

him "you'll never make a telephone engineer.")

This last story, and others indicating the personal or economic roots of technological change, will not be found in this volume. For example, the authors don't even refer to Lester Germer's statement that the work that won his colleague Clinton Davisson a Nobel Prize, the discovery of electron diffraction, began as an effort to supply evidence vitally needed in a key patent suit. (See *PHYSICS TODAY*, July 1964, page 20, and November 1964, page 67 for discussion on this point.)

In spite of this caution in the discussion of motivation, the editor, his two main authors William H. Doherty and John W. Emling (both top Bell engineers) and the dozens of other contributors have performed a great service. Their prose does not measure up to the best produced by Bell's most graceful writers, such as physicist Karl Darrow or electrical engineer John R. Pierce. The excellent illustrations and photographs partially compensate. Implications and motivations must be sought elsewhere (John Brooks's *Telephone* and N. R. Danelian's *AT&T: The Story of Industrial Conquest* are two good places to start). But for completeness, accuracy, and fairness to the achievements of outside-company scientists and engineers, Bell has produced a model that other corporations could do well to imitate.

GEORGE WISE

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Semiconductors and Semimetals, Vol. 11: Solar Cells

H. J. Hovel

254 pp. Academic, New York, 1976. \$14.50

The solar cell constitutes probably the most striking example of a difficulty that solar-energy conversion technology faces. Although mature and sophisticated, the predominantly space-oriented technology can not be transferred to the large-scale terrestrial application of which we are so much in need. Both the production costs and the energy balance of fabrication appear prohibitive. In the face of elegant solutions, the solar-cell researcher faces the frustrating task of reopening the technology for economical reasons. Much of the work required leads right down to the level of fundamental research in solid-state physics.

The book on solar cells by Harold Hovel must deserve praise, from this point of view. It is a solid-state physicist's book on a field that must not at this time be left exclusively to the semiconductor-device technologist. The author has made contributions to the material aspects of solar cells in research as well as in development;

as a consequence, his book bridges the gap between the two very successfully.

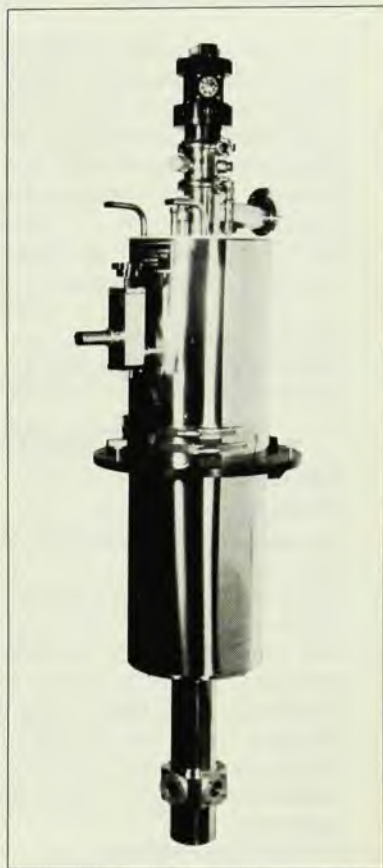
Hovel describes the present state of the art, the technological limitations and the key problems to be solved, in the clear terms of semiconductor physics as the researcher knows it. Don't expect to learn how the pn junction works under illumination or what "surface-recombination velocity" means. But once you know these things firmly on the level of Charles Kittel's book, solid-state physicists from the advanced graduate-student level upwards will read through the book with delight. It will probably stimulate many of them to turn their research experience into some urgently needed contribution to a very relevant area of applied research.

The book summarizes the state of the art in an extended introduction. Read together with the addendum, which updates the field to a time six months before publication, this material leaves one with a good impression of where the field stands and of the principal tendencies and problems. Hovel provides details in the chapters between.

The basic processes that generate the photocurrent and determine the spectral response appear in the middle section. Hovel then defines solar-cell characteristics and treats questions of efficiency, effects of temperature, light intensity and radiation damage. He devotes a long chapter to solar-cell technology, with the emphasis on Si, GaAs and CdS-Cu₂S cells, and on pn-junction, Schottky-barrier and heterojunction cells. Material and configurations outside these major categories are not ignored, however. Throughout the book, Hovel takes care to outline the requirements of large-scale terrestrial use of solar cells. A separate section covers the promise of thin-film and polycrystalline cells and the inhibiting role of recombination on grain boundaries. Approaches to overcome difficulties with these methods he describes in detail, and in this area too the book is very much up to date.

