'patches' to subroutines, etc., after testing was devised. The absolutely rigid control of this field is a tremendous problem in itself, and no laxity can be allowed. The problems of the effect of changes, both within a programming run and between programming runs, are major ones, and clear-sighted control is imperative.

After the initial few months of operational running, the responsibility of individual programmers was raised to runs instead of subroutines within a run. Currently, the examination of further possible applications is becoming more detailed as some of the experienced programmers are freed from the initial task. Optimization of programs, as and when the opportunity or the need arises, has been and is still a profitable exercise. New languages and programming aids are being reviewed continually. Within the programming organization we have a few non-programmers who maintain test accounts and devise test data for re-written patched routines. They critically examine all the output resulting from testing sessions—in fact they form an integral part of the testing section, and the programming organization.

Concluding remarks

Each of the points mentioned above, for example Coding or Storage Allocation or Machine Testing, is worthy of an hour's talk in itself. I can only hope to have outlined some of the problems and sketched out a possible means of approach.

Book Reviews

Data Acquisition and Processing in Biology and Medicine, Edited by Kurt Enslein, 1962; 191 pp. (Oxford: *Pergamon Press*, 50s.)

I was recently approached by the editor of a medical research journal to referee a paper submitted by an author from the United States who was proposing to make a quantitative science of a particular branch of medicine—no British doctor could be found to pass judgement on the paper. As an applied mathematician I was intrigued to find that the non-medical references in the paper were to geological papers. This reflects an attitude of mind on the part of U.S. research workers which is wholly to be applauded and which, outside operational-research circles perhaps, is unfortunately too seldom found in Britain. The explanation, at least in part, of this greater U.S. willingness to cross inter-disciplinary barriers is to be found in the impact which electronic instrumentation in general and computers in particular have had in the U.S. There, good computing facilities in universities and research centres are the norm; here, they are still the exception.

An example of what this means in scientific endeavour is to be found in the book under review, which is the edited proceedings of the 1961 Rochester Conference. The reports cover papers read at five sessions, concerned with computers in biology and medicine, computers and psychiatry, pattern recognition, clinical and research instrumentation for biological systems, and instrumentation for electrocardiography and electroencephalogy. It is interesting to note the degree of automation aimed at—one writer reports that electrocardiograms are already recorded on tape for running into a computer, but it is planned to use the cardiograph as an on-line device to the computer. The combination of intricate medical instrumentation, advanced computer techniques and highly sophisticated statistical treatment in some of the experiments is fascinating.

One of the papers on pattern recognition extends to the study of chest X-ray photographs the techniques used to assess the cloud photographs taken from the Tiros satellite.

The papers on computers have much to interest British readers. To me, most impact was made by the remarks by Lusted on the problems of education facing medical schools. Doctors, he says, must somehow be taught to compute when necessary, and he cites the work of doctors at Tulane University who have developed a computer program called "Probe" which allows the medical researcher who does not know programming to run his own medical data on the computer; they attach great importance to allowing the researcher "to get his hands on the machine."

I am not, of course, competent to review the papers in this volume for their medical contents; but I can wholeheartedly commend the book to British research workers if only for the insight it gives us of the attitude and approach of our transatlantic colleagues to research problems.

Until British universities and research establishments are equipped with computers in depth, as are their U.S. counterparts, one cannot imagine such a volume being written by British research workers.

Andrew Young.

Modulation and Coding in Information Systems, by Gordon M. Russell, 1962; 260 pp. (London: *Prentice-Hall International Inc.*, 42s.)

The purpose of this book, as stated in the Preface, is "to give an introduction to the theory of information processes, primarily those of modulation and coding . . . applicable to the fields of power-system control, industrial control, data transmission and processing and all types of communication . . .". In saying this, the author does the book a slight disservice, for he suggests that the material is theoretical, dealing perhaps with information theory, coding theory and the like. But there are several excellent texts already on the market dealing with such theoretical aspects of communication and control systems. By contrast, there is a plethora of books dealing with the techniques and the gadgets, many of them very bad.

The merit of Mr. Russell's book is that it deals with both sides of the coin; both the theoretical and the practical, side by side. The theoretical work is elementary, but design principles and methods are clarified thereby, being circuit techniques for various data processings, logical operations upon signals, modulation, switching and gating, and a host of other operations.

In my opinion the book is most suited to the practical design engineer at the beginning of his career, after graduation, and perhaps to provide the research student with some necessary background of technique. Unfortunately, very few references are given to guide the young reader further—so necessary in this vast field. But there are plenty of numerical examples for him to feed upon, on his way.

