condensed into a shorter monograph with, I think, much more satisfying results.

This would still leave room for a number of nice insights which Agassi injects along the way. For instance, he disputes the view that Faraday gained from his isolation and singular devotion to work, analyzing specific examples where isolation led to inefficient operation (p. 230). He also has an explanation for Faraday's method of performing so many experiments and so many variations of experiments in pursuit of a particular relationship. Agassi believes this was a natural outgrowth of Faraday's theoretical "program"—a program which consisted of explaining existing theories in terms of lines of force. Instead of filling in the detailed rules and laws theoretically, he would suggest to himself various possible empirical corollaries which he would then probe experimentally (p. 230).

All of this I find quite stimulating. But at the same time it seems to me that the book has some major difficulties. Most important, perhaps, is that it doesn't take proper account of Williams's 1965 biography. Agassi states that most of his research and even a first draft of the book were completed in 1956; indications are that no major modifications were made after that. References to Williams appear mainly as addenda at various appropriate points; a detailed discussion of the work is avoided. This avoidance is critical because the major thread through Williams's book is Faraday's continual concern—originating in the 1820's when he was experimenting with steel and glass (Agassi neglects this phase of Faraday's work)—with activity occurring in the space between atomic centers. Williams casts this all in terms of a stronger relationship to the atoms of R. J. Boscovich than I would choose to make, but that's not the point here. Clearly he emphasized the same sort of theoretical commitment by Faraday as Agassi, and this should be recognized.

Agassi's style, which is florid and often entertaining, can also be obscure. The book would have gained considerably from an additional revision to tighten up the language.

Matching the passages where Agassi has added new scope to the interpretation of Faraday, there are a number of places where he seems to wander off on the wrong track. I shall mention three instances. In the first he discusses the origins of Faraday's self-imposed semi-isolation and calls it in large part a reaction to the controversy with Wollaston in 1821 over the discovery of the rotation around a magnet of a wire carrying an electric current (p. 34). No mention is made of Faraday's affiliation with the small and self-contained Sandamanian church. The exact impact of this relationship on his scientific work cannot be assessed, but its influence on the rest of his life was obviously considerable, and in the direction of an isolated and asocial existence. I don't think it should be ignored in treating these same characteristics in his scientific activities. Second, in his discussion of the concept of conservation (p. 203ff) I think Agassi is wrong not to differentiate more strongly between energy and force. Admittedly these are words that lacked clear differentiation in the early 19th century, and when Faraday talks of conservation of force he sometimes means something very close to the conservation of energy. But this very confusion made it even more important that measurements and calculation be done so that very specific comparisons could be made and units could be defined. This Faraday, unlike Mayer and Joule, did not do. Third, in a discussion of Ohm's law Agassi describes it as being false for circuits with appreciable inductive effects (p. 242); but such is not the case as long as the current is unidirectional and constant.

Both books are well indexed by name and subject and are easy to use for reference purposes. I welcome them as additions to the Faraday literature.

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A New Kind of Man

Coulomb and the Evolution of Physics and Engineering in Eighteenth-Century France. C. STEWART GILLMOR. Princeton University Press, Princeton, N.J., 1971. xx, 328 pp., illus. $13.50.

"One of the broader theses of this book," says Stewart Gillmor, "is that the great development of 'empirical' physics of the late eighteenth century came not only from improved and sophisticated experimental techniques and the wide use of mathematical analysis but from a fusion of these methods of investigation as seen in the work of a man like Coulomb" (p. 82). One might take exception. Wasn't Newton himself the same sort? Actually, Gillmor would agree; Coulomb followed Newton's style closely and deliberately. Yet the fact remains that until the late 18th century physics remained largely divided between the gadgeteers and the mathematicians, each claiming, perhaps accurately, to be Newtonian. Studies in heat, physical optics, magnetism, and electricity seemed beyond mathematical treatment except in trivial ways. Celestial mechanics, on the other hand, could not be bought into the laboratory. Gillmor's thesis seems fair and significant.

