

THE **CONTROL REVOLUTION**

Technological and Economic
Origins of the Information Society



JAMES R. BENIGER

"A masterly treatment of some of the
most important developments in the
making of modern society."
—JOURNAL OF AMERICAN STUDIES

The Control Revolution

Technological and Economic Origins
of the Information Society

James R. Beniger

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Preface

TO SAY that the advanced industrial world is rapidly becoming an Information Society may already be a cliché. In the United States, Canada, Western Europe, and Japan, the bulk of the labor force now works primarily at informational tasks such as systems analysis and computer programming, while wealth comes increasingly from informational goods such as microprocessors and from informational services such as data processing. For the economies of at least a half-dozen countries, the processing of information has begun to overshadow the processing of matter and energy.

But why? Among the multitude of things that human beings value, why should it be information, embracing both goods and services, that has come to dominate the world's largest and most advanced economies? Despite scores of books and articles proclaiming the advent of the Information Society, no one seems to have even raised—much less answered—this important question.

My own desire to understand the new centrality of information began in the summer of 1963, before my junior year in high school, when the National Science Foundation sponsored my participation in an eight-week program in mathematics and computer science at Oregon State University. At a time when no teenage hacker culture had yet emerged, living with thirty students from around the country while learning to program proved to be the next best thing, my personal windfall from Sputnik (I still delight in being one of the youngest people to have run a program on vacuum tubes). Why have computers become so central to modern society, I wondered that summer, when all they can do is to transform information from one form to another? How could our

entire era, popularly described even in the early 1960s as the “Computer Age,” be evoked by so modest an activity as information processing?

Even if we could explain the growing importance of information and its processing in modern economies, I realized, we would immediately confront a second question: Why now? Because information plays an important role in all human societies, we would also have to explain why it has only *recently* emerged as a distinct and critical commodity. Material culture has also been crucial throughout human history, after all, and yet capital did not displace land as the major economic base until the Industrial Revolution. To what comparable technological and economic “revolution” might we attribute the emergence of the Information Society?

My answer, as the title of this book indicates, is what I call the Control Revolution, a complex of rapid changes in the technological and economic arrangements by which information is collected, stored, processed, and communicated, and through which formal or programmed decisions might effect societal control. From its origins in the last decades of the nineteenth century, the Control Revolution has continued unabated, and recently it has been accelerated by the development of microprocessing technologies. In terms of the magnitude and pervasiveness of its impact upon society, intellectual and cultural no less than material, the Control Revolution already appears to be as important to the history of this century as the Industrial Revolution was to the last.

But history alone cannot explain why it is information that increasingly plays the crucial role in economy and society. The answer must be sought in the nature of *all* living systems—ultimately in the relationship between information and control. Life itself implies control, after all, in individual cells and organisms no less than in national economies or any other purposive system.

My interest in such systems developed from the first course I attended as a Harvard freshman, Soc Sci 8, taught in the fall of 1965 by the cognitive scientist George A. Miller. Although I had the great pleasure, fifteen years later, of being George Miller’s colleague at Princeton, I doubt that he can ever know how much his early teaching on information processing and communication inspired at least one undergraduate to view things social as interacting processing systems—and to appreciate the importance of communication and control in all such systems.

Once we view national economies as concrete processing systems engaged in the continuous extraction, reorganization, and distribution of environmental inputs to final consumption, the impact of industrialization takes on new meaning. Until the Industrial Revolution, even the largest and most developed economies ran literally at a human pace, with processing speeds enhanced only slightly by draft animals and by wind and water power, and with system control increased correspondingly by modest bureaucratic structures. By far the greatest effect of industrialization, from this perspective, was to speed up a society's entire material processing system, thereby precipitating what I call a crisis of control, a period in which innovations in information-processing and communication technologies lagged behind those of energy and its application to manufacturing and transportation.

Identifying the crisis of control and the resulting Control Revolution has helped me to answer another question that has nagged me since my days as an American history major, namely, why the period 1870–1910 is so interesting to modern students and seems so decisive for society as we know it today. Here my thinking has been most influenced by Alfred Chandler of the Harvard Business School, one of the few historians to exploit the view of societies as material processing systems. Chandler's 1977 book, *The Visible Hand: The Managerial Revolution in American Business*, first suggested to me the possibility that the American economy had become a distinctively more *purposive* system during those decades.

The Information Society, I have concluded, is not so much the result of any recent social change as of increases begun more than a century ago in the speed of material processing. Microprocessor and computer technologies, contrary to currently fashionable opinion, are not new forces only recently unleashed upon an unprepared society, but merely the latest installment in the continuing development of the Control Revolution. This explains why so many of the computer's major contributions were anticipated along with the first signs of a control crisis in the mid-nineteenth century.

