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AMERICA BY DESIGN: SCIENCE, TECHNOLOGY, AND THE RISE OF CORPORATE CAPITALISM. By *David F. Noble.* New York: Alfred A. Knopf. 1977. Pp. xxvi, 384. $12.95.

INTRODUCTION

Nearly everyone would agree that advanced industrial society would be unthinkable without its complex, scientifically based technology. In discussing the growth of modern technology, however, scholars as well as laymen have often committed the sin Marxian theorists call "reification"—that is, they have mistaken the *creations* of particular societies in particular times and places for sovereign *forces* that move by their own internal logic to determine human actions. To David F. Noble, the author of *America by Design,* the currency of this reified notion of science and technology seems paradoxical, for during the very time in which that notion has risen to importance, modern technology as a social process has come increasingly "under the conscious control of human authority, in the specific form of private corporate capital" (p. xxvi). In this important new study, Noble tries to break through the paradox, to reveal the human and social realities behind the "myth of the machine," by tracing the development of modern technology within its American matrix—corporate capitalist society.

Noble's "primary thesis" is explicitly Marxian. In his view, American technology has evolved in symbiosis with corporate capitalism: technology has provided capitalism "the wherewithal for unlimited productive growth by implicating science in the production process," while the corporation has cleared the way for the use of technology by "offsetting the destructive tendencies inherent in an unchecked, competitive market economy by making possible the regulation of production, distribution and prices." The tendency of this symbiosis, he believes, has been to preserve and even to strengthen the basic social relations of capitalism by giving them an appearance of rationality and efficiency; as a result what Marcuse calls a "technological veil" has

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been thrown over a system that remains unjust and exploitive (p. xxiii).

In trying to establish this thesis—to rend, as it were, the technological veil—Noble has obviously set himself a large task. True to his conception of technology as a *social* product, he has chosen to approach his task through an extensive analysis of the class most responsible for giving American technology its characteristic form—the engineering profession, and especially those engineers connected with the vanguard of "science-based" industry, the chemical and electrical industries. Occupying key positions within the technologically most advanced sectors of the corporate economy, these men, along with like-minded professors and executives, were in Noble's view the catalysts in the compounding of technical and capitalist reason. They allegedly performed this service in the period between 1900 and 1930 by designing—in accordance with a "world-view of corporate reform"—new customs and institutions that would bring society as a whole into closer conformity with the needs of science-based industrial corporations (p. xxv).

The thesis advanced in *America by Design* deserves careful consideration, for the issue of whether corporations have come to dominate modern technology and its practitioners has obvious significance in wider realms than the history of engineering per se. Noble's argument also bears directly on the status of modern professions in general, for, as we shall see, it challenges the notion that professional autonomy is possible when large private corporations control access to the most remunerative forms of professional practice and have a strong influence over professional education. He implicitly attacks as well a commonly held notion about "post-industrial" society, namely, that as expert professionals make more and more of the decisions in both the public and private sphere, older questions of class conflict are becoming obsolete. The actual historical relationship between a key component of the so-called "new class" of professionals and private corporate capital clearly provides a test of the validity of this idea. Finally, Noble's portrait of engineering, according to the *Foreword* by Christopher Lasch, forms part of a comprehensive critique of modern American capitalism that is being developed by recent left-wing scholarship. This critique centers on the so-called "second industrial revolution" that occurred roughly between 1880 and 1930, and Noble's contribution attempts to show how engineers participated during that era in forging the basic tools that would eventually make the world safe for oligop-

oly (pp. xi-xiii).

America by Design thus addresses several important questions. But the degree to which the book in its various parts illuminates each one varies. Because of this, because much of the evidence Noble draws upon is unfamiliar, even to American historians, and because the many strands from which he weaves his "primary thesis" are themselves of interest, it seemed best in this review to follow his argument step by step. Once the merits and faults of the parts fall into perspective, the meaning of the whole, it is hoped, will emerge more clearly.

I

The so-called "corporate reform" efforts of engineers after 1900 form the centerpiece of Noble's discussion; the second and third of the three parts into which the book is divided chronicle those efforts. The first part of *America by Design* sketches the background; it tells the story of how technology, as represented by the professional engineer, became "wedded" to industry, as represented by the giant corporation. Here also, by cataloging the social problems corporate capitalism faced in the early twentieth century, Noble tries to recreate the atmosphere which gave corporate reform its sense of urgency.

Noble's contentions in Part I are central to his argument as a whole, for they outline the actual state of affairs which the engineers' social "designs" supposedly both assumed and meant to perpetuate. That state of affairs can be described as follows: after emerging late in the nineteenth century, science-based industry—which Noble defines as "industrial enterprise in which ongoing scientific investigation and the systematic application of scientific knowledge to the process of commodity production have become routine parts of the operation" (p. 5)—experienced great expansion and concentration between 1880 and 1920. In the two leading science-based industries in particular, first in the electrical and later in the chemical industry, the need to consolidate and exploit patent control over important inventions and processes combined with more general forces encouraging industrial combination to usher in an age of giant corporations (p. 18). Because these firms were the first to institutionalize the application of scientific method to manufacturing operations, they set the pattern for other highly technological enterprises, such as the petroleum, rubber, and auto industries.

