

1926 occupies only a little more than ten pages; there is no mention of any of the fascinating experimental or theoretical topics of current research. Instead, geometrical optics (the topic that drives almost as many students from physics as does mechanics) occupies 17 pages, and almost two whole chapters are devoted to heat. The choice of emphasis is, of course, not an arbitrary one: It is necessary for Karplus's approach, given the limitations imposed by a one-semester course. Furthermore, the general approach appears to be very up to date, with many examples drawn from current events. Unfortunately such a book becomes dated very quickly. How long will there be undergraduates who can relate to Luis Alvarez's conclusions from the films of President Kennedy's assassination?

Cooper's *Introduction to the Meaning and Structure of Physics* takes a completely different approach. Starting from Aristotle (with one of the few treatments that does not make him a total dunderhead), he continues in an essentially historical order—with, of course, concessions to logical continuity when historical developments cross. The topics covered are:

kinematics and dynamics, including celestial mechanics, developed through Laplace; light, through Young; electrodynamics, from Gilbert to Hertz; thermodynamics, and a bit of kinetic theory and statistical mechanics; relativity, mentioning the general theory; atomic physics, through the Schrödinger equation, with qualitative application to the hydrogen atom and the solid state; the Dirac equation; and elementary-particle physics, with rudimentary Feynman diagrams and even with quarks.

All this makes for a very full year's work. Although no derivatives or integrals are mentioned, the differential equations of electromagnetism and of quantum mechanics are discussed thoroughly, albeit qualitatively. It is, unfortunately, very difficult to reduce this vast quantity of material, for, as all of physics, it all hangs together tightly and intricately. Omitting sections can get one into difficulty later; the only solution seems to be to have students read all the material, but to have them study only some of it carefully, for all of it would be too much.

Cooper appears to prefer having students stand, perhaps in awe, before the "cathedral-like" structure of

physics. His book provides the equivalent of a catalogue raisonné with comments, glosses and explanations of a created structure. Cooper writes a consistent, excellent prose style, with none of the condescension that some physicists, including Karplus, display in texts of this kind. The whole format is consistent with that style. Even the diagrams are unusual for a physics text: They are freehand line drawings of a simplicity and clarity that all of us would like to see in our own endeavors at the blackboard.

Karplus, by contrast, tries to make students feel at home in the structure of physics. His book provides a sort of *House and Garden* view of the more manageable portions. His explanations of technical matters are always models of clarity; I am sure his wide range of teaching experience—from elementary school to college—has contributed a great deal to this clarity. His prose style is somewhat inconsistent; one gets the impression that the text alternately addresses school children and college students. This ambiguous attitude is perhaps best represented by a picture of Vitruvian man, redrawn from Leonardo in the style of "Dick and Jane," with a fig leaf added.

For teaching, Karplus's text has many advantages over Cooper's. At the end of each chapter Karplus provides a summary, an excellent and very thorough bibliography and a long list of good homework problems. Mathematical symbols and physical quantities are also listed at the ends of chapters, and Karplus has taken care not to use any symbol for more than one quantity, for example P is pressure, $\mathfrak{p}$ is momentum and M is mass. Cooper does not interrupt the flow of his text with problems, but puts them at the end after the appendixes; his values for constants and conversion factors are scattered throughout the text, and there is no adequate listing in any one place.

In discussing philosophy, the authors' differences are perhaps most obvious. Cooper's historical approach permits him to examine the philosophical problems from many different viewpoints, and to show how current views have evolved. Karplus is apparently addressing an audience that is much less interested in philosophy than Cooper's and thus limits himself to fairly straightforward expositions of simple operationalism and its consequences.

Cooper's book is clearly an excellent text for a freshman or sophomore "physics-for-poets" course. Karplus's text appears better suited for a fairly technical high-school level course—as a competitor for PSSC, for instance.

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Thomas Von Foerster is assistant professor of physics at Harvard University. He is currently helping to teach a "physics-for-poets" course, for which Cooper's book is one of the texts.

The Stanford Two-Mile Accelerator

R. B. Neal, ed.

1169 pp. W. A. Benjamin, New York, 1968. \$35.00

During the past two decades a deplorable tendency has arisen among accelerator physicists and engineers. Instead of publishing the results of their work in reputable journals, they have, more and more, written internal laboratory reports, which are often hastily composed and capriciously circulated.

The Stanford linear-accelerator group has been caught in this trend, but it has fought a noble rearguard action. In the 1955 linear-accelerator issue of the *Review of Scientific Instruments*, they presented a careful and detailed account of the Mark 3 accelerator. Then they proceeded to the tremendous task of setting up the Stanford Linear Accelerator Center (SLAC) and of building the two-mile accelerator. Now, once again, they have presented us with a comprehensive and well organized account of this splendidly successful project, this time in book form.

