pers tell us of the rise of metaphorical rhetoric in physical sciences and in mathematical economics, but with little attention to substantive consequences. Only the two main leaders of the movement, Klamer and McCloskey, explicitly address the question of consequences (Solow, the third editor of the book, is a sympathetic skeptic).

We are told that if we explicitly recognize and study the rhetoric of our profession, we should become more understanding, better-tempered, and especially more effective in persuasion—unless, I suppose, the other party to the dialogue also studies rhetoric. In short, we are told to lead a well-rounded, moral life and even our narrowest scientific studies will prosper. Aside from the costly admonition to remedy the academic deficiencies in our upbringing, this sermon seems innocuous. Yet it is not unanimous: a guru among literary critics, Stanley Fish, tells us to ignore literary studies if our discipline is working fairly well (p. 22). To date, the only clear consequence of the study of rhetoric for economics appears to be conferences and volumes such as these.

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An Industrial Research Program

Science and Corporate Strategy. Du Pont R&D, 1902–1980. DAVID A. HOUNSHELL and JOHN KENLY SMITH, JR. Cambridge University Press, New York, 1988. xx, 756 pp., illus., + plates. $39.50. Studies in Economic History and Policy.

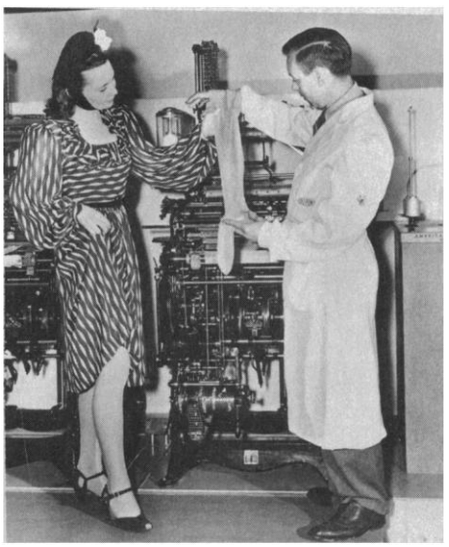
Corporate managers today recognize that research is fundamental to remaining competitive, but this has not always been the case in the history of American industry. Indeed, relatively few companies around the turn of the century dedicated space and manpower to research; firms that did, such as General Electric, Parke Davis, and Bell Telephone, were exceptional. Hounshell and Smith's incisive study of the evolution of research at Du Pont examines how one of the leading research-intensive firms in corporate America institutionalized so-called "R&D." Du Pont established two laboratories for research and development within the first decade of this century. One laboratory was more oriented to the everyday missions of the firm's several divisions, whereas the other focused on topics not directly related to divisional interests. This two-pronged approach to research strategy—centralization versus decentralization—remained a characteristic of Du Pont throughout the century.

Its coffers swollen from the spoils of World War I, Du Pont applied its substantial capital to a diversification strategy wherein it acquired new technology, not so much by developing in-house discoveries as by taking over companies with an established interest in a particular technology and then building on that knowledge base. Thus, soon after World War I this munitions monopoly acquired firms specializing in dyestuffs, finishes, and other products. Through the 1920s and early 1930s Du Pont R&D emphasized commercialization over invention, resulting in high-profile products such as Duco finish, tetraethyllead, rayon, and cellophane. Du Pont supplemented this strategy by contracting with the British-based Imperial Chemical Industries for a general exchange of research information.

However, Depression-era economic realities and reemerging antitrust concerns led Du Pont to begin shifting from a commercialization strategy to a plan of developing entirely new ideas for products within the firm, beginning in the late 1920s. Du Pont hired a number of promising young chemists to staff its new fundamental research program, among whom was Wallace Hume Carothers. How the company interpreted the mission of fundamental research depended on the administrator heading that enterprise. At first the program aimed to understand the science underlying Du Pont technology, but by the later 1930s and thereafter fundamental research at Du Pont meant that "scientists move into uncharted fields to be pioneers, scouting out the territory and laying claim to its riches before others appear on the scene" (p. 366). The first discoveries by the fundamental research group in the 1930s, neoprene and nylon, were among the most profitable in the history of the firm.

As was the case in many other firms during World War II, Du Pont researchers engaged in a variety of projects for the government, including development of protection against gas warfare, synthesis of pharmaceuticals, and, most of all, adaptation of Du Pont products for wartime uses. Du Pont research in the late 1940s and 1950s was the basis of assorted commercial successes with fibers (such as Orlon and Da-

The Du Pont Experimental Station in 1925 (top) and 1987 (bottom). [From *Science and Corporate Strategy*]



"Exhibiting nylon stockings at the New York World's Fair, 1939. As part of its response to . . . Merchants of Death charges, Du Pont invested substantial sums for an exhibit, The Wonder World of Chemistry, at the New York World's Fair in 1939. The fair proved to be an excellent forum in which to introduce nylon, which was to go into commercial production the following year." [From *Science and Corporate Strategy*]

cron) and plastics (such as polyethylene), and somewhat less success when the company ventured into biological chemicals, which Hounshell and Smith interestingly attribute to both corporate hubris and naivété. A push to counteract a decline in the success of established products by searching for new products and new applications of existing products characterized much of Du Pont R&D in the 1960s and 1970s, as can be seen, for example, in the firm's entry into the housing products industry and in the efforts of the photo products division.

