sizing technology and markets in accounting for size and concentration, as compared to alternative explanations emphasizing the quality of entrepreneurship, access to capital, or public policy. As he points out,

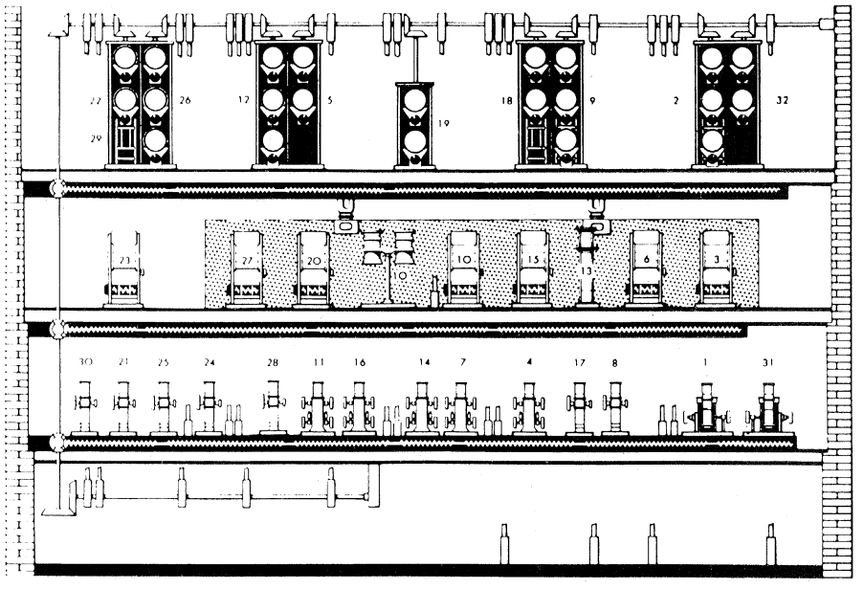
> Entrepreneurial ability can hardly account for the clustering of giant enterprises in some industries and not in others. The most brilliant industrial statesmen or the most ruthless robber barons were unable to create giant multinational companies in the furniture, apparel, leather, or textile industries. Yet, in other industries the first to try often succeeded [p. 373].

Antitrust legislation is shown to have been less important in its effect on size and industrial concentration than were technology and market requirements. The Sherman Anti-Trust Act of 1890 was ostensibly directed at the control of size, but its main effects in this respect were at best ambiguous. It did effectively discourage cartel-like controls over price and output by separate firms, but precisely in so doing it unquestionably accelerated the growth of large-scale enterprise. It did encourage the formation of oligopolies where monopolies already existed and discourage oligopolistic firms from merging into monopolies, but

> in these formative years of modern industry, federal action under the Sherman Act never transformed an oligopolistic industry back into a traditionally competitive one. Nor did it prevent the rise of the giant integrated firm where markets and technology made administrative coordination profitable [p. 376].

There are problems with Chandler's book. It is too long and too repetitious and occasionally burdens the reader with excessive detail. More seriously, it is not nearly as clear as it should be on the central issue of the benefits flowing from administrative coordination within the large firm. Before the analysis can be regarded as fully persuasive it will be necessary not only to identify but to quantify, at least crudely, the reductions in information and transaction costs that are achieved in substituting the coordinating activities of large firms for the role of the marketplace. Moreover, the book gives no attention to the larger questions of the social costs of bigness in business. With respect to the last point it may perhaps be legitimately rejoined that the benefits of specialization, so obvious and so widespread in the business world, should not be peremptorily denied in scholarly research. There is, in any case, no imminent danger of a shortage of academic treatises on the social costs of large-scale enterprise. If Chandler has ignored, for example, the impact of the increasing speed of industrial operations upon the well-being of the worker, the subject is currently receiving extensive treatment by other scholars. Chandler's book, although not covering all aspects of the large corporation, constitutes a major contribution on a surprisingly neglected subject: the role of organizational innovation in the growth of industrial societies.