During the same period in which industry was increasingly coming under the control of large corporations, the profession of

engineering was taking its modern form. In the training of engineers, formal education at the college level was becoming the norm, and "shop-floor" experience was fading into the past. Chemical and electrical engineering had initiated this change; in these fields, unlike mechanical engineering, a true "shop-culture"—the historian Monte Calvert's term for a form of professionalism based on the primacy of on-the-job training in industry—had never developed.[1] Here the roles of basic science and laboratory training had been crucial from the start, and the locus of this sort of expertise was the universities and technical schools (pp. 26-27). As all of industry grew technologically more complex, formalized "scientific" training came to rule all types of engineering and thus largely to define the professional engineer.

While the image of the applied scientist was coming to represent half of the modern engineer's self-concept, the changes in industry mentioned above were insuring that the image of the corporate team-player would emerge as the other half. The domination of science-based industry by giant, vertically integrated corporations precluded, for the vast majority of engineers, older forms of professional practice such as business ownership and independent consulting. Instead, effective work within corporate hierarchies became the principal route to professional success, and the best-rewarded corporate work lay in management. Thus, when one of Noble's key figures, William Wickenden—himself a successful engineer-manager and teacher—undertook a massive study of engineering education in the 1920s, he found that the career patterns of two-thirds of the engineering graduates since 1884 had shown "a healthy pattern of progression through technical work toward the responsibilities of management." Wickenden's advice to ambitious engineers, was succinct, if unsurprising: To succeed financially and socially, they would eventually have to "leave the engineering of materials and enter the engineering of men" (p. 41).

In Noble's view, then, the marriage between the science-based corporation and the professional engineer was on firm ground by 1920, for "the large corporations needed the technical knowledge which only the professionals could provide. On the other hand the professional engineers required human organization and material resources in order to render their knowledge

1. Calvert expounds this idea of a "shop culture" and discusses the conflict between it and the more modern "school culture" in his book, THE MECHANICAL ENGINEERS IN AMERICA, 1830-1910 (1967).

functional, and the large corporations had secured a monopoly on these" (pp. 43-44). It is important to note, however, that Noble does not claim these intrusive realities prevented engineers from developing and at times using a more traditional kind of professional identity—*i.e.,* the one based on the "monopoly of esoteric knowledge" common to doctors, lawyers, and scientists (p. 40); he claims only that the old-style "corporate" identity was bound to be less significant than the new in guaranteeing professional prestige and success. The new style of professionalism, he insightfully points out, also directly undermined the old in two ways. First, the need to advance as *individuals* within corporate hierarchies inhibited any sense of collegial autonomy engineers might have had as a class of experts. Second, the importance of *corporate* priorities in the minds of actual or potential engineer-managers detracted from the sense of personal autonomy that the "independent expert" often feels (pp. 41-42).

Having established to his satisfaction the state of science-based industry and the engineering profession in the early twentieth century, Noble devotes a brief chapter to the social and economic problems corporate America faced at that time. The picture he presents derives from the familiar critique of American corporate capitalism developed by "New Left" historians like William Appleman Williams, Gabriel Kolko, and James Weinstein.[2] Thus Noble asserts that after a period of intense, often chaotic price competition and expansion of output in the late nineteenth century, a wave of mergers and consolidations spread through American business around 1900. The temporary stability and high profitability that monopoly and oligopoly brought could not be maintained through stasis, however. To survive, American capitalism needed new means of insuring continuous, efficient utilization of expensive manufacturing facilities; expanded opportunities for the investment of monopoly profits; and expanded, stable markets for an unprecedented volume of goods (pp. 54-55). In the social sphere, the emerging corporate order had to face threats to social stability and to the continued dominance of capital that might make these economic goals unattainable. Among these threats Noble includes: the tremendous surge of immigration from southern and eastern Europe; the rise of a

2. In particular, see G. KOLKO, THE TRIUMPH OF CONSERVATISM (1963); J. WEINSTEIN, THE CORPORATE IDEAL IN THE LIBERAL STATE 1900-1918 (1968); W.A. WILLIAMS, THE CONTOURS OF AMERICAN HISTORY (1961); and the work of the economists P. BARAN & P. SWEEZY, MONOPOLY CAPITAL (1966).

strong social-reform movement in Progressivism; and, especially, the mounting challenge from organized labor and from large, highly visible radical organizations like the Socialist Party and the Industrial Workers of the World (pp. 55-60).

