obviously true of those employed by industrial enterprises and such commercial undertakings as banks and insurance companies. It is true of the professional man whose clients are able to pay him only with money derived directly or indirectly from profitable transactions, either past or present. It is also true of the scientist living in the remotest ivory tower; the connexion between the selling at a profit and his income may also be remote and indirect but nevertheless exists. He may be living from an endowment made possible by commercial activity, or he may be a member of an institution with a Government grant or an income from invested funds. The Government grant is derived from taxes, all of which can be traced ultimately to a commercial activity. In the same way income from invested funds or property can be traced to business activity.

These economics may be naïve, but I think the point is fundamental, and that unless we are prepared to reject the basic monetary system of our culture we must recognize that we all live by the consequences of the buying and selling which we transact with each other.

That I have only generalized and rambled is due mainly to a lack of competence to do anything else; it is also partly due to the inherent characteristics of my theme which is concerned with the way in which people think, especially the way in which they think about other people whom they call by incompletely defined names.

As a last generalization I make the suggestion that there is a serious fault in our system of education. This fault is not that insufficient time is given to teaching scientific subjects, which some people would contend. It is that we do not teach an understanding that all progress has been and will be based on scientific discovery. Because of this omission we mature, both scientists and non-scientists, without an appreciation of the importance of controlling and exploiting science. I make this criticism without the ability to make a constructive suggestion other than that a step in the right direction would be the teaching of the history of science and scientists, with a minimum of technical detail, expressed in simple language; this might prove to be of more value and more interesting than the history of wars and politicians.

Conclusion

Almost to conclude, and by way of a summary of what I have tried to assert should be our attitude to science, I quote from an article entitled "Using the Scientific Mind" in the *Sunday Times* of 12 May 1963, by Lord Hailsham:

> It is not enough to buy a scientific mind. You must have it yourself if you wish to use it in others. We are moving out of the pre-scientific era and no one, not a managing director, not a Cabinet Minister, not junior counsel conducting a running down case, can afford to preserve a lot of useless lumber in his mental attics.

Before I stood up here some of my best friends were non-scientists and others were scientists; to avoid losing all of them I must state categorically that I have not said all non-scientists believe all scientists are unworldly pedants, nor that all scientists believe all non-scientists are mercenary ignoramuses. This is far from the truth, but I do believe that if we and our descendants are to live in an environment which will permit a fulfilled existence, both spiritual and material, then it must become as difficult to divide people into two mutually exclusive groups labelled "scientist" and "non-scientist" as it is today to classify an individual permanently as either a motorist or a pedestrian.

Book Review

Redundancy Techniques for Computing Systems, by RICHARD H. WILCOX and WILLIAM C. MANN, 1962; 403 pages. (London: *Cleaver-Hume Press Ltd.*, 80s.)

This book is based upon the Symposium on Redundancy Techniques held in Washington in February, 1962. Like all such books, consisting of more or less direct reproductions of the papers presented at a conference, it suffers from a number of disadvantages. Some of these are: non-uniformity of style, or more seriously, of notation; duplication of material; lack of coherent plan, apart from that imposed by the organizers of the original conference; and the absence of introductory material, however brief, without which the book cannot be self-contained either as a textbook or as a work of reference.

The book contains 21 papers, abstracts of two further papers, and a bibliography. About half of the papers treat the subject from the point of view of mathematical statistics or information theory. In these the presentation varies from a fully rigorous treatment to a bald statement of a series of results. Some results are given graphically or as numerical tables, others are stated in analytic form.

The style of the papers ranges between the extremes of the formal academic and the "chatty." While some readers may find this somewhat disconcerting, it can to a certain extent offset the tedium of reading the same basic argument in several different guises. It is inevitable that a certain amount of repetition will occur in such a collection of papers. What is interesting, however, is not that different arguments often lead to similar conclusions, but that occasionally similar arguments lead to differing conclusions. It is undoubtedly tiresome for the reader to have to learn a fresh notation for each chapter of a book, particularly since some authors omit to define all their terms. It must be assumed that it was in the interests of timely production that the editors declined the task of re-writing the mathematical expositions in a uniform notation.

