of cosmic radio emission", "Experimental data on the development of extensive air showers in the upper half of the atmosphere", "Radiation units of length and critical energies", "Particle number fluctuations in an electron-photon shower", "An analysis of the angular distributions of particles created in high-energy nuclear interactions in a photographic emulsion" and "Passage of high-energy nucleons through the atmosphere and production of mesons". Finally, there is a bibliography of all papers published by the cosmic-ray group of the Lebedev Institute during the period 1934–62.

The literature on high energy interactions and air showers is vast, and most of these articles will interest only specialists in the field, but even here the price will probably deter many prospective purchasers. Of much more general interest is the Chudakov group's search for photon-induced showers; if astronomical objects which emit strongly in the radio and visible regions emit very high-energy photons as well, this might well be the only way of detecting their very short-wavelength radiation. It is good to have a description of this experiment more generally available.

Getting data home

ELECTROMAGNETICS IN SPACE. Antenna Considerations as Related to Space Communications. Karl R. Spangenberg, ed. 277 pp. McGraw-Hill, New York, 1965. $15.00.

by Hans J. Hagger

Space technology could not play its role in widening our knowledge of extraterrestrial regions without the help of applied electrodynamics both for telemetering measured data and for guidance and remote control over very large distances. Spangenberg died when only the galley proofs for this book had been printed, but nevertheless his initial guidance made this book possible. The various sections were written by leading engineers at the Lockheed Missiles and Space Company. Most of the data have never been published before.

The book starts with a review of fundamental electromagnetic relations, and even this first chapter may be considered an excellent introduction at an intermediate level. Chapter 2 deals with the problems of power and receiver sensitivity related to very long-range communication. Chapter 3 is devoted entirely to ground antennas and the material incorporated is also very helpful for other applications in the antenna field. Chapter 4 deals with spacecraft antennas, discussing environment conditions in space and the consequences on antenna characteristics and on the choice of materials. Mechanical requirements and retracking mechanisms of spacecraft antennas are also considered. In the next chapter impedance factors of radiating elements are discussed and the radiation mutual coupling factor is applied to the more complex radiating elements and their combination. Chapter 6 deals with antenna arrays, the impedance perturbations in simple arrays, the effects of beam scanning and the design procedure of large antenna arrays. The topics covered are extremely useful for designers of antenna arrays not only for space applications, but also for other purposes. An index and a selected number of references to each topic covered are included.

This book offers up-to-date information both on electromagnetics in space and on complex, modern antenna systems. The presentation of design factors for complicated combinations of radiating elements is completely new, and it provides a basis for future antenna work. The book covers the most difficult field of space engineering, and only the future will clarify its real value. It will be appreciated by all research workers and designers in space electronics and most modern and future antenna work.

* * *

Hans J. Hagger, who is a specialist in electricity and electronics is associated with Albiswerk/Zurich.

One-upmanship

THE ART OF RESEARCH, A GUIDE FOR THE GRADUATE. By B. E. Noltingk. 151 pp. American Elsevier, New York, 1965. $5.75.

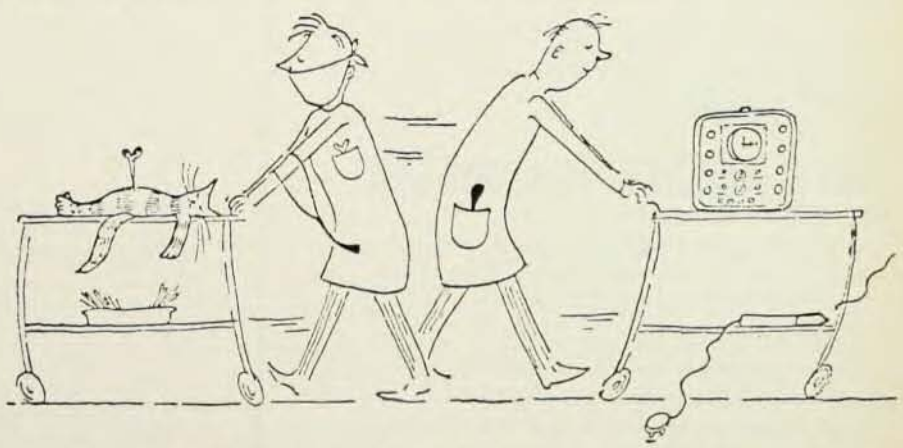
by Michael Danos

The information contained in this guidebook is quite true, the style is fluent and the tone is mildly amusing. The "art" discussed is that of the "state of the art" of a patent application rather than of the "Art of the Fugue." The cartoons, drawn by Josie Randall, are delightful.

To amplify this description, the titles of the six chapters of the book (together with my elaborations spelling out some of the questions) are "What? (—is research, and—are the scientific fields) Where? (—is research performed, and—should you settle) When? (—should you change your job, and—should you come to the lab, and —should you write a paper) Who? (—should do research, and—is productive) How? (—should you plan a program, and—should you acquire experi-

* * *

The reviewer, a nuclear physicist, has been associated with the National Bureau of Standards since 1954.