Hounshell and Smith have drawn upon an impressive volume of manuscript resources, publications, and interviews, clearly evident in their copious documentation in this volume. Their discussions of what it meant to be a researcher at Du Pont and how the firm institutionalized research ("The conduct of research" and "The pursuit of science at Du Pont," chapters 15 and 17) stand out. Whereas much of the book relies on detailed case studies to illustrate particular research strategies, these two chapters tend to generalize more on the everyday life of the bench scientist and the efforts of Du Pont to incorporate research as a recognized function of the company. For comparative purposes it would have been helpful if the authors had placed Du Pont research more in the context of industrial chemical research and chemistry in general. This might have indicated whether research strategy at Du Pont was representative of the upper-tier American chemical industry and clarified the extent to which Du Pont contributed to the stream of chemical science. The reader also should be aware that one scientist's research is another scientist's development or quality control. Terms like "fundamental research," "applied research," and "development" can mean many different things, despite the penchant of companies (and others) historically to couple "R&D." The authors could have made it more explicit at the outset what they assumed to be research and what they assumed to be development.

A very successful feature of *Science and Corporate Strategy* is its portrayal of Du Pont's integration of research and marketing strategy, though the detailed descriptions of internal administrative changes and product engineering could have been condensed somewhat. The work of Hounshell and Smith may convince other companies to be as open with their records to outside scholars as Du Pont presumably was. If so the field will benefit, and the companies will learn a great deal about themselves too.

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Ventures in Metallurgy

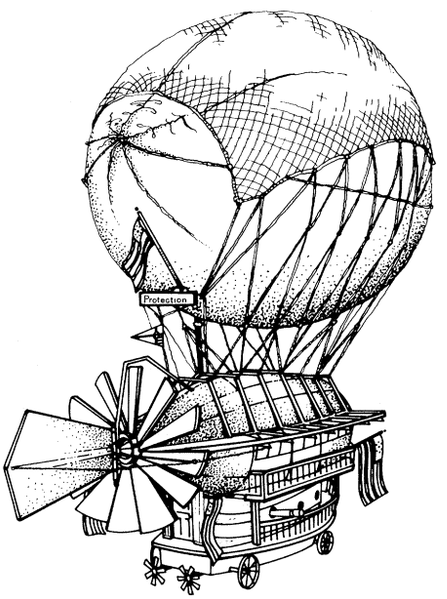
From Monopoly to Competition. The Transformations of Alcoa, 1888–1986. GEORGE DAVID SMITH. Cambridge University Press, New York, 1988. xxxiv, 554 pp., illus. $29.95.

Alcoa has grown from an idea in the mind of a talented inventor to the world's largest producer of aluminum and its products. The young man with a fascination for aluminum was Charles Martin Hall, who arrived at a workable process for smelting aluminum on 23 February 1886. One hundred years later, the company that Hall established as a result of his successful woodshed kitchen experiments achieved annual sales and operating revenues near $5 billion.

Having access to countless documents dating back to the company's origins, George David Smith provides an engaging account of Alcoa's ingenious development of a market for aluminum as well as its internal organization and management style. Aloca's cultivation and protection of the aluminum market serve as one major theme of the book. The company achieved this protection by forward integration into the manufacture of end-products and backward integration in order to secure a reliable supply of raw materials and electrical power. After their aluminum patents expired, it was this vertical integration that led to Alcoa's virtual monopoly of aluminum production in the United States until World War II.

Smith relates an exciting story of the research and development that led to so many aluminum products we take for granted today. For example, aluminum's lack of strength was a disadvantage in the cable market until 1908, when an electrical engineer at Alcoa developed steel-reinforced aluminum cable. One year later a proposal to form an independent research organization within the company was turned down. Alcoa suffered the consequences of this decision in World War I, when it encountered problems with processing hard alloys. By World War II Alcoa had formed its research department, focusing on new alloys, process innovation, and new product design. According to Smith, "research had become essential to continuing growth, the protection of markets, and the control of costs" (p. 175).

No history of Alcoa would be complete without a discussion of the company's many



"The Crepar Palace Air-Ship, a fanciful design for the application of aluminum to aviation," 1898. Alcoa "was not especially captivated by [such] schemes, but aluminum did gradually find applications in flight." By World War I, the Germans had developed an aluminum alloy, Duralumin, that was both light and strong enough to support large structures in flight. Alcoa "tried in vain . . . to develop a Duralumin substitute [but] no easy solution . . . was found until Paul Merica of the National Bureau of Standards and other Government researchers proposed a theory for the mechanism by which heat treatment, rapid cooling, and aging at room temperature caused aluminum-copper-magnesium alloys to develop extraordinarily high strength. . . . At the continuing urgings of the Navy," Alcoa finally succeeded in developing a Duralumin-type alloy that could be produced satisfactorily on a large scale. [From *From Monopoly to Competition*; courtesy of Alcoa]