gave voice to a few of Engelbart's concerns:

> Our welfare as a nation requires the best possible utilization of all our resources…In the area of information-handling technology there is also an educational frontier bearing directly on our national welfare. The equipment now at our command has far surpassed the visions of 1950. Our ability to use that equipment, however, has not kept pace. We are far short of obtaining the major benefits which could be ours through effective application of existing systems… We must give solid support to the exploration and development of new frontiers of technique and application.[882]

Instructing undergraduates at Berkeley, Engelbart had worked out a few parlor games that helped demonstrate the organization of circuits that formed a computer's architecture. Arranging simple circuits into complex hierarchies exemplified the principle of emergence, a topic of growing importance in AI circles. The interaction of simple structures—a neuron in one of two binary states for example—could form complex webs of great sophistication. One game involved assigning simple tasks, like raising or lowering one's hand, to individuals and observing the waves and patterns that propagated through the system. "They mystery associated with computers tends to be dissipated," Engelbart wrote, "when a person is assigned a very low-order task in a system of like elements, where no single element comprehends the over-all significance of its roles," but in combination, complex behaviors emerge. Even laymen could see how the Boolean

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[881] Engelbart, Douglas. "Information Handling," Engelbart Papers, box 17, 22. Like Berkeley, Engelbart felt that the basic prerequisite to grasp how a computer worked was a knowledge of mathematical logic. It never failed to surprise how very sophisticated structures could be built from a sequence of rudimentary Boolean operations. Computer newcomers could profitably begin here.
[882] Leary, Frank. "Computers Today," *Electronics*. April 28, 1961, 90.

operations they enacted could be delegated to computer circuits, and how functional structures such as counters, registers, and adders could composed from basic elements.[883]

DEC, the market leader in minicomputers, also believed in education—an investment in future markets. The firms "Education Product Catalog" from 1971 stated the issue in terms familiar to Engelbart:

> Today, our lives and our frontiers of knowledge are changing at a rate unimaginable in the pre-computer age. This faster pace demands sharper minds, minds attuned to the potentials (and limitations) of electronic computing. Not just among graduate mathematicians but among all high school and college students. The school computer I s the key to giving these students the background they need. It is the key to meeting the challenge of education in the computer age.[884]

DEC had introduced smaller, slower systems, such as the PDP-8/S, at price points under $10,000, with an eye to school installations. By 1982, DEC estimated over one million students used its systems every year. School computers were allowing students to manipulate large, complex data sets, learn the fundamentals of programming, and become dedicated DEC customers.

Engelbart believed that computer pedagogy ought to be fun and engaging. Further, he believed computers should not be conceived as preassembled objects, but as systems of primitive components that only in their arrangement achieve great complexity. These lessons were natural analogues for Engelbart's view of computer networks: ordinary people performing relatively low-order tasks could together form a highly productive whole. "There is little question that high-capacity, reliable computer service will soon be generally available, upon instant demand, at the fingertips of any professional who can derive enough value from this service," Engelbart reasoned. While much attention was

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[883] Engelbart, Douglas. "Games That Teach the Fundamentals of Computer Operation." *IRE Transactions on Electronic Computers*, 1961, Engelbart Papers, box 1, folder 2, 31.
[884] "Education Product Catalog", DEC, 1971. Computer Product Literature, box 4.

paid to building such services, there was "remarkably little effort" invested in the equally important project of improving the value they could provide an individual.[885] Engelbart's lab was dedicated to this proposition. Augmentation meant "learning how to use computer aids to increase appropriate human capabilities"—not merely for computer technicians, but for office workers.

Even by 1959, two years before Engelbart set up his lab, he attended a lecture that forecast a coming revolution in the way computer hardware was used. Engelbart took reams of notes on "scaling"—making productive technologies work at with smaller, cheaper parts, without a sacrifice in quality—an objective that would continue to be an integral part of ARC's mission. Engelbart copied one speaker's words verbatim: in an address titled "Shrinking the Giant Brains for the Space Age," electrical engineer Jack Staller said "The problem is to compress a room full of digital computation equipment into the size of a suitcase, then a shoe box, and finally small enough to hold in the palm of the hand."

Staller naturally wanted powerful computer capable of flying in space capsules, but Engelbart had other ideas in mind. Two years later, he composed a short epilogue to Mauchly's call for computer education—for him, a rare excursion into a popular form. "Researchers postulate a possible future…where every man who wants one can buy a small computer as he may one day buy his own nuclear generator for power. Perhaps the computer builder of 1961 finds it hard to comprehend the development of individually available computer power."[886]

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[885] "THINK PIECE – Possible Intellect-Augmentation Research," November 11, 1965. Engelbart Papers box 1, folder 24.
[886] Engelbart, Douglas C. "Computers and the Challenges of Man," *Electronics*. April 28, 1961, 93.

Engelbart calculated that the shape of the technology curve is not linear but parabolic. It was in 1965 that Gordon Moore, a future chairman of Intel, formulated his famous "law" stating that the number of transistors that can be placed on a microchip doubles every two years. Nonetheless, Engelbart was already reckoning with the meaning of the logarithmic scale of processing power. Computer developers of the day certainly could not apprehend the applications of the future, but Engelbart was confident of a "tremendous upsurge in intellectual mobility." Democratically inclined, Engelbart felt that the best use of new technology could be determined by outsourcing the easy use of computer equipment to the masses. Integrated circuits (first demonstrated only a year earlier) were soon to precipitate an enormous vault in power and affordability to small machines. Engelbart was ready.

With the benefit of hindsight it seems a facile point that computers were always a futuristic technology. This is to say that, by virtue of their rapid growth and vast potential, people working with computers were nearly always preoccupied with the shape of the future. Berkeley, Diebold, Licklider, and Engelbart had this in common, and there were others of the sort. Information science attracted some of the boldest, most idealistic minds, those happiest to daydream where ever-advancing state of the art might lead, even if the realities were consistently more surprising than any forecast.

When Engelbart arrived at SRI he attacked a hundred problems at once. "Our only hope for creating a healthy and stimulating atmosphere here, lies in our establish long-range goals," he told colleagues.[887] With NASA and some third party industrial backing ("since…the byproducts of this program would be of great value to industry), he believed he could establish SRI as an important institution in the computer field, one

[887] Engelbart, Douglas. "Lab Planning,Notes." Engelbart Papers, box 3, folder 9, 2.

which would soon occupy "a very large dollar volume in our economy."[888] In 1962, he read Licklider's "Man-Computer Symbiosis," and determined that the head of IPTO was a kindred spirit. He visited Washington, pestering Licklider to establish an ARPA contract site at SRI. "Symbiosis" and "augmentation" were complementary goals, he enthused.[889] Licklider was intrigued, but worried that the fanciful engineer might have difficulty putting together an organized project, and that SRI was too far off the ARPA map to be chaperoned.[890] He instructed Engelbart to draw up a document that laid out his goals in a coherent treatment. Engelbart went back to Menlo Park and to the drawing board.

The document Engelbart produced, one that would provide the basis of a decade-long ARPA sponsorship, was called "Augmenting Human Intellect: A Conceptual Framework," and submitted in October 1962 to the Air Force Office of Scientific Research, and brought with Robert Taylor from NASA to ARPA in 1963. Next to Bush's "As We May Think" (which it quoted liberally), and Licklider's "Man-Computer Symbiosis," it is arguably the most important text in the history of personal computing. Engelbart's proposal is a strange artifact—part academic paper, part epistemological musing, part manifesto, and part speculative fiction. A unique product of the permissive intellectual environment cultured by Licklider and Taylor, it bears little resemblance to technical requests for funding research contractors typically submit to defense agencies. Here Engelbart laid out his broadest definition what "augmentation" might mean, how it might be applied in a research environment, and how it could benefit society. Its pages

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[888] "Authorization," 1966. Engelbart Papers, box 1, folder 17.
[889] Engelbart. "The Augmented Knowledge Workshop," 191.
[890] Waldrop. *The Dream Machine*, 211-216.

offer a glimmer of foreshadowing of the products he would unveil six years later in San Francisco.

What was meant by a "conceptual framework"? It is not an idle question; Engelbart returned to the term again and again, beginning with a short thought piece for the Air Force – "The Augmented Human Intellect: Search for a Framework" in 1960.[891] To an extent, Engelbart wished to define the rules of the game. He would, with a stroke of the pen, set in motion a discipline of study by outlining its current and future research objectives, and by identifying a subset of computer problems that were of a kind and amenable to a coordinated approach. These were the "framework," but something further was implied by the qualifier "conceptual." Engelbart was interested on a basic level in how humans manipulate knowledge, and what tools and techniques we use to do so most effectively. In its more anthropological turns, "Augmenting Human Intellect" performs a form of metalinguistics, delving into the way communication and understanding meet through the media of culture, language, and technology. Engelbart sought a "common language" for man and machine, one similar to the protocol language recommended by Licklider for the "intergalactic network."[892]

Engelbart was a reader of the language philosopher Benjamin Whorf and of the linguist Alfred Korzybski. Whorf's seminal contributions were in showing how linguistic structures affect thought; accordingly, Korzybski viewed human perceptions as simultaneously shaped and limited by what is expressible in language. Thinking about the computer in terms of language, rather than in terms of logic or mathematics had radical

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[891] Engelbart, Douglas C. "Augmented Human Intellect," Air Force Office of Scientific Research Proposal. The MouseSite Digital Archive. Stanford University. Accessed 5 Sept. 2010. <http://sloan.stanford.edu/mousesite/EngelbartPapers/B6_F2_AugmProp1.html>
[892] Bardini. *Bootstrapping*, 33.

consequences. As Terry Winograd has observed, AI is the apotheosis of traditions of Western reason that has, through Aristotle, Descartes, and Leibniz, attempted to formalize all knowledge "through a precise method of symbolic calculation."[893] Bardini writes that such rule-governed systems "are to the mind what bureaucracy is to human social interaction."[894] If we return to Jon Agar's thesis, this is a more important perception than it appears.

Following Winograd, symbol systems were not really made of logical relationships, but *linguistic* ones, which are only a subset of all formal relations.[895] Thus for Engelbart, the computer was not a "thinking machine," but a "language machine," a potential partner in dialogue. The first step in making computers to work with humans identifying the core structures of language in each system and getting them to translate quickly and easily. One of the subtler contributions of "Augmenting Human Intellect" was a reimagining of the relationship between users and their programs. Alan Kay's later work in object-oriented programming, as well as Xerox and Apple's graphical user interfaces were all products of this new course. Engelbart's attitudes toward symbols and abstractions linked Whorf and Korzybski and subsequent studies of literacy by Havelock and Ong, among others.[896] By establishing a very elemental model for what knowledge

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[893] Winograd, Terry. "Thinking Machines: Can There Be? Are We?" in James Sheehan and Morton Sosna, eds., *The Boundaries of Humanity: Humans, Animals, Machines.* Berkeley: University of California Press, 1991, 198-223.
[894] Winograd. "Thinking Machines," 200.
[895] Engelbart, Douglas. "Longer proposal for AHI." March 1, 1962, Engelbart Papers, box 5, folder 1, 12.Many of the problem solving relations, such as lists, data groupings, and type polymorphism had been developed, or were under development in AI circles. Engelbart recognized that these tools, particularly Newell and Simon's Information Processing Language and McCarthy's LISP, could be useful in constructing common languages. "Since the computer processes will be primarily symbol manipulation as opposed to numerical computation," Engelbart wrote, "we…expect to make use of the elegant programming techniques [heuristic-program AI has] evolved."
[896] Walter Ong and Eric Havelock were scholars of ancient history for whom the invention of writing was a pivotal moment in human intellectual history. They argued, in different fashions, that the invention of the technology of writing fundamentally changed the inventors, for the use of symbols permits a kind of

workers actually *do*, Engelbart began to craft a design philosophy that sought to extend their minds in the most fluent way possible.

As obliges anyone introducing a novel concept, Engelbart carefully defined his terms. "By 'augmenting human intellect'" he wrote, we mean increasing the capability of a man to approach a complex problem situation, to gain comprehension to suit his particular needs, and to derive solutions to problems."[897] While highly technical, augmentation was a humanistic project through and through. Engelbart was steeped in a philosophy of interactivity passed down from second-order cybernetics through Licklider.[898] He viewed human engineering and machine engineering as methodologically equivalent and coterminous.

The work of his lab could often be seen as somewhat unscientific. As Engelbart described it, augmentation implied "a way of life in an integrated domain where hunches, cut-and-try, intangibles, and the human 'feel for a situation' usefully co-exist with potent concepts, streamlined terminology and notation, sophisticated methods, and high-powered electronic aids." The focus on such "soft" factors of technological use obviously derives some influence from "Man-Computer Symbiosis." Licklider was

analytical abstraction—seeing reality as a text to be preserved, arranged, and manipulated—that oral traditions do not. For a sampling of readings on the subject of language and culture, and writing and knowledge see: Havelock, Eric. *The Muse Learns to Write: Reflections on Orality and Literacy from Antiquity to the Present*. New Haven: Yale, 1998.
Korzybski, Alfred. *Science and Sanity: An Introduction to Non-Aristotelian Systems and General Semantics*. Chicago: Institute of General Semantics, 1995.
Ong, Walter J. *Orality and Literacy: The Technologizing of the Word*. New York: Routledge, 1982.
[897] Engelbart, Douglas C. "Augmenting Human Intellect: A Conceptual Framework." The MouseSite, Stanford University, October 1962. Accessed 5 Sept. 2010.
<http://sloan.stanford.edu/mousesite/EngelbartPapers/B5_F18_ConceptFrameworkInd.html>
[898] Ibid. At the end of his proposal, Engelbart paid tribute to Licklider's "symbiosis" as a key driver in effort for a "modern computer." He also referenced Stanislaw Ulam who had called for close man-computer interaction under the name "synergesis," and Simon Ramo whose popular evangelism had influenced even the scientific vanguard.

evidently one of Engelbart's intended audiences; IPTO, helmed by someone very friendly to human factors in engineering would seem an attractive source of funding.

Since Engelbart was consecrated to solving basic social and economic dilemmas—a commitment he himself termed "an epiphany"—his framework was consciously addressed to wider macro-social issues.[899] He had confidence that his proposed program could compete in "social significance" with research on nuclear power, space exploration, or cancer therapies.[900] In the introduction to his prospectus, he restated his long-range intent as a kind of central objective:

> Man's population and gross product are increasing at a considerable rate, but the complexity of his problems grows still faster, and the urgency with which solutions must be found becomes steadily greater in response to the increased rate of activity and the increasingly global nature of that activity. Augmenting man's intellect, in the sense defined above, would warrant full pursuit by an enlightened society if there could be shown a reasonable approach and some plausible benefits.[901]

The immediate research itinerary reflected this mandate. Engelbart resolved to first identify the "factors that limit the effectiveness of the individual's basic information-handling capabilities" in order to meet the "various needs of society" for improved problem solving, and, second, to develop "new techniques, procedures, and systems" to better match these capabilities to the "progress of society." The program was equally invested in the practice of problem solving and in creating concrete tools for the job. Each mutually reinforcing purpose combined basic and implied research, sociology and device engineering, psychology and software. Among the many ARPA-funded programs during the 1960s, Engelbart's was unique in its explicit acknowledgment of the big

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899 Bardini. *Bootstrapping*, 11-12.
900 Engelbart, Douglas C. "Program on Human Effectiveness." December 12, 1961. Engelbart Papers, box 5, folder 7, 1.
901 Engelbart. "Augmenting Human Intellect."

picture. Without all the publicity, he quietly assumed the role of the philosopher-scientist Wiener had inhabited.

The augmented human was defined by feedback. Information flowed through computer circuits just as it did from the rearview mirror of an automobile, through its driver, to its accelerator and steering wheel. Gregory Bateson wondered, considering a blind man and his cane, where does the blind man's self begin?[902] The same attitude toward the whole system could be found in Engelbart's conception of the augmented human. The term "cyborg" was not yet in currency when Engelbart's composed his framework; it had been invented in 1960 by NASA scientists Manfred Clynes and Nathan Kline in the context of adapting human physiology for spaceflight. "The purpose of the cyborg," Clynes and Kline wrote, "is to provide and organizational system in which…robot-like problems are taken care of automatically and unconsciously, leaving man free to explore, to create, to think, and to feel."[903] Engelbart would have concurred with the sentiment.

There were many such adapted organisms among us: "Individuals who operate effectively in our culture," Engelbart concluded, "have already been considerably 'augmented.'"[904] As Donna Haraway has said, "we are all cyborgs."[905] Thus, Engelbart's mission was one of evolution rather than creation, redesign rather than design. For Engelbart, as for Clynes and Kline, "augmenting human intellect" was never intended as a narrow focus on intelligence. "Intellect" was seen as embodied and socially distributed:

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902 Bateson, Gregory. "The Cybernetics of 'Self': A Theory of Alcoholism," in *Steps to an Ecology of Mind*. Chicago: University of Chicago, 2000, 318.
903 Clynes, Manfred E. and Nathan S. Kline "Cyborgs and Space," (1960) in Chris Hables Gray, *et al*. eds., *The Cyborg Handbook,* New York: Routledge, 1995, 31.
904 Engelbart. "Augmenting Human Intellect."
905 Haraway. "A Cyborg Manifesto," 250.

"If we then ask ourselves where that intelligence is embodied, we are forced to concede that it is elusively distributed throughout a hierarchy of functional processes—a hierarchy whose foundation extends down into natural processes below the depth of our comprehension. If there is any one thing upon which this 'intelligence depends' it would seem to be *organization*"[906] For computers to function well as tools designers had to concentrate on the areas of motor control and muscle memory, what Engelbart termed "subprocesses." This kind of open attitude toward feedback took on a very cybernetic flavor. Engelbart joked that "what we are seeking is an 'intelligence amplifier.'" This science fiction trope owed its origin to W. Ross Ashby, an English psychiatrist and one of the founders of the cybernetics movement. Intelligence amplification can be accomplished, over time, genetically, Ashby pointed out. "What is new is that we can now do it synthetically, consciously, deliberately."[907] Implied in this statement is that Engelbart had begun a process of elective co-evolution, by which complex cybernetic biological systems would merge with purpose-built electromechanical instruments.

Engelbart's analysis of the nature of tool use took circumscribed steps into the province of cultural anthropology. Culture had evolved four main media of augmentation: artifacts, language, methodologies, and training.[908] Artifacts were built objects, language the means of knowledge transfer, methodologies standardized approaches to problems, and training the system of skill accumulation. Engelbart's team was interested in all four; each would be tested in the Petri dish of laboratory experiment. "*Evolved* is a good word to use here," he noted, "because our appreciation for the potential worth of possibilities to be developed had to evolve too, and only came

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[906] Engelbart. "Augmenting Human Intellect."
[907] Ashby, W. Ross. *Introduction to Cybernetics*. New York: Routledge, 1964, 172.
[908] Engelbart. "Augmenting Human Intellect."

with the experience and perspective gained in our earlier work." What he termed an "evolutionary process" was a neat description of the haphazard character of laboratory culture and the generally piecemeal trajectory of discovery. The biological metaphor epitomized an attempt to formally integrate the essentially stochastic nature of intellectual breakthroughs into a coherent practice.

To this end, Engelbart planned to use the computer programmers under his command as the first test subjects.[909] This technique, which called a "*bootstrapping* approach," was itself dependent on feedback.[910] By assimilating the fruits of previous work the research team could more effectively pursue the next frontier; successful bits of hardware, for example, were used in the design of new bits. At the same time, every technology was subject to the "usefulness" test—if it was elegant but didn't work as planned, it were thrown out. At the Fall Joint Computer Conference, Engelbart referred to the work of his "bootstrap" group as inherently recursive and self-directed—"developing tools and techniques to make it more effective" at developing tools and techniques. His conception of bootstrapping had an unpredictable circularity in common with Wiener's purposive systems, or Jay Forrester's system dynamics. He called it a "total system basis"—a combination of empirical study and imaginative exploration. Fred Turner argues that this process of collective feedback was actually elevated to a fundamental model of social organization. In Engelbart's environment, individual engineers "might see themselves as both elements and emblems of a collaborative system designed to amplify their individual skills." Encouraging engineers to play with each other's tools became a popular strategy at IPTO's Principal Investigator (PI) conferences,

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[909] Ibid.
[910] Bardini. *Bootstrapping*, 24.

and an important ingredient of the creative, synergistic milieus fostered by later software startups like Google and PayPal.[911]

To make plain the tangible benefits of augmentation, Engelbart included a fictive foray into the future of interactive computing where we meet "Joe," a typical knowledge worker. Armed with a light pen, keyboard, and two monitors, Joe edits text, builds diagrams and flow charts, references his online dictionary, switches between files—a preview of some of what Engelbart would debut at the 1968 FJCC. He inhabits his personal workstation like a cockpit; anything he needs to do is a flick of the fingertips away. One activity that benefitted greatly from an interactive medium was what would be known as what-you-see-is-what-you-get (WYSIWYG) word processing. "It's fun," Engelbart's protagonist effused. "Put that sentence back up here between these two—and blink, it's done. Group these four statements, indented two spaces, under the heading 'shorthand,' and blinko, it's done."[912] The act of manipulating text, visually, on screen allowed users to follow associated trails rather than rigid narratives—to play, test, and experiment. Joe continued: "You are quite elated by this freedom to juggle the record of your thoughts, and by the way this freedom allows you to *work* them into shape. You reflected that this flexible cut-and-try process really did appear to match the way you seemed to develop your thoughts. Golly, you could be writing math expressions, ad copy, or a poem, with the same type of benefit." At the time of Engelbart's writing, document preparation via computer was possible only with clumsy card-entry systems like the Friden Flexowriter, and no dedicated software existed for the purpose. It would have been seen as superfluously expensive to mimic the vehicle of a paper and pencil in a

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[911] Turner, Fred. *From Counterculture to Cyberculture: Stewart Brand, The Whole Earth Network, and the Rise of Digital Utopianism*. Chicago: University of Chicago, 2006, 107.
[912] Engelbart. "Augmenting Human Intellect."

computer when the familiar technology worked adequately and computer time was so dear. But Engelbart imagined a suite of applications—graphics editors, file-sharing, hypertext—that, as an ensemble, would make composing and editing online a value proposition. What could be done in a physical office could be done better in a virtual one. "Existing, or near-future, technology," he predicted, "could certainly provide our professional problem-solvers with the artifacts they need to have for duplicating and rearranging text before their eyes, quickly and with a minimum of human effort."[913]

This sort of free-ranging fantasy was uncommon in ARPA proposals, as was his thorough failure to hint at a military application of his research. Nevertheless, in 1963 he was able to found the Augmentation Research Center (ARC) at SRI on the back of a grant from NASA and, subsequently, ARPA. The ideas laid out in "Augmenting Human Intellect" were not static; they continued to develop in an experimental context. They would supply the groundwork for a number of future developments: a countercultural techno-utopianism that blended the ideals of self-reliance, mind-expansion, agrarianism and information exchange, the office computer as imagined by the researchers at Xerox PARC (many of them alumni of Engelbart's lab), and the cheap, "personal" microcomputer that the hobbyist community, exemplified by the Homebrew Computer Club, mythologized.[914] Engelbart, more than any other, was the agent by which the great

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[913] Ibid.