Given their position in the social order, Noble tells us, the reaction of engineers to such a social and economic situation was predictable, though important nonetheless. Except for a few maverick engineer-reformers like the Taylorite Morris Cooke, most "progressive-minded" engineers understood—and probably approved of—the fact that "radical engineers . . . had to choose between being radical and being engineers" (p. 63). Thus, they hoped to bring to pass whatever visions they had of an "affluent, humane, tranquil, and powerful America" by pursuing the twin goals of technological progress *and* corporate growth—the poles around which their own careers revolved (p. 64). Because they believed corporate growth was a necessary condition for (or even the *raison d'être* for) social improvement, Noble's engineers were close to being "corporate liberals," a group whose importance remains a controversial issue in American historiography. But fortunately he does not have to confront this problem directly, since the "corporate reforms" his engineers promoted shared a technological flavor that allows them to be treated separately from the usual list of "corporate liberal" causes, such as labor-management cooperation and limited government regulation of business.[3]

Before analyzing the actual attempts of corporate engineers to "design" new social institutions, we need to assess how adequately Noble has portrayed the preconditions summarized above. First of all, his discussion of professionalization in chemical and electrical engineering is quite strong and genuinely adds to the understanding of the engineering profession provided by previous historical works like Calvert's and like Edwin Layton's *Revolt of the Engineers* (1971). Still, even though it is meant only to prepare for the "designs" that follow, the first part of the book has serious faults. Thus, while the majority of the corporate engineers to be treated later in the book came from the ranks of electrical engineers, the initial development of the electrical man-

3. For recent works which use the concept of "corporate liberalism," see those cited in note 2 *supra*, as well as J. GILBERT, DESIGNING THE INDUSTRIAL STATE (1972); R. RADOSH & M. ROTHBARD, A NEW HISTORY OF LEVIATHAN (1972); and J. ISRAEL, BUILDING THE ORGANIZATION OF SOCIETY (1972). The concept has often been criticized, most extensively in K. McQuaid, A Response to Industrialism: Liberal Businessmen and the Evolving Spectrum of Capitalist Reform (1975) (unpublished dissertation, Northwestern University).

ufacturing industry itself—the economic base, as it were, on which their superstructure of projects was erected—receives insufficient attention; only seven pages of direct discussion and analysis are included in Part I, to which fifteen more are added later. Furthermore, all of the fifteen and most of the original seven are devoted to a single set of problems—*i.e.*, those surrounding the control of patents and inventions. The hard data that could establish claims about the industry's economic concentration, its profitability, and the size and complexity of its manufacturing facilities relative to other sectors are omitted. The same problem is even more acute for the chemical industry. This failure is especially critical because both these industries are so wide-ranging that generalizations built on the handful of examples included—such as the cases of electric lightbulbs and radios—cannot be safely carried to all product and service lines.[4]

A lack of information about vital issues also mars Noble's sketch of the social and economic situation at the start of the century. Though the reader does not require a detailed retelling of the story of "monopoly capital," he does need to know how and why the science-based industries *specifically* came to feel the economic pressures that Noble asserts affected corporate capitalism as a whole. Noble's general summary merely *assumes* the basics of monopoly capital; it does nothing to prove their applicability to the case at hand. Similarly, Noble assures us that the science-based industries felt the unsettling effects of social protest and reform movements. Yet aside from mentioning a strike or two, the electoral strength of Socialists in towns like Schenectady—a center of General Electric operations—and, much later in the book, the opposition of workers to Frederick W. Taylor's version of scientific management, he omits any detailed account of the interactions that must have occurred between science-based firms and the social movements of 1900 to 1930. Thus, in both the economic and social spheres his account would have benefitted from fewer familiar generalizations about capitalist America and more specifics about the social and economic history of the industries he knows best.

This deficiency is especially puzzling when one looks at the restricted range of "corporate reform" discussed in Parts II and

4. This point is stressed, for example, by the economist Jules Backman in his studies of both industries in recent times. *See* J. BACKMAN, THE ECONOMICS OF THE ELECTRICAL MACHINERY INDUSTRY (1962); J. BACKMAN, THE ECONOMICS OF THE CHEMICAL INDUSTRY (1970).

III of *America by Design.* The very general framework developed in Part I could open outward toward all sorts of "corporate liberal" causes: the reshaping of America in line with corporate needs was to be an epic undertaking. But instead Noble chronicles only an inner circle of ideas and institutions, all closely related to the process of production in science-based industry itself. This set of projects he summarizes under the following categories: "standardizing science and industry, reforming the patent system, routinizing research, transforming education, and developing modern management" (p. 321). The specificity of these reforms seems to demand a specific explanatory context for them, a context provided for *technical* education and partially for patents and research, but not for the others.

The lack of economic background material also weakens Noble's case because it leaves him with no effective reply to an alternative explanation of the shape of science-based industry, one that relies more on its technological essence and less on the general character of monopoly capital. Thus, Alfred D. Chandler, in his 1977 study of the evolution of business enterprise in America, *The Visible Hand,* concludes that the effort to gain monopoly profits and perpetuate the conditions for exacting them has not been sufficient to establish or to preserve concentration or vertical integration in American industry. Instead, Chandler argues, vertical integration, huge individual firms, and a high degree of concentration only proved profitable in industries that met certain technological and economic preconditions—industries "where the processes of production were capital intensive and energy-consuming, and where the creation of a marketing organization assisted in the selling and distribution of mass-produced products."[5] Since Chandler believes that the electrical-equipment and chemical industries did meet these preconditions, his list of the priorities facing twentieth-century managers in these industries resembles Noble's—for example, both authors emphasize the need to design more efficient management methods and to organize large research establishments. But Chandler's explanation of the *processes* underlying the priorities is more cogent, since it explains better why some industries and not others had to recognize those priorities.