Although some readers may see this as a "multidisciplinary" approach to history, my goal has been to understand not multiple subjects but only one: the origin of the Information Society. If the world economy uses information for the same general purpose as does a single organism, if economic changes influence theoretical work on information processing, and if the resulting technological breakthroughs increase our material control, as I will argue in the following chapters,

then it seems a shame to leave this interesting phenomenon of information processing and control divided up—like a secret treasure map among conspirators—among biologists, economists, historians, and engineers. We segment experience only to make it easier to understand, after all, and although the various academic disciplines have beyond question proved themselves good means toward that end, they are surely not ends in themselves.

I am not advocating that social scientists regularly try to elucidate the subject matter of many specialties. Indeed, this book could never have been written had not generations of scholars devoted themselves to narrower and more manageable topics. But their contributions will not be complete unless we occasionally attempt to bring their separate truths together into a larger one. From this perspective, my goal might seem to be narrow: to understand the expanding economy of information as a means of control.

My research and writing have profited from both the criticism and the support of many people. Among these, Alfred Chandler, Thomas Parke Hughes, and Tony Oettinger have my deepest gratitude and respect. Each generously read large sections of the manuscript, offered many useful suggestions, and—though not agreeing with everything I wrote—provided warm encouragement. Without people like these, scholarship would be just another job.

Other scholars who kindly gave of their time to comment on various sections include Will Baumol, Daniel Bell, Al Biderman, Robert Bierstedt, Lord Briggs, Claude Fischer, Alexander Leitch, Marion Levy, Niklas Luhmann, Allan Mazur, David Sills, Neil Smelser, and Art Stinchcombe. Susan Cotts Watkins not only carefully read my penultimate draft but also provided invaluable advice and encouragement over regular lunches during her year at the Institute for Advanced Study. Robert Wright, a former student of mine and now an accomplished science columnist and editor, managed to scribble many helpful comments on an early draft while commuting on the New York City subways.

Because questions of living systems took me furthest from my own formal academic training, I made a special effort to solicit the advice of biologists. Among those who generously responded with useful comments, encouragement, or both, I would like to thank A. G. Cairns-Smith, Manfred Eigen, Richard Keogh, Ernst Mayr, Claude Villee, Paul Weisz, and Ed Wilson. Through a faculty seminar and coteaching

with several members of Princeton's biology department, I have also learned a great deal from John Bonner, Henry Horn, Bob May, and George Sugihara.

Additional stimulation came from invitations to test various ideas in this book on a range of audiences: the American Association for the Advancement of Science, the American Association for Public Opinion Research, the American Sociological Association, the Annenberg Schools' Washington Program, Harvard's Program on Information Resources Policy, the National Academy of Science, New York University's Media Ecology Conference, the Social Science History Association, and the University of Pennsylvania Department of the History and Sociology of Science, as well as a number of brownbag luncheon meetings sponsored by the graduate students in my department at Princeton. For invitations to make these various presentations, I am grateful to Michael Armer, Hamilton Cravens, Tom Hughes, Elizabeth Martin, Tony Oettinger, Neil Postman, Everett Rogers, Howard Schuman, David Sills, and Charles Turner.

For sustaining my morale throughout the conception, planning, and writing of this book, I am particularly indebted to Clifford Nass, who entered the process as a mathematics and computer science major in my undergraduate course on technology and social change, graduated to our doctoral program in sociology, and finished as my (prize-winning) teaching assistant, collaborator on several projects, and friend. Among Cliff's many contributions, in addition to making detailed comments on each draft of the manuscript, I must single out his patience in convincing me to take seriously the concept of *preprocessing*. Of the hundreds of other students with whom I have argued various of this book's ideas over the past ten years, seven undergraduates stand out in my mind as particularly influential: Paul Fernhout, Bob Giuffra, Howard Pearlmutter, Glenn Picher, Peter Swire, Nicholas Ulanov, and David Wonnacott.

Much credit for this book belongs to Harvard University Press. Michael Aronson spotted merit in my partial manuscript and enlisted wise reviewers to suggest improvements. I learned a great deal about writing from the spidery green line of my copy editor, Patricia Flaherty, a gracious diplomat who made the book read better.

Literally hundreds of employees of Princeton University and of the Annenberg School of Communications at the University of Southern California helped with the preparation of this book. Among these contributors, I must single out for special thanks the staffs of Princeton's

Firestone Library and University Computer Center, USC's Doheny Library, the Annenberg School's Learning and Production Centers, and my secretary, Rachel Osborn. I am particularly indebted to Peter Clarke and Susan Evans of the Annenberg School, among the first to appreciate *The Control Revolution* and among its most steadfast supporters, for providing me with a comfortable home in which to complete it.