Why Coulomb into the breach? Gillmor does not tell us—he simply describes. Coulomb was a new kind of man, a scientific engineer, and as such found himself at the one point of intersection of the empirical and the mathematical, in fluid (and in this case, soil) mechanics as well as in the practical mechanics of rigid structures. Later, it was not a big step to the study of electricity and magnetism. Furthermore, Coulomb came up through the military service, through the one branch of the civil service able to accommodate scientific engineering. The Corps du Génie had existed since the days of Louvois and Vauban, providing the necessary matrix of need and tradition. And it was far more likely that the engineer would move into the Academy's sphere than to have an academician move the other way. Once in the Academy, Coulomb brought with him a new sense for measurement, for the problems of working with real physical objects, that the abstract mathematician often lacked. Contemporary science was born from the fusion.

To say all this is to go beyond the limits of Gillmor's essay, no doubt. He sticks to the business at hand. After a two-chapter biographical sketch, there are four chapters dealing with Coulomb's many memoirs in detail, followed by a brief epilogue. The whole is presented with grace and clarity, and it is clear that Gillmor is fully competent to understand the magnitude of Coulomb's achievement. The bibliography and the attention to detail show that the research was not merely adequate but exhaustive. Not only is Coulomb's work explained, the work of his predecessors is always summarized. The only ingredient lacking in Gillmor's story is information on Coulomb's personality, information that is, apparently, simply not to be found. Coulomb remains a man who seemed to desire his privacy and did not intrude his personality into his work. Such men were rare in the 18th century.

In any case, Gillmor's book is a welcome addition to the literature of 18th-century science. Until recently, various periods in the history of science have seemed curiously disconnected, a result of the lack of sufficient monographic studies. Coulomb's life embodies one of the intellectual connections bridging the great divide of the French Revolution. We are fortunate that the story has been told so well.

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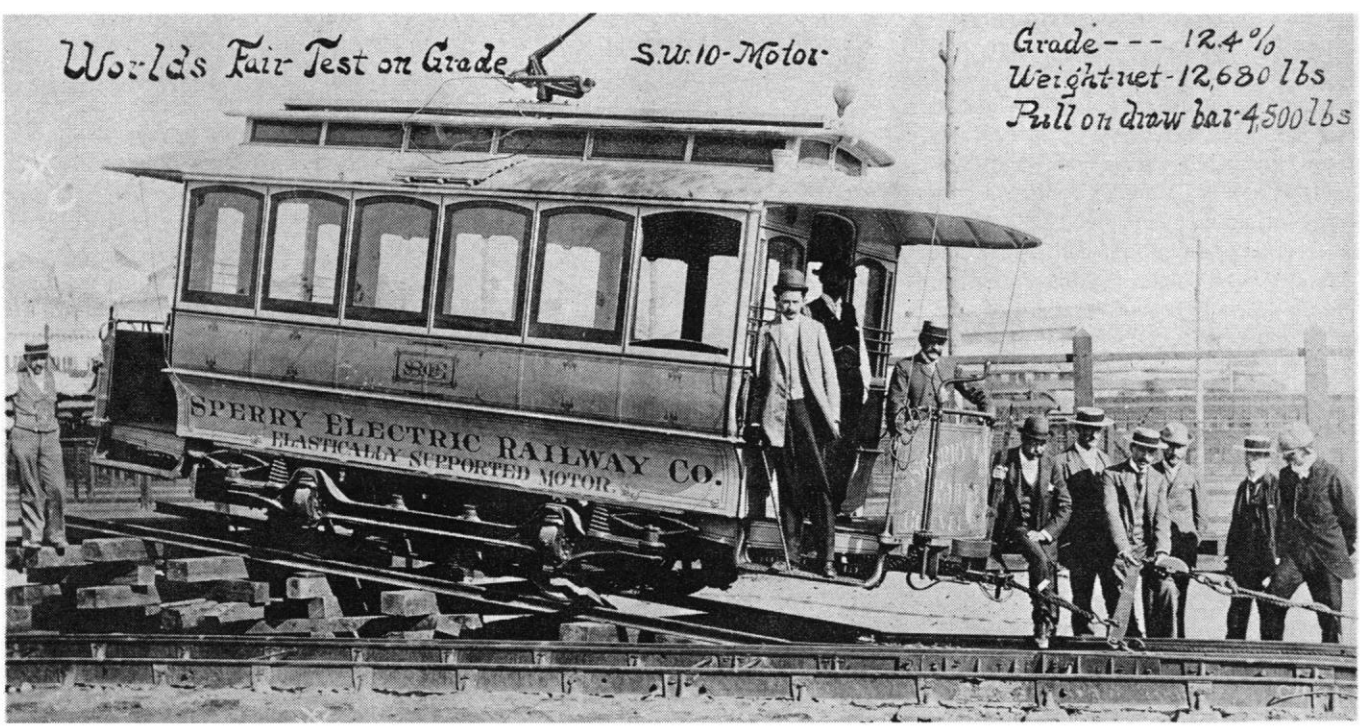
Inventor and Entrepreneur

