standing among men who live by thought. That both of these efforts were not entirely successful is perhaps more of a criticism of us than of Oppenheimer.

The contributors to this book, probably by choice, hardly touch upon the unspeakable hearings of 1954, at which Oppenheimer's services to his country were rewarded by his condemnation as disloyal, a procedure which reminds one of the Athenians' ostracism of Miltiades after his victory at Marathon. It might have been appropriate to include in this book the stirring speech about this injustice delivered by George Kennan at Oppenheimer's funeral service in Princeton. But perhaps it is better to simply describe Oppenheimer's achievements, and let each reader recognize the worth of the man we were privileged to have among us.

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Quanta and Ontology

Quantum Physics and the Philosophical Tradition. AAGE PETERSEN. Published in cooperation with the Belfer Graduate School of Science, Yeshiva University, by M.I.T. Press, Cambridge, Mass., 1968. x + 202 pp. $7.50.

Niels Bohr was convinced that the development of quantum mechanics contained a lesson, "an epistemological lesson with bearings on problems far beyond the domain of physical science." Although he wrote many essays on this theme in his later years, Bohr never attempted a full-scale discussion of the philosophical implications of quantum physics. Philosophers have taken up some of the issues raised by the statistical nature of quantum mechanics, but the subject as a whole has never attracted their attention in the way relativity did.

In this book Aage Petersen, who served as Bohr's assistant for many years, has undertaken an analysis of the relationship between quantum physics and traditional philosophy. Petersen considers *the* philosophical tradition to be an inquiry into the structure of being or the nature of reality, culminating in the work of Immanuel Kant. Classical physics is consistent with this ontological mode of thought, as he calls it, but quantum physics is not; it represents something new. In order to analyze how and where quantum physics departs from the tradition, Petersen has chosen to emphasize the concept of correspondence, and not the concept of complementarity, which Bohr himself stressed in his later writings. By giving the idea of correspondence such a prominent place, Petersen calls attention to the ways in which quantum mechanics is a rational generalization of the older physics. For, as Bohr put it: "The correspondence principle expresses the tendency to utilize in the systematic development of the quantum theory every feature of the classical theories in a rational transcription appropriate to the fundamental contrast between the [quantum] postulates and the classical theories." Petersen follows Bohr in stressing the indivisible nature of a quantum phenomenon, which requires the specification of the whole experimental arrangement for its definition. He, too, sees the goal of physical theory as unambiguous communication rather than intuitive understanding.

I am not sure that Petersen's concern over the relationship between quantum physics and the ontological mode of thought will be widely shared. Twentieth-century philosophers hardly seem to have been bound by one set of categories, anyway. We even know that Bohr read William James and profited from his reading, which suggests that Petersen may not have used the most relevant philosophical starting point.

Petersen draws an interesting parallel between the philosophical impact of quantum mechanics and that of the calculus, with its ensuing debate over the nature of continuity and limits. This debate was settled by a rigorous theory of limits within mathematics, and not on philosophical grounds, and Petersen suggests we may well see a similar outcome to the unresolved questions about the interpretation of the quantum theory, where we are still in the "pre-Cauchy" stage of the discussion. This is typical of Petersen's attitude. He does not pretend to have settled the difficult questions over which Bohr and Einstein struggled for a quarter of a century. On the contrary, it is his view that "our present understanding of the topic is much more primitive than is usually believed," an opinion in which Bohr and Einstein might well have concurred.

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An Achievement of Magnitude

The Stanford Two-Mile Accelerator. R. B. NEAL, Ed. Benjamin, New York, 1968. xiv + 1170 pp., illus. $35.

When I see one of the world's great suspension bridges, or when I see, on television, the Apollo spacecraft going into orbit, I feel proud to belong to the same human race as the men who conceived these projects and brought them to fruition. I get the same feeling when I look down upon SLAC, the two-mile-long accelerator at Stanford, from Skyline Boulevard, where it appears as a long line upon the landscape, and I get the same feeling as I read this book. There is a difference between SLAC and a suspension bridge. The beauty and usefulness of a bridge are apparent to most of us without special training, whereas one needs considerable technical knowledge to appreciate the beauty and usefulness of SLAC. This knowledge can be increased by reading this book.

SLAC is at present not only America's longest particle accelerator but also its most expensive; it cost $114 million exclusive of considerable preconstruction, research-and-development, and preoperation funds. It is therefore of interest to all taxpayers to see how this money was spent. It takes a book of 1170 pages to tell the story. The development of particle accelerators can be measured in several ways: A description of the first betatron was, I believe, published in two papers in *Physical Review*, one theoretical and one experimental. Most of an issue of the *Review of Scientific Instruments* was devoted to the Cosmotron. Hansen's first traveling-wave linear accelerator, the Mark I, a forerunner of SLAC, was described in 1948 in a single paper with three authors. This book is the work of 90 authors. This comparison is a familiar one at SLAC, and 10 pages are devoted to the history of accelerator projects at Stanford. I found particularly appealing a photograph, which is by now famous, of the Stanford Mark I linear accelerator being held up by four physicists headed by Bill Hansen, who remains a legend at Stanford.