[914] When PARC was founded in 1970, Robert Taylor, lately director of IPTO, was hired as associate manager. PARC set about building a computer dream team, recruiting several members of Engelbart's lab a few miles down El Camino Real. Taylor was aided by reduced ARPA funding for computing projects, particularly after the controversial Mansfield Amendment of 1973, limiting defense appropriations to strictly military-applicable research.
Hiltzik, Michael, A. *Dealers of Lightning: Xerox PARC and the Dawn of the Computer Age.* New York: Harper, 2000.

currents of interactive computing migrated from Licklider, Fano, and Olsen's Cambridge to the sunnier, more radical environs of Silicon Valley.[915]

This shifting of the locus of momentum is, like other slowly developing processes, a history not well enough understood. The two dominant narratives of the digital computer's development—one of military command and control, and the contrasting cultural story emphasizing the decentralized role of hobbyists and hackers—are geographically distinct. The first centers around M.I.T., Jay Forrester, the Lincoln Lab, and Whirlwind. The second, highlighting Stewart Brand, Xerox PARC, and Homebrew, is decidedly Californian. While each is persuasive in its own limited domain, the histories of computers are too many to be encompassed in a single tidy package. But what began in the early 1960s as a shared enthusiasm for collaborative programming and dedicated computer access in labs like Lincoln and BBN became a deluge in the 1970s on the opposite coast. Engelbart, connected through IPTO to Licklider and through Bill English and Stewart Brand to the counterculture bridged these two worlds. Robert Taylor, himself a butterfly in the many circles of late twentieth-century computer science, was also able to comfortably inhabit both military and countercultural realms, becoming

[915] This shifting of the locus of momentum is a historical event, that like other slowly developing processes, is not well enough understood. The two dominant narratives of the digital computer are the military-research establishment account of Edwards, centered around the M.I.T. of Vannevar Bush, Jay Forrester, Whirlwind and the Lincoln Lab, and a contrasting cultural story, told by Turner, Markoff and others that emphasizes the decentralized role of hobbyists and hackers in California, from Stewart Brand, to Steve Jobs and Steve Wozniak at Homebrew, to radicals like the "phone phreak" Captain Crunch. Each of these narratives has merit; the histories of computers are too many to be encompassed in a single tidy package. But what began in the early 1960s as a shared enthusiasm for collaborative programming and dedicated computer access in labs like Lincoln and BBN became a deluge in the 1970s on the opposite coast. Engelbart, connected through IPTO to Licklider and through Bill English and Stewart Brand to the counterculture bridged these two worlds. Robert Taylor, himself a butterfly in the many circles of late twentieth-century computer science, was also able to comfortably inhabit both military and countercultural realms, becoming the rather low-key doyen of Xerox PARC. This history will show, in part, how Cambridge, Washington, D.C. and Palo Alto shared several important beliefs in common, and how the scientific and cultural approaches to interactive computing can be reconciled. The cross-contamination of these two worlds remains a developing area of scholarship, and much work—perhaps biographies of Taylor, Larry Roberts, Leonard Kleinrock, or Alan Kay—is yet to be done.

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Engelbart, a protégé of the M.I.T. and Pentagon-connected Licklider, was both a physical, and intellectual go-between. What he proposed represented the culmination in the shift in attitudes towards human-computer symbiosis that was occurring at the core of computer science. Many early efforts (some funded by IPTO) had labored to created smarter and smarter machines—some perhaps worthy of the forecasters' designation of "Giant Brains." The heuristic learning programs of Newell and Simon aimed to supplant some aspect of human mental function while shedding new light on the formal elements of human cognition. By aping the nuance and judgment of human thinking, they believed machines might one day surpass their human creators in problem solving ability.[916] Engelbart summarized the work being done in the fields of automation and AI: "Substitution for people in command and control applications seems typical of the projected applications."[917] His tack was entirely different—rather than replacing human capacity by a computer's, augmentation would improve the whole system. A "man-

[916] Engelbart clipped several newspaper articles describing the grand ambitions of AI; one 1961 UPI brief called "Robots May Do Our Thinking," cited Berkeley professor Edward Feigenbaum: "There appears every likelihood that intelligent machines can…think much the same way as an intelligent human being does." Another, from the San Jose Mercury wondered, "Is Day Due When Computer Replaces Executive?" Clippings, Engelbart Papers, box 4, folder 17.
[917] Engelbart, Douglas. "Individual Information-Handling Problems," January 21, 1960 memorandum. Engelbart Papers, box 17, folder 7.

machine team" could produce a "much bigger total payoff," even without dramatic breakthroughs in understanding the nature of intelligence.

Thinkers like Engelbart and Licklider owed much to Wiener, even if the debt was not always acknowledged. Where cybernetics enabled the analogy of brains and computers, the apostles of interactive computing worked to get these two information processing systems working on the same level. To a public versed in the cybernetic register, the idea of man-machine interaction would not have been startling. It was also a favorable alternative to the fully automated workplace of Wiener's nightmares. While I have, to this point, focused largely on how interactivity was formulated by different actors close to the subject, I will next examine how their work was packaged for popular consumption, in both a new quiver of philosophical tropes and in new products aimed at the individual computer user.

Part 5 – The Hippies and the Hobbyists

Chapter 20 – Tactile inputs, hypermedia, and the "peculiar origami of the self"

Just like Licklider, Engelbart inspired followers. Some of them commanded popular audiences, linking computer augmentation to psychedelic mind-expansion. Others made commercial products, seeding a world unfamiliar with the name Douglas Engelbart with devices he inspired. In this section I identify two parallel forces operating on the margins of the mainstream that took up the gospel of personalized computing. The first, the "hippies," were a brand of West Coast radicals for whom high technology and a back-to-nature, communalist lifestyle were not in contradiction. The second were computer tinkerers, amateur and professional, heirs to the ham radio builders of a previous era, who apprehended how thinking with a machine could augment their productivity, and could be downright fun. The mythos spun by writers of the "counterculture" school of computer history (foremost Turner and Markoff) is too often blind to both the intellectual and technical antecedents for the late-sixties and early-seventies computer culture in California.[918] Yet their narrative, deemphasizing the top-down control model of IBM or McNamara's automated battlefield, is essentially correct. Doug Engelbart, whose ruminations on man-machine interaction touched off an entire movement in the Bay Area, himself had countercultural dalliances, notwithstanding his defense-aerospace benefactors. The joy of using computers for exploration is written in the technologies he created.

One of the first areas Engelbart attacked was the poverty of input/output devices, a problem mentioned by Licklider as an ongoing challenge. To Engelbart, building an

[918] Markoff, John. *What the Dormouse Said: How the 60s Counterculture Shaped the Personal Computer*. New York: Viking, 2005.
Turner, Fred. *From Counterculture to Cyberculture: Stewart Brand, The Whole Earth Network, and the Rise of Digital Utopianism*. Chicago: University of Chicago, 2006.

interactive computer system was in some way a matter of realizing a personal fantasy. "I had very real images in my mind of sitting at a display console, interacting with a computer, seeing all sorts of strange symbology coming up that we could invent and develop to facilitate our thinking," he recollected. Before he had even studied computers in a formal setting, he was struck with the intuition that "if a computer could read a card, it could sense keys and any other action I might want to do. If it could drive a printer or a card punch, it could put whatever I wanted onto a display."[919] To materialize this vision, computer I/O would have to be better oriented to normal human motor activity.

Humans involved in complex neuromuscular activity, such as playing tennis or driving a car, perform simultaneously on two levels. The higher, conscious level deals in abstract commands—"hit a backhand," or "turn left at the light,"—and the lower, motor level fulfills these commands in a coordinated fashion. Engelbart called the sources of these actions the "dynamic processor" and the "routine processor." Input/output systems should ideally serve both. The routine processor, the site of embodied knowledge, was too often overlooked by AI programmers; "in conjunction with *all* of the different motor effectors of the human body, [it] can really deliver a great deal more information in a given time to the outside world than that we normally can deliver vocally."[920] In essence, Engelbart argued that if the sum of human behavior was seen as information processing, physical sensorimotor activity was of much higher bandwidth than conscious thought. He needed inputs to tap this channel, graphics to engage the full depth of the human visual field.

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[919] Engelbart, Douglas C. "The Augmented Knowledge Workshop," in *A History of Personal Workstations*, Adele Goldberg, ed. Reading, Mass.: Addison-Wesley, 1988, 214.
[920] Engelbart, Douglas C. "General Program Possibilities." 1961 SRI Seminar, box 2, folder 17. Douglas C. Engelbart Papers (M0638), Stanford University Special Collections and University Archives, Stanford, Calif., 30.

Engelbart's top deputy, Bill English, was an electrical and mechanical engineer who treated his lab at SRI like a woodshop. He brought a post-doctoral researcher, James Bliss, with a degree from M.I.T. in tactile communications.[921]. This was truly a novel approach to computer science. In the months following the ARPA contract, Engelbart and his team experimented with numerous input devices: foot and knee controllers, nose pointers and light-hats to capture the eye's movement, a five-key handset with 31 possible keystroke and chord combinations.[922] There was a persistent feeling that light pens and tracking balls were not ideal instruments to manipulate text and structured items with physical commands. They were simply too physically awkward. Even though the selection techniques ARC explored were uneconomic with contemporary RASTER-scan monitors, by 1964 Engelbart realized that display technology was subject to the same laws of scale as processors; screen selection would become an important aspect of interactive computing.[923]

One prototype, built in 1963 by Bill English, showed promise. A small wooden box, controlled by two perpendicular wheels attached to small actuators, with three buttons and a cord coming out of the back like a tail, it earned the nickname "mouse" around the lab. True to the bootstrapping ethic, a set of experiments were devised wherein lab members tried different selection methods and catalogued their effectiveness with each technology. The verdict showed that the mouse, often in concert with the keyset, was faster and more accurate than the pointers or joystick. It was less awkward

[921] ARC, like the Lincoln Lab, but unlike the nearby Stanford Artificial Intelligence Laboratory (SAIL) was deliberately interdisciplinary. Engelbart often expressed interest in constructing a wider "bootstrap community" of "mature professionals from various organizations and various backgrounds." One such was Stewart Brand, who was brought in on a temporary basis as a photographer and videographer. "Quarterly Report No. 5," May 7, 1967-August 8, 1967. Engelbart Papers, box 2, folder 9.

[922] Engelbart, Douglas C. "Online Computer Systems," 1968. Engelbart Papers box 1, folder 16, 1.

[923] Engelbart. "The Augmented Knowledge Workshop," 194-195.

and fatiguing than the light pen which had to be held close to the screen.[924] When Engelbart left several devices attached to a computer workstation, users consistently preferred the mouse.[925]

The mouse integrated well with the graphical interface Engelbart was building, called the NLS ("oN Line System"). The NLS was a shared platform for ARC's computers that functioned as a proto-virtual desktop, the immersive operating environment later successfully marketed by Apple and Microsoft. Many of its features became standards on these later systems, including hypertext links, electronic mail, search-by-relevance, and screen windowing.[926] NLS had another unique attribute designed to make using it a more intuitive experience. With Bush's "associative trails" in mind, Engelbart designed the NLS such that "Every object in a file should be addressable, because I wanted to do remote jumping and manipulation." Files and directories were assigned multiple, flexible addresses that could be called by clicking a mouse button. It was hoped that the user could maneuver around the address layout in a way that corresponded with his "mental map of his working domain." It was thus intended to be adaptive to the workspace of the individual.[927] Searching through files became a matter of "link hopping on-line (i.e., for automatically hopping to the statement

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[924] Engelbart. "Online Computer Systems," 1-2.
[925] English, William K., Douglas C. Engelbart, and Melvyn L. Berman "Display-Selection Techniques for Text Manipulation," *IEEE Human Factors in Electronics* 8 (March 1967): 5-15.
[926] Unsurprisingly, the lead programmer on ARC's NLS was Jeff Rulifson, who moved to Xerox PARC in the 1970s to work on distributed office systems. When Apple was subcontracted to build computers for Xerox, Steve Jobs visited PARC's office and viewed many of the software developments on hand. "Why isn't anyone commercializing this?" he famously exclaimed. See:
Ceruzzi, Paul E. *A History of Modern Computing*. Cambridge, Mass.: MIT, 2003, 274.
Smith, Douglas K. and Robert C. Alexander. *Fumbling the Future: How Xerox Invented, then Ignored the First Personal Computer*. Lincoln, Neb.: iUniverse, 1999, 242.
[927] Engelbart. "The Augmented Knowledge Workshop," 220.

referred to by a link) [which] would provide… directly for the 'associative trail' techniques prescribed by Bush in his classic 'Memex' paper."[928]

In 1965 an eccentric Harvard graduate student named Ted Nelson first used the term "hypertext" to refer to such an arrangement. Nelson, himself inspired by Bush, was working on a collaborative word-processing system that could track changes through multiple versions of a document. He published an address he had given at the national conference of Berkeley's ACM detailing a file structure that could save and organize such evolving projects. "Hypertext," he defined as "a body of written or pictorial material interconnected in such a complex way that it could not conveniently be presented or represented on paper."[929] Engelbart was traveling a parallel path. Nelson ambitiously predicted, "Such an object and system, properly designed and administered, could have great potential for education, increasing the student's range of choices, his sense of freedom, his motivation, and his intellectual grasp. Such a system could grow indefinitely, gradually including more and more of the world's written knowledge." These very same principles motivated Tim Berners-Lee, a technologist at the CERN particle accelerator in Geneva, who developed an open-source application he called the "WorldWideWeb."[930]

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[928] "THINK PIECE – Possible Intellect-Augmentation Research," November 11, 1965. Engelbart Papers box 1, folder 24.
[929] Nelson, Theodore H. "A File Structure for the Complex, the Changing and the Indeterminate," *ACM: Proceedings of the 20th National Conference,* August 24-25, 1965, 97.
[930] Berners-Lee, Tim with Mark Fichetti. *Weaving the Web: The Original Design and Ultimate Destiny of the World Wide Web by Its Inventor*. San Francisco: Harper, 1999, 5. Berners-Lee paid homage to both Nelson and Engelbart as pioneers whose values of openness, freedom and modularity influenced the web. Nelson has criticized Berners-Lee's adaptation of his ideas—one-way links only, proprietary online material—as an oversimplification. Others have criticized Nelson's project as impractical and overhyped, the "longest running vaporware project in the history of computing," according to *Wired*. Wolf, Gary. "The Curse of Xanadu," *Wired*, June 1995.

Engelbart's hypertext was meant to invoke a kind of flow state. As much as any of his inventions, the branching links of NLS resembled nothing so much as a conversation. A user, triggered by a word or phrase, digressed easily from task to another. Multiple windows facilitated multiple simultaneous conversations. Engelbart began his 1968 demo by saying, "If, in your office, you as an intellectual worker were supplied with a computer display backed up by a computer that was alive for you all day, and that was instantly responsive to every action you had, how much value could you derive from that?"[931] This statement exemplified how computers were positioned at ARC: as interlocutors, as office aids, as partners.

Nelson's contributions to the culture of computer interactivity are weighty enough to merit consideration in their own right. He is notable for propagating the hypertext concept and for his wild-eyed prophecy of ubiquitous digital, graphical media terminals. Just as significantly, he served as a de facto interpreter of Engelbart's work to a different generation. Nelson was a sociologist and an educator and, above all, a revolutionary; Stewart Brand claimed he has been "accurately depicted as the Tom Paine of the personal computer revolution." Brand explained: "The enemy was Central Processing, in all its commercial, philosophical, political, and socio-economic manifestations. Big Nurse."[932] For Nelson, it was usually figured as IBM.

His 1974 screed, *Computer Lib/Dream Machines* aimed to mobilize opinion to the cause of machines made more human. It is a kind of Escher's "Drawing Hands" – two books back-to-back, meeting in the middle, each revealing part of the other.

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931 Engelbart, Douglas. 1968 Fall Joint Computer Conference demo, San Francisco. Video accessed 5 Sept. 2010. <http://sloan.stanford.edu/MouseSite/1968Demo.html>

932 Brand, Stewart. "Foreword to the 1987 Edition," in Ted Nelson, *Computer Lib/Dream Machines*. Redmond, Wash.: Microsoft Press, 1987, i.

Computer Lib was a primer on current computer technology after the fashion of *Giant Brains*; its central premise was summed up by its subtitle: "You can and must understand computers now!" *Dream Machines* was a more exploratory journey into the machines of the future and their capacity for hypermedia, video, art, and education. Both faces of the codex are punctuated with Nelson's personal politics—anticorporate, distrustful of unilinear broadcast media, and libertarian. This politics defied standard partisan demarcations: Nelson introduced a 1980 piece he wrote for *Creative Computing* with an epigraph from Barry Goldwater.[933] In general, however, Nelson was happy to play the role of a conduit from a technological establishment he despised and a rising revolutionary counterculture that was just beginning to appropriate and *détourne* computers to its own ends.

"The chasm between laymen and computer people widens fast and dangerously," Nelson warned in the opening pages of *Computer Lib*. Technological knowledge was jealously guarded by a priesthood of adepts. He abhorred the creeping professionalization of the computer discipline. How could ordinary people experience the information revolution when even hobbyists and computer buffs were isolated from the often-classified breakthroughs achieved in universities and ITPO contract sites? Nelson was a strident Paine-like pamphleteer, self-publishing his book, preaching to any who would listen. "This book," he lamented, "is a measure of desperation, so serious and abysmal is the public sense of confusion and ignorance…Most of what is written about computers for the layman is either unreadable or silly."[934]

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[933] Nelson, Ted. "Object and Actor Languages," *Creative Computing*. October-November 1980. Box 6. Keith Henson papers (M1292), Stanford University Special Collections and University Archives, Stanford, Calif.
[934] Nelson, Ted. *Computer Lib*, Redmond, Wash.: Microsoft Press, 1987, 1.

Yet there was nothing inherently mysterious about the workings of computers. As Engelbart attested, they could be understood by means of simple logical games. They needed to be understood because computer automation was transforming the economy, but also because information processing was mankind's primary activity. Nelson shared with Engelbart and Licklider the information-centric Weltanshaaung developed by Wiener. "Computers are simply a necessary and enjoyable part of life, like food and books," he wrote. "[They] are not everything, they are just an aspect of everything, and not to know this is computer illiteracy."[935] *Computer Lib* was a first course, designed as much to soothe as to initiate. The book, he hoped, would "make you feel more comfortable (or at least able to cope) when new machines encroach on your life."

In fact, there existed a number of avenues of information science that did not fit into Nelson's liberationist philosophy—game theory, decision theory, hard AI, operations research, to name a few. His prose illuminated a viewpoint shared privately by many in Licklider and Engelbart's camps: "Man has created the myth of 'the computer' in his own image, or one of them: cold, immaculate, sterile, 'scientific,' oppressive." While this image attracted the McNamaras and Forresters of the world, scientists at the Pentagon and General Electric, there were others who "see computers for what they really are: versatile gizmos which may be turned to any purpose, in any style. And so a wealth of new styles and human purposes are being proposed and tried, each proponent propounding his own dream in his own very personal way."[936] Computers could be warm, he averred. They were instruments for information handling, no different in this

[935] Ibid.
[936] Nelson, Ted. *Computer Lib*, Redmond, Wash.: Microsoft Press, 1987, 2.

way than a toaster, a bathtub, or an automobile—all associated with warm human activities.[937] Thinking with symbols and language could be creative and empowering.

This was where *Computer Lib* became *Dream Machines*. The "flip side" could be read first, or in place of its slightly more technical cousin. "Feel free to begin here," Nelson advised. "The other side is just if you want to know more about computers, which are changeable devices for twiddling symbols. Otherwise skip it."[938] Marshall McLuhan, the media guru of the 1960s, had taken cybernetics to mean that the world was uniting as a single information system.[939] Communication flowed through particular channels he called "media," technological paradigms like Mumford's technics, which themselves, in their form and structure, determined the meanings that were drawn from communication. Hence his oft-quoted and oft-misunderstood maxim, "the medium is the message." Nelson disagreed. The computer was yet another agent of the mass media—a sibling to books, radio, television, and movies. It mediated people's interactions with knowledge. "Anything can be said in any medium," Nelson wrote. But it *was* more open, and potentially a great deal more multidirectional (denoted by the term "hypermedia") than its forebears. The computer was, rather, a "projective system" that could be converted to any purpose. The free flow of information held the key to breaking down entrenched formalities like the "time slot," or the "program."[940] But it would need to be designed that way. Nelson complained, ""The computer and electronics people are like generals preparing for the last war…THE TECHNICALITIES MATTER A LOT,

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[937] Nelson, Ted. *Dream Machines*, Redmond, Wash.: Microsoft Press, 1987, 2-3.
[938] Nelson, Ted. *Dream Machines*, Redmond, Wash.: Microsoft Press, 1987, 1.
[939] "If the work of the city is the remaking or translating of man into a more suitable form than his nomadic ancestors achieved, the might not our current translation of our entire lives into the spiritual form of information seen to make of the entire globe, and of the human family, a single consciousness." McLuhan, Marshall. *Understanding Media: The Extensions of Man*, Cambridge, Mass.: MIT, 1994, 61.
[940] Nelson, Ted. *Dream Machines*, Redmond, Wash.: Microsoft Press, 1987, 5.