In each section, the treatment first introduces the theory and thereby provides the basis for the analysis of experimental results. As a critical comment, one may ask whether Hovel presents the formalism in excessive detail and length. Undoubtedly formalism is important, but one does not read the book for this much detail, particularly since most of it is based on stringent assumptions. A richly varied set of illustrations demonstrates what can be expected for the performance of a solar cell on the basis of the theoretical model. He then summarizes the experimental situation, discusses discrepancies from the theoretical predictions in terms of solid-state physics and identifies problem areas for the researcher. An excellent summary condenses each chapter at the conceptual level. If in a hurry, read at least the in-

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roduction, all the summaries and the addendum.

The illustrations, which are very good and numerous, cover all the possible variations of materials and parameters in solar-cell performance; Hovel bases most on calculations only. Given the analytical approach of the text, one would appreciate a larger number of figures that compose theory and experiment in the same diagram. The units could be purified ("mils" should disappear from a book that one hopes will in large numbers cross the frontier of the last country to use them) and made more consistent, particularly in the figures.

These minor comments should not reduce the value of the book—a value based on its building of a bridge between the technologist who encounters the difficulties and the researcher who can probably contribute to their elimination. Leaving solar-energy conversion at this point solely to the engineer would represent a possibly fatal mistake for this promising field. Beyond the presently recognized solutions and approaches, the technology of solar-energy conversion can undoubtedly benefit from materials science on a broad basis. Once one identifies the problem areas, as Hovel has attempted in this competent, up-to-date and comprehensive review, aspects of materials science presently unconnected to the mainstream of solar research may offer better solutions. May the book succeed!

B. O. SERAPHIN
University of Arizona
Tucson

Introduction to Modern Theoretical Physics, Vols. 1 and 2

E. G. Harris

780 pp. Wiley, New York, 1975. \$21.95
(each volume)

In the 780 pages of these two volumes, Edward G. Harris sets out to cover more or less the entire standard first-year graduate curriculum in classical and modern physics, as well as non-trivial portions of the second year and occasional topics known only to specialists or historians.

I must confess to having opened the book anticipating the mixed pleasure of counting the ways in which so innocent an enterprise could come to grief. To my surprise, I set the book down not only convinced that it can be done, but even wondering whether, perhaps, it might not have been worth doing. It is really remarkable how much Harris has put into so little space, without sounding breathless or telegraphic, and with even more attention to historical background than many specialized first-year texts. He has

managed it by a careful selection of important representative topics within each area and a thoughtfully organized and compact, yet often quite complete and even elegant, style of mathematical analysis.

As you watch the trick being performed, the secret behind it becomes clear: The conventional beginning graduate course (three or four of which are contained in these volumes) uses a text of perhaps 800 pages, of which considerably less than half are actually covered in the classroom and a sizeable proportion of these, quite superficially. If I examine what Harris has to say on many subjects I have taught, however, I find that he offers practically nothing that was not in my lectures, but—and this really surprised me—he has omitted almost nothing that I managed to fit in. Most graduate texts are at least as much treatise as text; this one is all text.

A major problem may be that your idea of what an introduction to a field must contain will differ from Harris's, but I thought that in most cases his judgment was quite sound. By not feeling obliged to follow any line of thought further than it can be pursued in a few lectures, he has managed to cover a surprising amount.

I can perhaps give an idea of the scope and level of the book by citing a few things I especially liked about it:

► Dirac notation is introduced, not in the section on the quantum theory, but much earlier in a purely mathematical exposition of linear vector spaces. Right on!

► A very readable eight-page summary of pre-Newtonian ideas about the solar system appears in the section on classical mechanics.

► The discussion of small oscillations concludes with a simple but not at all trivial discussion of nonlinear perturbations.

► The Landau and Lifshitz volumes repeatedly appear at the head of the lists of references given at the end of each chapter.

► After a ten-page historical introduction, the development of quantum mechanics starts right in with the operator formulation.

There were some points that bothered me:

► Although I agree with Harris that the ideal first-year curriculum should include a taste of general relativity, I draw the line at classical unified-field theories; he does not.

► The exposition of non-relativistic second quantization follows the somewhat mystifying ancient way of re-quantizing the ψ -field, rather than viewing it as a straightforward mathematical reformulation.

► The exposition of thermodynamics is also somewhat old-fashioned. Carnot cycles abound, and entropy is introduced via $dS = dQ/T$, rather than through a microscopic statistical definition.