actual deployment of nuclear reactors.

Petrosyants's book invites comparison of the US and Soviet systems of nuclear development. In the US we have a hybrid: "Private" enterprise is heavily regulated by the Nuclear Regulatory Commission and subsidized—and, in the case of the LMFBR, directed in detail—by the Energy Research and Development Administration. In the Soviet Union, all is done by the government, although, to be sure, Petrosyants implies he has his battles with the Ministry of Public Health. The evidence suggests that our system—open, responsive to public criticism and untidy—leads to greater concern for safety, but that it also, paradoxically, is less aggressive and less diverse.

How can this be? One explanation may be that the Soviets delegate more authority to the experts than do we. As far as I can gather, from Petrosyants and from other sources, the Soviets identify technical heroes and give them much sway; their projects seem to be run by Soviet Hyman Rickovers. Indeed, the whole Soviet nuclear development reminds me of Rickover's Naval Reactors Branch. There is a continuity in the Soviet nuclear development that is lacking in much of the American development. I. V. Kurchatov, when he was alive, enjoyed the full confidence of his government; he (with help to be sure) gave the Soviets atomic energy. This tradition persists: the Kurchatov Institute, the primary center for *applied* nuclear energy, includes nine full members and several corresponding members of the USSR Academy of Sciences. The Institute appears to go about its business much less encumbered by bureaucratic meddling than do the American National Laboratories. In nuclear energy, the Soviet system may have *less* red tape than does the American.

But something is lost in this approach. A full debate on nuclear energy, such as we are having in the US, is unthinkable in the Soviet Union. And secrecy goes much beyond this; for example, Petrosyants discusses uranium reserves throughout the world without a single allusion to the Soviet reserves. He all but omits the considerable Soviet development of nuclear submarines.

The lessons to be drawn from Petrosyants's book are important for all who are concerned with the current nuclear debate; and the messages it implies about our two systems cannot be ignored.

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Alvin M. Weinberg, Director of the Institute for Energy Analysis, Oak Ridge Associated Universities, was Director of Oak Ridge National Laboratory during 1955–74. He visited the Soviet Union in 1959 as a member of the first US group invited to Soviet nuclear laboratories and again in 1972 when he spent several days at Minsk.

A History of Engineering and Science in the Bell System: The Early Years (1875–1925)

M. D. Fagen, ed.
1073 pp. Bell Telephone Laboratories, Murray Hill, N.J., 1975. $15.00

"Only the Deity has so far been found competent to inspect His own work and find it good." The remark appears on page 860 of this survey of the Bell System's technical achievements during the telephone's first half-century. The assertion refers to the hazard inherent in allowing manufacturing people to inspect their own products. It might also be applied to the hazard inherent in allowing a company's researchers to write their own history.

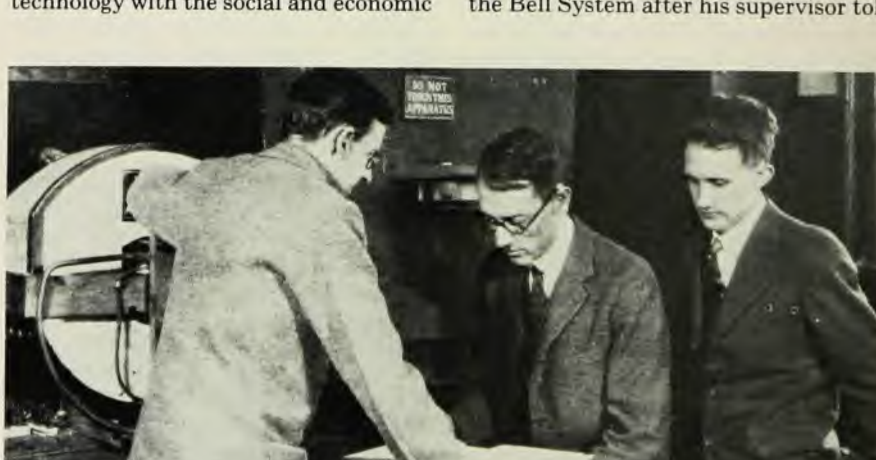
In entrusting the writing of technical history to a team of insiders directed by editor Morton D. Fagen, the leaders of the Bell System have decided for completeness and against detached analysis. The result is a bit self-congratulatory. But, after all, the Bell Laboratories and their corporate ancestry do have a lot to congratulate themselves upon.

With the above qualification, this book can be heartily recommended to all concerned with the role of science and technology in the growth of American industry. Few will have the stamina to read the entire 1073-page volume, but most can sample it with profit. It is the most comprehensive account extant of the technical evolution of a major industrial corporation. The book does not, however, do justice to the complex web linking technology with the social and economic aspects of that corporation's development.

The book is organized by technical categories (such as "Station Apparatus" or "Materials and Components"), each covered chronologically. The overall story begins in 1875, when the entire plant of world telephony consisted of a single iron-wire circuit with Alexander Graham Bell at one end and Thomas J. Watson at the other. By book's end, the Bell System has virtually achieved its goal of a nationwide hookup and is on the threshold of connecting up worldwide.

At times the authors seem determined to describe every insulator design, handset modification and switchboard layout that contributed to the achievement. This overload of detail is a bit wearying. But it does succeed in conveying the increase in complexity that gave that much-overused phrase "systems approach" a real meaning in this application. Developing the ability to plan on the scale of a national system is an achievement of which Bell is justly proud.

Of more potential interest to readers of PHYSICS TODAY is the account of the diffusion of science into telephony. As early as 1884, Lord Rayleigh urged "practical electricians" to "rise above ohms and volts." Rise they did. Oliver Heaviside, working independently, devised a mathematical treatment of alternating current. George A. Campbell of Bell applied it to the practical problems of wire transmission—providing, in the process, an unsurpassed demonstration of the dollars-and-cents value of mathematical physics. It took a tip from a second academically trained scientist, John Stone, and the experiments of a third, Harold D. Arnold, to adapt the invention of Lee de Forest and bring the electronic amplifier into telephony. (De Forest, also a PhD physicist, began his career with Western Electric, but he left the Bell System after his supervisor told



Pioneers in electron diffraction. Clinton J. Davisson, Lester H. Germer and colleague C. J. Calbick (l to r) are shown with apparatus for studying electron scattering at Bell Laboratories, 1925.

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.

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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–Cu_2S 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-