The first three chapters should be of interest to anyone with a knowledge of linear control theory. The state space and matrix notations, necessary in later chapters, are very clearly introduced. The chapter on multivariable systems covers material that is not generally found in standard textbooks, but is a natural extension of conventional theory.

The next chapter is an island of stochastics. Its chief merit is the discussion of the optimum estimator and optimum stochastic control, but the summary of random processes and optimum filtering seems unnecessarily long.

Nonlinear-system analysis is covered in two chapters. The first is mostly a review of now standard techniques: describing function, phase plane, and optimum switched systems. The second covers Liapunov's theory, and its author, A. M. Letov, states with characteristic Soviet modesty that it is "the single and solid foundation of the modern theory of automatic control." Opinions may differ on that point, but the fact remains that the chapter is prerequisite to the understanding of much of the current Russian research. In addition, it presents two important and recent ideas: the extension of the method to the study of performances and its connection with dynamic programming.

Optimization techniques are dealt with rather summarily in chapter 7, which discusses dynamic programming and the maximum principle. Unfortunately the basic differences (closed-loop versus open-loop) and the numerical problems involved in practical applications are not explored very deeply. Some of this is found in chapter 9, which describes the present capabilities and future possibilities of computer process control. The last chapter is a nonmathematical discussion of large-scale systems engineering.

There is an excellent section on inertial systems, but this has very little connection with the rest of the book. An article on learning systems, for example, would have been far more appropriate.

State-of-the-art books such as this one would be even more useful if the bibliographies were carefully evaluated, as was partly done by L. G. Shaw in his chapter on stochastics. The most serious problems in the field of control are fast becoming those of filtering published research, and of minimizing the time required to keep up to date. This book is a very commendable and, on the whole, successful effort in these directions. It manages to keep mathematical developments to a relatively simple level. Graduate students and research engineers will find it a quite useful frame of reference and guide for further study rather than a self-contained textbook.

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Photoconductivity

Photoelectric Effects in Semiconductors. Solomon Meerovich Ryvkin. Translated from the Russian edition (Leningrad, 1963) by A. Tybulewicz. Consultants Bureau, New York, 1964. xvi + 402 pp. Illus. $22.50.

Ryvkin's book, *Photoelectric Effects in Semiconductors*, is a welcome addition, both because the number of books on this subject is small indeed and because it gives an authoritative account of the state of the art as reflected primarily in the Russian literature. The coupling between the Russian and the American or European literature is still weak enough to merit a digest of the Russian literature by a Russian author. In this field, Ryvkin is a recognized expert of long standing.

A book on photoconductivity can legitimately claim the major part of modern solid-state physics to be within its province. It follows that any actual book on photoconductivity must be to some extent abortive and, in any event, largely confined to the author's major interests and experience. In the present case the major emphasis is on the intricate variety of recombination processes that make up the lifetimes of free carriers. There are also thorough and helpful discussions of photomagnetoelectric effects, ambipolar drift and diffusion, and P-N junction photocells. The treatment throughout is phenomenological, and the emphasis is generally on semiconductor materials, although, particularly in the chapters on recombination, the behavior of insulating materials is included.

I found the first half of the book, which is concerned with the measurement of photocurrents and their various relaxation processes, somewhat more detailed than necessary. Many of the problems treated are of a highly specialized character that every experimenter expects to resolve as he goes along. Also, in Ryvkin's chapter "Meaning of the concept lifetime," I would have preferred more emphasis on the lifetime of free carriers as the primary parameter determining the sensitivity of photoconductors. The various relaxation processes due to trapping are significant and informative about the density and location of traps, but these processes play a secondary role.

Several major topics that are closely allied to photoconductivity are not included or are given only minor attention in this book. These are space-charge-limited current flow, noise currents, the physics of contacts and of capture processes, and the physics and chemistry of defect states. This is more a measure of the difficulty of writing a comprehensive book on photoconductivity than a criticism of the present volume.

In summary, Ryvkin has given a thorough discussion of a number of major topics in photoconductivity on (approximately) a senior level. Although the book is translated from the Russian language, the English is fluent.

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Modern Mathematics

Elementary Concepts of Modern Mathematics. Flora Dinkines. Appleton-Century-Crofts (Meredith), New York, 1964. xii + 457 pp. Illus. $6.50 (pt. 1, 247 pp., $2.45; pt. 2, 132 pp., $1.45; and pt. 3, 107 pp., $1.45).

"Sufficient unto its purpose is the rigor thereof" might well describe this text. And the purpose of the text, as stated by the author in the preface, is to introduce the undergraduate student to some of the topics that have come to be called "modern mathematics." I consider the volume admirably suited for courses in summer institutes where exposure rather than depth is desired. But I forsee considerable difference of opinion as to the place of courses based on this text in the four-year undergraduate program of the mathematics majors. Such a course could not

qualify as an essential pre-calculus course; and a post-calculus course covering these topics should be more sophisticated. Except for the section on Boolean algebras, the treatment is more intuitive than axiomatic, although definitions are numerous. I prefer this kind of approach in the elementary courses for which this text is intended, and in no way fault the book for its lack of sophistication.

