make their own adaptations." The illustration is made by means of the example of the class of equations

$$\frac{dy}{dx} = \lambda \frac{y(x - \mu y + \nu) + \rho}{x(y - \mu' x + \nu') + \rho'}$$

members of which occur in certain branches of physics. An analysis of the equation in an appendix shows the three types of singularity in the (x, y) plane associated with the equation: saddle point, focal point and nodal point. In numerous photographs of families of solutions generated by the automatic variation of the initial condition or a parameter, these singularities show up astonishingly clearly. It is plainly evident that here is a powerful method of discovering solutions of complex non-linear equations quickly, and gaining an understanding of them readily. Indeed, as far as I know, it is the only practicable way of achieving this.

A chapter on partial differential equations treats of the solution by the serial and parallel methods of parabolic, elliptic and hyperbolic equations, and investigates the stability of the processes together with the influence on the solution of component tolerances. The stability investigated is that of the computer process and not that of the iterative process *per se*; thus the serial methods do badly in the appraisal, because of the build up of positive exponentials in the successive stages of the computation, due to the presence of noise and hum, a situation aggravated by the reduction of the difference-mesh. In the following chapter, however, higher-order difference approximations of the derivatives obtained by means of the Lagrange interpolation formula are developed with a view to exchanging the difficulty of the elimination of instability to that of the suppression of spurious solutions. An appendix to this chapter tabulates the interpolation coefficients.

The final chapters of the last part are devoted to the solution of integral equations. The authors point out that there has been little development in this field; so their exposition is largely exploratory. Of great interest is a scheme they have developed for the solution of Fredholm's integral equation of the second kind. This employs a process of iteration whose rate of convergence is shown to be superior to the well known Neumann sequence. Errors are analysed, and methods are proposed for the solution of equations in which the simple iterative methods would diverge; these are the methods of asymptotic convergence, double expansion and kernal transformation. Finally there is a brief discussion on the analogue computation of general integral transforms and the solution of integro-differential equations.

The concluding chapter of the book gives a discussion on the future of ultra-high speed electronic techniques.

The book is addressed to all in the analogue field that aspire to take part in the exciting developments that are possible. It does not lay down principles of computing, but in reporting new ideas and results throws out a challenge to designers and users to accelerate the rate of advance of the art. There is no spirit of rivalry in it towards those in the digital field; indeed, in the final paragraph of the book the authors quite rightly assert " . . the importance of appreciating the *complementary* character of the two great approaches to computation, the digital and the analogue; and the still more exciting possibilities which now exist for their fruitful combination in future computing devices."

The book is well produced and the price in relation to the contents is reasonable. Most chapters have one or more appendices giving the underlying theory of some subject occurring in the chapter. Ample references to works, not limited to the English language, are listed at the end of each chapter. In addition to the normal index, there is an author index.

There are a few misprints, none of which is serious: also there are ambiguities in one or two of the mathematical statements; but in the attempt to interpret these correctly the reader will gain a fuller understanding of the relevant matter. Presumably to keep the size of the book down many steps in many of the mathematical arguments are omitted, imposing heavy though rewarding labour on the curious reader, as I myself have found out.

L. N. CARLING

An Introduction to Electronic Analogue Computers, by M. G. HARTLEY. 1962; 155 pages. (London: *Methuen and Co. Ltd* 21s.; New York: *John Wiley and Sons Inc.*)

The object of this monograph is to provide an introduction to electronic analogue computation for the reader with some knowledge of electronic circuits. The first two chapters discuss the historical background, including mechanical differential analyzers, and the essential differences between analogue and digital computing techniques.

Chapter 3 introduces the operational amplifier and its use in linear function units for summation, integration, and the simulation of more complicated transfer functions. The effect of amplifier gain on the errors which occur in sign-reversing and scale-changing is mentioned, but the effect of grid current is deferred until chapter 5, and the influence of grid current on the accuracy of integrators is not discussed.

Chapter 4 introduces the complete analogue computer and illustrates the setting-up and scaling of a problem, the introduction of the initial conditions and the avoidance of over loading, taking as example a particular second-order equation.

The design of d.c. operational amplifiers using thermionic valves is discussed in chapter 5, including the problem of zero drift and the use of chopper stabilization. The frequency response required for computing amplifiers is barely mentioned, and some discussion of this topic could well replace the rather extended treatment of the causes of zero drift.

The particular problems of transistor computing amplifiers are treated in chapter 6, where some performance figures of typical amplifiers are given, but no mention is made of the advantages of silicon transistors both for input stages and choppers.

The final chapter surveys auxiliary equipment such as multipliers, non-linear function generators and analogue-to-digital converters. A more important item than any of these, however—the means of extracting the required solution from the analogue computing circuit—is not mentioned. Some information about cathode-ray tube displays, chart recorders, and *x-y* plotters would surely have been more valuable than some of the matter included, since one or more of these is essential to any computing installation.

Two misprints have been noted; a negative sign is missing in the text of Fig. 3.11.*b*, and the word "assumed" at the end of section 3.5 should presumably be "summed." References for further reading are given at the end of each chapter, but there is no bibliography of more advanced textbooks.

Subject to the omissions mentioned, this monograph would be a suitable text for a final-year student in Electrical Engineering, and for post-graduate students of other disciplines such as Mechanical and Civil Engineering, and Nuclear Reactor Technology. For post-graduate electrical engineering courses it would be a useful introduction to the subject, before tackling the longer standard works.

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