Most of the detailed circuits shown in diagrams use valves, not transistors, and little advice is given as to their relative merits and uses. The book is fairly well indexed.

COLIN CHERRY.

Solutions Numeriques des Equations Algebriques, Volume II by EMILE DURAND, 1961; 445 pp. (Paris: *Masson et Cie*, 90 N.F.)

This is the second volume of Professor Durand's treatise on the numerical solution of algebraic equations. The first volume, which I reviewed in this *Journal*, Vol. 5, p. 32, was concerned with the solution of single equations in one variable, while this volume deals with systems of equations. Of its 445 pages, some 422 pages are devoted to two problems of fundamental importance: the solution of simultaneous linear algebraic equations, including the inversion of matrices, and the calculation of the eigensystems of matrices. There is only one short chapter on the solution of general systems of equations.

Chapter I provides the theoretical background for the treatment of the two fundamental problems. This is a difficult field to present since a large amount of material must be covered, and this must be done without upsetting the balance of the book. Professor Durand has been remarkably successful in condensing this material into a reasonable space without rendering it unintelligible.

The next three chapters are devoted to the solution of linear equations and deal respectively with direct methods, iterative methods, and the inversion of matrices, of which the third is closely related to the first since direct methods are used. The standard direct methods are covered very thoroughly, and my only criticism of this section is of the treatment of numerical stability and of attainable accuracy. Two examples will serve to illustrate my point.

When discussing the use of small pivotal values it is suggested that this leads to inaccuracy when the pivot has been obtained as the difference of two comparatively large quantities. This is quite misleading since the use of a small pivot, even at the first step, will result in a poor solution even though no rounding errors have yet been incurred.

As a second example, when discussing the improvement of an inverse, obtained by a direct method, by the iterative procedure $X_{k+1} = X_k(2I - AX_k)$ it is suggested that this is usually of little value. It is useless to discuss the effectiveness of this procedure without some reference to the nature and precision of the arithmetic used in computing the original inverse, and performing the iterative procedure. In fact if the formula is written in the form $X_1 = X_0 + X_0(I - AX_0)$ and X_0 is computed by a direct method using single-precision arithmetic, then X_1 will, in general, be a substantial improvement on X_0 provided inner products are accumulated when computing $I - AX_0$.

The section on iterative methods is concerned primarily with full sets of equations. Naturally a special discussion of the techniques which have been developed in the last decade for the solution of linear systems arising from partial differential equations could not be included, but much of the discussion on convergence rates will be of interest to workers in this important field. I was pleased to find that the superiority of direct methods for non-specialized sets of equations was emphasized.

The last 250 pages are devoted to a detailed examination of techniques for the solution of the algebraic eigenvalue problem. Considering how rapid have been the advances in this field over the last ten years, Professor Durand is to be congratulated on giving an account which covers almost all the important techniques which had been used up to the time of publication. The value of his examination is enhanced by the fact that virtually all the techniques which he discusses have been programmed by the group at Toulouse. The most important of the techniques which have been omitted are Householder's reduction of a symmetric matrix to tri-diagonal form and Francis' Q–R transformation with its associated device for dealing with complex conjugate eigenvalues of real matrices, though probably the former was in use only at N.P.L. and the latter only by Francis when this book went to press. In my review of the first volume I regretted the absence of an assessment of Rutishauser's Q–D algorithm. In this volume there is, in fact, not only a discussion of the Q–D algorithm but also a very thorough treatment of Rutishauser's L–R algorithm. It is to be hoped that this will do much to popularize the use of the L–R algorithm, though I would like to have seen even greater emphasis given to the importance of a preliminary reduction to Hessenberg form.

My one criticism of this section is much the same as that on the section on direct methods of solving equations. Although I find myself in fairly general agreement with the assessment of the relative stability of the various techniques, I feel that the reader is not given much insight into the factors which make one method very stable, while another, apparently quite similar, method is violently unstable. In discussing methods which involve similarity transformations using elementary matrices, the significance of pivoting receives little attention; pivoting seems to be regarded as a method of avoiding a breakdown of the process when zeros arise in the key positions, rather than something which is, in general, of vital importance for stability.

A very large number of numerical examples are given throughout the text and these have been well chosen to illustrate the effectiveness and deficiencies of the techniques. There is also a collection of interesting exercises, some theoretical and some numerical, at the end of each chapter. This is by far the most comprehensive account which is available of the practical aspects of matrix computations, and I heartily recommend it to all serious students of the subject.

J. H. WILKINSON.