seaward barrier (Africa?), but the very area involved has to be ignored in order to bring about a good "pre-drifting" fit. Mantle movements in both continental and oceanic segments having magnitude and velocity enough to justify the drift theory seem well established. So, too, is the decoupling of continental and oceanic crust in the circum-Pacific region. The probability of drift seems fairly high, but many of the arguments, both geological and geophysical, involve too much special pleading for comfort. Both geologist and geophysicist must go considerably farther before the theory can be considered either firmly established or disproved.

## Enrico Fermi's Papers, 1939 to 1954

Volume 2 of **The Collected Papers of Enrico Fermi** (University of Chicago Press, Chicago, 1965. 701 pp., $22.50), edited by Edoardo Amaldi, Herbert L. Anderson, Enrico Persico, Emilio Segrè, and Albert Wattenberg, is divided into two distinct parts.

Beginning with item Number 129 (the first paper in volume 2), we have almost 100 papers that deal in one way or another with interactions of neutrons with matter, and with other problems that are relevant to the chain reaction in uranium.

The first paper, item Number 129, was published in 1939, shortly after Fermi arrived in the United States from Stockholm with his family and his newly acquired Nobel prize. (The Fermis used the trip to Stockholm as a way of escaping from Fascist Italy.) We can trace the course of events of those historic days in the transition from the publication of Fermi's papers in the *Physical Review* to the secret reports that he made to various agencies of the United States Government as the grave and fateful meaning of the subject became apparent to the Roosevelt administration. Almost all of the latter material is now declassified but not easily available. They present a story of the development of the ideas of the nuclear chain reaction—the discoveries, measurements, and calculations that it was necessary to make, or to invent, before the first chain reactor could be realized.

Paper 228, again in the *Physical Review*, marks the end of the war period and the resumption of more normal research and publication. In the intervening years, Fermi had moved from Columbia to the Metallurgy Laboratory in Chicago to Los Alamos and then back to Chicago as a professor. His subsequent papers were chiefly concerned with researches in meson physics and with cosmic radiation. For Fermi, this was another period of great contributions, both in research and as a teacher and a source of inspiration to graduate students. His enormous talents as a teacher are demonstrated by the quality of the physicists who did their doctoral dissertations under his supervision, for the roll of Fermi's students reads like a "Who's Who" of the leaders of contemporary physics.

The postwar papers, about 40 in number, were all done in the space of less than 9 years, and they represent an important section of the most brilliant and fruitful contributions to experimental and theoretical physics of the period. The chief subjects to which Fermi turned his attention were as usual those fields that were most promising for future knowledge. First of all, there were papers on meson physics (now called particle physics), cosmic rays, and the interaction of slow neutrons with matter. In meson physics he was chiefly concerned with problems of the production and scattering of pions from nuclei, notably hydrogen. His papers show not only his theoretical and experimental ingenuity but also his instinct for the important questions of physics. In cosmic rays, he presented his very fruitful theory of the origin of cosmic rays through the collision of charged particles with cosmic magnetic fields. In neutron physics, he pressed the development of the beautiful methods of neutron interference, reflection, and diffraction which have been so useful in studying both the solid state and nuclear properties, including the interaction of electrons and neutrons.

Fermi was active up to the time of his untimely death on 28 November 1954, and his last papers are dated 1954. He left his distinctive mark on the physics, and on the physicist, of two worlds.

None of these papers speak to the larger public, outside of physics and technology, on the great issues that were raised by Fermi's contributions to the release of nuclear energy. Fermi was not unaware of these issues. He knew them, he understood them, and he felt very keenly about the political and cultural implications of his great contributions.

He served on the General Advisory Committee to the United States Atomic Energy Commission where not only his scientific gifts but also his wisdom and insight had a large influence on fateful decisions. These contributions are an important part of his complete works, but unfortunately they are not included in his published works.

Fermi died the noble Roman that he was.

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## Earth Science

Peter C. Badgley's **Structural and Tectonic Principles** (Harper and Row, New York, 1965. 538 pp., $13.95) covers rock deformation from single fractures to the evolution of entire mountain ranges. The book should be interesting reading for professional geologists and probably also for scientists interested in summaries of structural features and syntheses of new data on worldwide mountain building and tectonic patterns. Extensive bibliographies are appended to each chapter and suggest that the writing of the text was completed early in 1963.

This book results from the Herculean and well-done task of summarizing modern structural and tectonic concepts (no attempt has been made to discuss the subject from a historical point of view). Beginning with a discussion of modes of rock failure, mechanics of deformation, and laboratory data pertinent to the behavior of rock materials, the author launches into fold structures by discussing them from the point of view of the various classifications that are currently in use. Succinct definitions lead the reader rapidly past a swarm of terms into brief discussions of the mechanics of growth of folds and competency of materials involved, kinematic classifications (vertical uplift, gravity gliding, and the like), and on to a discussion of fold types based on their position in the tectonic framework.