Another friend, Kay Ferdinandsen, offered advice on all drafts of the manuscript and sustained my efforts in countless other ways. Sometime between the completion of Chapter 6 and the start of Chapter 7, we managed to get married.

I must acknowledge my other good fortune, during the most formative period of my thinking about the Information Society, in having become acquainted with two of the pioneering scholars of the subject. Although I would have relied heavily upon their published ideas in any case, getting to know them in person before their deaths provided a special inspiration in my life as well as in this work. It is to them, Fritz Machlup and Ithiel de Sola Pool, that I gratefully dedicate this book.

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Introduction

Here have we war for war and blood for blood,
controlment for controlment.

—King of England to the French
ambassador (Shakespeare, *King John*)

ONE TRAGEDY of the human condition is that each of us lives and dies with little hint of even the most profound transformations of our society and our species that play themselves out in some small part through our own existence. When the earliest *Homo sapiens* encountered *Homo erectus*, or whatever species was our immediate forebear, it is unlikely that the two saw in their differences a major turning point in the development of our race. If they did, this knowledge did not survive to be recorded, at least not in the ancient writings now extant. Indeed, some fifty thousand years passed before Darwin and Wallace rediscovered the secret—proof of the difficulty of grasping even the most essential dynamics of our lives and our society.

Much the same conclusion could be drawn from any of a succession of revolutionary societal transformations: the cultivation of plants and the domestication of animals, the growth of permanent settlements, the development of metal tools and writing, urbanization, the invention of wheeled vehicles and the plow, the rise of market economies, social classes, a world commerce. The origins and early histories of these and many other developments of comparable significance went unnoticed or at least unrecorded by contemporary observers. Today we are hard pressed to associate specific dates, places, or names with many major societal transformations, even though similar details abound for much lesser events and trends that occurred at the same times.

This condition holds for even that most significant of modern societal transformations, the so-called Industrial Revolution. Although it is generally conceded to have begun by mid-eighteenth century, at least in England, the idea of its revolutionary impact does not appear until

the 1830s in pioneering histories like those of Wade (1833) and Blanqui (1837). Widespread acceptance by historians that the Industrial Revolution constituted a major transformation of society did not come until Arnold Toynbee, Sr., popularized the term in a series of public lectures in 1881 (Toynbee 1884). This was well over a century after the changes he described had first begun to gain momentum in his native England and at least a generation after the more important ones are now generally considered to have run their course. Although several earlier observers had described one or another of the same changes, few before Toynbee had begun to reflect upon the more profound transformation that signaled the end—after some ten thousand years—of predominantly agricultural society.

Two explanations of this chronic inability to grasp even the most essential dynamics of an age come readily to mind. First, important transformations of society rarely result from single discrete events, despite the best efforts of later historians to associate the changes with such events. Human society seems rather to evolve largely through changes so gradual as to be all but imperceptible, at least compared to the generational cycles of the individuals through whose lives they unfold. Second, contemporaries of major societal transformations are frequently distracted by events and trends more dramatic in immediate impact but less lasting in significance. Few who lived through the early 1940s were unaware that the world was at war, for example, but the much less noticed scientific and technological by-products of the conflict are more likely to lend their names to the era, whether it comes to be remembered as the Nuclear Age, the Computer Age, or the Space Age.

Regardless of how we explain the recurrent failure of past generations to appreciate the major societal transformations of their own eras, we might expect that their record would at least chasten students of contemporary social change. In fact, just the opposite appears to be the case. Much as if historical myopia could somehow be overcome by confronting the problem head-on, a steadily mounting number of social scientists, popular writers, and critics have discovered that one or another revolutionary societal transformation is now in progress. The succession of such transformations identified since the late 1950s includes the rise of a new social class (Djilas 1957; Gouldner 1979), a meritocracy (Young 1958), postcapitalist society (Dahrendorf 1959), a global village (McLuhan 1964), the new industrial state (Galbraith 1967), a scientific-technological revolution (Richta 1967; Daglish 1972; Prague Academy 1973), a technetronic era (Brzezinski 1970), postindustrial

society (Touraine 1971; Bell 1973), an information economy (Porat 1977), and the micro millennium (Evans 1979), to name only a few. A more complete catalog of these and similar transformations, listed by year of first exposition in a major work, is given in Table 1.1.