BUT THE UNIFYING VISION MATTERS MORE."[941] Berkeley, Licklider, and Taylor had all predicted the future shape of computers by analyzing the myriad ways they might be employed—as small, kitchen machines, or as networked communication devices. Their prophecies, enabled by their advocacy, had all borne more fruit than the prognoses of those who only projected forward technical specifications. Nelson adopted this long view of what computers could do.

The great revelation of Engelbart's 1968 demo, for Nelson, was that computers could be powerful enablers of *consciousness*. His "special concern" was to help others write, think, and show by computer.[942] In this context, his manifesto's title took on a dual meaning: its subject was, of course, the shape of things to come. With characteristic lyricism he wrote, "Technology is an expression of man's dreams." But using a computer should also evoke a feeling of lucid dreaming: "To work at a highly responsive computer display screen, for instance, can be deeply exciting, like flying an airplane through a canyon, or talking to somebody brilliant. This is as it should be." Nelson was fond of a quote he erroneously attributed to Bertrand Russell, a logician born at the tail end of the Romantic age: "The reason is, and by rights ought to be, slave to the emotions."[943] Though the quote was not Russell's, its meaning to Nelson was clear—computers should be instruments of passion and joy as much as of logic.

Thus, computers in schools should be employed to promote curiosity and wonder. Nelson worried that "Computer-Aided Instruction," or CAI, a subject near to the hearts of

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[941] Nelson, Ted. *Dream Machines*, Redmond, Wash.: Microsoft Press, 1987, 1.
[942] His long-running "Project Xanadu" was, at heart, an idealized office suite dedicated to these aims.
[943] Nelson, Ted. *Dream Machines*, Redmond, Wash.: Microsoft Press, 1987, 10. Nelson actually misattributed the quote to Russell. The quote "Reason is, and ought only to be, slave to the passions," derives from David Hume's "Dissertation on the Passions" published nearly two centuries earlier at the other bookend of the Romantic Movement.

Engelbart and Licklider, might only expand the regimented boredom of current compulsory education. Articles appearing in *Scientific American* and elsewhere posited computers as aids in the organized taxonomy of subject units, the memorization of rules and axioms, and "objective" evaluation.[944] *Dream Machines* advocated less "instruction" and more augmented exploration. The process of learning was exceptionally amenable to the branchings of hypertext. "I think that when the real media of the future arrive, the smallest child will know it right away (and perhaps first)," he explained. "That, indeed, should and will be the criterion. When you can't tear a teeny kid away from the computer screen, we'll have gotten there." If computers were not *fun*, they were much less valuable.

Nelson had high regard for the co-inventor of hypertext. Appointing himself a modern-day Huxley to Engelbart's Darwin, he wrote of the mouse as one of the best of existing selection mechanisms. He cited Engelbart as a leading investigator of "collateral structures"; Engelbart had also recognized the utility of "prefabricated environments" for easy navigation as an alternative to the rote learning of compiler languages. Nelson further proposed the term "thinkertoy" to describe systems to help people think. This was a translation: it was "the same general idea for which Engelbart, for instance, uses the term 'augmentation of intellect.'"[945] Nelson was more comfortable in the avant-garde than Engelbart, but he carried significant influence among artists, writers, programmers, hackers, and computer enthusiasts, particularly on the West Coast.[946] By drinking deeply of Engelbart's ideas he imbued rather dry technologies some of the flair and panache of

[944] Suppes, Patrick. "The Use of Computers in Education," *Scientific American.* September 1966, 206–220.
[945] Nelson, Ted. *Dream Machines*, Redmond, Wash.: Microsoft Press, 1987, 6.
[946] Markoff, John. *What the Dormouse Said: How the 60s Counterculture Shaped the Personal Computer*. New York: Viking, 2005, 158, 171.

1960s cultural politics. The way we might imagine Engelbart's media machines, embodied all the "strange inversions and foldovers of the rest of the mind and heart." Computer graphics, hypertext, communication devices uniquely helped blossom "the peculiar origami of the self."

Another apostle of Engelbart's revolution was the prodigious programming visionary Alan Kay. Kay was as much an artist as a computer scientist; a math and biology major at the University of Colorado, he spent most of his time playing guitar semi-professionally and writing stage music for university productions. Continuing his Renaissance career at the University of Utah under David Evans and Ivan Sutherland, one of his first assignments was to decipher a rare Norwegian variant of Algol-60—Simula—gathering dust on a paper tape in Evans' office. As Kay poured over the machine code, he discovered that the language was actually structured similarly to SKETCHPAD, having the capability to define classes, subclasses, and methods as discrete "objects," selectively callable by outside processes. Though the objects were made up of widely different functions, the packages had a coherent overall purpose, allowing them to be manipulated like building blocks in a larger meta-structure. This "polymorphism" of types, Kay thought, made programming much simpler and more intuitive. When Kay joined Robert Taylor's squad at Xerox PARC, he drew on these principles to build the Smalltalk programming environment. "Object-oriented programming," in Kay's phrase, was instituted in several different iterations of Smalltalk, commercialized on the Apple II and other platforms, and widely used for teaching computer literacy to children.

Kay's humanistic orientation ran deeper than most of his contemporaries. He described Smalltalk in sweeping metaphysical terms: "Smalltalk's design—and existence—is due to the insight that everything we can describe can be represented by the recursive composition of a single kind of behavioral building block that hides its combination of state and process inside itself and can be dealt with only through the exchange of messages." The parts, in other words, contained the same power as the whole. Like Wiener, Kay was proud to lay claim to a long intellectual heritage, promulgating his outlook's many antecedents in Western philosophy. He was aware of the structural similarity of his universal claim for Smalltalk's genesis and Leibniz' monadology. Smalltalk's objects were equally, he claimed, "Platonic ideals from which manifestations are created."[947]

In contrast to Nelson, Kay always had one eye toward practicality, and some ability to exist in a business environment. Several of his projects at PARC were ultimately brought to market, sometimes staying within their allotted budget. A corporate environment was something of a transition; after working enormous ARPA contracts at Utah, he had to ask PARC's Bill English (who had lately moved from SRI) "What's a budget?"[948] There was a sense that, though private, PARC inherited the intellectual tradition that had begun at IPTO. "Bob [Taylor] was always foisting Licklider's papers on us," hardware engineer Chuck Thacker recalled.[949] PARC managed a balance between business discipline and a missionary fervor to save the world. Kay remembered its collegial atmosphere thus:

> A lot of daytime was spent outside of PARC, playing tennis, bike riding, drinking beer, eating Chinese food, and constantly talking about the Dynabook and its potential to amplify human reach and bring new ways of thinking to a faltering civilization that

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[947] Kay, Alan. "Smalltalk," in Thomas J. Bergin and Richard G. Gibson, eds. *History of Programming Languages II*. New York: ACM, 1996, 512-513.
[948] Kay. "Smalltalk," 527.
[949] Waldrop, M. Mitchell. *The Dream Machine: J.C.R. Licklider and the Revolution that Made Computing Personal*. New York: Penguin, 2002, 363.

desperately needed it (that kind of goal was common in California in the aftermath of the sixties).[950]

The "Dynabook" was Kay's long-sustained dream of creating a notebook-sized computer with a tablet graphical interface, running a Smalltalk-kernel operating system. It would have adapted Engelbart's NLS to present a virtual desktop overlapping, stacking documents on a bitmapped display.[951] The goal was to get affordable, personal machines into the hands of children, endowing them with the opportunity to, as Ted Nelson put it, "write, think, and show" via computer.[952] Kay agreed with Nelson that computers ought to be not only a "personal dynamic vehicle," but a medium. Before PARC, Kay had worked with engineer Ed Cheadle who hoped to produce an interactive digital computer, like the room-sized TX-2, small enough to fit on a desk.[953] The software system he designed, FLEX, was stripped-down but functional; much of its code was ported to Xerox's desktop model Alto, which Kay quixotically referred to as the "interim Dynabook."[954]

PARC is justly famous for inventing the first "personal" computer. Claims like these are made to be disputed; the TX-0, Datapoint Corporation's 2200, MITS' Altair 8800, and even Honeywell kitchen computer (none were ever sold) could be construed to fit the definition. Nevertheless, the Alto was the first machine to fit the form it would be recognized for decades after, spurring Apple, Commodore, Tandy, and IBM's subsequent models. When Xerox V.P. of Corporate Planning asked Kay how to anticipate trends in

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[950] Ibid.
[951] Kay. "Smalltalk," 530-531. Kay opted for an iconic interface rather than a direct symbolic approach after consulting with PARC's Jef Rulifson—another ARC transplant and the lead programmer of NLS.
[952] Kay's original paper—"A Personal Computer for Children of All Ages,"—written at PARC several years after he began developing the concept, is available on the web (accessed 5 Sept. 2010): <www.mprove.de/diplom/gui/Kay72a.pdf>
[953] Kay. "Smalltalk," 518.
[954] Robert Taylor Oral History, Computer History Museum, Woodside, Calif., October 2008, 23. Accessed 5 Sept. 2010. <http://www.computerhistory.org/collections/accession/102702015>

the marketplace and defend against them, Kay's famous response was "Look, the best way to predict the future is to invent it."[955] What Kay failed to predict was the latency between invention and commercialization.

Xerox never marketed the Alto under that name. Xerox management in Rochester, New York rarely visited the company's laboratories in Palo Alto, operating on the other side of a geographic and cultural divide. Reporters Douglas Smith and Robert Alexander write,

> From the time of its invention in the late 1940s through the end of the 1970s, computer technology remained unaffordable, inaccessible, and useless to most people. Computers were owned by corporations and universities, not individuals; operating the technology required a knowledge of protocols and arcane as any used in international diplomacy; and, all the effort yielded results for a narrow set of applications… The greater possibility to define and dominate the unfamiliar business of personal computing smoldered unproductively within the company for more than a decade.[956]

Smith and Alexander's book is titled *Fumbling the Future: How Xerox Invented, then Ignored the First Personal Computer*. Did Xerox "fumble the future" by ignoring the utopic dream machine created by its revolutionary longhair engineers? The phrase seems to suggest that Xerox let PARC's efforts go entirely to waste. In fact, several PARC innovations found their way into the product lines of Xerox's core business; the laser printer that was invented by Gary Starkweather in 1969 leant a critical ingredient of the company's copier technology.[957] Further, it assumes, teleologically, that Xerox misjudged future developments that were fully evident before their time. Rather, from the point of view of Xerox headquarters in 1973, the Alto personal computer, costing tens of

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[955] Kay. "Smalltalk," 527.
[956] Smith and Alexander. *Fumbling the Future*, 15.
[957] Conversely, several PARC technologies not intimately related to personal computing would also be commercialized elsewhere, notably, Robert Metcalfe's work on Ethernet protocols, which would form the basis of his start-up 3COM. See Metcalfe's original paper, which he wrote with PARC's David Boggs. Metcalfe, Robert and David Boggs. "Ethernet: Distributed Packet Switching for Local Computer Networks," *Communications of the ACM*, July 1976, 395-404.

thousands of dollars to produce, would have seemed nothing more than an interesting skunkworks lark—a demonstration piece like the "cars of the future" that routinely appear at the North American International Auto Show. There was no market for personal computers. The hobbyists that two years later responded in such force to the January 1975 *Popular Electronics* cover advertising MITS' Altair 8800, the "World's First Minicomputer Kit to Rival Commercial Models," were, to Xerox, an ancillary community.[958] In 1975 MITS was shipping approximately 1,000 machines a month at $621 (assembled); this was small change for a company that brought in roughly $2 billion in revenues.[959] Letting the personal computer sit on the shelf and harvesting smaller, incremental technologies from PARC made business sense from Xerox. It would be eight years before IBM entered the PC market with its eponymous machine, and sales ramped. Though it never directly entered the marketplace, the Alto influenced Apple, Windows (Microsoft began by offering a form of BASIC for the Altair 8800), and future desktop computing systems. There is a clear line of succession from Engelbart, through Kay, to PARC, and to Jobs and Wozniak, and Engelbart is thus largely credited as the grandfather of personal computing. He, Nelson, Kay, and other articulate clairvoyants of interactive computing gave life to an intellectual environment where personal machines would become ubiquitous.

Despite the many tangible products that came out of Engelbart's lab, there were many who viewed ARC as marginal within the greater IPTO experiment. It was "soft" science—focused on human psychology and communication; engineers at the nearby Stanford Artificial Intelligence Laboratory (SAIL) and on the East Coast were more

[958] Roberts, H. Edward and William Yates. "Altair 8800 minicomputer," *Popular Electronics* 7 (January 1975): 33-38.
[959] "Worlds Most Inexpensive BASIC language system," *Popular Electronics* 8 (August 1975): 1.

concerned with the mechanics of timesharing and logic programming. Robert Taylor remembered, "Even in the ARPA community, there were a lot of people who thought that Engelbart's work was silly. To Them, Engelbart was not doing serious science. They just didn't understand the importance of writing and communicating, or the human implications of a computer's acting as a communications device."[960] But Licklider and Taylor were potent allies, and ARC, which became one of the four inaugural ARPANET nodes, slowly won converts. Moreover, Engelbart's vision tapped into a certain public consciousness of the value of working with a computer; machine "augmentation" could be both liberating and exhilarating. This vision, as it was exported to the public, was an integral component of what would become the hacker ethic, and, later, the personal computer revolution.

Doug Engelbart took what had been an inchoate idea shared among a small community of true believers and helped make it a religion among a new generation of engineers. He invented for it a new lasting theoretical basis for future development of computers that responded to their users in physical, graphical, and linguistic modes. At the same time, he provided substantial experimental evidence for the speculative front launched by Licklider, Ramo, and other prophets of interactivity. Programs and devices that aid in man-machine symbiosis *could* be built and they *were* effective. Engelbart was by no means alone in his campaign, nor did he create a movement out of wholecloth. Yet he represents the point at which interactivity transitioned from an idiosyncratic cult outside the computer science mainstream to the mainstream itself. "For centuries, men and machines have been co-operating, and have had interfaces across which information had to be interchanged," he wrote. "Suddenly, though, we find the phrase 'man-machine

[960] Waldrop. *The Dream Machine*, 289.

interface' joining the OK list and representing a significant new problem area."[961] Engelbart was profoundly aware of the history of information science and the role he played. Centuries of Western reason had progressively elevated problem solving to a formal process divorced from human creativity and spontaneity; the augmentation project reconceived it as a symbolic dialogue or a social interaction.

Chapter 21 – Computer culture as counterculture?

Technology is not only about plastics and circuits, gears and engines. New and more powerful tools are created every day, only to be cast aside in favor of alternative, or, sometimes, older methods. To gain acceptance, products must connect with a market. They require the good fortune to be born in a time and place where their superior benefit is undeniable to a group of users—a trait Xerox's Alto lacked. Likewise, they must weave a narrative of social utility, engineering elegance, affordability, and, perhaps most of all, inevitability. Marketers call this ambiguous factor "cool." "If my competitors will

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[961] "Edits for *Electronics* article," Engelbart Papers, box 1, folder 15.

all be using this item, I must as well," the prospective customer thinks. Thus all technological success stories embed an element of futurism. When a computer makes the most sense as a purchase is when it is practical today and indispensable tomorrow.

If Engelbart had been operating in a cultural vacuum, it seems likely that no market might have ever embraced the mouse, the virtual office, or the computer word processor. Other computer histories need not include Engelbart. He and his ilk did not *discover* interactive computing; they *made* it. To read only the history of today's popular products amounts to gross survivorship bias. In fact, Engelbart was not a lonely engineer, toiling in an obscure workshop. He was a participant in a cultural movement of which computers played a small, but important part. The figure who serves as the best guide through this movement is the author, journalist, publisher, futurist and philanthropist Stewart Brand. His contribution to the digital state of the art is less than some contemporary reporters have construed, but as a maker of mass consciousness, he is unsurpassed.

Our technologies tell us a good deal about ourselves: who we aspire to be—and, by extension, how we see ourselves as a society. In 1967, the game theorist, nuclear strategist, and atomic age futurologist Herman Kahn published a book titled *The Year 2000*, in which he speculated on the role computers might play in society thirty years hence.[962] Among his predictions was something resembling the Singularity hypothesis of mathematician and science fiction author Vernor Vinge: "If computer capacities were to continue to increase by a factor of ten every two or three years until the end of the century (a factor between a hundred billion and ten quadrillion), then all current concepts

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[962] Excerpted in *The Whole Earth Catalog*, Fall 1968, 17.
Ghamari-Tabrizi, Sharon. *The Worlds of Herman Kahn: The Intuitive Science of Nuclear War*. Cambridge, Mass.: Harvard, 2005.

about computer limitations will have to be reconsidered."[963] Kahn considered not only improvements in processor power, but in input-output devices, simulation, programming, and understanding of the art itself, estimating an upward error band of several billion times above his initial guess. Thus, he concluded, "It is necessary to be skeptical of any sweeping but often meaningless or nonrigourous statements such as 'a computer is limited by the designer—it cannot create anything he does not put in,' or that 'a computer cannot be truly creative or original.'" Kahn's futurism is reflective of a period of enthusiastic re-making. He imagined a society where every technological and political boundary could be transgressed.

He went on, "By the year 2000, computers are likely to match, simulate or surpass some of man's most 'human-like' intellectual abilities, including perhaps some of his aesthetic and creative capacities, in addition to having some new kinds of capabilities that human beings do not have." If such achievements actually proved impossible, this would be an equally sensational discovery. Kahn viewed computers as humanity's foil. In their parallel evolution they mirror their human creators; they could be either something dull, mechanical and programmable, or conversely, something magically transcendent. Kahn's reviewer in the Fall 1968 *Whole Earth Catalog* perceived the book to be less a window into the future than a picture of the technologically optimistic present. Profoundly, he

[963] To Vinge, a "technological singularity" occurs when the pace of technological advancement—artificial intelligence, for example—reaches a near vertical asymptote. Technology on the other side of the "singularity" becomes so advanced that it cannot be understood or even perceived by previous science. The idea has analogues in I.J. Good's 1965 assertion that if machines came to design themselves in more sophisticated ways than could humans, the resulting recursive positive feedback loop would cause an "intelligence explosion" far beyond the understanding of present machine designers. Stanislaw Lem had earlier spoke of an "essential singularity in the history of the race," arrived upon in the course of the "ever accelerating progress of technology." See:
Vinge, Vernon. "The Coming Technological Singularity: How to Survive in the Post-Human Era," VISION-21 Symposium, NASA Lewis Research Center, March 30-31, 1993. Accessed 6 Sept. 2010. <http://www-rohan.sdsu.edu/faculty/vinge/misc/singularity.html>
Matlis, Jan. "Quickstudy: The Singularity," *ComputerWorld*, July 24, 2006. Accessed 6 Sept. 2010. <http://www.computerworld.com/s/article/112442/The_Singularity>

wrote, “We are what we think our future is.”[964] This was a perception at the intersection of technology and culture, touching on the most serious social aspects of computer science. The artifacts of the “information age” are found, it follows, in the literature of the information age itself. Historians of the era, he implied, are faced with the task of becoming historians of the future.

The reviewer’s name was Stewart Brand, and he was a professional peddler of Big Ideas like this. The *Whole Earth Catalog*—countercultural bible, idea farm, and bulletin board for a nouveau social and environmental cybernetics—was his homemade jungle gym. Though the *Catalog*’s content ranged from gardening implements to books on Eastern religion, Brand smuggled in enough computer talk—in Nelson’s radically democratic, interactive idiom—to influence a great number of people on either side of the cordon of the computer priesthood. Later, when he helped found the Whole Earth ‘Lectronic Link (WELL) online community, organized the first “Hackers’ Conference” in 1984, and published the *Whole Earth Software Catalog*, Brand became directly associated with promoting information technology.[965] In 1968, however, he was more notable as one of Ken Kesey’s Merry Pranksters, a member of both Greenwich Village bohemia and the burgeoning West Coast psychedelic scene. Brand found himself at the

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[964] “Review of Kahn,” *The Whole Earth Catalog*, Fall 1968, 17.

[965] The WELL, one of the most vibrant early Internet communities, has been a subject of much reminiscing. Brand told the *San Francisco Examiner* that the community was the “kind of thing coffee shops were supposed to be about, but are pretty hard to find these days.” The reporter agreed, describing communicating over the network as “a back-fence chat.” Computer popularizers like Brand and Berkeley made rich use of one particular asset—the social network. In real life, they founded societies, organized conferences, and spoke regularly with experts outside their fields. Here Brand was importing a despatialized version of that network to the early Internet. Prominent users included Berkeley’s Lee Felsenstein and the famous phone booth hacker Captain Crunch. See:
Ferrell, J.E. “Teleconferencing is like a back-fence chat,” *San Francisco Examiner,* July 8, 1985 clipping, box 26, folder 1. Stewart Brand Papers (M1237), Stanford University Special Collections and University Archives, Stanford, Calif.
For a retrospective on the WELL, see:
Rheingold, Howard. *The Virtual Community: Homesteading on the Electronic Frontier*. Cambridge, Mass.: MIT, 2000.

crossroads of just about every major cultural trend between 1960 and 1980, and managed to integrate all of them into a *gestalt* of personal liberty, autonomy, and psychedelic experimentation. His tortuous, ambivalent relationship with computers is unfit for a short description, and therefore we must trace its roots before evaluating The *Whole Earth Catalog* as computer literature.

