The chief algebraic tool introduced here is the system matrix, whose genesis can be described in the following simple manner. The dynamic variables in any system can be grouped into three sets: input variables, output variables, and all other variables. Furthermore, this grouping can be done in such a way that these variables, for any linear system, are related by a set of four matrix operations. The four relevant matrices, when suitably grouped together, define a system matrix. An algebraic equivalence theory for such matrices is then used to discuss equivalence classes of systems; for example, one may generate by a set of equivalence operations classes of systems having the same input–output relationships. Such a technique naturally works equally well for continuous- and discrete-time systems.

Using algebraic methods based on the system matrix, Rosenbrock deals with the full range of linear dynamical system theory in a powerful, elegant, and general way: treating such topics as reduction to state-space form, minimal realizations, controllability, and observability. In this treatment it emerges in a natural way that many of the ideas first developed in a purely state-space context such as controllability and observability can be treated in a much more general way and, moreover, in one which is algebraically much simpler.

The book continues with a general treatment of the topics of stability and control, including a development of the fundamental theory on which the design technique referred to in the preceding is based and concludes with a short treatment of time-dependent systems.

This is a most important contribution to the literature on dynamical and control theory and should be read by every engineer and applied mathematician active in this field. It has been developed as one of a series of course texts for a master's degree; it thus contains a number of illustrative exercises which would facilitate its use in a special topic course on control theory at the postgraduate level.

Electric Energy Systems Theory: An Introduction—Olle I. Elgerd (New York: McGraw-Hill, 1971, 564 pp.). *Reviewed by H. H. Happ, General Electric Co., Schenectady, N.Y. 12345.*

This book consists of a preface, 12 chapters, two appendices, and an index. It is part of the McGraw-Hill Electrical and Electronic Engineering Series. The author states that the book is to serve as a modern power-systems text for use by senior undergraduate and first-year graduate students, to be taken over two consecutive semesters or three quarters. It is well suited for schools that wish to offer an introductory power-oriented course as part of a broad systems program. It is clear in its exposition, and it can be used not only in the classroom but also for self-study. It is probably most useful when teaching is by a power-systems specialist who can provide additional complementing practical insight.

The first set of three chapters of the book (70 pages) briefly describe power systems; the second set of three chapters (130 pages) is devoted to the basic components of a power system: the synchronous generator, three-phase transformer, and the transmission line; the third set of three chapters (190 pages) is devoted to the analysis of power systems in the steady state; and the final set of three chapters (142 pages) is devoted to systems under fault conditions.

The first six chapters are more hardware-oriented than are the last six chapters, and they seem to serve as introductory material to the main topics which are presented in the last six chapters.

In chapter 1 the author states the well-known growth of electric energy production and extrapolates the needs to future years. He also shows the forms of the energy sources and indicates correctly that the dominant future energy source undoubtedly will be nuclear. Throughout this introduction he properly stresses the impact of electric energy upon the ecology, but the author surprisingly does not include nuclear fuel wastes or, really, its guardianship, as a major problem that confronts us.

Chapter 2, entitled "Fundamental Concepts of Electric Energy Systems Engineering," reviews fundamentals such as the power formula ($p = vi$), electric field energy, magnetic field energy, and dissipative energy. Direct current and alternating current, real and reactive power, single-phase, three-phase, and complex power, and phasor computation thereof are briefly presented. The author finishes the chapter with a brief description of the per unit system.

Operational considerations in power systems are considered in chapter 3. After a brief description of the distribution, subtransmission, and transmission levels, the author describes the static transmission limits and the mix of typical load characteristics. This is followed by a description of the effect of the power balance on the frequency and the reactive balance on system voltage.

The second quarter of the book starts with consideration of the synchronous machine by means of analogs and then develops the general machine equations: the presentation of the latter material is somewhat difficult to follow. From the general equations the author then derives the steady-state machine models. The author elects to present the transient-state machine models separately in later chapters.

Chapter 5 describes the power transformer in a very nondetailed manner, with the emphasis placed on its equivalent-circuit representation.