Although 90 authors contributed to this work, the hand of Richard Neal, the editor, is visible everywhere. The vast amount of available material has been carefully organized, providing internal consistency and avoiding unnecessary duplication. This is, in short, a very valuable addition to the literature on particle accelerators and a credit to the SLAC organization. Throughout it conveys the impression of enormous competence that has continually emanated from the SLAC organization.

SLAC began its history in a meeting of a few Stanford scientists held on 10 April 1956. The study group was gradually increased, and was supported by voluntary studies by two architect-engineering firms. Within a



KLYSTRON GALLERY AT SLAC. The two-mile gallery has a 24-MW S-band klystron every 12 meters. On the shelf above and to the right of the first klystron is one of the 120 ion-getter vacuum pumps.

little over a year, a proposal was prepared for a two-mile electron linear accelerator; this proposal was submitted to several Washington agencies. Then began a long waiting period while the proposal was studied and then approved by a National Science Foundation panel, by a panel drawn from the General Advisory Committee of the Atomic Energy Commission and by the President's Science Advisory Committee. Hearings were held before the Joint Congressional Committee on Atomic Energy. In late 1960 a \$3 million study contract was awarded to Stanford by the AEC and, finally, in September of 1961 the project was authorized at an estimated cost of \$114 million.

In the meantime the Stanford group had been busy with design and model studies of critical machine components and, upon authorization, construction began almost immediately. In May of 1966 a staff, now including about a thousand persons, had completed the main construction and demonstrated a beam of 10-GeV energy. By January of 1967 the beam had reached its design energy of 20 GeV; time and cost estimates had both been met. Composition of this book must already have been under way, for it describes the status of the machine as of July, 1967.

Very few readers will be competent to understand completely all parts of this book. But it includes something of interest for everyone—scientific historians, project administrators, high-energy physicists, accelerator physicists, electronic engineers, mechanical engineers, civil engineers and

operating engineers. All will find much of interest and value in their respective fields.

After a brief introduction, the book begins with a very well written statement of aims and purposes, a succinct statement of the "why" and "how" of the accelerator and its experimental program. Chapters follow on SLAC history and administration. Two chapters of general description bring the reader to page 162, where the scientific layman may choose to stop, because now the authors get down to business with a reasonably esoteric chapter on beam dynamics. From this point on, the text deals with one component or discipline after another, and is generally written with clarity and considerable detail.

I found two chapters particularly interesting. The first was on klystrons. As a design goal, it was decided that the accelerator would be powered by 240 klystrons of about 20 MW output at 2856 MHz, and, moreover, that these amplifiers should have useful lives of several thousand hours. Neither of these goals was near realization when the SLAC project was initiated. Intensive development programs initiated at SLAC and in industry continued through many months of frustration and tube failure. Four pages of this chapter show poignant pictures of ceramic output windows that failed for various reasons. But eventually, in time for the final operation, the effort was crowned with success.

The other chapter that particularly fascinated me was on support and alignment. The accelerator was to be

aligned over its whole two-mile length to an accuracy of 0.010 inches, a precision better by an order of magnitude than could be achieved using conventional optical methods. Under the personal supervision of SLAC's dynamic director, W.K.H. Panofsky, the survey group developed an alignment system using a laser beam and 277 rectangular Fresnel lenses that achieved an alignment precision well within the requirement. This system is enclosed in a two-mile long 24-inch pipe. Ports in the pipe provide "access for a lean and agile technician to do maintenance."

There is very little to criticize in this book. In a few places, SLAC appears to claim credit for developments not entirely its own. For example, in discussing the administration, the system of involving the same persons in all phases of work associated with a given component, from early design to final test, is widely used in other accelerator centers. The chapter on history and development makes no mention of the important contributions to the linear-accelerator art of John Slater's group at MIT or of W. Walkinshaw, D. W. Fry and their group at Harwell.

There are a few other trifling statements of which a reviewer can be critical. But these fade into insignificance in comparison with the vast quantity of valuable and interesting information that crowds every chapter. This book deserves a place in the library of any physicist interested in accelerators, in high-energy physics, or merely in large, complex and well executed projects.

JOHN P. BLEWETT
Deputy Chairman,
Accelerator Department
Brookhaven National Laboratory

John Dalton and the Progress of Science

D. S. L. Cardwell, ed.

(Conf. Proc., Manchester, England, 19-24 Sept. 1966) Manchester Univ. Press (Barnes and Noble), New York, 1968. \$9.50

John Dalton would have been proud and pleased by this detailed look into the value and significance of his scientific contributions. Dalton was a man who made mistakes as well as many valid conclusions from the evidence he had at hand. To understand his sig-