duced and the concept of elastic strain energy was created. Benvenuto does not dwell on the birth of continuum mechanics, but moves quickly to a discussion of the development of energy methods for elastic structures. During the latter half of the 19th century much exciting work in this field was done by Italian engineers and mathematicians, most notably Luigi Federico Menabrea and Alberto Castigliano. Castigliano's lasting contribution was his theorem that for a linearly elastic structure, by taking the partial derivative of the strain energy with respect to a load, one can obtain the component of displacement along the load at its point of application. Benvenuto also discusses other contributions to structural mechanics, including those of Alfred Clebsch, James Clerk Maxwell and Otto Mohr.

In the closing paragraphs of this fine history, Benvenuto expresses a note of disappointment. Modern engineers, he writes, know only the formulas of their profession: The circumstances of their derivations have been forgotten. In reply, I would suggest that the principles of mechanics are themselves monuments that may outlast the domes of the Renaissance. Like other monuments, these too have a fascinating history, and as long as there are dedicated scholars like Benvenuto, that history will be accurately recounted.

The Maxwellians

Bruce J. Hunt
Cornell U. P., Ithaca, N. Y., 1991. 266 pp. $34.95 hc
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The theory of electromagnetic phenomena presented in James Clerk Maxwell's culminating work on the subject, *A Treatise on Electricity and Magnetism* (1873), differs significantly from the theory that appears in modern textbooks on classical electromagnetic theory. In *The Maxwellians* Bruce Hunt presents a fascinating account of a central episode in the recasting and further development of Maxwell's theory, focusing on the work of his British followers—especially George Francis FitzGerald, Oliver Lodge and Oliver Heaviside—in the last quarter of the 19th century. FitzGerald, a graduate and later a professor of natural and experimental philosophy at Trinity College, Dublin, was the major architect of the broad intellectual vision of this group of three. Lodge, a graduate of University College, London, who became a professor of physics at University College, Liverpool, was the chief experimenter, interlocutor and propagandist. Heaviside, a self-educated telegrapher who was for the most part isolated from the academic community, was the mathematical brains of the outfit and the one who made the important technological connections.

The central theme in Hunt's story is the shift from Maxwell's own emphasis on the vector and scalar potentials A and ψ as the central field variables of the theory—with the basic equations phrased in terms of them—to the familiar modern form of the theory, in which the electric and magnetic field vectors are the basic variables, the fundamental equations are the four symmetrical "Maxwell's equations" and the potentials are demoted to an auxiliary role. Heaviside is eponymously honored in this connection in that the four equations are sometimes referred to as the Heaviside–Hertz form of Maxwell's equations. (Heinrich Hertz's work on the reformulation of the equations was in part independent and in part influenced by Heaviside.)

FitzGerald, however, also played a central role in recasting the equations: Among the British interpreters of Maxwell he gave the most thought to the element of arbitrariness in the potentials and the related problem of potentials that are propagated instantaneously—as is ψ in the Coulomb gauge. These problems motivated what FitzGerald referred to as "the murder of ψ" and the attendant rephrasing of the equations. Also associated with this rephrasing was the work of Heaviside and John Henry Poynting on energy localization and transfer in the electromagnetic field, as expressed in terms of the electric and magnetic field vectors.

Branching off from the main theme of the book is a variety of interesting episodes and developments. A detailed account of the origins of the FitzGerald contraction hypothesis serves to show that this was something more—something deeper—than a mere *ad hoc* response to the Michelson–Morley experiment. In connection with the issue of the propagation of potentials and fields, as investigated by Fitzgerald and others, Heaviside developed in 1888 a formula for the field around a rapidly moving electric charge, exhibiting contraction along the direction of motion by $\sqrt{1-v^2/c^2}$. Knowing this and assuming that intermolecular forces behaved in the same way, FitzGerald early in 1889, during a conversation with Lodge concerning the 1887 Michelson–Morley experiment, first formulated the contraction hypothesis. Turning to the more immediately practical connections of electromagnetic theory, Hunt shows how concerns with telegraphy and telephony motivated many of Heaviside's theoretical advances and how in turn Heaviside made important contributions to the technology of transmission lines, such as the practice of inductive loading to reduce distortion of the signal, "now recognized," according to Hunt, "as the most important technical innovation in telephone transmission between [Alexander Graham] Bell's original invention in 1876 and the development of the first electronic amplifiers in 1912."

Throughout, the book is a good read—clear, cogent and interesting, with a good balance between the coverage of personalities and their interactions and that of technical issues. Extensive use of archival materials—correspondence, notebooks and working papers—enriches the narrative so that it is concrete, lively and convincing. One might have wished for a bit more engagement with the existing historical literature on the subject for the purpose of making stronger connections with the broader history of electromagnetic theory. This single caveat notwithstanding, *The Maxwellians* makes an important contribution to our understanding of the history of electromagnetic theory, and I highly recommend it to both physicists and historians.

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Quantum Signatures of Chaos

Fritz Haake
Springer-Verlag, New York, 1991. 242 pp. $59.00 hc
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The Transition to Chaos in Conservative Classical Systems: Quantum Manifestations

Linda Reichl
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ISBN 0-387-97753-8

Most physicists have grown up with the belief that elementary mechanics is represented by the well-worn standard examples of regular, or integrable, systems, such as a few linearly coupled pendula or a lone planet circling the Sun. This naive faith in the ultimate simplicity of nature extends even to the atomic and subatomic realm, where the Schrödinger