Chapter 6 covers the "high-energy" transmission line, and it does so more thoroughly than the previous two chapters cover their respective areas. The author first describes the functions of high-voltage transmission lines and their designs and then follows this with a good presentation of the line parameters—the inductance, capacitance, resistance, and conductance per unit length—for both the single-phase and the three-phase line. For long lines he develops equations which take the distribution effect into consideration, and he also presents equivalent circuits for long lines.

The third quarter, devoted to steady-state analysis, starts out with system modelling and load-flow analysis (Chapter 7). The author introduces the load-flow equations first in terms of branch impedances and admittances, and in the "control-theory" language of state and control vectors. He interrupts the basic theme halfway through the chapter by presenting some basic network theory such as network terminology, the primitive network, graph theory, and loop and node transformation matrices. He returns to the discussion of the load-flow problem by presenting the iterative schemes used in the load-flow solution, namely, the Gauss or block substitution process, and the Gauss-Seidel and Newton–Raphson methods. The only procedure that is considered in detail is Gauss' method, due to its simplicity, as the author states. I was sorry to find that the author did not discuss in detail the slightly more complicated but vastly more practical Gauss–Seidel iteration process (better known as the nodal iterative procedure) which has been used in industry for many years. This chapter does not appear to be well organized, partly, no doubt, because of the complicated material.

Chapter 8 discusses optimum operating strategies, better known as economic operation of power systems. Economic dispatch with line losses is first covered, leading to the well-known criterion of equal incremental cost dispatch and the solution algorithm. The author also considers the case where transmission losses are entailed, and he derives a rather complicated but compactly presented expression for incremental transmission losses and an algorithm for dispatching generation. The more general problem of optimizing all control variables in a power system is described briefly.

The control problem in power systems is considered in chapter 9, the strongest chapter of the book. Whereas the other chapters in the book cover more or less standard (i.e., well known) material, this chapter covers some novel material. The author divides the control problem into the two categories of MW-frequency and Mvar voltage problems, with a proper heavy emphasis on the former. First, the control methods previously in use in both categories are presented. These are followed by a presentation of methods from the author's research efforts which he has suggested in previous publications.

Surge phenomena and symmetrical fault analysis are covered in chapter 10. After a brief introduction and classification of transients, he presents the wave equations and their solution, symmetrical short-circuits and related concepts, and a description of the behavior of the synchronous machine during a balanced short-circuit. In the rest of the chapter he presents a detailed numerical example of a three-phase short-circuit problem, employing the familiar Z-matrix method. A minor point to be noted concerns the notation used by the author. The Z-matrix employed in this chapter is different from that which he introduces in chapter 7, but he denotes both of them by Z_{bus}. Obviously, utilizing Z_{bus} for both matrices may cause some confusion to the student.

Chapter 11, entitled "Unbalanced System Analysis," is devoted exclusively to the presentation of symmetrical components. The author presents the material in this chapter in a compact manner. In the first half of the chapter he presents the basic symmetrical component transformations, followed by a presentation of the sequence impedances of synchronous machines, transformers, and transmission lines. The remainder of the chapter is devoted to digital computation of unbalanced faults; he describes briefly the assembly of sequence networks, general formulas for solution, and the determination of fault matrices and their specialization to the several cases of equal phase impedances, single-phase to ground short-circuit, and phase-to-phase faults.

The concluding chapter 12 is on the subject of transient stability analysis. He first states the assumptions underlying the models used in the analysis. The swing equations are next presented, as well as the generator transient power equation, for the cases where saliency both is considered and is ignored. Methods of solution of the swing equation, both analog and digital, are presented. The solution of the swing equations for a two-generator system is next presented under the assumptions of constant turbine power throughout the postfault period and constant voltage behind transient reactance. The effects of load frequency control and of voltage control are described briefly.

Two short appendices are included: appendix A presents the "Elements of Vector and Matrix Algebra," and appendix B presents the listing of a load flow using Gauss's method given earlier in chapter 7 and a detailed eight-bus example. The book has good references and a number of student exercise problems at the end of each chapter.