Brand was born in Rockford, Illinois in 1938, the son of an advertising copywriter and a ham radio operator. Amateur radio and the computer hobbyist culture share much in common: a do-it-yourself aesthetic, the salvaging of cheap parts, kits marketed by electronics companies like Heath, and, critically, a predilection to fraternal community formation, either over the shortwave or through flyers, meetings, Usenet groups. That Brand came from such Midwestern technical stock, like the integrated circuit co-inventors Jack Kilby and Robert Noyce, is easily forgotten in light of the divergent path he traveled. Eager for his son to be intellectually stimulated, Arthur Brand sent him to Phillips Exeter Academy and then to Stanford University, where he majored in biology. At Stanford, Brand studied with population ecologist and prophet-of-doom Paul Ehrlich, who impressed him with the need for guardianship of natural resources, and the fragile balance of ecological systems. Conservation formed one of the core tenets of Brand's philosophy thereafter. "My philosophy comes from Biology, principally evolution and ecology," he noted in his journals, "and might as well be called pragmatic."[966] The ethic of naturalism was comingled with the humanism common to the generation that reached adulthood in the 1960s, and was shared by select older thinkers like Licklider and Engelbart. "I care about my generation, about people…" Brand confessed, "about the

[966] Brand, Stewart. November 1962 journal, Brand Papers box 17, folder 13.

future and the possibility of improving it (i.e., making it survivable.)"[967] He sought not only a salve against social and environmental breakdown, but a method to augment the individual. He professed the "need for civilian-available training…to raise individual capability beyond what the individual thinks is possible."[968] Not intimately familiar with computers at the time, Brand spoke of psycho-spiritual training. Nevertheless, he would have doubtless recognized an intellectual compatriot in Engelbart.

Brand's journals wonderfully reveal a personality in formation. They are an excellent microcosm of the type given to captaining cultural movements—"Uneven moods. Excessive. Excellent enthusiasm and courtesy, then moroseness and rudeness… Informed lightly on many topics, entirely ignorant by choice on the rest." From the beginning, Brand exhibited a kind of breathless megalomania, the ability to connect with tremendously varied groups, and a restlessness that compelled him to move on to the next Big Idea before the last one was stale. The journals are also shine a spotlight on a generation; they reflect the independent, questioning character of 1960s youth culture, the passion for things natural and authentic, notes of sincerity of purpose and the shallowness of inexperience. At his graduation in 1960, Brand wrote: "Bohemian, I'm finding, stands for a set of values which are totally Romantic, to wit: Everything natural and simple is good; the bad in us comes from over-civilization. The supreme pleasure is in the spontaneous moment, and no pleasure is to be denied. The life of man is Art. Love conquers all. These things are quite true and practicable."[969] He had begun to see the

[967] Brand, Stewart. 1957 journal, Brand Papers box 17, folder 3.
[968] Brand, Stewart. 1966 journal, Brand Papers box 17, folder 11. Brand was experimenting, like many of his peers, with the concept of metamorphosis, of elected evolution. If technology (chemical or computer) would aid in the transformation, it was welcome. "Would the caterpillar prevent metamorphosis if he could?" he wondered.
[969] Brand, Stewart. July 4, 1960 letter. Brand Papers, box 2, folder 15.

romance of social utopia coexisting with the natural environment, embraced by a set of ideas implicit in the later back-to-the-land movement, or that historian Fred Turner calls, more broadly, "the New Communalism."[970] Simultaneously, Brand saw "grace in iconoclasm"—that is, a fierce emphasis on individuality and personal liberty that seemed at odds with the ethos of community. Brand wrote at length of the Soviets, who he deemed a hyper-rational, mechanical menace dedicated to stamping out individualism.[971] Reconciling these two values would occupy much of his life's work; at their crossroads appeared the Personal Computer—a weapon to fight entrenched power, a mirror to explore one's own mind, and a medium to communicate with others.[972]

After graduation, Brand was conscripted into the army, where he endured officer candidacy school and became a platoon leader at Fort Dix, New Jersey. Fort Dix was a repressive bureaucracy, but Brand found solace in the weekends he took in nearby Manhattan, fraternizing with avant-garde artists like John Cage and Robert Rauschenberg. In a letter to his father he stated, "My attitude toward the Army continues to be about the same as my attitude toward gravity. Omnipresent, amoral, limiting, but capable of being put to use."[973] Despite a desire to discipline himself and learn to adapt under pressure, Brand was a poor army officer. His commanding colonel wrote several letters of reprimand; one read, "Your potential as an officer has not been limited by your intelligence, but by your arrogant attitude. Time and again you have made it painfully

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[970] Turner, Fred. *From Counterculture to Cyberculture*. 4-5

[971] He wrote, in 1957, that "If there's a fight, then, I will fight. And fight with a purpose. I will not fight for America, nor for home, nor for President Eisenhower, nor for capitalism, nor even for democracy. I will fight for individualism and personal liberty. If I must be a fool, I want to be my own particular brand of fool—utterly unlike other fools. I will fight to avoid becoming a number—to others and to myself." Brand, Stewart. 1957 journal, Brand Papers box 17, folder 3.

[972] Brand wrote, "I want a new medium, for all of us." Brand, Stewart. June 15, 1972 journal, Brand Papers box 18, folder 1.

[973] Brand, Stewart. November 22, 1960 letter. Brand Papers, box 2, folder 15.

obvious that you consider yourself too god for your job and too superior to be bothered by the responsibility of an officer within a training company."[974]

Discharged from the army in 1962, he worked washing dishes in Yellowstone National Park, and logging in Oregon. He dabbled in psychedelic drugs, took Ken Kesey's "acid test," but declined to ride the Magic Bus east.[975] As Tom Wolfe put it, Brand epitomized "the restrained, reflective wing of the Merry Pranksters."[976] He became a serious photographer; his chief subject was Native Americans. Photojournalism suited Brand's provocative, artistic temperament. In the army, he learned "that bureaucracy is terrified of the truth, any truth," and it became an explosive in his hands. "I learned the rage and shame that despotism brings," he wrote, melodramatically, "and I learned the joy of resistance."[977] Thus, if conservation was one pillar of Brand's outlook, information comprised the other. The *Whole Earth Catalog* served as an information vehicle, a guide to a self-sustaining lifestyle, and a portal to a wider community, a wider world.

In 1966, perhaps motivated by Ehrlich's teaching, Brand sent a letter to architect Buckminster Fuller wondering "why haven't we seen a photograph of the whole earth

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[974] "Report from commanding officer," August 14, 1962. Brand Papers, box 4, folder 10.

[975] When his parents wrote to express concern that Stewart was becoming involved with unsavory, druggy-types, he responded with some vitriol that hallucinegens were a legitimate outlet of personal freedom. "[T]hey accelerate access to information, to alternatives, thus to freedom," he wrote his father. "More freedom forces more responsibility—due to the inexorable working of an old old equation—and any increase of freedom and responsibility is what I call education. And I'll goddamn well defend it from Federal or any other regulation of its content or availability. On this matter I'm an Arch-conservative." Psychedelics were tools of communication and exploration, as computers could be. Brand's defense of drug culture mirrored his later defense of cyberculture, as a unrestricted zone of personal freedom. Brand, Stewart. February 8, 1966 letter. Brand Papers, box 5, folder 20.

[976] Wolfe, Tom. *The Electric Kool-Aid Acid Test*. New York: Bantam, 1999, 12. Brand's first exposure to LSD-25 occurred on December 10, 1962 with Dr. John Sherwood of the International Foundation for Advanced Study. The then-legal psychological study asked participants to "explore new areas of experience," and later describe them in a group-therapy session. Brand, Stewart. December 10, 1962 journal. Brand Papers, box 4, 14.

[977] Brand, Stewart. "Autobiography." 1963. Brand Papers box 4, folder 13.

yet?" A picture of the entire globe from space, Brand thought, could catalyze earthlings to consider the frailty of the relatively small, shared living space we inhabit. Though Fuller replied that such a photo would be technically difficult, he joined in the sentiment.[978] Brand began producing buttons that urged NASA to release the rumored photo. When one was finally released, in November of 1967 it did become the symbol of a global consciousness, along with its better-known successor, "The Blue Marble," taken by Apollo 11 astronauts en route to the moon. In 1970, U.S. Senator Gaylord Nelson proposed the creation of Earth Day, for which the photo became a symbol. Brand's hope was not original. Astronomer Fred Hoyle had said in the 1940s that the first photograph of the earth taken from space would let loose "a new idea as powerful as any in history." Hoyle believed that the photo had been an important emblem for environmentalism: "Quite suddenly everybody has become seriously concerned to protect the natural environment."[979]

The Whole Earth Catalog was at least a small agent of this change. The catalog got started when Brand was returning by plane to California after attending his father's funeral. Like Engelbart, he began to think about large social problems and what he could do to help. "So many of the problems I could identify came down to a matter of access," he thought. "Where to buy a windmill. Where to get good information on bee-keeping. Where to lay hands on a computer without forfeiting freedom."[980] So *The Whole Earth Catalog* was born as an access service, its content managed by its users. To a certain set, it would be part virtual community, part search engine. When Steve Jobs, founder of

[978] 1966 letter, Brand Papers, box 6a, folder 1.
[979] Melloan, George. "Mankind, Science and Fred Hoyle," *The Wall Street Journal*, June 9, 1971, 16.
[980] Brand, Stewart. February 18, 1969 letter to Edward Cornish. Brand Papers box 6, folder 5.

Apple Computer, was invited to give the commencement address at his and Brand's alma mater, Stanford University, he closed on this point:

> When I was young, there was an amazing publication called The Whole Earth Catalog, which was one of the bibles of my generation. It was created by a fellow named Stewart Brand not far from here in Menlo Park, and he brought it to life with his poetic touch. This was in the late 1960's, before personal computers and desktop publishing, so it was all made with typewriters, scissors, and polaroid cameras. It was sort of like Google in paperback form, 35 years before Google came along: it was idealistic, and overflowing with neat tools and great notions.[981]

It is not an anachronism suggest an analogy with Google. The mission, function, and culture of the Catalog served as an inspiration to many technology startups, Jobs' included. The values of free information, personal exploration, and community formation animated the entire venture of the personal computer, and *The Whole Earth Catalog* gave them a voice.

Funded with a grant from the Portola Institute, Brand began typesetting and layout in himself in 1968 in the back of his small "Truck Store."[982] The first was published in the fall of that year with the spare subtitle "access to tools." "Tools" Brand defined very broadly, in the sense that Fuller, Wiener, or Mumford might have meant. Knowledge was a tool, as was information, as was language. Many of its pages were dedicated to book reviews, others to how-to guides. One aspect conspicuously lacking considering the Catalog's association with the counterculture was politics. For Brand, his project was about information sharing and lifestyle, and not about staging tired class battles. "What I am fighting is the shutting off of science from the rest of human discourse," he explained.

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[981] "Text of Steve Jobs' Commencement Address, 2005," Stanford University. Accessed 6 Sept. 2010. <http://news.stanford.edu/news/2005/june15/jobs-061505.html>

[982] The Portola Insitute was a nonprofit in Menlo Park; Brand's grant was facilitated in part by Bob Albrecht, an inaugural member of the Homebrew Computer Club and later founder of the People's Computer Company.

"No ads. No politics."[983] As he recollected in the 30th anniversary issue, "At a time when the New Left was calling for grassroots political (i.e., referred) power, *Whole Earth* eschewed politics and pushed grass-roots direct power—tools and skills."[984] As Fred Turner observes, the *Catalog* was less about collective action and more about internal self-discovery. The "New Communalism" imagined a remaking of the world by spiritual adepts, akin to the revivals of the Second Great Awakening, the 19th-century romanticism of Thoreau and Emerson, or the great Puritan project of the city on a hill.[985] It was politics by example—not by demonstrations, votes or guns.[986]

The eschewal of traditional politics reflected a libertarian distrust of large institutions, but it was also a product of a late 1960s retreat from political engagement to the terrain of *culture*. Culture meant something different to the *Whole Earth* crowd; throughout its five-year run it made no mention of "civil rights." Responding to a critique by a progressive activist staffer Brand said, "Work I did a few years ago with Indians convinced me that any guilt-based action toward anyone (personal or institutional can only make a situation worse. Furthermore, the arrogance of Mr. Advantage telling Mr. Disadvantage what to do with his life is sufficient cause for rage… Responsibility is individual stuff."[987] To deny politics is, of course, to take a political stance, one popular among latter-day proponents of Internet freedom.[988] Brand was influential in this respect.

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[983] Brand, Stewart. August 25, 1975 letter to Lynn Margulis. Brand Papers, box 2, folder 3.
[984] Brand, Stewart. "We Are As Gods," *The Whole Earth Catalog*, Winter 1998, 3.
[985] Turner, Fred. *From Counterculture to Cyberculture: Stewart Brand, The Whole Earth Network, and the Rise of Digital Utopianism*. Chicago: University of Chicago, 2006, 37.
[986] Roszak, Theodore. *From Satori to Silicon Valley: San Francisco and the American Counterculture*. San Francisco: Don't Call It Frisco, 1986.
[987] "Letters to the Editor," *The Whole Earth Catalog*, Fall 1968, 47.
[988] Some contemporary critics have noted how the literature of Internet freedom—former Grateful Dead lyricist John Perry Barlow's "A Declaration of the Independence of Cyberspace" for example—has much in common with the emerging economic libertarianism associated with the Goldwater/Reagan wing of American conservatism. One of the leaders of this "technolibertarianism" was the infamous anti-feminist

Time magazine wrote in 1969, "It is a sort of Sears Roebuck-Consumer Report for the minorities of the cybernetic age—from activists who want to improve the environment or create a Utopian society to abdicants who simply want to write bad poetry in the woods."[989] By design, the catalog appealed more to the latter; by selling the virtues of a sustainable freedom trip, Brand hoped to accomplish the former via a slow-burning values revolution.[990]

The Whole Earth Catalog was an unexpected success. It sold, in total, two-and-a-half million copies between 1968 and 1984 (regular publication was suspended in 1972), reaching a circulation of 150,000 at its peak in 1969.[991] *The Last Whole Earth Catalog*, a 1972 issue Brand had announced with great pomp would be its last, won the National Book Award. By attaining such popularity, Brand's enterprise educated a wide number about advances in the interactive computing state-of-the-art. Twelve pages of the *Last Whole Earth Catalog* were devoted to personal computers. The contrast between high technology and back-to-the-land primitivism was explicit. In *Time*'s words:

> Do-It-Yourself Utopia, Want a computer? The catalogue offers a choice: a spiffy, $4,900 Hewlett-Packard tabletop model with a 19-register magnetic core memory—or a $1.95 book of instructions on how to build one yourself. Want to start a commune? The Whole Earth Catalog lists how-to books on primitive house building (adobe huts, log cabins, teepees, metal domes constructed from jettisoned auto bodies), organic farming, sewage disposal, practical sociology.

How the catalog assimilated computer advocacy into its far-ranging set of concerns is a matter of considerable interest. At first blush, owning a computer and building a teepee

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and Reagan speechwriter George Gilder, who became a leading Internet evangelist through his publication, the *Gilder Economic Report*. See,
Borsook, Paulina. *Cyberselfish: A Critical Romp through the Terribly Libertarian Culture of High Tech*. New York: Perseus, 2000.

989 "Missal for Mammals," *Time*, November 21, 1969. Accessed 6 Sept. 2010. <http://www.time.com/time/magazine/article/0,9171,841655,00.html>

990 "A significant way to affect politics without being *of* them may be the judicious selection and dramatization of 'issues', subjects for public learning." Brand, Stewart. June 15, 1972 journal. Brand Papers box 18, folder 1.

991 Carpenter, Teresa. *The Village Voice*, September 6, 1983.

have little, if anything, in common. To understand why information technology featured prominently in the catalog's pages, we need to know something about Brand's intellectual formation, and the context in which he first encountered the West Coast computer culture.

Brand shared with other important advocates of computer interactivity a deep rooting in the philosophy of systems, and in the social cybernetics inspired by Wiener's *The Human Use of Human Beings*. This philosophy was most expertly expressed by Gregory Bateson and by Heinz von Foerster, whose "second-order" cybernetics took account the observer as an essential feedback node within the system.[992] It represented a movement beyond linear, zero-sum thinking toward holistic inclusion of entire environmental, social, and psychological systems. Brand developed a working relationship with both men, and shared with each a sincere mutual admiration. Brand was happy to play the role of liaison between cybernetic thinkers and the consuming public. The personal computer was just one of the media through which Brand translated cybernetic ideas.

As a Stanford undergraduate, Brand had some limited contact with cybernetics. In 1959 he wrote a boosterish piece on Stanford's new Center for Advanced Study in the Behavioral Sciences (CASBS), intended for the *New York Times Magazine*. "Fruits of a Scholar's Paradise" included interviews with scholars like Alex Bavelas and short abstracts of the work of Newell, Simon, and George Miller. Brand even attempted to compare algorithmic and heuristic programming.[993] The article was rejected, but it

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[992] Brand wrote that von Foerster's whole systems analysis ranked with Zen Buddhism as among his foremost "apostles of illusion-clearing." Cybernetics was only one component of a pastiche metaphysics Brand and the hippies assembled from a menu of non-linear, cyclical philosophies of mind. Brand, Stewart. August 22, 1972 journal. Brand Papers, box 18, folder 2.
[993] Brand, Stewart. Notes for "Fruits of a Scholar's Paradise," Brand Papers, box 25, folder 10.

exposed Brand to a current of computer and cybernetic research to which he would return years later.

He wrote in his journal at the time that his biological interests lay in ecology, "which deals with the relation between organism and organism, and organism and environment."[994] Biology was an avenue to the study of systems—systems governed not principally by metabolism or by natural selection, but by information transfer. "Information is information. Not matter or energy," Brand noted while reading *Cybernetics* for the first time in 1966. He was very taken with Wiener and Shannon's construction of information as (negative) entropy. "It is useful to view learning negatively," he continued "as a reduction in the randomness of sequences of behavioral events, rather than as the incorporation of order in a blank photographic plate."[995] This meant that social organization of the kind Brand exercised—building networks, planning collective events—was really all about the dissemination of information. To create a meaningful community one might as well distribute buttons or list valuable books as call a meeting. This concept of information as an organizing principle was allied closely to Licklider and Taylor's efforts to manufacture in intergalactic network. The important science was to establish stable, complementary feedback loops across many information processing systems.

Brand held cybernetics to be something more than a formulation of information exchange. For him it was, as Wiener had always hoped, a metadiscipline, creating a unified map of all other sciences. In reverential, Heraclitean tones, he wrote: "Cybernetics is the essential science, precisely the science of essences and their flow,

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994 Brand, Stewart. 1958 journal. Brand Papers, box 17, folder 4.
995 Brand, Stewart. August 21, 1966 journal. Brand Papers, box 17, folder 11.

practical mysticism."[996] Practical mysticism, it could be said, was what Brand and his followers were ultimately after. It had to be holistic and monistic—as the concept homeostasis was. It had to be dynamic—as the feedback process was. In his profile of the CASBS, he offered that systems theory's popularity was due to its bringing together "an understanding of how many different kinds of physical and biological and even social things operate by taking a whole notion of a system—a dynamic open system, that is continually moving but has to maintain a moving equilibrium."[997] In general terms, this was the CASBS' mission statement: getting scholars in different fields to interact and discover the common properties of their respective studies. Brand's interest, admittedly, always remained macroscopic—a mile wide and an inch deep. Hence cybernetics was an attractive subject; it invited the intellectual traveler willing to ignore details and focus on Wiener's "structural similarities."[998]

In 1972, as the *Whole Earth Catalog* was winding up its initial run, Brand began reading the works of psychiatrist and cybernetician Gregory Bateson, then a local figure at Palo Alto's VA Hospital. An anthology of Bateson's short works, *Steps to an Ecology of Mind*, had just been published, and he was offering a course at U.C. Santa Cruz, entitled "Biology of Culture and Consciousness," which Brand attended, tape recorder in hand. Bateson was warm, funny, idiosyncratic, and given to abstract musings on social and ecological regenesis. He became, for a time, Brand's intellectual guiding light. As Brand described it, *Steps* compiled in one single volume applications of cybernetics and

[996] Brand, Stewart. Draft review of Bateson's "Steps to an Ecology of Mind," 1972. Brand Papers, box 18, folder 2.
[997] Brand. Notes for "Fruits of a Scholar's Paradise."
[998] "Besides circuit the other principal realm of cybernetics is the hierarchical relation of part to whole, trees to forest, steps up the meta-ladder of increasing abstraction and wider relevance, where at each level are fewer understandings and grander," Brand explained.
Brand, Stewart. "Both Sides of the Necessary Paradox," June 12, 1973 draft. Brand Papers box 7, folder 2, 21.

formal logic to the biology and psychology of Balinese natives, porpoises, insects, alcoholism, and schizophrenia. In short, a tour de force. He began drafting a profile of Bateson for *Harper's*, conducting interviews in the latter's home.[999] Bateson revealed to Brand a humanist side of biology that substantiated the blended undertaking in the *Whole Earth Catalog*. "Mere purposive rationality unaided by such phenomena as art, religion, dream, and the like, is necessarily pathogenic and destructive of life," he said. "Its virulence springs specifically from the circumstance that life depends upon interlocking *circuits* of contingency, while consciousness can only see such short arcs as human purpose may direct."[1000] Brand saw clearly how the concept of circuits could be applied to the self. He sought an environment where goal-directed, conscious behavior could be transformed into something more naturalistic and unconscious. Working and thinking were meant to be spontaneous, creative moments; the psychological circuits to a variety of stimuli. Brand's endeavor shared this in common with Engelbart's.

