Book Review

The Concept of Energy. By E. J. Hoffman, Ann Arbor Science Publishers, Inc., Ann Arbor, Michigan (1977). 573 pp. $29.50.

Hoffman's purpose in this book, stated in his Preface, "is to examine and show the significance of the mathematical origins of the concept of energy." He calls for a "reappraisal of some . . . notions of thermodynamics," notes a necessary "parallel role of mechanism" in explanation, and promises "venture into intuitive notions of flow and relation to a space time system of coordinates." In his Preface and Epilogue, he associates with his objectives some notions about the illusory nature of what is an acceptable explanation or description of nature.

Hoffman's primary approach to the concept of energy makes use of the properties of differentiable functions of the necessary and sufficient observable variables and constraints that describe changes in states of physical systems and of the empirical experience that there may be constructed functions of the physical variables that remain invariant under certain transformations. In several places, he emphasizes, reasonably enough, that the relations among the variables and their derivatives must be taken from smoothed experimental data and that the many different possible representations are tautologies. The latter half of his development is less coherent.

The first five chapters contain Hoffman's development of mechanics and equilibrium thermodynamics. In Chaps. 3 and 4, he emphasizes the Joule Thomson effect and data and uses these in his manner to develop enthalpy and heat capacity functions. He goes on to cover some of the conspicuous topics of chemical thermodynamics. The following topics occur in the succeeding five chapters: differential geometry; formal representation of fluid flow; rate mechanisms; statistical approaches to explanation, or correlation; and nuclear energy.

Personal taste will dictate one's appraisal of Hoffman's success in reaching his reasonable objectives and of the usefulness of his methods. I prefer my own upbringing in thermodynamics and statistical mechanics, which, I suppose, is largely Gibbsian (and followers). I did appreciate Hoffman's transformation (pp. 14-20) of Kepler's laws, which were inferred directly from observation, into Newtonian form, and his identification of mass and weight. This example illustrates his claims. His emphasis on system constraints is useful in thermodynamics. Concepts of functions and invariance are, of course, fundamental to the concept of energy, and the experiential nature of their usefulness deserves attention but is not news.

For me, Hoffman's development of the concept of energy is weakened by his overemphasis on his methods, by omission of some central aspects of the concept of energy, by unclear statements, and by a number of errors in labeling symbols and typography; on the last, I am willing to forgive as I am forgiven. Some examples of what I found wanting follow.

His emphasis on the use of the Joule-Thomson effect and data neglects other means of introducing equations-of-state in thermodynamics. In the discussion of statistical mechanics, the process of going from microscopic particle mechanics to macroscopic functions is too important an aspect of energy to be left to the "contrivance" on p. 427. On one hand, one may go from interparticle potential functions to equations-of-state and other functions in varying degrees of approximation, and, on the other hand, there remains the intriguing question of irreversibility and the much-discussed arrow of time. What is colliding in this example on p. 427 and how an average momentum change is determined is not stated. In the discussion of the Stefan-Boltzmann and Planck radiation laws, he omits the density of states in a bounded radiation field and leaves the dependence of the total radiant energy on the fourth power of the absolute temperature more of an empiricism than is warranted.

Inasmuch as he introduces Hamiltonian mechanics in Chaps. 1 and 6 and the Schroedinger equation in Chap. 9, he could have indicated that energy and time are canonical conjugates, a relationship that leaves room for some magic and mystery lurking behind the empiricism of ordinary experience. To me, the resulting form of the uncertainty principle is an important aspect of the concept of energy. This uncertainty is used on p. 422. In the expression on this page, the uncertainty of position and momentum, $\hbar$, defined on p. 407, should appear.

He begins his chapter on nuclear energy with a discussion of the mass-energy relations of special relativity, but leaves special relativity unnecessarily confused on p. 449. Subsequent discussions of nuclear fuel burnup, plant performance, fuel and enrichment costs, and net energy are not up to date.

Some errors are transparent, others are not. For example, p. 12, line 3, one can read (U_3, U_4) for (U_2, U_3). However, mistakes in labeling symbols on p. 37 are perplexing. Here and there, the referrents for the pronoun "this" or "these" are not specified. On p. 58, paragraph 4, line 4, the possessive form makes one stop and wonder. There are other instances.

Hoffman mentions fairly enough the problem of usage of symbols and units. I would urge that international agreements (e.g., IUPAC) be used in writings on energy.

In conclusion, I suggest that the book may be interesting and perhaps useful to engineers brought up primarily on the classical mechanics of conservative systems and who encounter thermodynamics later. To those who have studied nuclear science and engineering through present-day curricula and those who read this journal, the book is unlikely to be useful.

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About the Reviewer: John P. Howe is adjunct professor of nuclear engineering at the University of California, San Diego, and is associated with the Energy Center there. Professor Howe, whose graduate training was at Brown, has long professional experience both in industry—at the General Electric Research Laboratory, Atomics International, and General Atomic—and in the academe—at Ohio State, Brown, Cornell, and the University of California. His war years were spent at the Met Lab, and were followed by a period at the Knolls Atomic Power Laboratory. Dr. Howe's principal interests are in metallurgy, the physics of solids, and energy policy.