integrals without comments, appear on pages 118, 122, 123, 140, and 150. Furthermore, except for a footnote on page 62, elliptic integrals are nowhere referred to in these tables.

In the foreward to their extensive collection of indefinite integrals Gröbner and Hofreiter [1] refer to these tables as one of the sources for their material. Nevertheless, the tables of Petit Bois are not comparable to these recent German tables, nor indeed to the recently enlarged compilation of Dwight [2], principally because these last two tables cover a much larger spectrum of classes of functions.

The reviewer noted only one serious error of commission, namely, on page 150 appears an evaluation of the indefinite integral of $\log (a + \cos x)$ which is manifestly incorrect.

In conclusion, this reviewer considers this compilation to supplement to some degree the information presented in several more recent tables, such as those cited; nevertheless, it cannot replace them in general use.

J. W. W.

1. W. GRÖBNER & N. HOFREITER, *Integraltafel. Erster Teil: Unbestimmte Integrale.* Vienna and Innsbruck, Springer-Verlag, 1949.
2. H. B. DWIGHT, *Tables of Integrals and other Mathematical Data*, fourth edition. The Macmillan Co., New York, 1961.

45 [P, Z].—ROBERT S. LEDLEY, *Digital Computer and Control Engineering*, McGraw-Hill Book Co., New York, 1960, xvii + 835 p., 24 cm. Price $14.50.

The author's purpose in writing this book, as stated in the Preface, is "to fill the need for a comprehensive, elementary engineering textbook in the large and still growing field of digital computers and controls." Without doubt, it is comprehensive; more than enough is included in over 800 pages for a year's course or for several years of graduate work if the Additional Topics are included. The author, is justifiably proud of the 750 exercises scattered throughout the text. The exercises form a framework to hold the book together and permit some of the author's objectives to be achieved, while the additional topics provide opportunities for rich learning experiences for honors or graduate students, as well as insights for the exceptional student seeking more than grades and credits.

The book is divided into five parts, each one reasonably independent and self-contained.

Part 1, entitled Introduction to Digital Programming Systems, serves to introduce digital systems and to stimulate interest in them through examples and the theory of their applications. It may be that an unwary and not too disciplined student, not familiar with the field at all, may be frightened away by the rather sophisticated examples. Chapter I does show, however, that digital computers and controls are tools—the means to realize highly complex programs. There is not, in the first chapter, on the other hand, any hint of what these tools are or what they actually do, or how. This is probably a good technique, for now curiosity alone should lead the student to Chapter 2 to discover the secrets of such remarkably versatile hardware. This chapter, however, will probably have to be read twice to be understood by most neophytes. As all good computer people do, Professor Ledley personifies the hardware; for example, "the computer is told"; control "interprets" and "tells ... the arithmetic unit what to do," etc. Without a previous knowledge

of the physical meanings and the allegorical nature of these personifications, a good number of questions may arise. Here, as throughout the text, the exercises do much to dispel such problems. The exercises are vital to the complete understanding of the material in this text, because of its often descriptive nature. Where the descriptions or analogies are weak, such as the use of the terms "read-in" and "read-out," "memorizing information," and the sentence "memory boxes are analogous to mail boxes," one must hope that the instructor can salvage the situation. Getting into an unfamiliar discipline is first of all a matter of mastering a new vocabulary; here the student will stumble a while before finding this key to new knowledge.

The input, output, and memory section of Chapter 2 is descriptive. The approach is to cite an application, show a system that can perform it, and then discuss the units making up such a system. This is logical, but the engineer will be given electrical specifications to meet, not end applications. All of the picture should be presented to him, but the greatest emphasis should be placed on where he will go—on the design of electronic circuits. This does not happen here. (An unusual feature in this book is that the history of computers is relegated to an additional topic of Chapter 2, accompanied by an interesting evolutionary tree showing computer development.) This chapter is rich in photographs, but the block diagrams are likely to carry far more meaning to the student.

In Chapter 3, after much assurance to the student that all this is really necessary, the book gets into some serious work. This chapter, concerned with coding and programming, is highly recommended. It contains numerous excellent presentations on number systems, binary arithmetic, coding, flow charting, symbolic code, multiple-address systems, decimal-coded-binary systems, more excellent exercises, and extremely interesting additional topics.

In Chapters 4 and 5, programming fundamentals and advanced programming, respectively, are both presented with clarity, and again are highly recommended, especially for prospective programmers. While it may be that so much attention to programming is discouraging to the engineer who is primarily concerned with hardware, the need for ingenuity, precision, and economy in coding is well demonstrated. This may serve to bring into sharper focus the similarity between the user's or programmer's requirements and the engineer's own disciplines.