In successive chapters Badgley bypasses the trees of terminology and observes the forest as a whole: jointing and fracture analysis; description, classification, and recognition of faults;

thrust faults; strike-slip faults; structures in metamorphic rocks; and tectonic aspects of igneous rocks. For each topic, he summarizes much of the recent literature, uses pertinent well-reproduced illustrations, and points out his differences or concurrences with other authors. For some subjects, the reader should be familiar with the cited papers. Badgley's (and his students') active research in the Rocky Mountain region heavily colors the text. For example, geologists who work in the Gulf Coast area will find very little on salt tectonics, normal fault development, or growth faults. On the other hand, extensive use of recent analytical and experimental work and excellent illustrations give the reader a broad insight into thrust-fault and strike-slip (wrench-) fault tectonics.

The last two chapters ("Factual data bearing on world-wide orogeny," and "Tectonic patterns and tectonic classification") summarize many of the new data and developments that should contribute to a better understanding of the evolution of the crust of the earth. These are the subjects of endless discussions, reams of published speculations, and, in some cases, of harebrained opium dreams. The data summarized in the text should cause many earlier concepts on mountain building to quietly disappear into oblivion. The new wealth of isotopic age determinations, paleomagnetic pole determinations, crustal layer delineation by geophysical techniques, and heat flow determinations (each of these topics is briefly discussed) have given new life to the concepts of polar wandering, continental drift, convection currents, and continental accretion. The final answer is still in the future, but my hat is off to Badgley for attempting a synthesis now. His book will be very useful to students of the earth—whether they are in the vales of academia or are pursuing an industrial career—if they wish to bring themselves up-to-date in structural and tectonic concepts.

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## Encyclopedia of Physics

Inherent difficulties are associated with the production of a one-volume encyclopedia such as this one—**The Encyclopedia of Physics** (Reinhold, New York, 1966. 852 pp., $25), edited by Robert M. Besançon. Obvious problems are encountered in compressing into a book of 852 pages a satisfactory explanation of each topic of importance in so large a field as physics.

One might begin by contrasting the book with the many volumes of the *Handbuch der Physik* or with a small dictionary of scientific words. An encyclopedia such as this one cannot possibly give a large number of complete and definitive review papers, like those in the *Handbuch*. Neither can it provide a concise definition of most important scientific terms, such as one might find in a dictionary.

After summarizing what this volume cannot be, it seems sensible to evaluate its success in achieving its main purpose. A first impressive measure of this success can be seen in the list of authors. More than 300 distinguished physicists have contributed to the volume. There are articles by Jesse Beams (University of Virginia) on the centrifuge, Glenn Seaborg (chairman of the Atomic Energy Commission) on transuranium elements, R. Tousey (Naval Research Laboratory) on ultraviolet radiation, and many other experts. The articles uniformly are written by people who have done significant research in the fields about which they write.

One reviewer cannot speak definitively on the many subjects covered. However, he can glance at many topics, and study in detail those about which he has special knowledge. And he can ask friends in other fields to spot check items on subjects in which they have worked.

The impressions that I have as a result of such an effort are uniformly favorable. For example, the brief two-page review by J. Delvaille (Cornell) on cosmic rays is an excellent survey of what was known about and speculated in this subject as of approximately a year ago. (It is difficult to be more up-to-date in any hardbound volume.) Delvaille's article is accurate and informative. It assumes a good background in physics, but is not very detailed or particularly mathematical. It refers to a good selection of articles in other sections of the encyclopedia, and contains an excellent brief bibliography. These characteristics seem to be equally common in the other sections of the encyclopedia.

In summary, this appears to be an excellent book for brief review of a topic in physics. It contains good references for a later, more detailed follow-up. As a result, it surely belongs in every physics department library, and could serve a useful purpose on the desk of many individual scientists.

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## Developments in Solid Earth Geophysics Series

The author, Tsuneji Rikitake, states that **Electromagnetism and the Earth's Interior** (Elsevier, New York, 1966. 320 pp., $22.50), which is based on a series of lectures that he gave at the University of Tokyo, is intended for graduate students. He has achieved his objective admirably for the book provides the student with a comprehensive summary of the current knowledge and theory of the geomagnetic field and its fluctuations and the attendant electromagnetic induction within the earth. Full use is made of mathematics, and the derivations are presented in detail; in some instances alternative solutions are suggested. The bibliography is comprehensive and up-to-date.

In the first seven chapters the geomagnetic field and its long period variations are described and the various theories for its origin are reviewed. The most widely accepted theory, that of a self-exciting dynamo in the earth's core, is presented in great detail. Rikitake analyzes very lucidly the different models of the assumed dynamo and quite candidly explains the fallacies inherent in the simplifications required in each analysis. At the present time, the self-exciting dynamo is the most likely explanation of the origin of the main geomagnetic field, but its secular variation and its westward drift are not well explained and the complex effects at the core-mantle boundary are not yet tractable to study.

The next seven chapters are concerned with the electromagnetic induction produced in the earth by the day-long and shorter period variations in the geomagnetic field. The theories of electromagnetic induction are developed in a homogeneous earth with a plane surface, in a thin plane sheet, in a thin hemispherical sheet, in a cylinder, and in a layered earth. With