Turning from the manner to the matter of the book, this is undoubtedly a valuable contribution to the science of com-

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more complicated but efficient algorithms; but these circumstances have so far been rare. The bottleneck problems present a different story; here they need one of the modified algorithms for the classical case, and if these have to be written, the little extra effort to cover both types of assignment could be faced.

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Book Reviews

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puter design. It is becoming increasingly important that means should be found for reducing the dependence of the performance of a system on that of its components. For various reasons, components may be inaccessible for replacement or repair, or the system must operate continuously, allowing no opportunity for maintenance. The idea of using some form of redundancy to achieve this end is by no means new, even in the computer field. It cannot be claimed that redundancy offers a technique where, by using enough equipment, one can achieve an arbitrarily high reliability. On the contrary, as is shown in one paper in this book, in certain by no means unlikely circumstances, by using enough equipment one can achieve an arbitrarily high unreliability. Nevertheless, there are fields of application where the various techniques may have a beneficial effect, and one of the achievements of this book is to begin to define these fields. One fact brought home by a reading of this book is that all too little is known of the statistical behaviour of large assemblies of components, how this behaviour is influenced by the properties of the components, and even the properties of the components themselves. If the publication of this book has the effect of stimulating research into these problems, it will have performed a great service to the designers and users of future generations of computers.

J. B. STRINGER.

Machine Independent Computer Programming, by MAURICE H. HALSTEAD, 1962; 267 pages. (Washington, D.C.: *Spartan Books*, $6.50.)

While we have increasing interest in and discussion of many varieties of mathematical and commercial source languages little has been published on the actual process of translation of a language to machine code, particularly in a manner that the student or non-specialist programmer can readily understand. Dr. Halstead has provided us with a primer of compiling technique, and we must be glad that he has been able to strip away the cabalistic overtones of the process so neatly.

The subject of this book is the Nelliac language and the minimum compiler required to compile itself in that language. Appendices illustrate actual compilers, expressed in the source language, to run on three different machines, and a Nelliac program for one of these that will accept absolute octal machine code as input and will therefrom produce Nelliac statements—a decompiler.

Nelliac is claimed to be a dialect of ALGOL 58; the latter was doubtless the inspiration of the Nelliac effort but the notation and format of the language differ so much that it is perhaps better considered a separate language. Remembering that the first rudimentary Nelliac compiler began running in February 1959 this difference is hardly a fault. Most of the notational flexibility of ALGOL in such matters as recursion, block structure, variable arrays, compound conditionals, formal parameters and functions has disappeared in Nelliac, deliberately, to leave a language suitable for single-pass compilation to absolute machine code. Unfortunately the resulting notation is unnecessarily difficult to read, and probably to write, accurately, particularly in the case of subroutines and conditional expressions. The required niceties of punctuation lack the redundancy required for easy comprehension.

The Nelliac language is more slanted towards data processing than either ALGOL or FORTRAN, and the user is more aware that he is using a computing machine. An example of the latter is the very useful implicit definition of the machine working store as an array in the language. This feature would seem necessary in a self-compiling compiler. The reader should note that the terms "function" and "procedure" have very different meanings in Nelliac from those more widely accepted through the influence of ALGOL.

The whole family of Nelliac compilers uses the technique of "generators", where the occurrence of given successions of symbols in the source text triggers the inclusion of predefined blocks of machine code. The book describes the exact coding for one computer; from the acquisition of individual characters of the source text from the input unit to the siting of the compiled object program in the working store of the computer, ready to run. Because of this ultimate transformation to absolute code the book also serves as a valuable handbook on single-pass assembly schemes.

The decompilation program included in the appendices completes the circle of source text to machine code to source text. Moreover, it is shown that programs originally written in machine code can be decompiled successfully, and it is claimed that this process can be a powerful aid in "debugging" machine code programs. The fact that any meaningful sequence of machine instructions can be converted mechanically to a meaningful sequence of Nelliac text on at least one machine would seem to call for some studies of the properties of those machine/language pairs for which this relationship holds.

It is unfortunate that whole-hearted recommendation of the content of this book must be tempered by concern at the low quality of the typesetting. Not only are there misprints, and footnotes that have wandered from their proper page, but here and there whole lines would appear to have been omitted by the printer.

H. D. BAECKER.