Part 1, then, despite an uncertain start, should leave the student with few doubts about the why of computers.

Part 2, the Functional Approach to Systems Design, approaches the subject from a mathematical rather than a purely descriptive level. This Part will prove to be a trial for most engineering students, for still there is no hint of hardware. However, as another contribution to the building of a solid foundation, it, too, has great value.

Chapter 6, Fundamentals of Numerical Analysis, presents several discussions of how problems may be prepared for systematic solution by computers. The section on accuracy and errors should dispel naive notions of the infallibility of computers.

Chapter 7, entitled Searching, Sorting, Ordering, and Codifying, is another very good introductory chapter, this time to data processing. Section 7-7, Codifying, concerns itself with error correction and superimposition. The discussion of self-

correcting and redundant codifications should prove of value in the engineer's career.

In Chapter 8 are found discussions of several special-purpose digital-computer system designs. These are all good, and again should broaden the student's outlook. With the nearly 300 pages so far devoted to introductions and elaborations, he may, however, have given up finding out just what makes these machines operate.

In Chapter 9, the system design of the Pedagac ("pedagogic automatic computer") is presented. None of the reasoning leading to this particular configuration is shown, leaving the student to accept it as a *fait accompli*. The appended Additional Topics present some fine challenges to student programmers, namely, the writing of an automonitor, a library of subroutines, and an ALGOL for Pedagac.

Part 3 deals with the Foundation for the Logical Design of Digital Circuitry. Chapter 10 provides a good, practical introduction to Boolean Algebra—a necessity for digital design. Propositional Calculus is brought in by way of background material, and is followed by a rapid, clear, and concise development of Boolean Algebra. The all-important parallel between computer logic and Boolean logic is firmly established, and a fine set of Additional Topics completes this chapter.

Chapters 11 and 12 deal with numerical representations of Boolean expressions and with many elegant computational methods of simplification and logical design, often the result of original work by the author and his associates. These are likely to be of much value to the serious computer designer. Chapter 13, entitled Boolean Matrix Equations and Fundamental Formulas, presents more simplification and computational methods. It is in this part of the book that Dr. Ledley reaches a peak of accomplishment. In Sections 11-9, 11-10, and in all of Chapters 12 and 13, it is design that is emphasized, not analysis or description. It was R. W. Johnson in the August 1961 edition of the IRE Proceedings who asked "Are electronics engineers educated?"—stressing how much analysis is taught and how little design, which is the life blood of engineering. In Part 3 of this book, Dr. Ledley teaches design. He achieves a clarity of presentation, never resorting to "mathmanship" or other "impressive confusion." The advantages of an interdisciplinary approach, at the elementary level (for example, algebra taught by a Professor of Engineering) rather than the highly sophisticated specialist trying to "write down" to students, are amply illustrated. In fact, the only quarrel is with the nomenclature, the use of the term "circuit" design when actually "logical" or "symbolic" design is meant. Chapter 14, Applications of Matrix Equations in Circuit Design, concerns itself with applying the methods and principles just learned to solving specific problems. (This chapter and its Additional Topics are unlikely material for engineering students, but are certain to have high appeal to logicians and mathematicians.)

Part 4, paradoxically named Logical Design of Digital-Computer Circuitry, reveals to the student how all the Boolean tricks he has learned may be used to group components logically to make them compute. Chapter 15 presents the logical realization of serial arithmetic. It is in this chapter that the long-postponed revelation—how does a computer actually work—is made; that is, what is it that a computer does when it computes? How is computation mechanized? The presentation is excellent.

Having exposed the "heart" of computers, the author follows through with

some extremely important and interesting elaborations in Chapter 16, Parallel and Rapid Arithmetic Operations. The student will again be challenged. Equally important, but not as obvious, is the control logic of a computer, lucidly presented in Chapter 17. Chapter 18 is unfortunate in that the packaging and logical design of the Pedagac are presented in such rapid order that the "thread of continuity" aimed for by the author is violently contradicted. A complete logic for the computer is displayed, rather than being built-up or designed in a step-by-step fashion. It appears as though after the foundation was built painstakingly and in great detail, the finished product is suddenly presented, fully built.