Elmer Sperry. Inventor and Engineer. THOMAS PARKE HUGHES. Johns Hopkins Press, Baltimore, 1971. xx, 348 pp., illus. $15.

Elmer Sperry was, by almost any standard, a remarkable person. His success as a scientist and engineer was symbolized by his some 350 patents and the accolades bestowed by his peers: the John Fritz Medal, the presidency of the American Society of Mechanical Engineers, and membership in the National Academy of Sciences among others. Too, his was something of a "rags to riches" story; born in relatively humble circumstances near Cortland, New York, in 1860, he was at the end of his life the wealthy head of industrial enterprises. He even became an object of general public interest; though he hardly challenged Edison's status as America's number one inventor folk hero, he was widely known and in 1930 was profiled by the *New Yorker*. A small-town boy in his origins, he traveled widely, in his later years becoming particularly fond of Japan.

How could a young American with limited technical education achieve such eminence? Talent was a vital prerequisite. But equally important, Sperry managed to choose fields in which the technology was not beyond his grasp and which repaid creative efforts. His first contributions were to the development of the arc lamp, but he moved from there into mining machinery, electric traction, automobiles, chemistry, and finally gyroscopic closed-loop or feedback control systems. As Hughes correctly suggests in this biography, "his rich career is a microcosm of the history of recent technology." But Sperry's success was based on something more: his ability to play varied roles of inventor, developer, and entrepreneur. His chief interest was in organized inventive activity, but he was also skilled in converting ideas into marketable items. Much of his work in gyros, for example, demonstrated an ability to invent to meet emerging needs. Sperry's career suggests that invention and innovation are closely linked with developments in the larger society.

Hughes has provided a model of first-rate biography, exemplifying the very best qualities of modern American historical scholarship. He was fortunate in being able to draw upon a rich store of materials both printed and manuscript. But what is even more impressive is his ability to analyze his information with sophistication and insight. He provides, for example, a subtle analysis of Sperry's various roles as inventor and entrepreneur-innovator and suggests the complex processes by which the heroic age of invention gave way to the modern era of organized research. Hughes's expositions of the development of Sperry's ideas and the



"The Sperry streetcar at the Chicago World's Fair, 1893. Elmer Sperry, right, has his hand on the brake. With him were three pioneers in electrical engineering education: Louis Duncan of Johns Hopkins, Dugald C. Jackson of Wisconsin, and H. J. Ryan of Cornell." The streetcar "was notable for its superior hill-climbing ability. [It] used a single motor, while other streetcars employed a motor for each axle. Because all axles and wheels were a part of a coupled system on the Sperry streetcar, one set of wheels and one motor could not lose traction and slip. . . . When the car ascended a hill and the front wheels lost contact all of the power went to the rear wheels, which maintained contact where the power was needed." [From *Elmer Sperry: Inventor and Engineer*]