isokinetic sampling, sensitized paper measurements, and the laser particle detection method, it has been found that several pre-1974 state-of-the-art towers exhibit drift fractions that are several orders of magnitude less than their guarantees.

Perhaps the most comprehensive study on the environmental effects of chemicals carried in the cooling tower plumes presented was conducted by F. G. Taylor, Jr. along with other members of the Environmental Sciences Division of the Oak Ridge National Laboratory, using the very large mechanical-draft cooling towers associated with the Oak Ridge Gaseous Diffusion Complex as their model. An inventory of plant and soil materials in the environs of the Gaseous Diffusion Plant reservation provided quantitative evidence of transfer of chromium and zinc to vegetation from cooling tower operation. As expected, from the atmospheric dispersion models, chromium and zinc, which are chemicals used in the corrosion treatment of the circulating water system, are found in concentrations in vegetation that are highest adjacent to the tower and decrease exponentially with increasing distance from the source. Using vegetation analyses, along a horizontal gradient, it was determined that the concentration in foliage and litter remains relatively constant. Distribution coefficients for hexavalent chromium added in solution to soils show that little chromium is absorbed. Values for zinc indicated the soil acts as a reservoir for the small quantities derived from drift.

The book also includes investigations of ecological effects of airborne salt. This subject is a particular concern of those on the coastal area or where brackish waters will result in a drift loss containing relatively high concentrations of salts. Techniques for experimentation and measurement of effects on vegetation are discussed. The results are compared with wind-tunnel studies and are considered along with impingement techniques for measurement of sodium and chloride uptake of various vegetation. The Chalk Point program for determining the ecological effect of salt spray from cooling towers is perhaps one of the best organized programs available at the present time. This program, operating in conjunction with the University of Maryland, is a sophisticated in-depth attempt to measure both the characteristics of the cooling towers themselves and the effect of the salt spray transported in the cooling tower plume.

James E. Carson of Argonne National Laboratory, in his comments on the meteorological consequences of thermal discharges from nuclear power plants and associated research needs, puts the problem in terms of the real world quite succinctly in stating "costly engineering decisions are presently being made which are based in part, on estimates of models which are not adequately substantiated by quantitative observations of the effects of thermal discharges from proposed nuclear plants on the atmospheric environment." His contention is that the state-of-the-art in meteorological knowledge and modeling is not quite adequate to yield the accurate predictions of atmospheric effects with a required degree of confidence.

An interesting comparison is presented by D. J. Moore of the Central Electricity Generating Board in England. The Board is responsible for power generation in that country. He reports the observations the British have experienced with their large natural-draft cooling towers that have been in operation in that country for a relatively long period, and his conclusions are as follows:

> The records at 10 climatological stations situated between 4 and 112 kilometers from the 2000 MWe station at Ratcliffe in Nottinghamshire concludes that no significant changes in rainfall, bright sunshine, or occurrence of fog can be attributed to the power station. The observer arrived at this conclusion by comparing the period between 1960 and 1967, before the station was commissioned, and from 1968 to 1971, after it was commissioned. As a result of this observation, the author states that they conclude persistent plumes are shown to occur mainly in conditions of high ambient relative humidity when natural clouds are usually present and that precipitation is very slight and again only occurs when natural rain is falling or conditions are close to those in which natural rain would occur and that fog, at ground level, is not observed.

In addition to the presentation of the technical papers, the symposium offered an opportunity for many of the investigators who were concurrently working in related fields to confront each other and discuss their conclusions in an atmosphere that could be considered highly productive and could result in an improvement in those areas about which there still appears to be some uncertainty. All in all, my feeling is that the symposium was an important conference with regard to the cooling tower problem and is probably the best single source for overall discussion of the problem available today. It should be a valuable reference source for those who are confronted with the problem of the evaluation of the environmental effects of cooling tower operation.

T. Shapiro

Oak Ridge National Laboratory
Engineering Division, P.O. Box X
Oak Ridge, Tennessee 37830

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About the reviewer: Ted Shapiro is a member of the Design Staff of the Oak Ridge National Laboratory General Engineering Division of Union Carbide Corporation. In this position he does conceptual designs and early evaluations of chemical processing aspects of major new projects at the Laboratory. Mr. Shapiro received a BS in chemistry from Boston University and has been engaged in graduate studies at the Massachusetts Institute of Technology, and continuing education at the University of Tennessee. He is the author of several publications relative to the environmental effects of large cooling systems.

Energy: Historical Development of the Concept (Benchmark Papers on Energy, Vol. I). Edited by R. Bruce Lindsay. Dowden, Hutchinson and Ross, Inc., Stroudsburg, Pennsylvania (1975). xiii + 369 pages. $25.00.