5. A. CHANDLER, THE VISIBLE HAND: THE MANAGERIAL REVOLUTION IN AMERICAN BUSINESS 372 (1977).

II

I might seem to have lavished inordinate analysis and criticism on only about 60 of the 320 pages of *America by Design.* I have done so because most of the remaining 260 pages contain an intellectual and, especially, an institutional history of *elite* groups—engineer-managers employed by leading industrial firms, professors in engineering schools, and key figures in quasi-public agencies like the National Research Council of the World War I era. Noble analyzes in great and sometimes exhaustive detail the programs and causes these elites supported and their rationales for sponsoring them. Yet because of the weakness in the foundation for these analyses, *America by Design* comes up long on "design" and rather short on "America." This diminishes its value as *social* history, especially from the Marxian viewpoint adopted, for that viewpoint assumes the close interaction of social, economic, and institutional forces (a point stressed in Christopher Lasch's foreword to the book itself [p. xiii]).

All this is not meant to deny the merit in Noble's institutional and intellectual history of "corporate reform." Each of the topics he deals with is significant, and the virtues and faults of his treatment of them deserve attention. The first project that he discusses—scientific and industrial standardization—seems relatively clear-cut. While variety in consumer goods might testify to the dynamism of free enterprise, a similar variety in the materials and machinery used in industry conflicted with what Noble sees as the requirements of the mass-production process —"uniformity, precision, reproducibility, and predictability" (p. 70). A need for fixed standards of quality and performance in consumer goods also became evident as mass marketing evolved. It was not surprising, therefore, that corporate engineers worked for greater precision in scientific standards as a basis for those of industry, or that when these efforts succeeded in creating a strong National Bureau of Standards, that agency would offer services of direct value to industry as well as to science (pp. 71-75). Though the problem of industrial standardization proved to be more complex than that of scientific standardization, Noble also shows that by the late 1920s important changes, often sponsored by the government, had come to the electrical, chemical, and auto industries—*e.g.,* product simplification, standard specifications for parts and raw materials, and more precise methods for rating the capabilities of materials and products (pp. 75-82).

While the standardization Noble sketches seems to have progressed rapidly and successfully, one doubts whether it achieved, or was intended to achieve, the purposes he ascribes to it. In his view the standardization movement aimed not only at reducing inefficiencies due to diversity, but also at controlling "competition in production," which engineers purportedly saw as a threat to corporate stability (p. 70). Yet his own illustrations show that standardization could work to increase competition as well as to reduce it. In the electrical industry, standardization did buttress the pre-eminence of General Electric, Westinghouse, and American Telephone & Telegraph in many fields and thus promoted industrial concentration; but in the automotive industry, it was first sponsored by *smaller* manufacturers, in order to break the limited monopolies that individual parts suppliers which provided unique products often held over their customers (p. 79). While Noble may be right in implying that cases like the former outweighed those like the latter, he cites no *quantitative* evidence that the trend lay in this direction.

According to Noble, the next link in the chain of corporate hegemony over technology was the attempt to control the process of invention, largely through the use of patents and organized research. Relying heavily for his data on the electrical-equipment industry—and again on General Electric, American Telephone & Telegraph, and Westinghouse in particular—he claims that by 1929 the patent system had become a prop for corporate prerogatives instead of a spur to individual invention. This was allegedly produced by action in three areas. First, the large corporations adopted policies in handling patent matters that effectively forced individual inventors to the wall. Thus, corporations intentionally used patent infringement suits to deplete a competitor's resources, made restrictive patent-pooling and licensing agreements, and filed multiple auxiliary patents around a primary patent to extend its useful life (pp. 91-95, 97-98). Second, firms in science-based industry set up large in-house research organizations to develop new inventions systematically. Once these were established, corporate managers gradually exerted greater control over the work of their researchers. For example, they instituted closer accounting of the time and effort spent by individual researchers and subdivided research projects into specialized units; in addition they began to require employees to sign over all patent rights to potential inventions as a condition of employment, and even eliminated bonuses for individual inventions (pp. 119-21, 101). Finally the corporations worked to "reform" the government

patent apparatus by introducing predictability and efficiency into its operations. These efforts first began to bear fruit during World War I, when the wartime regulation of industry encouraged patent pools and other devices of value to large corporations; after the war new laws gave the Patent Office a more "professional" complexion and made the appeals process more centralized (pp. 102-08). The result, according to Noble, was a new "formalism" in the patent system that put corporations at an even greater advantage over individual inventors, since the latter found it difficult to cope with the "intricacies and complexities" of the new procedures (pp. 108-09).

Noble draws a rather drastic conclusion about the cumulative effect of these changes: Because of them, and because the courts refused to counteract them by applying antitrust laws more vigorously to patent-related cases, by 1930 the patent process had become so corporatized "as to render subsequent judicial and legislative efforts to check corporate monopoly through patent control too little, too late" (p. 88). He supports this statement with statistics that show a trend in the direction claimed—by 1950, for example, fully seventy-five percent of new patents were assigned to corporations. Also, in the late 1930s, seventeen percent of the patents went to large firms with over $50 million in assets, while such firms had received only three percent in 1916. Still, the apparent difference in the percentages for corporation-held patents and patents of *major* corporations indicates something less than the full-blown "corporate monopoly through patent control" that Noble's examples—like patent pooling among such giants as General Electric and American Telephone & Telegraph—imply.[6] Furthermore, these relatively few examples are restricted to the pre-1930 period; thus, they fail to justify the claim that events since 1930 have been just more of the same, an acute and conspicuous failure, since other writers on the electrical-equipment industry have argued that the importance of patent-pooling and licensing agreements in maintaining market positions has *declined* markedly since World War II.[7]

