to them, France can implement a nuclear program because "a centralized administration allows the government to ignore social movements" and centralization exists because "French territorial unity has existed for at least six centuries, providing a basis of a centralized and stable state." Now centralization was less a consequence of territorial unity than a mechanism for maintaining and expanding the kingdom. Moreover, just a quarter-century ago France was widely regarded as an unstable state, despite the six centuries of its history. Centralization, even abetted by the lack of an independent judiciary, is thus not a sufficient condition for an elected government to pursue policies that are intensely opposed by significant minorities. Also necessary is a strong dose of political authority as exemplified in the current presidential regime. Born of the peculiar circumstances of the Algerian war (contrast Italy, which has gotten along with an unstable regime since 1946), this regime is undoubtedly maintained by negative preferences regarding a potential leftist or communist government. As the right can exploit the public's fear of the left, it has wide latitude in most areas of public policy, including nuclear power. Skimping on this relatively short-run political context, Nelkin and Pollak overemphasize long-run historical and sociological considerations.

My quarrels with various interpretative statements in *The Atom Besieged* could run to many pages, and I would advise reading the book with a heavy filter. Nonetheless, it is a worthy contribution on a subject of great public concern.

HOWARD ROSENTHAL
Graduate School of Industrial Administration, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213

Foundations of a Profession

History of Chemical Engineering. Papers from a symposium, Honolulu, April 1979. WILLIAM F. FURTER, Ed. American Chemical Society, Washington, D.C., 1980. xii, 436 pp., illus. $39. Advances in Chemistry Series, 190.

At several crucial junctures in the Manhattan Project, when conflicts arose regarding priorities in research and development, the leaders of the project created blue-ribbon committees to study and to report on the choices faced. Chemical engineers dominated many of the committees. Indeed, Warren K. Lewis, professor of chemical engineering at the Massachusetts Institute of Technology and dean of American chemical engineers, seems to have been the automatic choice as chairman of these review panels. It is striking that the physicists and chemists who managed the bomb project should have turned to chemical engineers so often for advice, especially since chemical engineering was a young profession, barely as old as many of the scientists themselves. The essays in this history of chemical engineering do not deal directly with the role of chemical engineers in the Manhattan Project, but the collection as a whole does much to clarify how and why chemical engineers, particularly in the United States, came to enjoy so much confidence and esteem so quickly. The book is especially valuable since little has been done to trace the history of this important discipline.

The 22 papers in *History of Chemical Engineering*, all but one written by chemical engineers themselves, may be divided into four topical categories. The volume opens with several essays that treat the genesis of the concepts fundamental to the emergence of chemical engineering as a distinct specialty; it concludes with brief reviews of the present image and future prospects of the chemical engineer. Sandwiched in between are essays on the individuals and institutions that contributed most significantly to the expansion and prosperity of the discipline during the 20th century as well as a number of studies that deal with the history of chemical engineering in specific national contexts.

Several generalizations emerge from the essays that take the conceptual foundations of the discipline as their subject. It seems clear, for example, that European and American chemical engineers followed two separate and distinct paths during much of the past century. In Europe, industrial chemists did not until recent years stray far from their roots in chemistry proper; chemists and mechanical engineers cooperated to meet the needs of European chemical industries. In turn-of-the-century America, however, a single chemical engineering profession emerged whose practitioners were distinct from both mechanical engineers and chemists. Unlike mechanical engineers, they were prepared to understand the strictly chemical aspects of industrial reactions; unlike chemists, they were trained to handle the problems of producing by the ton rather than by the test tube. Crucial to the emergence of this profession was the concept of unit operations, that is, the concept that a small number of elemental operations such as filtration, distillation, and evaporation are the common denominators of all chemical processes used in industry. Chemical engineers have come to look to the concept of unit operations as the origin of their science in much the way chemists look to Lavoisier's concept of element as the origin of modern chemistry, and for much the same reasons. Both concepts served to tie together facts and phenomena that would otherwise remain isolated, and both were invaluable pedagogical tools. Armed with unit operations, teachers did not need to give special courses on each of the scores of chemical process industries that might hire young engineers; instead instruction could be organized around a small number of operations common to all industries.

Unit operations became the basis of American education in chemical engineering early in the 20th century, and MIT was the pioneer in bringing the notion into currency. On this the writers in this volume agree. But there is debate, somewhat nationalistic in tone, over exactly when and where the concept of unit operations was first described. John T. Davies and D. C. Freshwater, both British chemical engineers, make a strong case for their countryman George E. Davis as the creator of the concept. American contributors, such as F. J. Van Antwerpen, emphasize the roles of Arthur D. Little, William H. Walker, and Warren K. Lewis—all of whom were associated with MIT. Perhaps it is best here to trust the judgment of Jean-Claude Guédon, a professor at the University of Montreal and the only trained historian among the contributors. In a very fine essay, Guédon all but ignores the question of who deserves priority for defining the concept of unit operations and instead examines the more fruitful question of why Europeans were so slow to adopt it. The idea did not occupy an important place in the chemical engineer's education in Britain and France until after 1925, and in Germany it did not win much attention until after World War II. Guédon seeks to demonstrate that the concept of unit operations could not have come into favor in Europe

because of the structure of the educational institutions and industries of Britain, France, and Germany. Although Guédon may be faulted for seeking to prove a modal negative, his provocative essay does much to clarify why chemical engineering followed different paths of development in America and Europe. In Europe, and especially in Germany, industry adapted itself to the products turned out by universities and technical schools; in America, the universities were sufficiently flexible to adapt their curricula to the demands of business. "It was," Guédon concludes, "easier to move industries in Germany and universities in the United States."