Part 5, Electronic Design of Digital Circuits, is the only part of the book dealing with electronics, and in a somewhat superficial manner, at that. Chapter 19, which discusses Problems and Limitations in Electronic Realization, includes a good presentation of digital gating systems. Static and dynamic storage and parametric amplifier methods are described clearly. No circuits are designed in this chapter, but the important topics of clock phasing, synchronization, and circuit reliability are discussed. An interesting Boolean-probabilistic method of logical design for increased reliability is developed. The preponderant use of semiconductors in today's equipment is acknowledged by a full discussion of their physical theory in Chapter 20, Semiconductor Elements in Digital-circuit Design. Both large- and small-signal equivalent circuits for transistors are shown, and some circuit analysis is carried out. Diode gates, transistor gates, and current switching are described. A typical transistor flip-flop circuit is analyzed, and finally, too, the physical theory and parametron analogies of tunnel diodes are discussed.

Continuing at the introductory level, Chapter 21 presents a review of magnetism, and a discussion of square-hysteresis-loop cores. The sections on magnetic amplifiers, magnetic core logic, and multi-aperture cores are excellent, and will prove useful in an engineer's later work. Again, an unusual and highly desirable feature here is the rather thorough discussion of recent developments such as microwave and cryotron computer components, including exercises in their use as logical elements.

Memory and input-output methods are described in Chapter 22, which includes a section on magnetic film memories. The discussions of coincident current techniques, the several methods of recording and reading from magnetic tape and drums, analog-to-digital and digital-to-analog conversions, visual displays, page scanners and line printers, in the 30-odd pages of this chapter, provide a wealth of introductory material for an interested student. The discussion of the sampling theorem for analog-to-digital conversion must be cited as also highly desirable. The exercises for this chapter concentrate on logic and programming, and provide no further electronic circuit design experience.

Chapter 23 completes a major work of this book, the electronic design of the Pedagac. Unfortunately, this device for providing continuity serves rather to disrupt the continuity. Three widely scattered chapters present descriptions of the complete machine, that is, the system, the detailed logic, and the hardware. The final design is displayed in completed form rather than being built up step by step, and although it serves as good illustrative material for developing important concepts clearly and concretely, an opportunity for making the book truly continuous is thereby narrowly missed. This, however, is the lesser of two criticisms; the other

is the extraordinarily large proportion of logic, mathematical theory, and purely descriptive matter to the material dealing peripherally with electronic design problems and their solutions.

Such might include the many input-output synchronization problems, the numerous problems of cross-talk and pick-up, the signal-to-noise ratio of input devices, the power requirements, the transmission of pulses over relatively long lines, failure localization, ground loops, and so forth, which every computer design engineer must face. Special circuitry, such as sense amplifiers, clock pulse generators, and magnetic-core switching-current pulse-generators are not mentioned, and, of course, may be found elsewhere. The point is, however, that these are the problems likely to haunt the engineer long after his Boolean expressions have been mechanized on paper. That is why this is a difficult book to evaluate. It is at once an extremely broad survey of the "state of the art," reflecting a familiarity with a good deal of the current literature and at the same time a thorough exposition of many of the basic principles and practices underlying the digital computer technology. As a textbook, it should prove valuable, for it is written to and for students, with illustrations and clarifications used profusely. This volume may also prove to be of value to those whose experience in the computer field, while long, may have been rather narrow—technicians, circuit designers, programmers, etc. One may question, however, whether this admirable work actually belongs in the publisher's Electrical and Electronic Engineering Series. For all its strong points, and they are many, the book's weakest area is precisely that of electronic or electrical engineering. It contains numerous excellent presentations of basic principles, and contributes greatly to the diffusion of knowledge in logical design methodology. These are valuable for the engineer's background and understanding, but are more likely to be used by mathematicians or logical designers. As a text in electrical and electronic engineering this otherwise remarkable book can hardly be placed alongside the books of Millman & Traub, Millman & Seely, Terman, and Skilling. It is a book that can stand on its own merits, and needs not to lean on an Electrical and Electronic Engineering Series, achieved by a title with the word Engineering in it. An alternative name for the book, such as "Elements of Digital Computer Programming and Logical Design," would not raise false hopes nor be misleading. This is perhaps a criticism of the publisher and editors and not properly of the book, but must be made, nevertheless.

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46 [Q].—DIRK BROUWER & GERALD M. CLEMENCE, *Methods of Celestial Mechanics*, Academic Press, New York, 1961, xii + 598 p., 24 cm. Price $15.50.

The title of this book appears to represent a compromise with an aspiration that must have had its origin more than a quarter of a century ago. In 1943 this reviewer overheard Bart Bok say, "I told Dirk the best thing he can do for Astronomy is to finish his book." Nearly ten years ago Brouwer was joined by the second author, with the same objective still in view. Both authors have been close collaborators in numerous astronomical endeavors since the end of World