The present volume is an introductory volume for one of the 20 series envisioned by the publishers, each series consisting of "from 12 to 40 or more volumes" that provide reprints of "classic and recent papers" in particular fields, with accompanying editorial comment. The papers in this volume are concerned with the development of the concepts of the various forms of energy, the transformation from one kind of energy to another, and the general principle of conservation of energy. The excerpts and full-length papers included here come from the writings of 32 individuals, from Aristotle (384-322 BC) to Joule (1818-1889). These constitute approximately 80% of the book; the remaining 20% is devoted to brief biographical discussions and editorial comments on the papers. Part I (170 pages) is devoted to "Energy—Early Ideas and Development of the Concept"; Part II (80 pages) concerns "The Nature of Heat"; and Part III (110 pages) treats "Energy—the Mid-Nineteenth-Century Breakthrough."

Selections from the Greek authors deal with simple machines and explore the interrelation of mechanical advantage and the distances through which the applied and resultant forces act. These excerpts—particularly that from Plato—seem only remotely related to the energy concept.

The portions chosen from the writings of da Vinci, Cardan, Stevin, and Galileo deal chiefly with the concept of momentum and its constancy, impulsive forces, and the assumed impossibility of perpetual motion, rather than energy.

The 17th and early 18th century papers—especially those by Descartes, Leibniz, d'Alembert, and Newton—show clearly the confusion resulting from the use of technical terms that are not precisely defined. Such terms as "quantity of motion," *vis viva* (living force), and *vis mortua* (dead force)—and the ambiguous use of "force"—are puzzling to the modern reader. A brief treatment of terminology might well have been included early in the book. The Descartes-Leibniz controversy as to whether "force" is proportional to velocity or to velocity squared has in it a lesson that is still of value in science. The papers selected to tell the story of the changing concepts of the nature of heat are on the whole well chosen, but for completeness, something about the early Greek usage should have been included.

In Part III some of the papers presenting the evolution of the concept of conservation of energy and the determination of the mechanical equivalent of heat seem less than essential. Hamilton's papers could have been dispensed with, and the 51 pages devoted to Joule's work include much of very little interest, especially the numerous numerical tables. On the other hand, I do not understand how Helmholtz's 1847 paper could have been left out.

It is interesting to note that all the men who contributed independently and almost simultaneously to the concept of conservation of energy used the term "force" rather than "energy." This usage of force was still current less than a hundred years ago, as exemplified by Edward L. Youmans' "The Correlation and Conservation of Force," 1890 edition. This readable and interesting small volume includes translations of papers by Helmholtz, Liebig, and Mayer with additional material by Faraday and others. (I notice that the editor, in his translation of part of Mayer's "Die organische Bewegung in ihren Zusammenhange mit dem Stoffwechsel," starts out using "force," then shifts to "energy" after a few pages.)

As a general thing, I feel that the original authors' own titles for papers (together with complete citations of where they appeared and when) should always have been given with each. Headings added by the editor should have been identified in some way as his, rather than letting them appear as though they come from the original authors.

The book is well made; both binding and printing are good. There are relatively few misprints—though two do appear in the same line in the "Series Editor's Preface." The "Subject Index" appears adequate, but six of the authors of included papers are omitted from the "Author Citation Index."

In the "Introduction"—which is written at a surprisingly elementary level—the editor asks, ". . . what after all is this thing, this energy we are talking about? What *is* it really . . . ?" However, he never gets around to giving his answer, other than by saying, "The key idea is simple: *constancy in the midst of change.*" That seems something less than helpful. At the elementary level of the "Introduction," it seems to me that he should have taken the trouble to point out clearly that energy is not a directly measurable quantity, and that it is a relative, not absolute, quantity.

An overall evaluation of this expensive book is difficult, in that I am uncertain as to whom it is directed—university students, professional engineers, historians of science, reference libraries, or others. Few individuals would find its cost justifiable, and it is questionable whether many libraries would feel that large quantities of reprints, many of which are already in their holdings (or obtainable when needed through interlibrary duplication service), justify shelf space and cost. As a large part of this volume was printed from photographic reproductions, which involve little typesetting expense, and royalties to authors were not involved, it seems to me that the book's price is unreasonable. (I could not help but wonder, by the way, at the statement on page v that the papers included were reprinted "with the permission of the authors!")

E. Scott Barr

Box 3174
Tuscaloosa, Alabama 35401

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About the Reviewer: Scott Barr retired recently from the University of Alabama after a long and distinguished career in physics teaching with his major research interest in infrared spectroscopy. He was associated with the Applied Physics Laboratory of Johns Hopkins University at Silver Spring, Maryland, in the 1940's. Dr. Barr's academic training was at the University of North Carolina.