that their book reads rather like a list of ingenious inventions, connected only by a thin thread. It is rather a reflexion on their students, because the authors are very competent mathematicians, who could well have produced a unified, deductive mathematical theory, so that all devices (also those which do not yet exist) would fall into their place. But they are also experienced teachers in a department of electrical engineering, and it appears that in their judgment such a mathematically based treatment would have been above the head of the average student. One may think, though, that they have gone a little too far. All their mathematics is compressed into some fifteen pages of appendixes. The text contains only formulæ without proof. Will it really help the student if he memorizes that a velocity jump upwards reduces the noise in an electron beam, without a proof, which would have taken only two lines of mathematics, or a simple diagram ? Will anybody who has only memorized the Manley–Rowe relations be able to apply them correctly ? This is a book which ought to go into several editions, revised and brought up to date. I wish that in the second edition the authors would add fifty pages or so of mathematics for the student who has more mental equipment than just a memory.

I do not want to obscure by these strictures the fact that this is a highly useful and important book, from which almost everybody will learn many new things. Some idea of the contents is given by the chapter headings: general principles, electron guns and focusing, klystron amplifiers, the reflex klystron, the travelling-wave tube amplifier, slow-wave structures, further tubes of the travelling-wave type, the magnetron and related tubes, parametric devices, cyclotron wave tubes, masers and semiconductor devices. The list of the "-trons" discussed would fill almost a page. Apart from being a text-book for the student, this book is a most impressive documentation of the staggering amount of inventive ingenuity which has gone into one of the explosive technical developments of our times.

D. GABOR

PHYSICS OF FAILURE

Physics of Failure in Electronics

Edited by M. F. Goldberg and Joseph Vaccaro. Pp. vi+255. (Baltimore, Md.: Spartan Books, Inc.; London: Cleaver-Hume Press, 1963.) 60*s*.

As the complexity of systems using electronic components increases, the designer is continually being confronted with new difficulties. One of the most challenging of his problems is that of ensuring reliability. Two typical classes of system where component stability is of crucial importance are those which are used in the control of missiles or artificial satellites, and those which will replace the present generation of digital computers. In the first class of system, reliability must be of the highest order since once the missile is fired no servicing is possible. In the second, one is more directly concerned with the statistical probability of component failure for, although servicing is theoretically possible in this case, it is not always practically so—if the system contains some 8 million active and 20 million passive components (as one such envisaged system does) it is unlikely that the system will ever work, unless component reliability is of the very highest order, because failure probability will always be critically high somewhere in the system.

The two classes of problem are, of course, not really distinct, nor are the questions that they raise. However, the latter type perhaps better illustrates the difficulty facing the engineer. In order that the most complex system shall function at all satisfactorily, the mean lifetime required of any component may well be so long that it is impossible to predict its achievement by merely life-testing samples from production batches. If, for example, a mean lifetime of 5 years were needed—before sampling technique could establish that component reliability of this order had been achieved—the system design would most probably have become obsolete.

Clearly the need for a new approach to the problem has become critical and it is this situation which has given birth to 'the physics of failure' as a subject in its own right. The aim of the 'failure physicist' is to investigate the causes of failure of components at the 'molecular engineering' level, thereby establishing the precise way in which his components are likely to fail under environmental stresses. This done, he should then be able to design components the lifetime of which under known or predicted stresses can be calculated from a set of 'failure equations'. The production batch tests on which prediction of reliability has for so long been based tell us nothing of the fundamental failure mechanisms and, in consequence, this new approach to the problem involves radically different techniques. The problem in general is admirably presented in the several survey papers contained in *Physics of Failure in Electronics*, which represents the proceedings of the first symposium ever to be entirely devoted to the subject. This was held in Chicago in September 1962 under the sponsorship of the Applied Research Laboratory of Rome Air Development Centre and the Armour Research Foundation of the Illinois Institute of Technology, and was attended by 350 people.

Apart from the survey papers, many more specific aspects of the subject were discussed. Several of the papers included deal with failure of specific components, for example, "The Physics of Resistor Failure"; "The Effect of Radiation Damage on Capacitance of Silicon Diodes", etc., while others are more concerned with what are essentially basic materials problems. Among these are to be found such topics as "A Study of the Primary Modes of Failure Occurring at Material Interfaces in Thin-Film Solid State Devices" and "Dislocation and Semiconductor Device Failure". Among 'active' devices specifically considered are travelling-wave tubes, and two papers consider the effects of residual gases on tube behaviour and life. There are of course also, as is to be expected, a number of papers devoted to failure mechanisms in transistors, tunnel-diodes and other active, solid-state devices.

The precepts of this emergent branch of physical/mathematical science are, as we have said, outlined in the survey papers, and even if the outline is not altogether without ambiguity and contradiction, the volume presents an excellent introduction to a new way of thinking about an old problem. It is unusual for published symposium proceedings to provide a good introduction to a subject, but this book is an exception and fully deserving of a place on the shelves of both the engineer/physicist approaching the subject for the first time and the reliability/life-study scientist for whom these problems have been a bane for so long.

G. D. SIMS

SUGAR TECHNOLOGY

Proceedings of the International Society of Sugar Cane Technologists

Eleventh Congress, Mauritius, September 24–October 5, 1962. Edited by J. R. Williams. Pp. lviii+1250. (Amsterdam, London, New York: Elsevier Publishing Company, 1963.) 200*s*.

This handsome, but not handy (weight 6 lb.), volume contains the texts of papers presented to the eleventh congress of the International Society of Sugar Cane Technologists. Various aspects of the cultivation of sugar cane (agriculture, breeding, entomology, pathology) are dealt with in 105 papers (770 pages); 16 papers (120 pages) and 19 papers (200 pages), respectively, are devoted to certain problems of processing and engineering encountered in the raw sugar factory, and 7 papers (75 pages) contain some information concerning by-products.