Circuits were the basis for consciousness, Bateson taught. The recursive "double-bind" theory of schizophrenia—when two messages conflict and negate each other—posited that such circuitous self-reference was fundamentally how the mind operated even in its healthy state.[1001] Jokes, religious belief, and paranoid schizophrenia were all products of these paradoxes. "I'm still getting used to the way Gregory uses the term 'circuit,' Brand confessed in his course notes. "It's appealing to me because it is at once

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[999] After cautioning Brand that his article might be "too difficult" for his readers, *Harper's* editor Lewis Lapham eventually published it in November 1973.
[1000] Brand. "Both Sides of the Necessary Paradox," 21.
[1001] Contemporary AI scholar and philosopher of mind Douglas Hofstadter has developed an adapted form of this hypothesis. For Hofstadter, self-contradictory "strange loops," layered one-upon-the-other in an infinite recursion are what give the mind its uniqueness, its seemingly endless complexity, and its capacity for self-awareness. Hofstadter's theory of mind has intriguing implications for machine cognition, as self-calling routines are quite common elements of AI system design.
Hofstadter, Douglas. *Gödel, Escher, Bach: An Eternal Golden Braid*. New York: Basic, 1979.

more general than ‘feedback loops’, more accurate somehow, and more open-system. It implies shimmering networks of what?... Of influence, I guess, which may be traced in part but never really isolated… Without circuit, without continual self-corrective adjustment, is no life.”[1002]

Bateson and Brand’s view of feedback was evidently quite distinct from that of Jay Forrester, for instance. While feedback could be a useful heuristic in automatic system design, or in management, it was in Bateson’s hands a much more slippery concept. As in von Foerster’s second-order cybernetics, Bateson believed a system could never be isolated and instructed to behave properly. As in quantum mechanics, the observer of the system played an intrinsic role in its function, as did myriad hard-to-account-for environmental inputs. One insight of cybernetics was that a manufacturing system may be no less “organic” than an ecosystem, no less susceptible to unintended consequences than other nonlinear functions. “The engineers have decided it is engineering,” Bateson warned. “All they have to do, you see, is to cut off the circuit so that you have an ‘input’ on one end and an ‘output’ on the other, and those two never join up out in the environment. The input-output literature is very large, it’s highly skilled engineering and all the rest of it, but it ignores the philosophy of the feedback.”[1003] The upshot, then, was that second and third order environmental considerations may take on much larger importance than simple input factors like price, inventory turn, or capacity utilization. Game theory could be similarly treacherous since it assumed the rules of the game were fixed. On the international arena, for example, rules were in fact set by the

[1002] Brand, Stewart. 1972, Bateson course notes. Brand Papers, box 30, folder 10.
[1003] Brand. “Both Sides of the Necessary Paradox,” 20.

players on the fly; no one could ever be sure what game was being played.[1004] Communications engineering necessarily implied a dose of social engineering; thus, Engelbart tried to engineer the environment itself, through bootstrapping and relentless experimentation, while at once hoping for positive serendipities and unexpected breakthroughs.

Brand saw the parallels between Bateson and Engelbart's thinking. As a consummate networker, he strived to include his friends at ARC in the wider countercultural explorations of consciousness, inviting figures like John Lilly and Timothy Leary to parties held by the Augmented Human Intellect Group.[1005] Likewise, Brand was himself a keen visitor to academic conferences on cybernetics. Von Foerster invited him to the December 1971 annual meeting of the American Society for Cybernetics: "This is, of course, a business trip for you," he wrote, "because your cybernetic intuition will be complemented by an exposure to the 'state of the art.'"[1006]

Brand also saw a homology between three windows on behavior that had become popular in the late 1950s and the architecture of a computer program. The first of these approaches was proposed by economist Kenneth Boulding at CASBS in 1965—that behavior is motivated by the "Image," or the stock of stored information and understanding that defines a subject's worldview. Second was "the Plan," the manner in which an organism or institution contrives to accomplish its directives, described by psychologists George Miller, Eugene Galanter, and Karl Pribam in a 1960 book, also coming from work at Stanford. Last, was the cybernetic model of "purpose," information, and corrective feedback, that Brand encountered through Wiener and

[1004] Ibid.
[1005] Brand, Stewart. June 7, 1969 letter to John Lilly. Brand Papers, box 6, folder 7.
[1006] October 8, 1971 letter from Heinz von Foerster. Brand Papers, box 6a, folder 4.

through Ross Ashby's *Design for a Brain* and *Introduction to Cybernetics*.[1007] He wrote in a paper draft, "Like a computer program, a Plan is a 'hierarchy of instructions'. Also as in a computer, the Plan is carried out by employing a mechanism of feedback."[1008] All of these approaches undercut the simple input-output structure in behaviorist psychology in favor of a complex directory of motivations, environmental response and homeostatic adaptation. More than any individual, Brand served as a nexus between these worlds, bringing together disparate conversations about interactive computing, general systems theory, and theories of mind.

This decade-long marinating in cybernetic theory manifested directly in *The Whole Earth Catalog*. The first issue included a review of Wiener's *Cybernetics*; computers, Brand suggested, were a natural outgrowth of the intellectual climate fostered by the Macy Conferences. Explaining why a text from 1948 remained relevant in 1968, Brand wrote, "McLuhan's assertion that computers constitute an extension of the human nervous system is an accurate historical statement. The research and speculation that led to computer design arose from investigation of healthy and pathological human response patterns embodied in the topological make-up of the nervous system." The likeness between machines and minds was only a small factor in cybernetics' profound durability: "Society, from organism to community to civilization to universe, is the domain of cybernetics," he continued. "Norbert Wiener has the story, and to some extent, is the story."[1009] In *The Human Use of Human Beings,* cybernetics' domain was "the whole

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[1007] Galanter, Eugene, George Miller and Karl Pribam. *Plans and the Structure of Behavior*. New York: Holt, Rinehart and Winston, 1960.
Ashby, W. Ross. *Design for a Brain: The Origin of Adaptive Behavior*. London: Chapman & Hall, 1952.
Boulding, Kenneth E. *The Image: Knowledge in Life and Society.* Ann Arbor: University of Michigan, 1956.
[1008] Brand, Stewart. 1967 draft on behaviorism. Brand Papers, box 25, folder 14, 9.
[1009] Brand, Stewart. "Review of Wiener," *The Whole Earth Catalog*, Fall 1968, 37.

earth of the mind." Brand enthusiastically cited Wiener: "Society can only be understood through a study of the messages and communication facilities which belong to it; and… messages between man and machine are destined to play an ever-increasing part."[1010]

The cybernetic outlook had consequences for ecology, as well. On the next page, Brand excerpted from Ashby's *Design for a Brain*.

> The development of life on earth must thus not be seen as something remarkable. On the contrary, it was inevitable. It was inevitable in the sense that if a system as large as the surface of the earth, basically polystable, is kept gently simmering dynamically for five thousand million years, then nothing short of a miracle could keep the system away from those states in which the variables are aggregated into intensely self-preserving forms.[1011]

The prospect of networking computers could be thought of as building synapses between individual neurons. Years later, when Brand promoting the WELL, he likened computer networks to a cybernetic, Gaia ecology: "[Computers] can hook you into a planetary nervous system. That way when you enter the world of computers, you will be involved more with the planet as a whole. I think that is to the greater good."[1012] Homeostasis was thus seen as the underlying condition of the brain, the social order, and the environment. The catalog embedded an informatic way of looking at natural history. The enterprise of making computers more "lifelike" appealed to Whole Earthers seeking a grand unified theory of consciousness.

The *Catalog* also reviewed Miller, Galanter, and Pribam's 1960 broadside against the stimulus-response behaviorist catechism. "The notion of being programmed, and self-programming, emerges as a convenience rather than a threat," Brand wrote. "The constant checking of feedback loops…yields a nice connectedness to the

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[1010] Quoted in *The Whole Earth Catalog*, Spring 1969, 18.
[1011] Ashby, W. Ross. Excerpted in *The Whole Earth Catalog*, Spring 1969, 19.
[1012] *PC Magazine*, "The Future of Microcomputing," 1985, 134. Clipping, Box 4. *The Whole Earth Catalog* Records (M1045), Stanford University Special Collections and University Archives, Stanford, Calif.

environment."[1013] An excerpt from psychiatrist John Lilly echoed this thought. A "Schema of the Levels of Functional Organization in the Human Biocomputer," examined the various hierarchical levels of feedback-control, all organized by a "Metaprogram Level" (a subconscious Plan), which dictated, "These programs are necessary for survival; do not attenuate or excite them to extreme values; such extremes lead to non-computed actions, penalties, illness, or death." This deep level of brain chemistry was the "software of the Biocomputer."[1014] Synopsizing von Foerster's *Purposive Systems*, Brand wrote, "You're a purposive system. So am I. We're very good at it, and not as good as we'd like to be. Humanity, as a whole, is lousy at it, and worried. This collection of recent cybernetic thoughts can cheer you up and give you better concepts to worry with."[1015] He trusted that studying human intelligence in computer terms might lead to a better integration with more mind-like computers, and a better Plan for humanity.[1016]

At first it is puzzling why a publication devoted to radical individual freedom should embrace a conflation of men and machines as programmed systems. The answer lies in what Brand called "self-programming." Once we understood the processes at work in the brain, we could begin to assert some control. Programming was how humans accessed the mechanism of the subconscious. Through enlightened programming, institutions could serve a limited function: "Human institutions exist primarily for the purpose of executing plans that their members, as individuals, would be unable or unwilling to execute." Brand and the *Whole Earth Catalog* culture jammed the 1950s

[1013] Brand, Stewart. "Review of Miller, Galanter, and Pribam," *The Whole Earth Catalog*, Fall 1969, 125.
[1014] Lilly, John. Excerpted in *The Whole Earth Catalog*, Fall 1968, 36.
[1015] Brand, Stewart. "Review of von Foerster," *The Whole Earth Catalog*, Fall 1969, 7.
[1016] Brand, Stewart. November 23, 1968 journal. Brand Papers, box 17, folder 11.

notion of mechanical, computerized man, creating an individualist philosophy organized around the principles of effectiveness and mind expansion. Lilly, for example, treated the human organism as a self-directed system, but also as an evolutionary program, running on logical circuitry, systematized into registers and subroutines essential for life. This model fascinated Brand because it provided a uniform basis to analyze all of biology, psychology, and nature alike. It did not destroy the notion of free will, but did show the relative smallness of large-scale human enterprises like Government and War—they were merely programs running on imperfect and vulnerable machines.

The prism of cybernetic science is not a "reading" of Brand's arguments. It was for him rather a concrete approach to specific scientific and engineering problems—programming a computer, developing a self-sustaining human habitat (the catalog offered instructions on building geodesic domes and do-it-yourself solar energy projects), and maintaining a social network.[1017] *The Whole Earth Catalog* was the first popular journal of cybernetics. It was many readers' first exposure to the forms of personalized computing advocated by Licklider and Engelbart. It is legitimate to treat it as a powerful modality of influence between an increasingly self-aware counterculture and a great number of engineers and scientists (many at SRI and PARC) who were subscribers or contributors.[1018] Bill English, for example, reviewed the *Tektronix* parts catalog in the first *Whole Earth Catalog*.[1019] Alan Kay remembered his initial reaction to the *Catalog* when it was passed around the PARC offices: "Oh yeah, that's the right idea."

[1017] The builder of geodesic domes and garage solar projects was a cousin to the computer hobbyist. Each resented the monopoly power exerted by large institutions over energy, construction, and information and determined to gain access and control in his or her own scaled-down world.
[1018] One of the first letters to the editor the *Catalog* received came from ARC researcher Dave Evans, recommending the magazine *Architectural Design*. "Letters to the Editor," *The Whole Earth Catalog*, Fall 1968, 17.
[1019] English, Bill. "Review of *Tektronix*," *The Whole Earth Catalog*, Fall 1968, 72.

Foreshadowing Jobs' comment, he "thought of *The Whole Earth Catalog* as a print version of what the Internet was going to be."[1020] Kay bought every book from the Whole Earth truck store for the PARC library.

Why would the *Catalog* resonate so with employees of an old-line appliance company? Machines seen as cold and sterile were at odds with Brand's version of naturalism. On reading McLuhan, Brand had observed, "It's true what they say, that the machine has put distance between men and the land. No longer laboring upon it, they return to it now in their leisure. Machines gave them that leisure, but they must learn to leave the machines if they would refind the land."[1021] But what if machines could be co-evolved as part of a more naturalistic existence? One of Brand's favorite subjects was the idea of co-evolution, which gave its name to the catalog's less phenomenally popular successor, *Co-Evolution Quarterly*. That organisms evolve in harmony, in tandem with their environment, was a fact sometimes missed by evolutionary biologists. Environments were not resources to be consumed, but agents of feedback. Etymologists studied insects; botanists studied plants, and too rarely did either apprehend the significance of the other's study on their own discipline.[1022] Brand learned the importance of whole systems from Ehlich who stressed the links between organisms in fragile symbiosis. With this understanding, Licklider's metaphor was apt. The tools we use evolve to suit our needs, but we also evolve to fit our tools. "When you design a tool," Brand reflected, "the best you can do is fashion a prototype and hand it over to the

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[1020] Turner. *From Counterculture to Cyberculture*, 112. Kay explained, "A lot of good ideas were had by idling through the Catalog when you didn't know what you were looking for." PARC's guru of human-computer interaction, Larry Tesler professed to read "every page."
[1021] Brand, Stewart. July 13, 1968 journal. Brand Papers, box 17, folder 9.
[1022] Brand, Stewart. April 7, 1974 journal. Brand Papers, box 18, folder 5.

local evolutionary system: 'Here, try this.'"[1023] Such a method was of course identical to Engelbart's bootstrapping experiments. It was evinced by the scattershot, open-ended format of the *Catalog* itself.

What Brand favored was "soft" technology; one "based on low-energy, a non-dispersive use of renewable resources, local materials, low or no waste, and which is culturally adaptable, satisfying, controllable, and has safe-guards against misuse."[1024] Solar and wind energy were obvious candidates.[1025] The computer, configured properly, might fit all these criteria. Brand's ethos was superbly summarized in a poem by his friend, the Zen writer Richard Brautigan, featured in *The Whole Earth Catalog:*

> I like to think (and
> the sooner the better!)
> of a cybernetic meadow
> where mammals and computers
> live together in mutually
> programming harmony
> like pure water
> touching clear sky.
>
> I like to think
> (right now, please!)
> of a cybernetic forest
> filled with pines and electronics
> where deer stroll peacefully
> past computers
> as if they were flowers
> with spinning blossoms.
>
> I like to think
> (it has to be!)
> of a cybernetic ecology
> where we are free of our labors
> and joined back to nature,

[1023] June 23, 1971 journal, *The Whole Earth Catalog* Records, box 1, folder 1.
[1024] Brand, Stewart. "Statement to the Select Subcommittee on Education," 1970. Brand Papers, box 30, folder 4.
[1025] Another engineering approach that reconciled the boundaries of the natural and the artificial was "bionics," the procedure of divining effective processes from nature. In a review of Heinrich Hertel's *Structure Form and Movement*, the catalog suggested we "learn from nature first, save time, and stay humble."
"Review of Hertel," *The Whole Earth Catalog*, Fall 1968, 33.

returned to our mammal
brothers and sisters,
and all watched over
by machines of loving grace.[1026]

No essay could have so succinctly captured the Whole Earthers' feeling: one day in the near future information technology and ecological consciousness would converge in a new homeostatic philosophy of computer-aided individual liberty and environmental sustainability.

[1026] Brautigan, Richard. "All Watched Over by Machines of Loving Grace," in *The Pill vs. the Springhill Mine Disaster*. New York: Delacorte, 1968, 1.

Chapter 22 – (Computer) power to the people!

Computers, like drugs, were part of an ongoing experiment. Their potential was as aids in the quest for self-reliance. "We are as gods and might as well get used to it," proclaimed the *Catalog*'s famous first sentence. The power to reshape the earth—through cities and culture as through deforestation and nuclear weapons—necessitated a reevaluation of man's relationship to technology. Accordingly, the *Catalog* advocated an intimate personal power—the "power of the individual to conduct his own education, find his own inspiration, shape his own environment, and share his adventure with whoever is interest." Tools to aid in this process should be "sought and promoted."[1027]

The value of the homespun extended to computers. Reviewing a 1966 hobbyist how-to manual, *We Built Our Own Computers*, Brand compared the ham radio phenomenon to the growing amateur computer culture: "Time was, kids built their own radios. Now it's rockets and computers, and so much the better. Once you've built one computer, you have a far more sophisticated relationship with all computers."[1028] The same issue reviewed, in honor of Arthur Brand, the Heathkit 5-Channel, 5-Watt CB Transceiver ("between ready-made and do-it-yourself.")[1029] In 1977 Heath released the H-8 computer kit, effectively bridging the eras of homemade electronics and homemade computers. "A kit YOU can 'do yourself,'" its brochure advertised.[1030] The transition from electronics to more complicated devices was seamless. The conclaves of amateur radio operators to which Stewart's father belonged betokened something of later computer hobby and on-line communities, a point understood by Bill English,

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[1027] *The Whole Earth Catalog*, Fall 1968, 3.
[1028] Brand, Stewart. "Review of *We Built Our Own Computers*," *The Whole Earth Catalog*, Fall 1968, 57.
[1029] "Review of Heathkit," *The Whole Earth Catalog*, Fall 1968, 41.
[1030] Altair and Heath, Computer Product Literature 1948- (CBI 12), 1974. box 31. Charles Babbage Institute, University of Minnesota, Minneapolis.

Engelbart's technician and a radio enthusiast himself. "*The Radio Amateur's Handbook* may be of interest to the communities…who've been fantasizing an underground radio net," Brand and English suggested. "Like a night of the week or month when all the world's long-hairs are on the air, vibing to each other and the stars."[1031]

The audience Brand targeted, one that cherished "the power of the individual," was made up of independent dabblers; many readers constructed computers out of spare parts. Fred Turner has romantically called this class of reader the "cowboy nomad," a resourceful soloist who moves from project to project in search of a challenge.[1032] Distrustful of authority and intellectually curious, he prefigures the mythic solitary computer hacker, traversing the wilds of cyberspace. As Steven Levy has pointed out, in its original formulation, "hacker" did not connote a subversive type.[1033] "Hackers" were only independent, hardscrapple coders, given to solving difficult problems in the dead of night, lit by a flickering CRT monitor, accompanied by cold coffee. This fellow had read *The Whole Earth Catalog*, had attended a computer club, and through these channels had come to know a community of brethren. Brand viewed these cellular, nomadic communities and declared "an era of tribal endeavor and cosmic consciousness." Western society, built on numbers, conformity, and hierarchy, had, "with the acceleration of electricity and computer automation…passed its breakpoint." Ted Nelson's nemesis, IBM, represented this old order. The hobbyists represented the new.

The Whole Earth Catalog transposed "intellect augmentation" into the countercultural key of "mind expansion." The two projects were not so different; Engelbart was interested in unlocking the creative, productive powers of consciousness,

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[1031] English, Bill. "Review of *The Radio Amateur's Handbook*," *The Whole Earth Catalog*, Fall 1969, 78.
[1032] Turner. *From Counterculture to Cyberculture*, 80.
[1033] Levy, Steven. *Hackers: Heroes of the Computer Revolution*. New York: Penguin, 2001, 46-47.

just as the hippies hoped to reach higher states of awareness. Engelbart himself dropped acid twice in 1966 together with his younger colleague Bill English. They visited communes and geodesic dome projects for inspiration. Engelbart's expeditions aimed to encounter new modes of social organization, new concepts of individual and group. In an interview with Fred Turner he explained that ARC's work was "very empathetic to the counterculture's notions of community and how that could help with creativity, rationality, and how a group works together."[1034] He sometimes attended parties hosted by English where he swapped brainstorms with the Portola Institute's Dick Raymond (a former SRI economist), Steve Durkee of the Lama Foundation (a New Mexico ashram), and Stewart Brand.[1035]

The *Catalog* reprinted an interview with Engelbart from *Voices* in the Fall 1969 issue revealing the true depth of his ambitions for the augmentation project.

> The rate at which micro-miniaturization is going, you could make a computer that would be more powerful than the biggest we have no, so small that you could surgically implant it, taking little enough energy so that you could find a way to get the energy from a person's metabolism to run it. And you could run out a lot of little electronic filaments that go out and interact with all sorts of sensa -- sensing many things about the condition of your blood and everything else all over your body, but also out to stimulate many of the things so that it could come out and control them.... You internalizing the computer like that....What's the you?... Could add tremendous coordination and timing....Or know when your body is needing nutritional things....It could stimulate sensory nerves for you to receive things from...Yours could be transmitting and mine receiving, and whatever you do I'm getting!...Suppose all these have a really common way to transmit meaning, but each knows how its owner's semantic image of the world goes...semantic trajectory...People wouldn't have to go to school with such a fantastic tutor inside them...What would baby-sitting become... With the people who are humanists I used to be just rejected roundly for being anti-humanist. With those people who were technologists I was ostracized for being a humanist.[1036]

The scope of Engelbart's endeavor ranged from creating better office machines all the way to fully transhuman cyborgs. Extrapolating from current rates of change in scale,

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[1034] Quoted in Turner. *From Counterculture to Cyberculture*, 109.
[1035] Ibid.
[1036] Engelbart, Douglas. Excerpted in *The Whole Earth Catalog*, Fall 1969, 28.

cost, and power led Engelbart inevitably to the territory of Toffler and Kahn. His ability to connect these ideas with a countercultural audience that included Timothy Leary, cyberpunk authors like Bruce Sterling and William Gibson, and device makers like Jobs and Wozniak assured their long life. *The Whole Earth Catalog* was Engelbart's broadcast frequency reached this public.

