with those in (5) and (7) up to $N + 2$, we obtain the coefficients listed in Table 1. For $L = 4$ we have to consider two correction terms $\alpha_1 H_2$ and $\alpha_2 H_{22}$ and equate coefficients up to order $N + 4$. This method can, with some loss of simplicity, be extended to $L = 5$ and 6.

The general formulas I_{LMN} can similarly be derived symbolically if the differential operators D^m are expanded in terms of $\mu\delta^n$; a list of these expansions is given in Chapter 9 of Kopal's book (1961), where the operator 2θ corresponds to the more widely used D, and in the introduction to Miller's report (1960).

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chapter shows the generality of solutions using dimensionless variables, not only in reducing the work in a particular problem but also for showing the connections between problems from different fields, such as mechanics and electricity, and so making possible the development of analogue computers.

The later chapters in the book are more specific and inevitably reflect the author's interests. A more comprehensive set of illustrations would have needed a team of writers covering other fields, but would have given a more balanced picture of the relations between mathematics and industry. Chapter 4 discusses "spinning in the textile industry," and is followed by one on "Nuclear Reactors," which shows how the partial differential equations are replaced by a large number of simultaneous linear algebraic equations which are adapted to computer solution. Chapter 6 discusses linear programming, an important part of operational research, using the "stepping stone" method and that of "fictitious costs." Chapter 7 shows how much work in aircraft design is solving equations with different boundary conditions corresponding to different profiles, and then discusses how computers have made possible the solutions of the equations of meteorology. The last chapter gives the mathematical analysis of burning wood and relates the analysis to the physics of the process.

Most chapters conclude with one or more references to other books or articles, but a more comprehensive bibliography which could have included other topics from, e.g., the electrical industry, would have been useful. As part of the aim of a series like this is to encourage students to use books, it is unfortunate that no index has been included. Despite this minor criticism the book will be found useful by that increasing body of teachers aware of the importance of relating their mathematics teaching to the problems of modern industry. It should certainly be ordered for all school and college libraries, and many teachers will want to buy a personal copy. P. J. WALLIS.

Symbols, Signals and Noise, by J. R. PIERCE, 1962; 305 pages. (London: *Hutchinson and Co.*, 21s. 0d.)

It is a pleasure to be able to commend a book as highly as this one can be commended. It is an excellent presentation of, and commentary on, the subject of information theory in its various aspects.

After a preamble on the nature of physical and mathematical theories, the book proceeds through the history of electrical communication, the problems of coding, the idea of measuring information and the problem of combating disturbances. It then discusses the application of these ideas in physics, computing, psychology and art, and ends with a brief mention of some recent investigations.

The author is in a senior position in the Bell Telephone Laboratories and has obviously been closely involved in a great deal of this subject. His historical account, which begins with the origin of the Morse code and with the problem of signalling over telegraph cables, is written with obvious human feeling. This is not a mathematical book, and the mathematical reader may find some of the treatment tedious. It is, however, very definitely a pro-mathematical book, in that it stresses throughout the dominating part played by mathematics in the development of the subject, and tries with a good deal of success to give the reader a feel for the things that motivate mathematicians. The author takes great care to indicate just how far he has attempted to present the subject with precision, and at what point he reverts to a description in general terms. He goes out of his way to help the non-mathematical reader to follow as much as possible of the book, even to the extent of giving a miniature textbook of mathematics in an appendix. (This is in fact probably too brief for its purpose, and is interesting rather as a glimpse of mathematics from a new angle for those who can understand it already.) A more useful appendix is a short but excellent glossary.

Many chapters begin with seemingly irrelevant and wasteful digressions, but these always turn out to be written with a worth-while objective. One even finds that the apparently casual examples in the early chapters are designed to prepare the ground for later chapters in the book. The end of each chapter is a clear summary of its main points. In the later chapters, which roam over such fields as psychology and cybernetics, there is much that will interest and intrigue the reader who is concerned with computers; here, however, the connection with information theory often becomes tenuous. It is clear that the simple matter of measuring amounts of information, which is the central concern of information theory, is only a beginning to a study of these other fields.

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The most fascinating chapter is probably that dealing with connections between information theory and physics. Examples are given of the transmitter power required to send teleprinter signals across interplanetary space against a background which may consist of astronomical bodies at various temperatures. On a smaller scale an interesting new version of Maxwell's demon is presented and shown to have a striking connection with information theory.

It is unfortunate to have to report also that the book is peppered with a number of small mistakes which are likely to throw the inexperienced reader off the track; for example, the word "not" is omitted here and there and this leads to some rather puzzling paragraphs. In spite of this, however, the book can be thoroughly recommended as background reading to anyone concerned with communication or computers. S. GILL.