6. This is not to say, however, that these examples are trivial or false. Leonard S. Reich, in studying the early development of radio in detail, makes an argument similar to Noble's about corporate research and patent strategies in that field and concludes that "in almost every case, research became a more important factor in competition for monopoly control than in competition for shares of the market." Reich, *Research, Patents and the Struggle To Control Radio: A Study of Big Business and the Uses of Industrial Research,* 51 BUS. HIST. REV. 209, 234 (1977).

7. *See, e.g.*, J. BACKMAN, *supra* note 4, at 110-11; 1 R. SULTAN, PRICING IN THE ELECTRI-

The problem of overstatement raised by Noble's discussion of the patent system extends to his analysis of industrial research as a whole. He seems to be trying to establish two distinct propositions—first, that industrial research became a largely corporate endeavor and, second, that it became a tool of monopoly and oligopoly—as though they were equivalent. In reviewing the expansion of in-house research between 1900 and 1930, he definitely establishes the plausibility of the first; only relatively large industrial firms could mount a steady, successful research effort, given the level of investment in personnel and facilities required and the often long periods before any payoffs on investment were realized. These constraints especially affected *basic* as opposed to applied research, and the former assumed ever greater importance over the years in both the chemical and electrical sectors (pp. 110-19). Demonstrating the second proposition, however, requires evidence that over the long run the *largest* firms have benefitted disproportionately from corporate industrial research; though he claims that they have (pp. 120-21), Noble does not supply that evidence. In fact, the studies of the economist Edwin Mansfield and his students indicate that the relationship between firm size and successful innovation is not simple and linear. Their most pertinent data come from an analysis of the chemical industry since 1930 and suggest that the four largest chemical firms did *not* innovate relatively more in products and processes than their somewhat smaller competitors. The only exception was the disproportionate success in the area of products of the largest firm, DuPont. But *size* alone could not have been the determinant here, for the other three of the top four did not approximate DuPont's degree of success.[8]

The rise of corporate industrial research, Noble says, had important human implications as well as economic ones, since the development of "research management" methods prevented truly free inquiry among employees in the industrial laboratories. Because true cooperation presupposes "individual autonomy and intention," and because the restraints researchers worked under negated these, Noble concludes that "their activities did not reflect a spirit of cooperative investigation so much as one of collec-

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CAL OLIGOPOLY: COMPETITION OR COLLUSION 28 (1974). Backman adds that patent monopoly, while very important in some product lines like electric lamps, has played a minor role in other parts of the industry that are just as concentrated today.

8. E. MANSFIELD, THE PRODUCTION AND APPLICATION OF NEW INDUSTRIAL TECHNOLOGY 66-67, 204-05 (1977).

tive subservience" (p. 120). His own evidence, however, suggests that this point has more formal than psychological validity for his discussion of professionalization emphasizes that, after 1900, engineers generally saw their own career interests as bound up with corporate needs, and he provides no proof that corporate requirements such as teamwork and hierarchical organization weighed more heavily on engineers in research departments than elsewhere in the firm. For *scientists* involved in basic research, his analysis might be more apt, but Noble does not discuss the plight of the scientist in the corporation in any detail; thus the supposed disjunction between cooperation and "collective subservience" is never illustrated.

A similar gap between institutional forms and the socio-economic conclusions inferred from them also mars Noble's discussion of cooperation in research between industry and universities. As he demonstrates clearly, after 1900 corporate engineers and their allies worked hard to make research in the universities relevant to the needs of industry—to have the schools, as one of them put it, become "integrated as research centers within the industrial structure" (p. 128). These efforts took on many shapes: firms supported university fellowships in industrial research, research institutes affiliated with schools undertook contract work, and university engineering departments themselves often did the same. At state universities the extension movement became more utilitarian, and engineering "experiment stations" were promoted alongside agricultural ones.[9] Finally, the Massachusetts Institute of Technology introduced its influential Technology Plan in 1920, which guaranteed participating firms that for a standard fee they could gain access to MIT faculty for consulting services and to MIT's personnel files for recruitment purposes (pp. 123-43).

Developments like these obviously brought the universities and the corporations closer together and mirrored a changing conception of the university's role in society—the spirit of the "multiversity" was already incarnate in programs like the Technology Plan. But Noble claims more—namely that such programs both (a) "shifted the burden of some significant costs, and risks, of modern industry from the private to the public sector" and (b) put a new set of constraints on the pursuit of knowledge, con-

9. Pluralists will take comfort from the inability of a formidable array of elite educators, executives, and scientific organizations to convince the United States Congress to support such stations (pp. 135-36).