Big plans like these were welcome in Brand's universe. Engelbart submitted a photo of the Andromeda galaxy to the Fall 1969 edition as a "peerless meditation target."[1037] His words even provided the epigraph for the January 1970 *Catalog*: "Any quantitative change by a factor of ten is a qualitative change."[1038] The cyborg-augmented human was such a change. A review of Henry Dreyfuss' *The Measure of Man: Human Factors in Design* called for computers cut to man's (intellectual) size. Helping humans become more effective required engineering systems that included man as a part.[1039] Stewart Brand personally reviewed Herbert Simon's manifesto on complexity, *The Sciences of the Artificial*. For Brand, the science of heuristic programming suggested that, in most respects, human intelligence worked on the same level as artificial. "I should like to point to evidence that there are only a few 'intrinsic' characteristics of the inner environment of thinking man that limit the adaptation of his thought to the shape of the problem environment," he wrote. "All else in his thinking and problem-solving behavior is artificial—is learned and is subject to improvement through the invention of improved designs."[1040] The real tool to a cybernetically-enhanced consciousness was, as always, communication. ARC was simply facilitating a process that had begun at the

[1037] *The Whole Earth Catalog*, Fall 1969, 7.
[1038] *The Whole Earth Catalog*, January 1970, 5.
[1039] "Review of Dreyfuss," *The Whole Earth Catalog*, Fall 1968, 22.
[1040] Brand, Stewart. "Review of Simon," *The Last Whole Earth Catalog*, 1971, 31.

dawn of the written word. "Communications critical," Brand jotted in his journal. "Intention. Voncention (abstract meaning), permits rearrangement, symbolic manipulation, leads to 'Cultural evolution' (Psycho-social evol)."[1041] Engelbart's lab and Brand's *Whole Earth Catalog* were allies in this effort.

When Stewart Brand published a revisionist history of computers in March 1, 1995's *Time*—"We Owe it All to the Hippies"—he incubated a retrospective myth that has led to several popular books, notably *New York Times*' reporter John Markoff's *What the Dormouse Said: How the 60s Counterculture Shaped the Personal Computer*. "Forget antiwar protests, Woodstock, even long hair," Brand crowed. "The real legacy of the sixties generation is the computer revolution."[1042] Naturally, Brand's account simplifies a difficult story into a provocative headline. As we have seen, the "computer revolution" had been so named earlier than the 1960s, and numerous abortive drives toward "personal computers" were undertaken in a variety of settings—the counterculture was not unique in wanting computers for the masses. D∂espite the hippies' and hobbysists' enthusiasm, the key to the personal computer's success was its integration into an established context of office technology. In the early 1980s engineers contrived to bring down prices while marketers convinced consumers that computers could indeed be used, by everyone, for ordinary office tasks. Yet Brand's myth is not without a shred of validity. A shared cybernetic heritage united the goals of a subset of the counterculture and a subset of computer designers. Through the networking and outreach of Brand, Engelbart, English, Kay, and Nelson, these groups largely merged in the late 1960s and early 1970s in the San Francisco area. There is evidence to conclude that "the hippies"

[1041] Brand, Stewart. August 22, 1972 journal. Brand Papers, box 18, folder 3.
[1042] Brand, Stewart. "We Owe It All to the Hippies," *Time*, March 1, 1995. Accessed 6 Sept. 2010. <http://www.time.com/time/magazine/article/0,9171,982602,00.html>

played a very important part in bringing personal computing to public recognition, and formed a core of its market as they migrated away from ashrams and into office parks.

Fred Turner writes that, "Between the 1960s and the late 1990s, Brand assembled a network of people and publications that together brokered a series of encounters between bohemian San Francisco and the emerging technology hub of Silicon Valley to the south."[1043] *The Whole Earth Catalog* was, for the many constituencies it brought together, what Peter Galison calls a "trading zone." The rhetoric of cybernetic utopia was a contact language—a shared creole in which engineers, social scientists, and interested amateurs could engage in support, education, and futurism without the burden of function-specific jargon.[1044] As Geoffrey Bowker has argued, Wiener himself had positioned cybernetics as a universal meta-discipline, conveying legitimacy on a wealth of different projects in the manner of a bazaar. Likewise, the *Catalog* served as a generalized form of the Cambridge community or the early EACM. Brand's tireless networking fostered the exchange.

After *The Whole Earth Catalog* ran its course, Brand held a "demise party," at which he promised to give away $20,000 in proceeds to whichever cause was judged worthiest by the attendees. The guests failed to reach a consensus; the portion of the cash that did not mysteriously disappear was divided among several projects. As a consequence, Brand and Raymond organized the nonprofit POINT to seed ambitious social ventures as Portola had the *Catalog*. One of these was, in 1974, *CoEvolution Quarterly*, a publication with even less editorial cohesion than its predecessor. Brand wanted to feature any article or piece of fiction that held his interest: "The stuff I'm

[1043] Turner. *From Counterculture to Cyberculture*, 3.
[1044] Galison, Peter L. *Image & Logic: A Material Culture of Microphysics*. Chicago: University of Chicago, 1997, 783.

looking for is visible in Baer's thoughts about math & language, Belson's movies, Durkee's mandala research, Engelbart's computer community, John Lilly's tank work, Fuller's 'the asking of original questions is the consequence of intereferences,' Koestler's *Creative Act*, Probath's head holograms, etc."[1045] Many dozens of notable intellectuals interacted through the pages of *CoEvolution Quarterly,* POINT board of directors, and gatherings hosted by Brand. An incomplete list would include: Kesey, sculptor Gerd Stern of the art collective USCO, bohemian anthropologist Michael Harner, Yippie founder (and future stockbroker) Jerry Rubin, Internet activist and POINT grant recipient Fred Moore, and media critic Jerry Mander, a POINT board member along with Bill English. The list of contributors to *CoEvolution Quarterly* is even more impressive, though reproducing it requires a rolodex as large as Brand's own.[1046]. Brand was the seminal influence of a 1972 article published in *Science* by two of his acquaintances, computer scientists at Stanford Edwin B. Parker and Donald A. Dunn. "Information Technology: Its Social Potential" proposed an cable-networked "information utility" for every home, noting the communicative and educational freedoms of something like ubiquitous Internet access.[1047] He corresponded with Abbie Hoffman and Herman Kahn about balance between population growth and the environment.[1048] He advised California

[1045] Brand, Stewart. July 30, 1971 journal. Brand Papers, box 18, folder 1. He elaborated that his cohort including Kesey, English, and IBM software designer Gordon Ashby were "full of skills, success, godlike powers. Unhinged for a place to put them. Purpose. We wallow in a slough of purposelessness, seeking the combination that will make it fertile."
[1046] Among those featured were: Linda Ronstadt, Carl Sagan, Ram Dass, Stewart Udall, Francisco Varela, Heinz von Foerster, James Watson, Lewis Mumford, Alice Tepper Marlin, John Lilly, Ursula LeGuin, Ivan Illich, Frank Herbert, Robert Heinlein, Allen Ginsberg, Robert Frank, Paul Ehrlich, Eric Drexler, Jacques Cousteau, Kenneth Boulding, Gregory Bateson, J.G. Ballard, Wendell Berry, Robert Callahan, Paul Krassner, R. Crumb, Gregory Bateson, Paul Ehrlich, Kevin Kelly, Gary Snyder, Hyman Rickover, and Lawrence Ferlinghetti and Michael McClure, both of whom edited an issue. Each submission was personally moderated and curated by Stewart Brand, if not directly solicited by him.
[1047] Parker, Edwin B. and Donald A. Dunn. "Information Technology: Its Social Potential," *Science* (June 30, 1972): 1392-1399.
[1048] "Correspondence," Brand Papers, box 6a, folder 1.

governor Jerry Brown on land resource economics and what would later become known as the New Economy—"growth…based on experience with an increase in cleverness."[1049] Effectively, Brand was everywhere in California in the 1970s, creating a traveling salon around himself and fixing computers as a key ingredient in a larger cultural conversation. The ethic he espoused never changed even as he floated from Stanford laboratories to desert communes. Bureaucratic, professional, and technical walls were consistently dissolved and new, improbable communities formed. Edmund Berkeley's dream of computers for the masses seemed on the verge of realization.

The Fall 1969 *Catalog* reviewed an imaginative dispatch from von Foerster and musician James Beauchamp on musical composition by computer: "Music by Computers. Goddamn right. When can we get our hands on them without having to tiptoe around some 18th-century Department Chairman?"[1050] The proposition hit home for Brand; it was much closer to fruition than he had guessed. In 1972 Brand visited his friends Bill English and Alan Kay at Xerox's Palo Alto laboratories and was energized by what he saw. His experience was documented as a long feature in *Rolling Stone*, with photographs by Annie Liebowitz: "Spacewar: Fanatic Life and Symbolic Death Among the Computer Bums." "Spacewar," which ran December 7, 1972, can be considered personal computers' germinal public moment. The Altair 8800 would not reach the market for nearly three years, but the *Rolling Stone* piece was Brand's battle cry for personal, interactive computing. He translated Engelbart and Kay's vision into whimsical, hyperbolic prose, equal parts futurist manifesto and gonzo journalism. "Spacewar," at last, put interactive computing on a world stage.

[1049] "Letter to Jerry Brown," August 25, 1975. *The Whole Earth Catalog* Records, box 1, folder 5.
[1050] Von Foerster, Heinz and James Beauchamp. "Music by Computers." *The Whole Earth Catalog*, Fall 1969, 78.

The article began with a bolt from the blue. "Ready or not, computers are coming to the people. That's good news, maybe the best since psychedelics." Offhandedly dismissing the "school of liberal criticism" that had fueled the automation debate several years before, Brand found perspective instead in an alternative cybernetic tradition—in the "romantic fantasies of the forefathers of the science such as Norbert Wiener, Warren McCulloch, J.C.R. Licklider, John von Neumann and Vannevar Bush."[1051] The survival of these "romantic fantasies" owed to the unlikely amalgam of the youthful energy of "the freaks who design computer science," and "an astonishingly enlightened research program," from the highest levels of the Defense Department. ARPA, Brand claimed was "one of the rare success stories of Government action." With the creation of a separate agency to house aerospace, the departing urgency of actual "spacewar" opened a large cavity in the Pentagon's research budget. In Brand's words, "Into this vacuum stepped J.C.R. Licklider," the first of many mythical heroes who transformed computers into something resembling a useful information medium.[1052] ARPA funded, in Alan Kay's estimation, ninety percent of the breakthroughs in interactive computing, few of which could have occurred absent the Pentagon's open checkbook. "The basic ARPA idea is that you find good people and you give them a lot of money and then you step back," Kay said. PIs then have three years to do "good things" – meaning anything new or interesting.[1053]

At the other end were hackers in interactive all-night joyrides, mashing buttons and blasting their friends at the "International Spacewar Olympics." They took turns

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[1051] Brand, Stewart. "Spacewar: Fanatic Life and Symbolic Death among the Computer Bums," *Rolling Stone*, December 7, 1972. www.wheels.org. Accessed 6 Sept, 2010. <http://www.wheels.org/spacewar/stone/rolling_stone.html>
[1052] Ibid.
[1053] Ibid.

playing and updating the code written by a couple of Lincoln Lab graduate students in their spare hours a decade before. The game took place on a PDP-10, designed for uninterrupted personal use, a machine historian Paul Ceruzzi describes as a legitimate ancestor of the personal computer.[1054] Spacewar, Brand discovered, was an immersive, social experience, that was nonetheless individually exhilarating—a blend of real physics, instant feedback, science fiction imagination, and visceral fun: "Something basic is going on." The hackers were not IBM suits; their doors at PARC, SRI, and SAIL were littered with clippings from Tolkien and anti-Nixon cartoons. In fact, according to John Lilly, when IBM attempted to prohibit the playing of Spacewar by its research team, several months of slackening productivity induced a reluctant lifting of the ban. Brand's comment: "Apparently, frivolous Spacewar had been the medium of important experiments. (In every computer-business story I've ever heard, IBM invariably plays the heavy.)"[1055] Kay told Brand, "The game of Spacewar blossoms spontaneously wherever there is a graphics display connected to a computer." Soon, it would be played over the Intergalactic Network.

Hackers were, to Alan Kay, among the last true "artisans." They were brilliant but unconventional kids, like Brand himself. Their talents, too often misapplied, evolved into a "kind of fanaticism"—a "love-hate relationship" around computers. In Brand's poetry, they were "scouting a leading edge of technology which has an odd softness to it; outlaw country, where rules are not decree or routine so much as the starker demands of what's

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[1054] Ceruzzi. *A History of Modern Computing*, 208.
[1055] Brand. "Spacewar."

possible."[1056] This description could have been imported to the mission statements of future dot-com startups.[1057]

Brand noted the variety of projects being undertaken at PARC, testimony to computers' wide applicability: "Until computers come to the people we will have no real idea of their most natural functions." Though, due to considerations of cost and size, they had remained in the province of rich and important institutions, they were not solely capable of bookkeeping, automatic control, and economic simulation. As Nelson had insisted, they were as plastic as any other medium. "Computers don't know shit," Brand wrote. "Computer function is mostly one-track-mind, in which inconsistency is intolerable. The human mind functions on multiple tracks (not all of them accessible); it can tolerate and even thrive on inconsistency."[1058] Alan Kay was working concurrently on the Dynabook, Smalltalk, and an art program called "Paintbrush."[1059] The Dynabook, he hoped, would be available from Xerox for under $500—no longer an impossible task, now merely difficult. Someone else had developed a program for household budgeting, ostensibly to alleviate domestic stress. Bruce Baumgart for example was working on an astrology program.

Yet the single most potent phenomenon at PARC was an office program: the word processor. Brand wrote, "The basic medium here is the text manipulation system developed at Doug Engelbart's Augmentation Research Center, which, as Doug puts it, allows you to 'fly' formerly unreachable breadths and depths of your information

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[1056] Ibid.
[1057] To wit, the computer printing company Indigo: "Everything that can be digital will be."
[1058] Brand. "Spacewar."
[1059] Computers were, according to Brand, "an art form waiting for artists, a consciousness form waiting for mystics." "Spacewar."

matrix."[1060] Using PARC's system, one could justify margins, import illustrations, number pages, add footnotes and headers, or incorporate corrections on the fly. It was productive, but it was not as fun as Spacewar. And fun with computers was meaningful: "Spacewar serves Earthpeace. So does any funky playing with computers or any computer-pursuit of your own peculiar goals, and especially any use of computers to offset other computers." Spacewar was the perfect emblem of this "heresy"; it was unplanned, uncontrolled, and totally spontaneous. "When computers become available to everybody," Brand predicted, "the hackers take over. We are all Computer Bums, all more empowered as individuals and as co-operators." This could only enhance the richness of human interaction.[1061] He ended, as always, with a series of prophesies in the Licklider-Engelbart fashion:

> …Spacewar, if anyone cared to notice, was a flawless crystal ball of things to come in computer science and computer use:
> 1. It was intensely interactive in real time with the computer.
> 2. It encouraged new programming by the user.
> 3. It bonded human and machine through a responsive broadband interface of live graphics display.
> 4. It served primarily as a communication device between humans.
> 5. It was a game.
> 6. It functioned best on, stand-alone equipment (and disrupted multiple-user equipment).
> 7. It served human interest, not machine. (Spacewar is trivial to a computer.)
> 8. It was delightful.[1062]

Though the Spacewar Olympians were coders of varying experience, they were hardly rank amateurs. Some, besides Brand, were interested in broadcasting this message more widely. One of the projects funded by the *Whole Earth Catalog*'s demise party was Pam Hart's Resource One, which sought to increase computer awareness by installing remote terminals in businesses around the San Francisco Bay Area. The aim was to

[1060] Brand. "Spacewar."
[1061] Ibid.
[1062] Ibid.

establish a public information-sharing network. Hart's endeavor attracted an ambitious computer engineer from Berkeley named Lee Felsenstein who had once been arrested with hundreds of other Free Speech radicals at the Sproul Hall sit-in. After graduate school, Felsenstein had visited PARC and been thrilled with the innovations he saw there. But rather than surf the state-of-the-art, Felsenstein was inclined toward the grassroots, computer-power-to-the-people movement that Resource One represented, preferring to work for the nonprofit.[1063] Felsenstein was an apostle of the philosopher Ivan Illich, who argued that for tools to be successful, they must be "convivial." Tools should be tested, exchanged, and repaired by a community of users—the basic bootstrapping process. When radio was a purely naval technology, Illich pointed out, it had little social significance. Only when amateurs took did the technology truly prosper. Felsenstein, who had built radios as a child, saw an analogy: the newest IBM mainframe, with its encyclopedic user's guide and dedicated service team was as much a mystery as the black monolith in Clarke's *2001*. In order to transform society, the computer had to become *personal*.[1064]

In May 1975, shortly after the debut of the Altair, Fred Moore circulated a flyer among his Portola, POINT, and academic contacts: "Are you building your own computer? Terminal? TV Typewriter? I/O device? Or some other digital black box? Or are you buying time on a time-sharing service? If so, you might like to come to a gathering of people with like-minded interests. Exchange information, swap ideas, talk shop, help work on a project, whatever."[1065] The first meeting occurred in a garage in

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[1063] Freiberger and Swaine. *Fire in the Valley*, 112.
[1064] Freiberger and Swaine. *Fire in the Valley*, 115.
Illich, Ivan. *Tools for Conviviality*. London: Marion Boyars, 2000.
[1065] Freiberger and Swaine. *Fire in the Valley*, 119.

Menlo Park; subsequent meetings were moved to the auditorium at the Stanford Linear Accelerator (John McCarthy's suggestion) to accommodate the crowds. Felsenstein responded eagerly and became the group's moderator and de facto president. Stewart Brand and his wife Lois attended, sitting quietly in the back.

The fledgling computer hobby society needed a name. An informal straw poll was taken; some of the suggestions were prosaic—the "Amateur Computer Club of America", the "MicroComputer Users Group". Others better reflected the spirit of fun Brand described in "Spacewar"—"Eight-Bit Byte Bangers," the "Steam Beer Computer Club." One paid homage to Edmund Berkeley, the dean emeritus of such computer associations: "Midget Brains." Finally, they settled on a name suggesting both amateurism and craftsmanship: "The Homebrew Computer Club."[1066] "Homebrew" was meant to instate a very different sensibility than what was tolerated at IBM or even DEC. The emphasis was heavy on exploration and transgressing boundaries, on pursuing what was interesting in the face of what was commercially or technically viable. The club was organized horizontally; there was no dictation from Felsenstein or Moore, no pecking order of officership. "There was a strong feeling that we were subversives," recalled Keith Britton. "We were subverting the way the giant corporation had run things. We were upsetting the establishment, forcing our mores into the industry."[1067]

Felsenstein ran the meetings in the style of an ad-hoc potlatch, a manner developed during his days as a New Left activist. They observed no standard rules of order, but generally proceeded with a mapping session in which members presented their questions or projects. Next, a speaker would deliver a formal presentation on their latest

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[1066] "Homebrew Computer Club," March 1975, box 9, folder 34. Silicon Valley Ephemera Collection (M0443), Stanford University Special Collections and University Archives, Stanford, Calif.
[1067] Freiberger and Swaine, *Fire in the Valley*, 118.

invention. The meetings concluded with a "Random Access" breakout, in which attendees communed in small groups to discuss common interests. Nearly everyone approved of the formula and the meetings gave rise to a number of bootstrap computer companies.[1068]

[1068] Freiberger and Swaine. *Fire in the Valley*, 122.

Chapter 23 – Selling the personal computer

In January 1975, the hobbyist magazine *Popular Electronics* appeared on newsstands advertising a home computer kit for $395 ($495 for the fully-assembled version). The machine, which did not come with a display or an input interface, was the Altair 8800, a granddaughter to Berkeley's Simon, made by the Albuquerque-based startup, MITS. MITS' president Ed Roberts left the task of naming his product to *Popular Electronics*; editor Les Solomon asked his 12-year-old daughter for suggestions and she replied "Why don't you call it Altair? That's where the Enterprise is going tonight."[1069] Thus *Star Trek*, and the Intel 8080 processor on which it was based, bestowed the name of the first home computer to achieve widespread popularity.

The Altair kit, like Simon, was primitive and klunky. It offered a fraction of the power of the smallest minicomputers in DEC's lineup. But it was cheap and it was first. MITS' Ed Roberts included a modular bus so that a second motherboard could be added to compile the 8k version of BASIC. Roberts later built paper tape readers, additional RAM cards, and interfaces to connect a teletype terminal, so that users would no longer have to program in binary using a series of switches on the front panel. Clearly, the Altair was not going to appeal to the mass market. But enough interested amateurs, many in clubs like Homebrew, were eager to get their hands on some form of computer power, that MITS sold hundreds of machines in 1975 and 1976, before any viable competitors could get off the ground.

The computer industry was about to undergo yet another metamorphosis, as it had when timesharing became popular on mainframes, and when upstarts like DEC began to

[1069] Milford, Annette. "Computer Power of the Future – The Hobbyists," *Computer Notes* 1 (April 1976), 7. Altair Users Group, MITS Inc. *Startup Gallery*. Accessed 6 Sept. 2010. <http://www.startupgallery.org/gallery/notesViewer.php?ii=76_4&p=7>

market machines small enough for small and medium-size businesses. The trials and transformations of the computer industry have been well documented by historians: Jeffrey Yost and Eric Swedin and David Ferro's accounts cover this terrain and more.[1070] Here we are concerned with how important changes in the landscape of the computer business were shaped by a community of users, and inspired by the rhetoric of information visionaries like Engelbart and Brand. The Homebrew Computer Club was a nexus of word-of-mouth, software sharing, and the ideals of democracy and interactivity. It was also, somewhat by accident, an incubator of business ideas. Many of MITS early competitors would emerge from the population of its first customers.