The writer who first identified each of the transformations listed in Table 1.1 usually found the brunt of the change to be—coincidentally enough—either in progress or imminent. A recent best-seller, for example, surveys the sweep of human history, notes the central importance of the agricultural and industrial revolutions, and then finds in contemporary society the seeds of a third revolution—the impending “Third Wave”:

Humanity faces a quantum leap forward. It faces the deepest social upheaval and creative restructuring of all time. Without clearly recognizing it, we are engaged in building a remarkable new civilization from the ground up. This is the meaning of the Third Wave . . . It is likely that the Third Wave will sweep across history and complete itself in a few decades. We, who happen to share the planet at this explosive moment, will therefore feel the full impact of the Third Wave in our own lifetimes. Tearing our families apart, rocking our economy, paralyzing our political systems, shattering our values, the Third Wave affects everyone. (Toffler 1980, p. 26)

Even less breathless assessments of contemporary change have been no less optimistic about the prospect of placing developing events and trends in the broadest historical context. Daniel Bell, for example, after acknowledging the counterevidence of Toynbee and the Industrial Revolution, nevertheless concludes, “Today, with our greater sensitivity to social consequences and to the future . . . we are more alert to the possible imports of technological and organizational change, and this is all to the good” (1980, pp. x–xi).

The number of major societal transformations listed in Table 1.1 indicates that Bell appears to be correct; we do seem more alert than previous generations to the possible importance of change. The wide variety of transformations identified, however, suggests that, like the generations before us, we may be preoccupied with specific and possibly ephemeral events and trends, at the risk of overlooking what only many years from now will be seen as the fundamental dynamic of our age.

Because the failures of past generations bespeak the difficulties of overcoming this problem, the temptation is great not to try. This reluctance might be overcome if we recognize that understanding our-

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Table 1.1. Modern societal transformations identified since 1950

Year	Transformation	Sources
1950	Lonely crowd	Riesman 1950
	Posthistoric man	Seidenberg 1950
1953	Organizational revolution	Boulding 1953
1956	Organization man	Whyte 1956
1957	New social class	Djilas 1957; Gouldner 1979
1958	Meritocracy	Young 1958
1959	Educational revolution	Drucker 1959
	Postcapitalist society	Dahrendorf 1959
1960	End of ideology	Bell 1960
	Postmaturity economy	Rostow 1960
1961	Industrial society	Aron 1961; 1966
1962	Computer revolution	Berkeley 1962; Tomeski 1970; Hawkes 1971
	Knowledge economy	Machlup 1962; 1980; Drucker 1969
1963	New working class	Mallet 1963; Gintis 1970; Gallie 1978
	Postbourgeois society	Lichtheim 1963
1964	Global village	McLuhan 1964
	Managerial capitalism	Marris 1964
	One-dimensional man	Marcuse 1964
	Postcivilized era	Boulding 1964
	Service class society	Dahrendorf 1964
	Technological society	Ellul 1964
1967	New industrial state	Galbraith 1967
	Scientific-technological revolution	Richta 1967; Daglish 1972; Prague Academy 1973
1968	Dual economy	Averitt 1968
	Neocapitalism	Gorz 1968
	Postmodern society	Etzioni 1968; Breed 1971
	Technocracy	Meynaud 1968
	Unprepared society	Michael 1968
1969	Age of discontinuity	Drucker 1969
	Postcollectivist society	Beer 1969
	Postideological society	Feuer 1969
1970	Computerized society	Martin and Norman 1970
	Personal society	Halmos 1970
	Posteconomic society	Kahn 1970
	Postliberal age	Vickers 1970
	Prefigurative culture	Mead 1970
	Technetronic era	Brzezinski 1970
1971	Age of information	Helvey 1971
	Communications	Oettinger 1971

Year	Transformation	Sources
1971	Postindustrial society	Touraine 1971; Bell 1973
	Self-guiding society	Breed 1971
	Superindustrial society	Toffler 1971
1972	Limits to growth	Meadows 1972; Cole 1973
	Posttraditional society	Eisenstadt 1972
	World without borders	Brown 1972
1973	New service society	Lewis 1973
	Stalled society	Crozier 1973
1974	Consumer vanguard	Gartner and Riessman 1974
	Information revolution	Lamberton 1974
1975	Communications age	Phillips 1975
	Mediacracy	Phillips 1975
	Third industrial revolution	Stine 1975; Stonier 1979
1976	Industrial-technological society	Ionescu 1976
	Megacorp	Eichner 1976
1977	Electronics revolution	Evans 1977
	Information economy	Porat 1977
1978	Anticipatory democracy	Bezold 1978
	Network nation	Hiltz and Turoff 1978
	Republic of technology	Boorstin 1978
	Telematic society	Nora and Minc 1978; Martin 1981
	Wired society	Martin 1978
1979	Collapse of work	Jenkins and Sherman 1979
	Computer age	Dertouzos and Moses 1979
	Credential society	Collins 1979
	Micro millennium	Evans 1979
1980	Micro revolution	Large 1980, 1984; Laurie 1981
	Microelectronics revolution	Forester 1980
	Third wave	Toffler 1980
1981	Information society	Martin and Butler 1981
	Network marketplace	Dordick 1981
1982	Communications revolution	Williams 1982
	Information age	Dizard 1982
1983	Computer state	Burnham 1983
	Gene age	Sylvester and Klotz 1983
1984	Second industrial divide	Piore and Sabel 1984