The book is organized into three independent parts: Part 1, Elementary Theory of Sets (234 pp.); part 2, Introduction to Mathematical Logic (120 pp.); part 3, Abstract Mathematical Systems (93 pp.). A novel feature is that each of these three parts is available separately in paperback form, at a considerable saving, of course, if one is not interested in the entire book. Also, answers to each section are printed at the end of each part rather than being collected at the end of the book. The author gave the answers more attention than most authors do; liberal use of figures and graphs is made in presenting the answers.

The book should receive serious consideration as a text for courses for either prospective elementary or junior high school mathematics teachers, *if* these students are already proficient in the rudiments of arithmetic.

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Space Science

Lunar Missions and Explorations. C. T. Leondes and R. W. Vance, Eds. Wiley, New York, 1964. xx + 669 pp. Illus. $17.50.

Lunar Missions and Explorations is a "textbook" written as an outgrowth of one of the University of California's Engineering and Physical Sciences Extension Courses. It is a textbook by assertion only; it is in fact a compilation of lectures given during the spring of 1963 by 14 lecturers drawn from the aerospace industry and from governmental laboratories. A majority of the lecturers are executives (and recognized authorities), and most have done commendable jobs of discussing their subjects.

These discourses range from a discussion of propulsion principles to generalized studies of vehicles to return man from the moon. Only one, Schurmeier's "Lunar exploration," treats a lunar mission (in this context Webster's *Collegiate Dictionary* defines a mission as a definite task or errand), and none considers exploration of the moon. Most deal with the trajectory and vehicular aspects of the U.S. lunar programs.

As I attempted to plow through Stoner's "Launch vehicle systems" (112 pp.) and Hornby's "Return launch and re-entry vehicles" (76 pp.), I could imagine myself not in a classroom but rather at a technical symposium attempting to assimilate a little from each of the highly technical and detailed slides appearing in endless procession. Indeed the book resembles the proceedings volume of a well-organized symposium more than it resembles a textbook. It is intended for professional engineers, and although a few nonprofessional readers will enjoy portions of the book, particularly the chapters "Lunar environment" and "Lunar exploration," most will find the discussions too technical. The latter chapter, primarily a discussion of photography of the moon by Ranger, is largely historical rather than expository.

The editing of the book was evidently hasty. The orbital period of the earth about the sun is given as 365.5 days (p. 4); the induction of a "gravitational" force by rotation is alleged (p. 92); "descent" is used in place of "ascent" (p. 133); and the numbers are omitted from one figure (p. 501), to cite a few instances of insufficient editing.

In a statement on the dust jacket, the publishers predict that the book will become a source document, but the index contains fewer than one entry for each two pages of text and eight of the 14 chapters have fewer than four references.

I suspect that all astronomers other than those enamored with radio astronomy will skip lightly over Rechtin's comment (p. 426) that listening to radio noise from stars is the essence of modern astronomy. I recommend the book only to those professionally involved in the lunar programs.

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Physicochemistry

The Physicochemical Principles of Igneous Petrology. A. N. Zavaritskii and V. S. Sobolev. Translated from the Russian edition (Moscow, 1961) by J. Kolodny and R. Amoils. Israel Program for Scientific Translations, Jerusalem; Davey, New York, 1964. x + 414 pp. Illus. $14.

Zavaritskii's *Physicochemical Principles of the Petrography of Igneous Rocks*, which was first published in 1926, was one of the first books to recognize the importance of physicochemistry to an understanding of igneous petrology. At the time of his death (about 1955), Zavaritskii was at work on a thorough revision and updating of this book. Sobolev has taken Zavaritskii's notes and brought to completion the revision of Zavaritskii's book.

This book is a good to excellent presentation of the application of thermodynamics and physical chemistry to igneous petrology, and it contains a summary of the many systems that have been studied and are of interest to igneous petrologists.

The first half of the book is devoted largely to the fundamental physicochemical aspects of igneous petrology, with creditable discussion of thermodynamics and of methods of representing equilibria in multicomponent systems and a general review of phase diagrams. Part 2 is devoted to the various well-studied unary, binary, ternary, and quaternary dry systems of importance to igneous petrology. Most of this work is a summary of the various dry systems that have been studied, mainly by Bowen and Schairer at the Geophysical Laboratory. This is followed by a general review of all systems of importance to chemical petrology where one component is a volatile, either carbon dioxide or water.

This book suffers in that it is somewhat dated. Sobolev's revision was probably completed in 1957; there are no citations from the literature published since that time, although a vast amount of data, particularly at very high pressures involving systems where one component is a volatile, have been published. The book has a substantial number of the standard errors that one finds in a volume of this kind. I noted such errors as the statement that alpha