straints which meant that "science had, indeed, been pressed into the service of capital" (p. 147). These conclusions are surely exaggerated. Regarding the first, Noble himself states that much of the "reorientation" and expansion of university facilities was being financed by industry or by philanthropic businessmen. This being so, he ought to show as well that they somehow earned a disproportionately high return on their investment, but this sort of data is nowhere presented. As far as the enslavement of science is concerned, most of Noble's examples of cooperation come from *engineering* research. Though engineers repeatedly stressed that basic science was becoming more and more important to industry, a key figure like William Wickenden could also assert that they had to rely for basic research on "a vast army of free, disinterested and even impractical researchers" in the universities (p. 128). Obviously such talk of freedom and impracticality has to be taken at less than full value; nevertheless, it shows that a divergence in both methods and goals between pure and applied science persisted and was recognized by elite engineers. Even the National Research Council, a group which Noble portrays as dedicated to "closing the gap" between science and industry, recognized that divergence when in 1919 it decided that its programs to encourage basic research and industrial research would have to proceed independently of one another (p. 164). Also, the forces repelling science and industry have probably intensified in many fields since 1930, because an increasing proportion of basic research has come to be federally funded and subject to a different set of priorities and constraints.[10]

Though Noble's case that science was reoriented is less than convincing, the "design" he discerns in the narrower field of technical education is visible to the reader. Corporate engineers, he shows, disliked the system of technical higher education prevalent at the turn of the century for two basic reasons. First, as outgrowths of the science curriculum, engineering courses, especially in chemical and electrical engineering, were heavily theoretical and insufficiently concerned with modern industrial practice. Second, the underfunded "shop work" that was supposed to compensate for these faults usually lagged far behind the state of the art in industry (p. 184). The largely successful attempts of engineers to overcome these problems ran along two principal

10. For some figures on this shift, see N. ROSENBERG, TECHNOLOGY AND AMERICAN ECONOMIC GROWTH 177-83 (1972).

lines—in-house post-graduate training within industrial firms and cooperative-education programs in the engineering schools.

Noble recounts the history of pioneering efforts in both these areas in detail, and what is more important, points out their uniformity in method and rationale. The most significant product of the in-house training idea was the corporation school; introduced by General Electric in the 1890s, it had spread by 1920 to many other large corporations and, in industries made up of smaller firms, to trade associations as well. These schools tended to share four aims: to introduce the engineering graduate to the full range of "real-world" technical problems of modern industry; to instruct him in modern management methods; to socialize him to the mores of corporate employment; and finally, to determine his potential role in the firm by testing his strengths and weaknesses with the new techniques of "personnel management" (pp. 170-79).

Cooperative education, which combined alternating periods of classroom instruction and actual work in industry, began in 1907 in the engineering department of the University of Cincinnati. Since cooperative education offered substantially the same benefits to industry as the corporation school at the same or smaller cost, it also became widespread by 1930. An interesting and important variant was introduced at MIT after World War I. As conceived by Magnus Alexander of General Electric for electrical and by the MIT-trained consultant Arthur D. Little for chemical engineering, the Institute co-op program was selective in admissions and offered graduate degrees. Like General Electric's in-house program, it emphasized management skills such as knowledge of economics and accounting. While the ordinary co-op programs consciously aimed at producing "an engineer for commercial production," MIT's program represented "an important new breeding-ground of America's corporate elite" (pp. 180-95). A common rationale, however, lay behind both forms of cooperative education as well as behind the corporation schools—as an official of New York Edison said, all these endeavors resulted from the fact that "corporations . . . no longer expect to find satisfactory help ready made, but are applying themselves to the task of making men as well as commodities." Noble adds in an ironic, though perhaps apt, aside that the real point had become "the production of men as commodities" (p. 179).

Since engineers consciously saw education in terms of "processing human material," it was logical that they would seek standardized procedures for collecting supposedly "objective"

information about students and for evaluating that information. Thus, along with the corporation schools, engineering schools led the way in developing systematic student records—including not just grades, but scores on standardized tests, evaluations by professors, and character profiles—records explicitly geared to the needs of actual and prospective employers. The complementarity of early corporate and college "personnel" systems is nowhere more clearly displayed than in the case of Purdue's engineering school: designed by Dean A.A. Potter, the Purdue procedures were not only adopted by other schools, but also became the nucleus for Westinghouse's corporate personnel system (pp. 188-89).

Having described the key features of the corporatization of technical higher education, Noble goes on to tell in great, perhaps excessive, detail the story of the national organizations that tried to impose the new corporate style on American higher education as a whole. The first great achievements of these groups came during World War I, when corporate engineers and like-minded educators held top administrative posts in the War Department programs which sought to provide technically trained manpower for the war effort. Through these programs and through the National Research Council, a semi-official body whose aim was to mobilize the academic community, the engineers and their allies managed to introduce industrial personnel methods into the Army, to encourage wholesale use of aptitude and intelligence testing, and to impose military training on students in more than 500 colleges (pp. 215, 207, 228, 218-21).

After the wartime emergency, Noble tells us, these people returned to their primary task of coordinating education and industry; they worked through the successors of wartime agencies—the "permanent" National Research Council and the American Council on Education, for example, as well as through new policy research groups like the National Industrial Conference Board. Among other functions, these groups acted as clearinghouses for educational reform along corporate lines. Aided by the Rockefeller and Carnegie foundations, they also sponsored studies in "personnel research," intelligence and aptitude testing, and the like, work that engaged the talents of important psychologists like L.L. Thurstone and of well-known industrial psychologists like Elton Mayo (pp. 229-31, 254-55).