NATHAN ROSENBERG
Department of Economics, Stanford University, Stanford, California 94305



Plan of the Washburn automatic, all-roller, gradual-reduction mill, 1879. "The creation of a continuous-process or automatic factory . . . involved a number of inventions, . . . which had to be synchronized . . .; it also required perfection in plant design." One such factory was that represented here, used to process wheat and other grains. "Flour mills had used continuous-process machinery since . . . 1787 [but] only after the grain-growing regions had expanded and after the railroad and ancillary storage facilities permitted high-volume year-round operations did demand for the large automatic mill appear. The need to find more efficient ways to process the hard-grain wheat of the northern prairies intensified the search for processing innovations in the Minneapolis area. The result was a series of innovations [that] involved gradual reduction, multiple grinding, steel rollers to replace grindstones, purifiers and aspirators, and reels for scalping, grading, and dressing the flour. . . . The 'new process' mills . . . produced high-quality flour in high volume and at low unit cost. Theirs quickly became the standard processing technology." By the end of the 1880's the average daily output for the Minneapolis mills, which had been 274 barrels in 1874, was 1837 barrels. "Comparable developments occurred [with] other grains. In the milling of oats, the output was so high that the leading processors had to invent the modern breakfast cereal industry in order to dispose of their surpluses." [Reproduced in *The Visible Hand* from J. Storck and W. D. Teague, *Flour for Man's Bread*, University of Minnesota Press, 1952]

Technology as Master

Autonomous Technology. Technics-out-of-Control as a Theme in Political Thought. LANGDON WINNER. MIT Press, Cambridge, Mass., 1977. x, 386 pp. $17.50.

This study of the idea of technology out of control makes an important contribution to our understanding of the problems of our industrial civilization. The basic argument is not that some persons or groups promote technologies against the public interest (true though that is), or even that our technology develops in its own way in spite of all our efforts to control it (also true in some respects). Rather, Winner is concerned with a more subtle effect: the artifacts that we have invented to satisfy our material wants have now developed, in size and complexity, to the point of delimiting or even determining our conception of the wants themselves. In that way, we as a civilization are losing mastery over our own tools.

Winner's starting point is a certain conventional wisdom, which although subject to widespread doubt has not been systematically scrutinized or replaced: (i) that men (sic) know best what they have made; (ii) that things men make are under their firm control; and (iii) that technology is essentially neutral, a means to an end; the benefit or harm it brings depends on how men use it (p. 25).

Against this Winner gives a set of propositions (to be found on p. 190) called "the master-slave paradox," asserting that we have a pathological de-

pendence upon technical artifacts; that technical forms impose a stringent discipline; that there is a tendency for technical means to redefine ends; that sophisticated technologies lead to a transformation of consciousness; and finally that

> technical artifice as an aggregate phenomenon dwarfs human consciousness and makes unintelligible the systems that people supposedly manipulate and control; by this tendency to exceed human grasp and yet to operate successfully according to its own internal makeup, technology is a total phenomenon which constitutes a "second nature" far exceeding any desires or expectations for the particular components.

In the course of the discussion these points are explained and defended, and a number of writings are insightfully reviewed. Among these are works by Don K. Price and J. K. Galbraith, and also Mary Shelley's *Frankenstein*. However, the work of Jacques Ellul, as represented in *The Technological Society* (French original 1951, translation 1964), is central to Winner's argument; I shall concentrate on it here. It is no discredit to say that Winner's main scholarly achievement has been to rescue Ellul's deep analysis by making it less idiosyncratic and more plausible in the present-day American context.

Ellul has proclaimed his enthusiasm for Marx, but it seems to me that his vision really starts with an insight of German academic sociology: the rise of "scientific rationality," replacing the thought-style of a traditional, agrarian society. In this world of ours, means are calculated narrowly for the best achievement of ends, and (most important) the ends themselves are of a narrow, calculated sort. Fun, generosity, spontaneity, and honor have no place in the culture of what Max Weber described as the "ascetic bourgeois" who created the spirit of capitalism. And it is in such a world that "rationalized" technological systems are most easily adopted.

Ellul makes a bold move beyond this well-known position, at two levels. First, he sees "*la technique*," which he almost personifies, as becoming the master, with man the slave; he portrays how it has shaped our thinking and being, inexorably and perhaps irreversibly. The meaning of this event for human history is then implicitly supplied by Ellul's religious perspective; Winner notes the functional analogy between *la technique* and the state of sin, or the action of Satan, as described in Ellul's other works.

