

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 rela-

tions, 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 re-tracking 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.

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One-upmanship

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

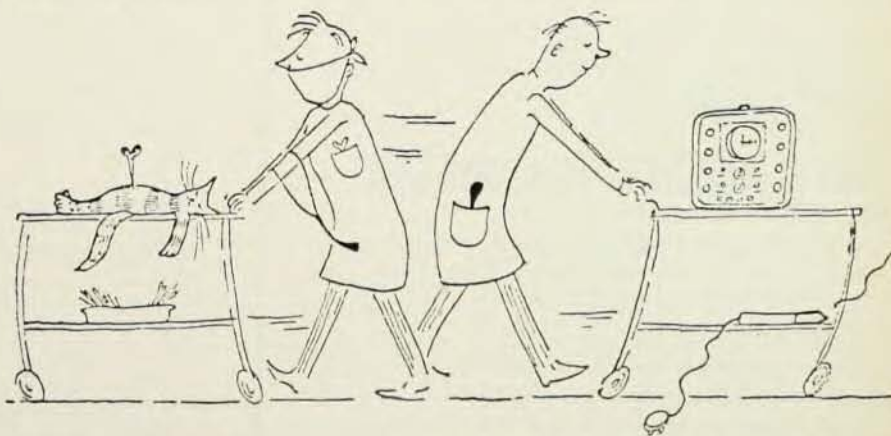
by *Michael Danos*

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-

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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*.