Those who commissioned these projects quite explicitly stated that their ultimate objective was "to decide how education can be organized to meet industrial specifications" (p. 254). Nor

did they eschew manipulative means to their ends; rather, they hoped "to find the critical tests that control individual conduct and use these to secure voluntary cooperation and stimulate individual responsibility" (p. 229). They also sought to promote more blatantly ideological causes such as "countering in the school sinister industrial tendencies and fallacies" like socialism (p. 229). Finally, Noble shows that these organizations were able to extend their influence, and thus the influence of "corporate reform," beyond the 1920s—the American Council on Education, for example, not only became the principal accreditation agency for American higher education, but its various programs in testing were the direct precursors of the now ubiquitous Educational Testing Service (p. 255).

As the foregoing illustrates, Noble develops a strong case for the idea that many familiar features of technical education, and of higher education generally, were originally promoted as a means of bringing the schools closer to meeting industrial "specifications," as defined by individuals with a corporate perspective. But on the crucial question of how great an *impact* these new programs and methods actually had in determining the nature of modern American higher education, he shows a proclivity here as elsewhere for overstrong conclusions. These new initiatives, he declares, effectively ushered in the control of higher education by the "business principles" that Thorstein Veblen had satirized and lamented in *The Higher Learning in America*. That many academics did not and do not see this is to be expected, says Noble, for

> the corporate reformers never required that all who pursued higher learning in America be conscious of the utility of their work, nor even that such work be of ultimate utility. Rather, they created an institutional apparatus which would correlate the activities of academics "behind their backs," thereby rendering such consciousness of purpose unnecessary. [P. 245]

Anyone aware of the gulf that has often existed between "service-oriented" university administrators and "intellectuals" in faculties wants to sympathize with this assessment. Unfortunately, only in the field of technical education does Noble clearly describe how the new systems qualitatively differed from the old. It is not just a want of imagination that prompts the reader to demand a glimpse of the "correlation" process *at work* in the other parts of the academy, for the general "reform" causes promoted by Noble's elite seem to be primarily *formal*—record-keeping, testing, accreditation, and the like. As such they would

be subject to various uses in practice, uses which cannot be predicted from the corporate engineers' purposes alone. Because of this difficulty, the reader finds no grounds on which to conclude that "corporate reform" actually altered the modern American university's status quo, which Laurence Veysey defines as a state of *permanent tension* between a dominant, business- and service-minded perspective and a less powerful, but still tenacious, viewpoint that stressed free inquiry, social criticism, and other "ivory tower" objectives.[11] Perhaps if Noble had chosen to write about the 1930s or 1960s, periods in which business and corporate values were vigorously attacked by intellectuals, he would have recognized that this tension survived early twentieth century "corporate reform" and remained a source of worry for later generations of corporate spokesmen.

III

In the last section of *America by Design,* Noble moves away from the universities and back toward industry. His theme is the evolution of modern management and the corporate engineers' role in that evolution. Again the framework is explicitly Marxian. By the early twentieth century industrial corporations realized that designing complex machinery to break the autonomy of skilled workers could only extract part of the potential surplus value of alienated labor. Corporations had also to undertake "the deliberate engineering of the work place and the work activity of labor" (pp. 259-60). According to Noble, science-based industry was for three reasons especially subject to this new imperative. First, the positivist attitude of many engineers proved amenable to notions about rationalizing the human side of the industrial process. Second, engineer-managers in these industries had half won the battle, since they, not the workers, controlled most of the information on which production depended. Finally, greater productivity and stability in the labor force was critical to continuous utilization of expensive plant facilities, a need that all highly concentrated industries felt (pp. 259-60).

Noble presents an impressive list of engineer-executives who helped develop important tools of modern management—men like Gerard Swope at General Electric, Alfred P. Sloan at General Motors, and Hamilton Barksdale at DuPont (pp. 278-83). His main concern, however, is with a single aspect of the new science

11. L. VEYSEY, THE EMERGENCE OF THE AMERICAN UNIVERSITY 439-44 (1965).

of management—its handling of the "human problem," which actually meant the problem of molding a docile and efficient work force. In his view, efforts to solve the "human problem" ran along two lines. The first, social engineering, involved "the conscious attempt to exercise management prerogatives through the medium of the workplace, through organization of the work activity of labor." The second, human engineering, "was the movement to control the human element of production . . . through the study and manipulation of human behavior" (p. 264).

Social engineering, as Noble defines it, first emerged clearly in the work of Frederick W. Taylor and his followers in scientific management. He provides a brief, synthetic account of Taylorism, based on the work of Samuel Haber and others;[12] that account's main purpose is to show how a "revisionist" conception of scientific management had developed early in this century, a conception that increasingly stressed problems like motivating workers and retreated from the absolute rule of the stopwatch (pp. 266-77). The new outlook in scientific management turned out to be quite close to attitudes that were developing simultaneously among "corporate liberal" managers, since the latter especially desired to systematize and modernize the "welfare" programs that many firms had been supporting since the 1890s, as well as to introduce more "scientific" procedures for handling employees as individuals and in groups (pp. 286-95). The two streams of management innovation, Noble argues, tended to coalesce between 1910 and 1930, to agree more and more that "human engineering" was the *sine qua non* of effective management.