Winner brings Ellul down to earth most successfully in a creative interaction with Marxism. He inquires into the long-standing and apparently permanent scandal of the socialist economies, in which workers are effectively deprived of their elementary rights, being permitted neither to choose their bosses nor to go on strike against them. Winner reminds us how unexpected this was by quoting from Lenin's *State and Revolution* on socialist workplace democracy. How to explain this calamitous betrayal? Invoking foreign hostility or apologizing for aberrant individuals is to evade the Marxist approach to political economy in this crucial case.

The relations between the "means," "mode," and "social relations" of production (in the Marxist terminology) are beautifully explicated by Ellul's analysis for high-technology society. The size, complexity, and vulnerability of the productive machine entail requirements for order, discipline, and "scientific rationality." The Marxists themselves have perceived and praised factory production for these features, while failing to notice the contradiction with their political ideals. And such a total system then further molds institutions and people for its smooth functioning. Hence we find the "convergence" of the capitalist and socialist economies, the merging of state and private institutions in the former, and also the loss of any chance of genuinely democratic control anywhere. Thus a Marxist analysis shows the obsoleteness of Marx's own model, and consequently of all the political action deriving from it.

To the extent that it holds, the Ellul-Winner thesis has depressing implications. A real restoration of control over technology would seem to require actions far more radical than citizens' participation campaigns against this or that new industry. Winner himself makes a rather general suggestion for "epistemological Luddism": personal experiments in seeing what it is like to kick the habit of some aspect of our enveloping technology. However, he does not spurn political efforts, provided that they avoid the fallacious assumption that technology is an inert system waiting to be legislated and recognize that technology *is* politics. He even offers some criteria for "good" technology, along generally alternative/intermediate lines.

What of the strength of Winner's main thesis? The detailed evidence he adduces for his sweeping assertions is fragmentary and unconvincing. He cites a few cases (and some of those dubious) from war, where "small is beautiful" never did apply anyway. But it may be that theses so general as this are not capable of strict testing. A deep change in our thought-styles cannot easily be seen from the outside, either in the temporal dimension or in the imagination. The possibility of genuine counterexamples is nearly precluded by the phenomenon itself.

This study is therefore best seen as contributing a radical insight on our technological society. Considered as describing a tendency rather than an accomplished fact, it serves as a warning and a guide. Its value is established by its explanatory power, as in the case of the socialist economies.

As a source for readings and reflections on the problem, the book is rich and rewarding, containing a more varied selection than this condensed review could survey. If it has a practical lesson, it is that of awareness: only by recognizing the boundaries of our socially constructed scientific-technological reality can we transcend them in imagination and then achieve effective human action.

JEROME R. RAVETZ
Department of Philosophy, University of Leeds, Leeds LS2 9JT, England

Potential Hazards

The Zapping of America. Microwaves, Their Deadly Risk, and the Cover-Up. PAUL BRODEUR. Norton, New York, 1977. xvi, 344 pp., illus. $11.95.

In his 1960 Godkin Lectures at Harvard C. P. Snow warned, "Some of the most important choices about a nation's physical health are made, or not made, by a handful of men, in secret, and, again in legal form, by men who normally are not able to comprehend the arguments in depth." The intense wartime development of electromagnetic radiation for radar, which was the subject of Snow's lectures, accelerated a pattern of well-known historical events. Maxwell formulated his equations of electromagnetics in 1864, and in 1888 Hertz first transmitted an electromagnetic signal using a spark-gap radiator. Marconi followed with radiotelegraphy, and in 1915 speech was first transmitted. With the first commercial radio broadcast in 1920, a proliferation was under way.

Less well known than this history are the questions about biological effects of radio-frequency and microwave radiation that soon developed, which ultimately grew into the controversies described in this book. Unlike x-rays, radiation at these lower frequencies lacks sufficient photon energy to break organic molecular bonds, and its effects were initially believed to be limited to tissue heating. By the 1930's, however, con-