SPECIALISTS arriving from either side of the frontier may well cross into each other's territory. Cartoon from The Art of Research.

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mental apparatus, and—should you react to unexpected ideas) Why? (—does anybody pay for research, and—do you like science)." The discussion is always uncomplicated, the level is kept from becoming deep. You may enjoy reading the book; perhaps you even will learn a point or two.

Emphasis on scattering

ADVANCED QUANTUM THEORY. An Outline of the Fundamental Ideas. By Paul Roman. 735 pp. Addison-Wesley, Reading, Mass., 1965. $17.50.

by D. B. Lichtenberg

By far the largest topic treated in this full and important text is the theory of scattering. The section devoted to this subject alone (Part Two of the book) is large enough to constitute a good-sized volume. In addition, there are introductory chapters on the principles of quantum mechanics and on the Dirac and Klein-Gordon equations (Part One), and two concluding chapters on symmetry principles (Part Three). Appendices on group theory, vector spaces, Dirac matrices and Green's functions complete the volume.

The section on scattering theory invites comparison to the well-known treatise of Goldberger and Watson, *Collision Theory*. Although the present work is not as complete as the work of Goldberger and Watson, it is less formidable and, is more suitable for the graduate student encountering for the first time the problems arising in scattering theory. However, this book is by no means a substitute for Goldberger and Watson.

Roman gives ample discussion to the fundamental concepts arising in the theory of scattering, such as the scattering S matrix, the transition or T matrix, and Möller's wave matrix. Such topics as partial wave analysis and effective range theory are also treated. The author rightfully devotes much attention to dispersion-relation methods and Green's-function techniques.

Disappointing is Roman's rudimentary treatment of the scattering of particles with spin. Although spin is mentioned in various places in the book and although helicity is defined, nowhere does the author use the concept of helicity amplitudes to give an adequate treatment of the scattering of particles with spin. Since one or both of the particles have spin in most problems in nuclear and elementary particle physics, this omission is unfortunate.

On the other hand, Roman has chosen to include a detailed description of the many-body problem, including the treatment of Hugenholtz and methods based on Green's functions. This material is very complicated, perhaps necessarily so. I therefore feel that this topic is too specialized for a text such as this and could have been left out to make room for the material on spin that was omitted. But of course this is a matter of taste.

The section on symmetry principles contains some material borrowed by Roman from his earlier book, *Theory of Elementary Particles*, but the point of view is broader in the present work. The fundamental connection between symmetry and conservation laws is emphasized, as it should be. This treatment is given within the Hamiltonian formalism, but a careless reader may get the impression that the discussion is more general.

Roman discusses how the methods of group theory may be applied to a problem in which a part of the Hamiltonian of a system is invariant under a certain transformation, but a small part is not. Since most of the symmetries in nature are apparently only approximate, this treatment of broken symmetry is useful.

However, the author puts too much stress on the difference between so-called accidental degeneracy and essential degeneracy of quantum mechanical states. For example, in a problem in atomic physics, Roman regards a deviation from the Coulomb potential as one which causes a breaking of an accidental degeneracy. He considers the degeneracy to be accidental because the perturbing term in the Hamiltonian has the same symmetry as the Coulomb term: namely symmetry under the three-dimensional rotation group. But there is another way of looking at the problem. In this second picture, which Roman mentions but does not emphasize, the Coulomb Hamiltonian is regarded as having a hidden higher symmetry: the symmetry of the rotation group in four dimensions. It is this higher symmetry that is related to the extra degeneracy, in which the energy of a state does not depend on its orbital angular momentum. The perturbing term, in this point of view, breaks the higher symmetry, and there remains only the degeneracy of states with the same orbital angular momentum and different spatial orientation.

But most of my criticisms of this work are minor and do not seriously mar this serious, well-thought-out and well-written book.

* * *

The reviewer is a member of the Physics Department at Indiana University.

What is QED?

QUANTUM ELECTRODYNAMICS. By A. I. Akhiezer and V. B. Berestetskii. Translated from Russian by G. M. Volkhoff. 868 pages. Interscience, New York, 1965. $22.50.

by Howard H. C. Chang

Since the beginning of the Space Age on 4 October 1957, Russian books on science and mathematics have been translated into English at a great rate. This practice is not an unalloyed bonanza, for poorly written and obsolete Russian books have been foisted on the unsuspecting public. Additionally, since the USSR is not a signatory of the Berne Convention regarding copyrights and there are no restraints on the publication of translations of Russian books, the practice has led in recent years to the appearance of two, and even more, translations of the same book. It is not all chaos, though, for Mezhkniga in Moscow keeps a detailed and up-to-date account of Western publishers preparing translations. When properly approached, Russian authors gladly assist their translators, providing them not only with errata, but often with an enlarged or revised edition.

Quantum Electrodynamics has a

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The reviewer is associated with the Stanford Research Institute.