Homebrew is justifiably famous, among the amateur computing clubs that sprung up concomitantly around the country, for its many prodigious alumni.[1071] Members of Homebrew, partly out of poverty and partly out of a sense of rugged independence, effected a shift in the dominant mode of interactive computing from the still-popular utility method of time-sharing, practiced by Doug Engelbart with NLS, to individually-owned desktop machines, or *microcomputers*. MITS' Altair kickstarted this trend, but the incipient computer builders of Homebrew made it a tidal wave. Alan Kay, author of the Dynabook concept, attended meetings in 1978 and encountered a sudden surge of competition.[1072]

One of the first startups was Harry Garland and Roger Melen's CROMENCO, a maker of peripherals and controllers for the Altair, and later standalone machines. With

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[1070] Swedin, Eric G. & David L. Ferro. *Computers: The Life Story of a Technology.* Westport, Conn.: Greenwood, 2005.
Yost, Jeffrey R. *The Computer Industry*. Westport, Conn.: Greenwood, 2005.
[1071] Other clubs thought of Homebrew as a pioneer; one, "The Flathead Computer Society" of Kalispell, Montana wrote Fred Moore for advice. "Homebrew Computer Club," Silicon Valley Ephemera, box 9, folder 34.
[1072] "Homebrew Computer Club," Silicon Valley Ephemera, box 9, folder 34.

Felsenstein, Homebrew member Bob Marsh started Processor Technology (ProcTec), which made the Sol-20 microcomputer, available in 1977 fully assembled, or as a kit, targeting the hobbyist market. Felsenstein also designed the Osborne 1 personal computer, with another Homebrew member, Adam Osborne.[1073] The Osborne 1 is considered the first commercially successful portable computer, packaged in a two-pound box, selling for under $2,000, and moving as many as 10,000 units a month.[1074] Osborne Computer Corporation was a dynamic and iconic American company, but it was also a financial failure, declaring bankruptcy in 1985. Victims of financial naïveté, breakneck competition, and a rapidly shifting market, Adam Osborne made famous the "Osborne effect"—killing demand for your current product by announcing, with great fanfare, its successor.

Steve Wozniak too was an early attendee; when he and his friend Steve Jobs built the Apple I motherboard in Jobs' garage, the brought it to a Homebrew meeting for feedback. Their first order came from a Homebrew member, Paul Terrell, who was opening up the Byte Shop, a computer retailer, in Mountain View. Apple was a partnership of Wozniak's can-do engineering talent and Jobs' restless entrepreneurship, a distillation of the former's happy-go-lucky personality and the latter's ruthless business sense. In one company they merged the multiple personalities of the Whole Earth crowd and provided a template for a generation's mutation from dreamers to capitalists.

While MITS and ProcTec served the hobbyist market—their products were disassembled, partially functional, and wholly inscrutable to computer illiterates—Apple was moving in a different direction. At the April 1977 West Coast Computer Faire,

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[1073] Ibid.
[1074] Grzanka, Leonard G. "Requiem for a Pioneer," *Portable Computer*, January 1984.

organized by Homebrew member Jim Warren, Jobs and Wozniak launched the Apple II next to calculator-maker Commodore's PET with a monitor and keyboard, in an attractive, closed package.[1075] Jobs saw the Apple II as a home appliance, not an obscure gizmo for hobbyists.[1076] His divulged his vision in Apple's first advertisement; a young man sits at a makeshift dinner table-office with an Apple computer, a book, and a pen, while his wife looks on admiringly from the background.[1077] It was this soft image of domesticity that was meant by "computer power to the people" as much as any radical political agenda. In a world of enormous batch processing installations and factory automation, a machine in the home or office could be just as destabilizing.

"You plunk down anywhere from $200 to $3,000, bring it home, put it together, plug it in and, presto—you've got a computer system at your beck and call," the front page of *The Wall Street Journal* exulted in February 1977. "The era of the home computer, it seems, is upon us."[1078] Ordinary people were using personal computers with graphical interfaces to create electronic music, play games, and prepare their taxes. The *Journal* estimated between 20,000 and 100,000 such machines had sold since 1975. The number might have been higher if less expertise were required to assemble them. Still, the owner of Kentucky Fried Computers in Berkeley reported that less sophisticated customers were coming into his shop every day.[1079] Jim Warren noted that a few small companies (such as Processor Technology) were beginning to offer pre-assembled

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[1075] Warren was also the chair of the Peninsula Chapter of Berkeley's ACM, dabbling in both professional and amateur computer organizations. "Homebrew Computer Club," September 1, 1976. Silicon Valley Ephemera, box 9, folder 34.
[1076] Campbell-Kelly, Martin and William Aspray. *Computer: A History of the Information Machine*. Cambridge, Mass.: Westview, 2004, 247-248.
[1077] Apple advertisements, *The Mac Mothership*. Accessed 6 Sept. 2010. <http://www.macmothership.com/gallery/gallery1.html>
[1078] Gumpert, David. "Home Input: The Computer Moves from the Corporation to Your Living Room," *The Wall Street Journal*, Feburary 4, 1977, 1.
[1079] Gumpert. "Home Input," 18.

computer systems for less than $1,000. At the same time, software suites, particularly for the CP/M operating system, were mitigating the need for microcomputer owners to invest in programming lessons. The market was on the verge of taking off, the *Journal* predicted. Radio Shack, ground zero for electronics hobbyists was reportedly interested (the Tandy TRS-80 was released six months later), and IBM was quoted ominously: "it's a matter of time."[1080]

Homebrew was not just a launchpad for new companies; it was the intellectual ferment for the entire microcomputer industry. Computer engineers traded design ideas and met their future customers face to face. Industry-wide initiatives, like the Apple IIe's open architecture, were born at Homebrew meetings. Reviews in the Homebrew newsletter had purchase across the country. It also imparted its values to the industry at large. "You can no longer optimize profits and screw people," Tandem Computer's president told *Mother Jones*. "Tandem's a socialist company." Stewart Brand was pleased at this fusion of idealism and commerce. He commented, "Maybe capitalism after all these years has finally found a way to operate benignly—that would be terrible news for the Left, wouldn't it?"[1081] Journalists carried forth this founding myth of Silicon Valley—capitalism with a soul—to the world, citing the town meeting atmosphere of Homebrew and the youthful excitement of PARC.

If Apple and Osborne carried Homebrew's message to a consuming public, then the People's Computer Company was its proselytizing arm. Founded by Bob Albrecht, an erstwhile member of the priesthood at Honeywell and Control Data, the PCC was dedicated to spreading the word of computers to the lay community, and, particularly,

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[1080] Gumpert. "Home Input," 1.
[1081] Talbot, David. "Fast Times for High Tech," *Mother Jones*, December 1983, 25.

children.[1082] Albrecht helped develop a community computer center in Menlo Park where families and kids could play on microcomputers with little restriction. He advertised a public class in the Homebrew newsletter: "What's a Computer?—(And What Can I Do With It?)—A Class for family and friends of computer people who always wanted to know about computers but didn't want to ask them. Learn how computers work, find out what jargon means, play some games and start programming." The cost of admission was $25.[1083] Starting in 1976, PCC published a thicker periodical that evolved out of an insert in the Homebrew circular; *Dr. Dobb's Journal of Computer Calisthenics and Orthodontia*. *Dr. Dobb's Journal*, which persisted in print until 2009, was the first publication devoted uniquely to computer software; its first issue reprinted the source code of an interpreter for Kemeny and Kurtz' BASIC language, intended for implementation on small home machines (Tiny BASIC).[1084] "There are lots of languages for talking to computers," read the subheading. "Most of them are O.K. For computer freaks but lousy for people. We will use the computer language called BASIC – great for people, not so good for computer freaks."[1085] According to Albrecht, *Dr. Dobb's* was "concerned with free and inexpensive systems and applications software for personal

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[1082] Freiberger and Swaine. *Fire in the Valley*, 113. Albrecht left Control Data, one of the leading manufacturers of cutting-edge supercomputers, due the company's unwillingness to develop a cheaper, home machine

[1083] "Homebrew Computer Club," February 16, 1977. Silicon Valley Ephemera, box 9, folder 34.

[1084] The first significant battle over digital rights occurred on Homebrew's home turf. Homebrew meetings had quickly become a kind of swap meet for programs and applications to be run on members' personal hardware (often an Altair). This unlicensed exchange particularly irritated the Altair's leading software vendor, a small firm named Micro-Soft that earned royalties from a form of BASIC MITS sold with its machines. In February 1976, its president, Bill Gates, published an "Open Letter to Hobbyists" in the Homebrew newsletter, accusing them of illegally usurping Micro-Soft's code. "As the majority of hobbyists must be aware, most of you steal your software," Gates wrote. "Hardware must be paid for, but software is something to share. Who cares if the people who worked on it get paid?" Gates' pitched battle led to the distinction of the proprietary software market that he helped create, and the Open Source movement. "Homebrew Computer Club," February 3, 1976. Silicon Valley Ephemera, box 9, folder 34.

[1085] "BASIC! Or, U 2 can control a computer." *PCC Newsletter*, October 1972, *DigiBarn*. Accessed 6 Sept. 2010. <http://www.digibarn.com/collections/newsletters/peoples-computer/peoples-1972-oct/1972-10-PCC-p5-medium.jpg>

computers, interesting projects for computer hobbyists, reprints of articles and schematics of general interest from many club newsletters, providing indices and directories to publications and organizations, and actively pursuing computer advocacy." It was, in short, the voice of computer democracy.

By the late 1970s, computer manufacturers were scrambling to tap this growing sentiment. Intel's 8080 microprocessor, a palm-size 8-bit, 2 MHz chip had fallen in price to just a few dollars a unit. Through the persistent advocacy of computer agitators such as Brand and the PCC, more and more Americans had become familiar with microcomputers and began to contemplate buying one for the home or office. A cursory review of computer product literature of the period reveals a sudden accent on computers' universal utility. MITS, of course, was in the vanguard. A glossy ad from 1975 proclaimed the dawn of the "Altair Age." 1975, MITS announced, would herald "the Age of the Affordable Computer. The Age of Computer Power for every business and every home in the Modern World."[1086] The 8800 had been streamlined since its unveiling in *Byte* in stylish black, the console adorned with a futurist font reminiscent of the cover art of Toffler's paperback *Future Shock*. It looked small and manageable, like a Betamax player—a significant departure from the traditional picture of gleaming, spaceship-sized industrial machines designed to awe with their engineering power. Its catalog depicted female secretaries merrily working on a teletype keyboard. Notwithstanding its formidable effort, MITS lacked the distribution channels or the peripherals to compete with larger vendors for the office or home user market; it remained principally a hobbyist machine.

[1086] "The Age of Altair," MITS June 23, 1975. Computer Product Literature, box 31. CPL, Box 31, MITS 6/23/75, "The Age of Altair"

Commodore Business Machines, makers of pocket calculators, was however equipped to market technology directly to individuals. In 1978, the PET had retailed close to $1,000. In 1981, Commodore expanded its product line to include the 8-bit VIC-20, selling at $300, which became the best-selling model of 1982. Commodore's ads proclaimed the VIC-20 "the friendly computer," a full-featured, color-graphics box "priced at little more than a video game."[1087] In fact, Commodore included a number of cartridge-based games from developer Adventure International, targeting hobbyists and children alike. The VIC-20 was deliberately steered to "first-time users," underscoring its accessibility to consumers with no programming experience. By 1982, Commodore had introduced the model 64 at $595, a full-featured entry-level machine offering 64 kilobytes of built-in memory (as much as upmarket micros from 1979), 3D graphics, and a music synthesizer.[1088] Commodore's literature made no mention of accounting or business applications; the 64 was plainly intended for frivolous personal consumption.

RadioShack was moving in this direction, attempting to position its Tandy brand less as a novelty and more as an essential household gadget, no different than a refrigerator. The company's 1978 product catalog made this case explicitly: "Why a personal microcomputer?" it asked. "Because today's complex lifestyles require a method of getting more things done in less time. The TRS-80 has made true computing a reality for the small business, laboratory, classroom and the home. RadioShack's TRS-80 is *the* personal computer for anyone and everyone."[1089] Who could use the TRS-80? The answer RadioShack proposed was: "truly anybody." Technical specifications were

[1087] "VIC-20," Commodore Computers, August 1982. Computer Product Literature, box 7.
[1088] Ibid.
[1089] "Catalog 1978," Tandy, 1978. Computer Product Literature, box 7, 3.

accompanied by a picture of a family, gathered around a dinner table, Mom proudly displaying her latest digital project.

The problem of information overload that had confronted Bush and Engelbart decades before had migrated from the laboratories of the science to the kitchen and the small office. Computer marketers, employing an iconography of confident, ordinary Americans rationalizing their lives through personal information processing, drew on the rhetoric that information surfers had popularized. American consumers demanded products that spoke to their needs for organization, efficiency, and intellectual exploration. Computers might have remained embedded business machines or controllers of industrial robots had Berkeley and his descendants not intervened.

According to Tandy, homeowners could use their TRS-80 to manage purchases by date, serial number and repair history. It could become an important asset in the intellectual development of their children. It could be an "automated teacher of math, spelling, American history, or what have you."[1090] Tandy's literature reproduced one father's testimonial: "This investment is one of the most significant value to our family and to the future education of our child that we have ever seen." The limits of the TRS-80 depended only on the imagination of the user. In utopian prose rare even in advertising, the company proclaimed the TRS-80 "makes possible the tapping of human innovation and creativity on an unprecedented scale."[1091] Brand would have been amused: Tandy depicted its product as a cybernetic appendage: "It is literally an extension of the mind. It is to man's mind what the lever is to his arm." It is evident that Radio Shack's marketing department expected its catalog readers to be familiar, at least

[1090] Ibid.
[1091] "Catalog 1978," Tandy, 1978. Computer Product Literature, box 7, 5.

through the filter of mass culture, with Wiener's idea of the "intellectual prosthesis," or Engelbart's augmented intellect. Computers were truly unique among the technological wonders of modern life in our celebration of their transformative effects on the mind. Edmund Berkeley could not have written it better himself.

The key element of consumer education for the industry was the fact that, in Tandy's words, "a computer works with alphanumeric information." It could thus replace a number of diverse processes: "It can alphabetically sort a mailing list, find subscribers who have not renewed, locate slow-moving inventory items, write purchase orders based on sales trends and current inventory levels, or simply catalog your butterfly collection." Moreover, it was an entertainment device: "you can spend hours playing really challenging computer games, from chess to Space War."[1092] By 1982, options had proliferated. Commodore boasted, "The 64 just so happens to be the most brilliant game machine you can buy." On its CP/M operating system, it could run titles like Gorf, Spiders of Mars, Mole Attack, Omega Race, Lightpen Artist, Midnight Drive, Avenger, Ace of Aces, and countless more.[1093]

Hooking a microcomputer up to the intergalactic network only increased its potency. Commodore offered a modem for $100 with a free month of online time. By playing the dual role of hardware manufacturer and Internet service provider, Commodore hoped to capture the promised benefits of desktop and utility computing—high margins and reliable income streams. From the consumer's point of view, access to online communities, bulletin boards, and remote networks suggested a world beyond the confines of the home machine. "Telecomputing, they call it," read the Commodore 64's

[1092] "Catalog 1978," Tandy, 1978. Computer Product Literature, box 7, 3.
[1093] "VIC-20." Computer Product Literature, box 7.

booklet. "They used to also call it expensive… Imagine your own stock market ticker through Dow Jones… Or instead of comparison shopping by foot, do it by computer through Electronic Shopping. Electronic mail – the future of business communications – is here in the present. Memos, data, programs can all be sent without having to depend on the Post Office."[1094] Computer networking was a way for computer buffs, wine aficionados, and gamers to connect with one another and form distributed "communities of common interest" as Licklider and Taylor had predicted. Commodore wanted to help even neophytes get into the act. The company's online information network supplied tips and support for Commodore users, public domain software for download, and software recommendations from Commodore programmers. Networking microcomputers, Commodore believed, was a fantastically important social development. "You change communications, and you change everything," Brand later told *PC Computing* magazine.[1095] Manufacturers were at the forefront of this change.

Tandy's annual financial report from 1978 provides a snapshot of the home computer market. Growth over the period of the late seventies was explosive. Figures from the Electronics Industries Association indicated that the personal computer market grew from $2 million in 1977 to $45 million in 1978, a hyperbolic rate of 2,150 percent. Units shipped grew even faster—from three million to 75 million over the same span.[1096] As Engelbart had said, "Any quantitative change by a factor of ten is a qualitative change." Despite the exaggerated cultural sway of groups like Homebrew, the engine of growth in standalone microcomputers was clearly the small business segment. Management commented, "The principal markets that have surfaced to date have been

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[1094] Ibid.
[1095] *PC Computing*, May 1989 clipping. *The Whole Earth Catalog* Records, box 4.
[1096] "Tandy annual report," 1978. Tandy. Computer Product Literature, box 44, 12.

the small business, the first-time computer user, education, and small parts of bigger businesses. Our impressions to date would indicate the hobbyist, while vocal and visible, is not the mainstream of the business."[1097] Longhairs and hobbyists preferred less slick, "some assembly required," models, like the Altair. Still, there were not enough digerati in 1978 to outpace the breakneck growth in the pool of ordinary computer users. Perversely, the cultural currents initiated by *The Whole Earth Catalog* and the PCC succeeded in making interactive computing a more acceptable presence in the office. The savvy business decision that Tandy made was to expand beyond its core constituency and market the TRS-80 more broadly to businesses. A 1978 study in *Datamation* (John Diebold's magazine) ranked Tandy first ahead of MITS, Apple, Commodore, and Heath in consumer brand preference. Notably absent from the list of personal computer OEMs was IBM. As the dynamics of the market shifted to favor office computing, that would change.

Years before, Engelbart had envisaged the convenience of a virtual, "paperless" office.[1098] The layout of his NLS was designed to emulate file folders; Xerox PARC's clickable icon interface created the familiar "drag to trash" deletion method. Still, convincing the business public that a personal computer was worth the cost required more than an intuitive interface. Products of use to businesspeople had begun to arrive. Daniel Bricklin, a Harvard MBA student, modeled VisiCalc, the first successful

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[1097] Ibid.

[1098] Seely Brown and Duguid have argued that attributing the "paperless office" to pioneers like Engelbart and Raskin amounts to "endism." Hard copy persists to this day because, in a McLuhanian sense, the physical act to tool use is an important shaper of content. That Engelbart and PARC failed to commercialize the concept, however, is no indictment of its forsightedness. The work of convincing businesspeople that their affairs could be conducted better on a desktop computer fell, as always, to private actors, competing in a market environment. Vision alone is a necessary but not sufficient condition for success. Apple, IBM, and Microsoft succeeded by exporting Engelbart's ideas to a pre-existing small enterprise market; they had customer relationships, pricing power, and vision. Seely Brown, John and Paul Duguid. *The Social Life of Information*. Cambridge, Mass.: Harvard Business, 2000.

spreadsheet application on accounting ledgers. The program, which took advantage of the interactive response of personal computers became "a computer game for executives," making possible quick "what if" and counterfactual questions.[1099] WordStar, for CP/M, incorporated most of Engelbart's dynamic word processing innovations in a cheap, floppy disk package. A diverse array of applications, if not the requirement for PC adoption, was at least the springboard. Tandy's 1978 report forecasted: "Almost every manufacturer of data processing or office equipment, and some who presently produce neither, are beginning to talk about developing new products for 'the electronic office,' ' the automated office,' or the 'office of the future'. And with good reason. By whatever name it is called, this is a concept whose time has clearly come."[1100] Its financial statements were flanked by stylish commercial art of office floors with dozens of microcomputers on desks. Unfortunately, Tandy's low price and head start could not deter the big players.

Wang, the makers of timeshared word-processing machines, began releasing closed architecture PCs after 1977. Wang's familiarity with the office market gave it a leg up. Wang computers, its ads claimed, "represent the marriage of computer technology with the evolving office systems environment, offering increased productivity, improved communications, job enrichment, and more emphasis on the human aspects of working."[1101] A technique to attract office managers, Wang understood, was to echo the 1960s cheerleaders of automation. By combining the computers' power with human judgment, businesses could sustain a formidable (and happy) workforce.

[1099] Campbell-Kelly and Aspray. *Computer*, 251.
[1100] "Tandy annual report." Computer Product Literature, box 44, 8.
[1101] "Wang Integrated Information Systems advertisement," 1979. Wang. Computer Product Literature, box 74.

The true giants of office machinery, IBM, had made a portable computer as early as 1976's 5100. The 5100 was essentially a scaled-up calculator marketed as an improved number cruncher, with the rudimentary operating environment of the APL and BASIC languages. The machine cost more than $9,000, offered limited functionality, and thus failed to bridge the gap between IBM's enterprise dominance and lower-market vendors like DEC. The example that IBM eventually chose to follow was Tandy's; when the decision was made to launch a microcomputer line in 1980, Big Blue moved swiftly. Senior executive William Lowe authorized engineer Don Estridge to bypass the traditional IBM product development channel and take a team to Florida to assemble, in secret, a personal computer.[1102] IBM was in such a hurry it even bypassed its prized vertical integration model, instead electing to outsource component production.[1103] Rather than the industry standard CP/M operating system, IBM chose Bill Gates' Microsoft to provide a comfortable platform for novice users.[1104] By 1981 IBM had an alternative to the personal computer upstarts, conferring "legitimacy" on the young industry.

A case study may serve to illustrate the centrality of the office to the personal computer industry. We have seen how IBM achieved instant penetration into the enterprise market upon entering the computer business in 1952, selling businesses on a suite of service and installation expertise, and the shear prestige of its brand. So too, IBM would come to dominate the personal computer market in the 1980s. Initially welcomed with cocksure irony by Steve Jobs, in a full-page ad in *The Wall Street Journal*,

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[1102] Campbell-Kelly and Aspray. *Computer*, 260.

[1103] Ceruzzi. *A History of Modern Computing*, 277. Using OEM parts also allowed the PC to be easily reverse-engineered, as firms like Compaq did.

[1104] A longstanding corporate legend has it that CP/M's creator, Gary Kildall was late for his meeting with IBM executives because he was flying his personal airplane. Bill Gates stepped in, and Microsoft's began its path to dominance.