Numerical Methods for Scientists and Engineers, by RICHARD W. HAMMING, 1962; 411 pages. (London: *McGraw-Hill Publishing Co. Ltd.*, 85s. 6d.)

This is the third book on Numerical Analysis published in the "International Series in Pure and Applied Mathematics" and it maintains the high standard set by its predecessors, Householder (1953) and Hildebrand (1956). This collection might become known as "The Triple-H" on numerical methods! The volume under review was written with the junior/senior level of American universities and colleges in mind; the style is rather chatty in places, but this is not unusual in American texts. As the title implies, it is written for scientists and engineers, but the author, a mathematician, does not pander unduly to their whims (*i* is used for the square root of minus one). The exercises are chosen to illustrate and supplement the text and are not derived from practical problems encountered by scientists and engineers.

The book comprises thirty-two plus one chapters arranged in four Parts as follows: I, The discrete finite difference calculus; II, Polynomial approximation—classical numerical analysis; III, Non-polynomial approximation; IV, Algorithms and heuristics. The last, or "N + 1"th chapter, entitled "The art of computing for scientists and engineers," is of particular interest and might have been better placed as chapter 0, since it outlines the kind of questions which everyone should ask himself *before* embarking on computing work. The treatment of difference methods given in Part I is seldom found in general books on numerical methods, but as the author is at pains to emphasize, for some purposes it has decided advantages over the more conventional differential approach, for example in the study of errors. The chapters in Part II on predictor-corrector methods for the solution of differential equations, and those in Part III on periodic functions and their applications to filters are particularly well written, as is to be expected of Dr. Hamming. All the material in the book is relevant for scientists and engineers. and it is treated with about the right amount of rigour, Unfortunately, the undergraduate is neither helped nor encouraged to pursue any topic which might be his particular interest or concern. The 44 references at the end of the book are only books which should be in any self-respecting college library. There are few references to original papers and those which are given are relegated to footnotes. The lack of such references can only be due to the admitted haste with which the author wrote the book, but it does detract from its value because students (particularly Americans) do tend to stick rigidly to a single text and they shut their eyes to all else. This is a bad attitude of mind but this text, along with many others, tends to foster such a narrow outlook.

Dr. Hamming takes as his motto:

"The purpose of computing is insight, not numbers."

This idea is very worth-while and ought to be brought home even to experienced computer users who are, all too often, slaves to the machine rather than vice versa. Chapter N + 1, which elaborates on this motto, ought to be read by all computer users whether actual or potential, and the remainder of the book provides a good grounding in numerical methods for the latter. G. N. LANCE.

The Dynamics of Automatic Control Systems, by E. P. POPOV, 1962; 761 pages. (London: *Pergamon Press*, 75s.)

This is an English translation of a textbook which has become a student standard inside the U.S.S.R. In the main the teaching of automatic control engineering in the U.S.S.R. takes place in six large identical electrical engineering institutes. Each institute has a total of about 6,000 students engaged on a six-year course and is divided into a number of departments, two of which are devoted to control engineering. One is concerned with heavy industrial control. Although it is not stated in the book, Professor Popov is head of the latter at the institute situated at Kiev. In his career he has spent some time in research at the famous (to the West) Institute for Automatics and Telemechanics in Moscow.

Comparison with university students in Great Britain is difficult. The Russian student starts at the Institute at 18 with less technical preparation than his counterpart in the U.K., but after six years his standard of course work is matched in control engineering only by the best of post-graduate courses. This textbook thus deserves close study by teachers and those interested in education in the control field.

It is a large book of some 760 pages and tribute must be paid to Dr. Booth of Birkbeck College for his energy and determination in translating so large a work. The success of the translation owes much to the fact that Dr. Booth himself is a computer and control engineer of distinction.

The work is divided into five separate parts. The first, 150 pages long, is devoted to an exhaustive introduction with the title "General Information"; it covers the concept of the closed loop, describes many practical installations and finishes with a history of the development of control theory. This is national in character and makes no mention of work outside the U.S.S.R. It does, however, make a change to read of Polzunov inventing the first automatic regulator in 1765 in place of the inevitable speed governor of Watt. Vishnegradskii published a general theoretical paper on automatic regulation in 1876 and became the Russian father of automatic control theory. Differentiation is also made between theory before the Revolution and after, up to the present day. Liapunov and Chebyshev are already familiar names and it is interesting to see them placed in the Russian perspective.

Part II forms the theory of linear systems, dealing with transient and steady-state frequency response analysis. It concludes with the Nyquist criterion of stability, only the name is now Mikhailov.

The third part is an extension of linear theory to cover "dead time" or delay, distributed parameters, and a short chapter on sampled data systems.

Part IV is reserved for non-linearities and deals again with transient and frequency response analysis and stability.

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