The range of projects that Noble treats under the rubric of "human engineering" is broad—it includes "industrial relations" research, the establishment of personnel departments, vocational education and guidance in public schools, industrial psychology, and the study of management in engineering schools. Except for the last of these projects, his analysis deals mainly with the institutional role corporate engineers played in promoting and running them; it adds little to our knowledge of their content. As with the reform of university education, the discussion does not illuminate the vital problem of where projects succeeded or failed in achieving corporate purposes.

12. *See, e.g.*, H. AITKEN, TAYLORISM AT WATERTOWN ARSENAL (1960); S. HABER, EFFICIENCY AND UPLIFT (1964); M. NADWORNY, SCIENTIFIC MANAGEMENT AND THE UNIONS, 1900-1932 (1955).

In his portrayal of modern management Noble does, however, provide valuable insights into why certain activities appealed to managers with an engineering background. One fine example is his explanation for the vogue of early industrial psychology, which tended to emphasize both "hidden laws" of behavior and the nonrational sources of conduct. The first notion attracted the engineer, Noble explains, because it promised a degree of control over people comparable to that exerted over inanimate objects, while the second allowed the engineer as manager to by-pass the troublesome phenomena of rational purpose and conscious values in his workers (pp. 297-98). The discussion as a whole would have been much stronger if this sort of clarity about the motivations behind projects like industrial psychology had extended to the accomplishments of these projects, or the lack thereof.

IV

In exploring the genesis of modern management, Noble pays more attention than in earlier parts of the book to groups who opposed the plans of the corporate elite—mainly to the workers who resisted scientific management and rejected corporate "welfare" work, but also to other groups like the progressive educators who attacked vocational tracking systems for school children. With this shift in emphasis he seems to be setting the stage for the qualified conclusions of his epilogue, conclusions which go against the tone of much of the discussion in previous chapters. For, in the epilogue, he tells us that the "designs" he has labored to uncover have *never* been completely translated into reality, because the structure that corporate engineers hoped to strengthen was flawed from the beginning: it did not serve society as a whole, but only "served the dominant class in society, that class which, in order to survive, must forever struggle to extract labor from, and thus control the lives of, the class beneath it." No matter how much engineers might mislabel or disparage their opponents, rational opposition to domination by corporate capital was bound to exist, and thus opposition to the engineers' "designs" was inevitable as well. And, Noble admonishes us, "no myth of classlessness, no 'end of ideology' ideology, however comforting, however innocent, can ever obscure" these facts (pp. 323-24).

Of course, the rhetoric is perfervid, but neither that fact nor the invocation of the theory of surplus value is the key historical

problem here. Rather, the problem is that Noble has introduced some historical complexities that neither the tone nor the content of his text have truly prepared us for; his failure to face these complexities throughout has severely limited the persuasiveness of his tale. All along we have been seeing with the eyes of the elite; now that we hear about the existence of conflict we want to know more about what the elite has been neglecting to tell us. Simply invoking that conflict does not adequately reveal the *interplay* between elite designs and events. But beyond this, Noble's concluding diagnosis of the *reasons* for conflict over corporate designs oversimplifies recent American history; it underestimates the true range of social forces and social perspectives that have done battle over issues like the role of the university in society and the aims and priorities of scientific research. Noble's Marxian viewpoint has sensitized him to the implications of clashes between corporate managers and the working class; but divisions *within* the middle-class that might undercut the hegemony of corporate values he has largely ignored. Thus, the various middle-class groups with vital interests wrapped up in the institutions that were the objects of corporate "engineering plans"—*i.e.*, the individual inventors, research scientists, university faculty and students, progressive reformers, and politicians—never receive their due as actors in the American socioeconomic and political structure. Their actions, just as much as those of the engineers, must be accounted for in explaining the shape of modern institutions.

When he debunks the myth of "the end of ideology" Noble means not only that class conflict continues to exist, but also that his twentieth-century corporate engineers have acted consistently in ideological ways. Since he does indeed seem to have established the latter proposition, he has achieved much of the purpose of *America by Design.* On the other hand, he clearly has fallen short of showing that the resultant of those actions and countervailing forces has shifted science, technology, and education themselves to an ideological role in American society. And it is on this latter question that the real degree of subservience of science and technology to corporate capital turns. Noble has failed in this larger task mainly because all along he has insufficiently addressed the problem of *pluralism* in the modern American social order. Even when, in the political sphere, "pluralism" stands discredited as a byword denoting an inability to confront the reality of corporate power and the existence of elites, it remains a valid historical and sociological concept—valid, that is, when it refers to the fact that social groups can arrange them-

selves along other axes of conflict or cooperation besides ownership of the means of production. Institutions involved in the promotion and practice of science and technology have not been immune to influence from these other kinds of intergroup division. It may be that the corporate elite's influence has been the determining one since 1900, and the influence of labor its only significant opposition, but examining elite organizations and attitudes cannot in itself establish this. Noble has thus been unable to transform a solid piece on the history of a professional elite into a compelling piece of social history.