selves in our own particular moment in history will enable us to shape and guide that history. As Bell goes on to say, “to the extent that we are sensitive [to the possible importance of technological and social change], we can try to estimate the consequences and decide which policies we should choose, consonant with the values we have, in order to shape, accept, or even reject the alternative futures that are available to us” (1980, p. xi).

Much the same purpose motivates—and I hope justifies—the pages that follow. In them I argue, like many of the writers whose names appear in Table 1.1, that society is currently experiencing a revolutionary transformation on a global scale. Unlike most of the other writers, however, I do not conclude that the crest of change is either recent, current, or imminent. Instead, I trace the causes of change back to the middle and late nineteenth century, to a set of problems—in effect a crisis of control—generated by the industrial revolution in manufacturing and transportation. The response to this crisis, at least in technological innovation and restructuring of the economy, occurred most rapidly around the turn of the century and amounted to nothing less, I argue, than a revolution in societal control.

The Control Revolution

Few turn-of-the-century observers understood even isolated aspects of the societal transformation—what I shall call the “Control Revolution”—then gathering momentum in the United States, England, France, and Germany. Notable among those who did was Max Weber (1864–1920), the German sociologist and political economist who directed social analysis to the most important control technology of his age: bureaucracy. Although bureaucracy had developed several times independently in ancient civilizations, Weber was the first to see it as the critical new machinery—new, at least, in its generality and pervasiveness—for control of the societal forces unleashed by the Industrial Revolution.

For a half-century after Weber’s initial analysis bureaucracy continued to reign as the single most important technology of the Control Revolution. After World War II, however, generalized control began to shift slowly to computer technology. If social change has seemed to accelerate in recent years (as argued, for example, by Toffler 1971), this has been due in large part to a spate of new information-processing, communication, and control technologies like the computer, most notably the microprocessors that have proliferated since the early 1970s.

Such technologies are more properly seen, however, not as causes but as consequences of societal change, as natural extensions of the Control Revolution already in progress for more than a century.

Revolution, a term borrowed from astronomy, first appeared in political discourse in seventeenth-century England, where it described the restoration of a previous form of government. Not until the French Revolution did the word acquire its currently popular and opposite meaning, that of abrupt and often violent change. As used here in Control Revolution, the term is intended to have both of these opposite connotations.

Beginning most noticeably in the United States in the late nineteenth century, the Control Revolution was certainly a dramatic if not abrupt discontinuity in technological advance. Indeed, even the word *revolution* seems barely adequate to describe the development, within the span of a single lifetime, of virtually all of the basic communication technologies still in use a century later: photography and telegraphy (1830s), rotary power printing (1840s), the typewriter (1860s), transatlantic cable (1866), telephone (1876), motion pictures (1894), wireless telegraphy (1895), magnetic tape recording (1899), radio (1906), and television (1923).

Along with these rapid changes in mass media and telecommunications technologies, the Control Revolution also represented the beginning of a restoration—although with increasing centralization—of the economic and political control that was lost at more local levels of society during the Industrial Revolution. Before this time, control of government and markets had depended on personal relationships and face-to-face interactions; now control came to be reestablished by means of bureaucratic organization, the new infrastructures of transportation and telecommunications, and system-wide communication via the new mass media. By both of the opposite definitions of *revolution*, therefore, the new societal transformations—rapid innovation in information and control technology, to regain control of functions once contained at much lower and more diffuse levels of society—constituted a true revolution in societal control.

Here the word *control* represents its most general definition, purposive influence toward a predetermined goal. Most dictionary definitions imply these same two essential elements: *influence* of one agent over another, meaning that the former causes changes in the behavior of the latter; and *purpose*, in the sense that influence is directed toward some prior goal of the controlling agent. If the definition used here differs at all from colloquial ones, it is only because many people reserve