With such an increase in the size of a project comes increasing complexity, and most of the problems of SLAC are problems of this complexity. For example, special techniques, using laser light, were developed to align the accelerator to unprecedented tolerances. These techniques, described in 23 pages, will be of interest to physicists and engineers in many other projects. The beam intensity is high, and the large beam power must be absorbed; problems arise, not only of thermal heating but also of radioactivity. These problems, faced for the first time at SLAC, will be important for other accelerators.

The development of high-power klystrons has been almost entirely a result of the Stanford linear accelerator program started by Hansen. The section of this book on klystrons will, therefore, be of especial interest to many persons. In reading this section, I recognized the names of many who were involved in the building of the first high-power klystrons for the Mark III accelerator, and one of the strengths of the Stanford development program became crystal clear to me: The developers of SLAC have been working on accelerators for 20 years, and their expertise is unsurpassed.

But with all the interest of this book for the technically minded, and I have mentioned only three of the many technical achievements, the book will remain primarily a book for libraries. Anyone building another SLAC will want a copy—or more probably 100 copies—but I know of no one in this position. Anyone really interested in one of the specialized topics will probably wish to compare the treatment of it here with other work in the field, and the useful parts of this work will find their way into reference books and textbooks. Nor can the book be recommended to replace Agatha Christie or Tolstoy on the bedside table. It will not, therefore, become a best seller; but all physicists who are interested in the detail and intellectual power necessary for a successful large project of any sort must dip into it from time to time. Otherwise, they may be tempted to undertake a large project with insufficient appreciation of the effort that will be required of them.

The authors must not be disappointed if this book does not become a compulsory textbook for all high-energy physics courses. Even with the limited circulation I have described, the book will have been well worthwhile.

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Unanswered Questions about the Red Planet

The Book of Mars. SAMUEL GLASSTONE. National Aeronautics and Space Administration, Washington, D.C., 1968 (available from the Superintendent of Documents, Washington, D.C.). viii + 318 pp., illus. $5.25. NASA SP-179.

Racing toward rendezvous with Mars, in stately Keplerian choreography, are two United States Mariner class space vehicles. They will fly by the planet within a few days of 1 August 1969. Each spacecraft contains a small scientific laboratory which will examine the planet: at optical frequencies with two vidicon cameras and three-color photography (the long-focal-length system is capable of resolution down to several hundred meters); in the ultraviolet with a moderately high-resolution spectrometer; in the infrared with a two-channel radiometer and a moderate-resolution spectrometer; and at microwave frequencies with an S-band occultation experiment. Cartography, relief, cratering statistics, and information on the composition and structure of the ionosphere, neutral atmosphere, and epilith should emerge from this mission. It will be a rather thorough remote reconnaissance of the planet, and the forerunner of more ambitious unmanned ventures which will add immeasurably to our still quite sparse knowledge of the red planet.

Mars has played a variety of roles in the development of scientific thought. Because Tycho Brahe had made extensive pretelescopic observations of the apparent motions of Mars; because Tycho on his deathbed exhorted Johannes Kepler to analyze these observations; and because Mars has, except for Mercury and Pluto, the most eccentric orbit of all the planets, Kepler was able to deduce his laws of planetary motion, which in turn provided the inspiration for Newtonian mechanics. (The high orbital eccentricity implies that some years are much more favorable than others for observing and for visiting Mars; 1969 and 1971 are the most favorable years in a period of almost three decades.) The year 1877 saw both the discovery of the two small moons of Mars and the codification of the concept of the Martian canals, both events raising enigmatic issues which are with us still. The passionate and articulate writings of Percival Lowell, arguing that the canals were artifacts of a race of intelligent beings, put Mars forcefully into the public consciousness—and probably had the side effect of making planetary astronomy somewhat disreputable in the minds of many astronomers. To Lowell's writings in the first decade of this century can be traced many of the popular stereotypes about life on Mars. Since the end of the Second World War serious ground-based and space-borne investigations of Mars have blossomed. But with virtually every finding an associated enigma has emerged.

At the present time there is a very long list of Martian enigmas: Are the polar caps largely frozen water or largely frozen carbon dioxide? In the latter case, does a major fraction of the Martian atmosphere—primarily composed of CO_2—really condense out at the winter pole? Seasonal changes in the relative contrasts and perhaps the colors of Martian dark areas have been observed for a century. Are these due to biological changes on Mars, to meteorological changes, or to some other phenomenon? What is the significance of the "leopard skin" fine structure which mediates the changes in the dark areas? The outlines of Martian dark areas change erratically over the decades. Areas hundreds to thousands of miles on a side appear and disappear. What possible explanations for such behavior are there? The pattern of bright and dark areas on Mars visible at longer wavelengths becomes generally invisible in blue light. This phenomenon is usually attributed to a "blue haze." If there is such an atmospheric haze, what are its properties? Or is it possible that we are observing nothing but an intrinsic loss of surface contrast in the blue? In the latter case, how can we understand the "blue clearings," occasional recoveries of blue contrast? The angular size of Mars appears to be significantly larger in blue than in red light. The effect is apparently too large to be accounted for by high-altitude haze or cloud layers. What is it due to? The general reddish coloration of the planet is often attributed to the presence of ferric oxides. But can ferric oxides really be a major constituent of the Martian surface? And perhaps the most significant of the Martian enigmas: at what stage in its chemical evolution is Mars? There is an entire continuum of