Guédon's intriguing essay is alone enough to make this volume worthwhile, and, though the other contributions do not all attain this standard, several are especially deserving of notice. H. C. Weber relates several colorful and revealing anecdotes about the founders of the influential program in chemical engineering at MIT, and H. C. Lewis's piece on Warren K. Lewis succeeds both in bringing the man to life and in explaining the devotion of his former students. Karl Schoenemann's essay on the development of chemical engineering in Germany explores in some detail the differences between the chemical engineer's role in German and American industry, and Vance E. Senecal has written a valuable summary of the history of chemical engineering at DuPont. Perhaps the real sleeper in the collection, however, is Gianni Astarita's sparkling sketch of the development of chemical engineering in Italy. Astarita weaves a biting critique of Italian government and institutions into his account, and his essay reminds us that it is important to study cases of retarded development as well as success stories if we are to understand the conditions that breed intellectual and industrial accomplishment.

History of Chemical Engineering is on the whole a rewarding book. Although several of the contributions are very amateurish and a few read like government reports, many others are of considerable value both to historians interested in the history of the applied sciences and, I would imagine, to chemical engineers concerned to learn more of their heritage.

JOHN W. SERVOS
Program in History and Philosophy of Science, Princeton University, Princeton, New Jersey 08544

Science and Government in Britain

Scientists in Whitehall. PHILIP GUMMETT. Manchester University Press, Manchester, England, 1980 (U.S. distributor, Humanities Press, Atlantic Highlands, N.J.), x, 246 pp. $38.

The present high level of interaction and mutual dependence between the scientific and political communities has been achieved through a variety of institutional devices, including the recruitment of scientists into the bureaucracy, the proliferation of science advisory committees, and the organization of bureaus and laboratories to administer or perform public R & D programs. As those who follow the fortunes of science and public policy in the United States are aware, the evolving relationship has not always been a smooth one, with multiple misunderstandings, recriminations, and often the need for painful accommodations on both sides.

That these developments and the attendant difficulties are by no means confined to the American experience is well illustrated by Philip Gummett, who in *Scientists in Whitehall* offers a guided tour of the inner recesses of British public administration most closely associated with the scientific community. In the process, he gives us the most comprehensive and informative account now available of the organized relationship between British science and government.

Two features of the book are particularly noteworthy. First, the author is careful to place contemporary developments in historical perspective. By reaching on occasion as far back as the 19th century, Gummett demonstrates that, though attempted solutions may change, the problems of reconciling the forces and prerogatives of science with those of politics and administration remain remarkably constant. American readers may derive some consolation in discovering that a generally earlier and greater public awareness of the need to balance scientific autonomy with public control, to support research stimulating industrial innovation, and to coordinate departmental programs has apparently not enabled the British to devise more durable and satisfactory arrangements for achieving these often conflicting objectives.

Second, the author makes a welcome attempt to identify the ways in which more general features of British public administration have shaped the relationship of science and government. We learn in particular how the existence of a professionalized civil service dominated by "generalists" has, despite successive reforms, limited the recruitment and stature of scientists and engineers in public service. Similarly, the principle of ministerial responsibility has acted as a constant and insurmountable barrier to the formulation of an overarching, coherent science policy.

The book's most persistent shortcoming is the failure to go beyond the institutional forms of scientists' public involvement to discuss the character and impact of their activities. Permutations in the organization and composition of advisory committees and in the division of responsibilities of the departments are presented in detail; given the importance that such matters have had in British discussions of science policy, the emphasis is not entirely unwarranted. But in the absence of an analysis of the effects of these transformations on specific policy choices or on the performance and direction of British science and technology, one is left wondering what is at stake in the debate.

The chapter on the scientific civil service, for example, gives no indication of the diversity of tasks that scientists can perform as public employees. The chemist doing sample analysis, the nuclear engineer inspecting power plants, the biologist administering a research grant program, and the physician advising on worker health policy merge their scientific, administrative, and policy-making roles in quite different ways. To treat them as an undifferentiated class of somewhat oppressed public functionaries does not greatly enhance our knowledge of the value and limitations of scientific training in public employment.

More surprising is the lack of substantive detail concerning the responsibilities, special concerns, and influence of top-level science advisers. The most prominent and presumably most influential emissaries of the scientific community in Whitehall, figures such as Lord Zuckerman and Lord Flowers, are given brief career sketches, but we do not learn to what extent or in what instances these individuals play decisive roles in shaping public policy.

When the author does discuss specific policy decisions or marshals evidence to evaluate the impact of concrete measures, interest gains considerably. Thus, the efforts to diversify the program of the atomic energy laboratory at Harwell and to promote industrial research in other