"to the most exciting and important marketplace since the computer revolution began 35 years ago," IBM shipped 13,000 PCs in the 4 months after its 1981 launch. By 1983, it had sold half a million.[1105] The IBM PC was assembled in the great part from off-the-shelf parts as Big Blue scrambled to get a late entry into the personal computer business. This was unusual for a company whose economies of scale permitted it to bundle everything from wires to memory to software in an integrated design. IBM had no great technological advantage over its more experienced rivals at Apple, Tandy, Commodore, or Osborne. But the Endicott, New York colossus had, as usual, a canny sales strategy.

Much has been made of IBM's software-licensing approach. IBM apprehended that opening its hardware to third-party software would allow competitors to mimic its central design. It would also, however, drive a new market of software users to IBM's familiar, trusted technology. The decision led to Microsoft's dominance of the new market of software; it created a de facto industry standard for word processing, database, email and spreadsheets; it spawned an array of clones and instituted a trend toward commodity pricing across the hardware market. This decision bloodied bundled hardware/software providers like Apple, though not necessarily the ill-fated Osborne Computer Corporation, who had released an MS-DOS compatible machine in 1983. Many firms, like Osborne, were done in by their own lack of scale in R&D and retail distribution.

But IBM really achieved its dominating position, as ever, through sales and marketing. IBM realized early that its eponymous personal computer was not only a toy for hackers, gamers, artists, and musicians. It was a compliment to the company's large catalogue of office products. If businessmen could be persuaded that, by typing their

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[1105] Freiberger and Swaine. *Fire in the Valley*, 349.

own memos and calculating their own expenses on a simple, affordable machine, they could enhance their productivity, the PC would be a winner. Firms would have to upgrade from a single computer in the billing department to one on every desk. Aided by an Apple-like operating environment from Microsoft and a reputation for best-in-breed service and repair, IBM became the most popular choice for industry. As the market swelled, the clones followed in IBM's wake.

IBM's advertisements for the PC reflect its orientation toward computer neophytes. While Apple and Commodore ads stressed speed, adaptability, and functionality of their systems for the tech-savvy, IBM targeted a new growth market: novice users. Though they included a sidebar of technical specifications, a series of ads that ran in *Personal Computing* magazine between 1981 and 1982 pictured business cuit-clad professionals interacting comfortably with their IBM desktops. "You might…have thought running a computer was too difficult. But you can relax again," proclaimed one ad. Then, in the unmistakable idiom of human-computer symbiosis, it continues: "Our literature is in *your* language, not in 'computerese.' Our software *involves* you, and the system *interacts* with you as if it was made to—and it was."[1106] Another concludes, "Experience the IBM Personal Computer. You'll be surprised how quickly you feel comfortable with it."

When IBM entered the office computer market, its chief competitor was the Massachusetts firm Wang Laboratories, known for its popular word processing systems. The firm's founder and chief engineer, Dr. An Wang, was a former graduate student of Howard Aiken who had pioneered several innovations in magnetic core memory and

[1106] IBM advertisements. Marcin Wichary homepage. Accessed 6 Sept. 2010. <http://www.aresluna.org/attached/computerhistory/ads/international/ibm>

digital displays that had reduced computers' response-time and improving their facility of use. In the late 1970s, Wang was ascendant in the enterprise market with its OIS (Office Information System), a microcomputer with a tightly integrated proprietary operating system, word processing, and productivity software that could network hundreds of users via individual workstations the size of an IBM PC. Each workstation ran on 64k of dedicated RAM, as much as the Apple II personal computers available at the time. Wang's advertising emphasized the humanizing aspects of office technology—the ability of computers to foster creativity, and improve communication in the workplace. A number of ads pronouncing "the office of the future, today," promised "the marriage of computer technology with the evolving office systems environment, offering increased productivity, improved communications, job enrichment, with more emphasis on the human aspects of working."[1107]

Wang was synonymous with word processing, but aimed to provide a range of capabilities to digitize office tasks including mail, calculation, and human resource management. Their advertisements neatly recapitulate the arguments for office automation that Berkeley was making to Prudential in 1949. Computers, properly programmed, could relieve human workers of dull tasks, acting like light-speed clerk. They liberated minds. Despite IBM's challenge, Wang clung to its franchise in the office even as the market migrated from distributed computers to desktop machines, though the incompatibility of their famous word processing programs with the IBM platform ultimately decreased Wang's share. The company filed for bankruptcy in 1992.

[1107] "Wang Integrated Information Systems advertisement," 1979. Wang. Computer Product Literature, box 74.

History repeats itself. There is an instructive symmetry in the way IBM came to dominate the market for mainframe and for personal computers. In each case, thought late to the party, IBM appreciated the potential of the office market. While the computer was an excellent tool for combat simulation, and stimulating toy for the countercultural set, where it thrived best was in making work more efficient, more communicative, and more interesting. The “computer revolution” never meant that automatic computers would be running our lives. To the emerging PC industry, it meant that, with computers, we would manage our own lives better.

Chapter 24 – Assessing the "influentials"

Marketing literature in recent years has focused on central role a class of people called the "influentials".[1108] While mathematicians and network theorists work on developing a model of influence (early studies suggest individual influence matters very little), cultural commentators like Malcolm Gladwell argues that there are among us native "mavens," "connectors," and "salespeople," who discover trends, create social networks, and tell us how to think and behave.[1109] This theory of "tipping points" is perhaps spurious as sociology, but it rests on the fundamentally correct notion that certain people are a great deal more culturally influential than others. This is a study of several such people who served as mouthpieces of scientific knowledge both to a general public. Their efforts at building networks, proselytizing to the heathens, and predicting future trends shaped and consolidated trends toward technological adoption. Men like Wiener, Berkeley, Diebold, Licklider, Engelbart, and Brand were agents of self-fulfilling prophesy.

Among these prophets I have identified what is, at heart, a single message with manifold implications. The world was made of information, and information would remake the world. As computers permeated more aspects of people's lives, they would become increasingly better integrated in feedback systems with their users. Though cybernetics revealed the computer-like logical architecture organic systems, subsequent computer history can be understood as a decades-long process of building machines

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[1108] Keller, Ed and Jon Berry. *The Influentials: One American in Ten Tells the Other Nine How to Vote, Where to Eat, and What to Buy*. New York: Free Press, 2003.
[1109] Watts, Duncan J. "Networks, Dynamics, and the Small-World Phenomenon," *The American Journal of Sociology* 105 (September 1999): 493-527.
Gladwell, Malcolm. *The Tipping Point: How Little Things Can Make a Big Difference*. Boston: Back Bay, 2002.

aligned more naturally to human activities. Giant Brains would not replace the industrial worker; computer-augmented intellects would. A profile of Stewart Brand in the *New York Times* summarized the basic beliefs that underlay his and his predecessors' line of argument: "Mr. Brand, who was once a biologist, finds the form and function of computers reminiscent of biological processes. He believes the machines are a liberating force, empowering a new generation of information adepts. He also worries that computers' impact must be monitored, but that those who ordinarily do the monitoring 'have been co-opted.'"[1110]

One of the most important jobs of the intellectual historian is to examine the workings of influence. In the case of computers, self-appointed ambassadors mediated public response through their commanding presence in the popular press. When reporters angled for a quote on the exciting future of computers they infrequently went to engineers on the front line at IBM or the Lincoln Lab; instead they engaged a sphere of public intellectuals that their writing helped to reinforce. As Fred Turner and Dianne Martin have shown, science journalists were the makers of computer rhetoric. Liberally deploying cybernetic metaphors, they convinced Americans that a revolution was in fact underway.

These intellectuals held a more embracing, more totalizing, and more human vision of the computer revolution than did industry executives or researchers in narrow, technical fields. They saw their futuristic worldviews engraved in the fantasies of science fiction literature. Often, they maintained close personal correspondence with science fiction writers, as had Wiener with Groff Conklin or Berkeley with Isaac Asimov. They

[1110] Collins, Glenn. "Stewart Brand: A New Catalog and All's Well." *The New York Times,* November 2, 1984, B8.

gave voice and self-consciousness to cultural movements that aimed to rescue computers from the suits and the academic elect. In the end, the suits followed their lead.

Histories of the computer are plentiful. There are stories to tell about laboratory breakthroughs, science management, the oscillations of the business cycle, and military planning. One popular narrative of the computer as a relic of spiritual and psychedelic experimentation does hint at a universal theme. Fred Turner perceives, though he does not firmly establish, that the philosophical tropes of cybernetics (circular causality, information exchange, homeostasis) wove together many of the dispersed initiatives toward improving computers' accessibility. I have attempted to show how these ideas united a community of believers across several decades of computer research. They were anti-militaristic, if not anti-establishment outright. They believed that, through more efficient information processing, many of the social and economic troubles of the twentieth century could be ameliorated. Finally, while they embraced some level of public planning, their arguments were more easily adapted to the private office than they might have suspected.

These beliefs, I believe, form a coherent intellectual thread from the first meetings of the cybernetic group at the Beekman Hotel in New York, to the many Homebrew spinoffs flourishing in the Silicon Valley of the early 1980s. Following the information ambassadors who made the popular translation of discovery their mission, I call attention to the demand, or consumption side of the production equation. History is written equally by the adopters of technology as by its inventors. Nonetheless, mine is only one history of digital computers—from Giant Brains to personal aids—that might be written. If we abandon certain reductionist frameworks such as the narrative of military contagion, or the determinism of smaller and faster processing power, we begin to see with clearer vision how unique moments in the vastly different "engineering cultures" of M.I.T., Palo Alto garages, and IPTO PI meetings in Utah or Champaign-Urbana fit together—and how they do not.

A number of avenues to future scholarship suggest themselves. More serious study should be directed toward the channels of transmission. Men like Wiener, Berkeley, and Brand are emblematic of a particular kind of public ambassador, but my list is hardly comprehensive. Alan Kay and Robert Taylor are only peripheral figures here. No serious cultural history has yet been written of the computer in late twentieth-century science fiction; this would prove a fruitful topic. Most obviously, due to considerations of time and space, my account has only spotlighted American culture. Slava Gerovitch and Jérome Segal have applied slightly different templates to the histories of information science in the Soviet Union and Western Europe.[1111] Still, there remains much to be understood about computer culture in Great Britain or Japan, for instance. Finally, while I have avoided a number of technical details, historians have yet to offer a synthetic treatment of software, programming languages, or operating systems in either their implementation or their use.[1112] I suspect that a history of computer software will reveal opposing trends toward practical hacks for applied problems, and broad philosophically-informed reboots, such as Kemeny and Kurtz' BASIC. The latter may conform to the computer democracy argument I put forward; the former may not.

[1111] Gerovitch, Slava. *From Newspeak to Cyberspeak*. Cambridge, Mass.: MIT, 2002. Ségal, Jérôme. *Le Zero et le Un*. Paris: Editions Syllepse, 2003.

[1112] Adele Goldberg's retrospective compendium, *A History of Personal Workstations*, is fine point of departure for such a project.

In the end, studies of popular influence are often, at best, fragmented and diffuse. I have demonstrated only that a number of agents succeeded in fostering a fertile environment that nurtured the information culture of the late twentieth century. This culture itself is the product of many different histories concerning hundreds of thousands of actors—the distributed computing model propounded by Licklider and others ensured that everyone could participate. Yet influence is an important factor. If today's users cannot recognize the names of Wiener, Berkeley, Diebold, Licklider or Engelbart, they are nevertheless familiar with their conceptual language.

Appendix 1 – Edmund Berkeley's automated psychologist: An historical footnote

One of the most famous chapters in the history of artificial intelligence concerns a system similar to Berkeley's automatic psychologist. Though intended as a prank, M.I.T. computer scientist's model of a Rogerian psychotherapist, ELIZA, named after the character in Shaw's Pygmalion, was an immediate sensation.[1113] One of the first credible experiments in Natural Language Processing, in 1966, ELIZA was embraced by hundreds of would-be patients who forged an emotional connection with the program, though its responses were a variety of canned phrases and deflections of the patient's question. A "session" might transpire as follows:

> Patient: I spend too much time with computers.
> ELIZA: Why do you mention computers?
> Patient: Because you are one.
> ELIZA: Does it please you to believe I am one?[1114]

To Weizenbaum's chagrin, some have argued that, while ELIZA was devised to be a simple linguistic ruse—a "chatterbot" playing on the recursion inherent in human interactions—similar programs might possess true therapeutic value, at least for patients who cannot see an accredited therapist.[1115]

The hullabaloo surrounding his creation drove Weizenbaum to question many of the core assumptions of the Artificial Intelligence field as it was constituted in 1966. In the end, he began to question the functionalism that underlay the discipline. To many, including perhaps Berkeley, because ELIZA's answers passed for intelligence, they *were*

[1113] Weizenbaum, Joseph. "ELIZA—a computer program for the study of natural language communication between man and machine," *Communications of the ACM* 9 (January 1966): 36-45.
[1114] A working version of ELIZA, with source code, is available at Charles Hayden's website: <http://www.chayden.net/eliza/Eliza.html> Accessed 1 Sept. 2010.
[1115] Colby, Kenneth. "Computer Method of Psychotherapy: Preliminary Communication," in *The Journal of Nervous and Mental Disease* 142, (1966): 148-152.

intelligent. The matter was only to iron out wrinkles and nuances. In 1967, M.I.T.'s AI pioneer Marvin Minsky would famously predict, "Within a generation, the problem of creating 'artificial intelligence,' will be substantially solved."[1116] We were on the precipice, according to Minsky, of an era that "will quite possibly be dominated by intelligent problem-solving machines."[1117]

Minsky's expectations quickly became part of the public dialog when the film 2001: A Space Odyssey hit screens in 1968. The movie established HAL 9000 (the Heuristically-programmed ALgorithmic computer) as one of the great villains of literature, one who is capable of speech recognition, facial and emotion recognition, chess, art appreciation, and music.[1118] Notably, Minsky served as an advisor to 2001's writer and director, Arthur C. Clarke and Stanley Kubrick, insisting that these developments in artificial intelligence were in fact likely by 1992, when HAL came online.[1119]

The tendency to analogize computer behavior to human behavior, even among those trained in the design of computer systems, was laid bare by ELIZA: it has been subsequently called the ELIZA effect.[1120] Weizenbaum worried that, easy as it was to ascribe humanity to a mechanism, it became equally appealing to scientists of a certain orientation—and the public—to ascribe mechanism to humanity. He penned a seminal 1976 diatribe against the wholesale equation of human and machine intelligence,

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[1116] Minsky, Marvin. *Computation: Finite and Infinite Machines*. New York: Prentice-Hall, 1977, 2.
[1117] "Will Computers Outwit Man?" *Fortune*, October 1964.
[1118] That HAL is merely one letter removed from IBM, his creators insisted, was purely coincidence.
[1119] Stork, David G. "Dawn of HAL: History of Artificial Intelligence - Dr. Arthur C. Clarke Interview." *HAL's Legacy, PBS*. 2001. Accessed 1 Sept. 2010. <http://www.2001halslegacy.com/interviews/clarke.html>
[1120] Hofstadter, Douglas. "The Ineradicable ELIZA Effect and Its Dangers," in *Fluid Concepts and Creative Analogies: Computer Models of the Fundamental Mechanisms of Thought*. New York: Basic Books, 1996, 155-168.

Computer Power and Human Reason to agitate for the liberation of spontaneous, creative human thought from the tyranny of computerized, technocratic, bureaucratic systems. "I would argue that, however intelligent machines may be made to be, there are some acts of thought that *ought* to be attempted only by humans," Weizenbaum wrote. "The lay reader may be forgiven for being more than slightly incredulous that anyone should maintain that human thought is entirely computable. But his very incredulity may itself be a sign of how marvelously subtly and seductively modern science has come to influence man's imaginative construction of reality."[1121]

ELIZA evidently could pass a Turing test—provided her interlocutor was willing to talk at length about his or herself.[1122] Whether the program represented a major step forward for natural language processing, or a gimmick exploiting the closed field of psychotherapeutic conventions, is still debated. The very real and profound experiences of ELIZA's patients show that the lines distinguishing emotion and reason, meaning and nonsense, formality and creativity are less apparent to human minds than we might presume.[1123] To Berkeley, these lines were themselves artificial, and complex computer programs would present many further opportunities to breach them. That we are willing

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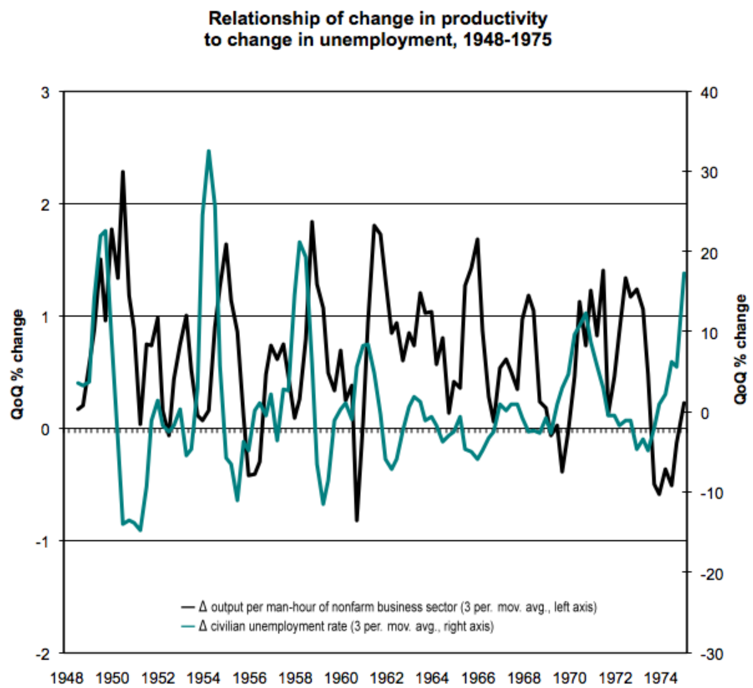
[1121] Mumford, Lewis. *Technics and Civilization*. New York: Harcourt Brace, 1936, 13.
[1122] Alan Turing's famous thought experiment posited an "imitation game," where a human judge and a computer communicate across a teletype in separate rooms. If after asking twenty questions, the human player could not verify whether his or her interlocutor was human or machine, then the computer could be said as intelligent. Turing spelled out the details of his test in a 1950 paper "Computing Machinery and Intelligence," in *Mind* (49), 1950, 433-460. In the spirit of the day's functionalist approach to intelligence, Turing does not attempt to answer the question, "Can a machine think," but only "Can a machine *appear* to think." Turing then raises nine popular objections to his interpretation of thought and suggests that the experiment could be constructed such that every objection was logically invalid. Turing concluded his paper with the following prediction: "We may hope that machines will eventually compete with men in all purely intellectual fields. But which are the best ones to start with? Even this is a difficult decision. Many people think that a very abstract activity, like the playing of chess, would be best. It can also be maintained that it is best to provide the machine with the best sense organs that money can buy, and then teach it to understand and speak English. This process could follow the normal teaching of a child…. I think both approaches should be tried. We can only see a short distance ahead, but we can see plenty there that needs to be done."
[1123] McCorduck, Pamela. *Machines Who Think*, Natick, MA: A.K. Peters, 2004.

to personify or credit things with intelligence is a staple of human existence: we do it everyday to the weather, our dog, or our car. How do we determine true autonomy from the exteriorization of our egos?

Appendix 2 – Did rising productivity lead to higher rates of unemployment?

A retrospective examination of the relationship of labor productivity to unemployment can tell us something about the merit of arguments marshaled for and against automation. It could also help us evaluate Solow, Kaldor, and Arrow's assumption that gains in productivity were a worthwhile sacrifice in return for growth. If the automation alarmists were to be believed, we should expect to see some long-term regression convergence between cyclical increases in productivity and rising unemployment. Fortunately, both of these variables are measured monthly and quarterly by the Labor Department's Bureau of Labor Statistics, and we can plot them side-by-side over a long period. Rather than apply a regression analysis to measure the covariance of these two series, I have constructed a visual aid that shows the relationship more graphically[1124]:

[1124] Data available at U.S. Department of Labor Bureau of Labor Statistics, "Labor Productivity and Costs," <http://www.bls.gov/lpc> (Accessed 4 Sept. 2010) and "Current Population Survey" <http://www.bls.gov/cps> (Accessed 4 Sept. 2010).



The above chart displays the change in productivity, measured by the quarterly percentage increase or decrease in output per hour, and the change in the civilian unemployment rate. To smooth the data, I have applied a moving average of the trailing three periods. As we can see, the data series do move in tandem over the years of the early 1950s. But over a longer window, the hypothesized relationship breaks down, and in fact turns negative between the years of 1948 and 1975, inclusive. Over the entire period, the coefficient of correlation between the two series is -.154, suggesting a negative divergence.[1125] If anything, rising productivity might be associated with falling unemployment, though the correlation fails the test of statistical significance.

Even to say that changes in productivity and unemployment are positively correlated (which they are not), does not answer the question of whether rising

[1125] To measure the linear dependence between the variables of change in unemployment and change in productivity, I have used Karl Pearson's product-moment correlation coefficient. The formula is defined as the covariance of the two variables divided by the product of their standard deviations.

productivity *causes* unemployment. The causal relationship may indeed operate in reverse; in a recession, for example, firms are likely to shed their least productive workers and segments first, which may prompt remaining employees to be yet more productive. Or, more likely, productivity and unemployment are merely two factors *inter alia* in the story of automation, and must be considered alongside the marginal cost of labor, input and raw material costs, capital structure, management practice, end market demand, the price per unit of processing power, etc. A multifactor sensitivity analysis is beyond the scope of this paper. Suffice it merely to say that the conclusion that automation *directly* causes unemployment is not borne out by available data for the decades of the 1950s and 1960s. While higher rates of peacetime unemployment during the early 1960s may have induced many to question the role of machines in the obsolescence of workers' skills, the sense of impending disaster is not supported by a basic analysis of the Labor Department's statistics over the period.

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