several things stand out: very excellent production and careful copy editing, including discussions following papers; about 70 lecturers from the US, one Canadian, two from the United Kingdom, and two Scandinavians—with the two-week meeting held in Bergen, Norway; and the very high price.

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Light at the junctions

THE PHYSICS OF ELECTROLUMINESCENT DEVICES. By P. R. Thornton. 382 pp. Barnes & Noble, New York, 1967. $14.50

by D. G. Thomas

This book begins with the brave statement that the study of electroluminescence is not one for faint hearts. One wonders sometimes whether there is a branch of physics, and particularly one that aspires to be useful, that can be tackled by faint hearts. But it is probably true that the subject of electroluminescence, that is, the direct conversion of electrical energy into visible or near-visible light by exciting a solid without significantly heating it, is one that had better be approached with a certain ebullience of spirit. The trouble is not the magnitude of the intellectual challenge, but rather the demands that are made on patience and imagination. There is great variety to the field, which spreads over the physics and chemistry of semiconductors. This book deals chiefly with the physics of the subject to omit any discussion of materials preparation. The author points out that materials preparation is extremely important, but a proper discussion would occupy too much space.

Generally speaking, a straightforward, elementary and reasonably critical account is given. The author presents an outline of the theory, such as it is, of the various subjects. The treatments are brief and not very deep; thus the theory of p–n junctions under forward and reverse bias are given, but for an appreciation of the problems that remain and of the approximations that have been made it would be necessary to refer to the original literature to which adequate references are supplied. Nevertheless the summaries are a useful introduction to the main subject of the book, which consists of an account of various specific electroluminescent processes. The immensely detailed work on the "classical" electroluminescent system of zinc sulfide embedded in a plastic dielectric is summarized, and the author gives an appropriate critique. More attention is given to electroluminescence generated by the dc forward biasing of well defined p–n junctions, and this reflects the direction the field is taking today. Spontaneous emission from gallium arsenide, gallium phosphide, silicon carbide and various semiconductor alloys is dealt with quite competently as far as the subject allows it. There is a quite lengthy account of injection lasers, which, as the author writes, is a more satisfying subject as one can say a good deal about it that is both clear and relevant. It is unfortunate that at present these devices do not work continuously at room temperature, and only exceptional ones generate visible light. These limitations are pointed out in the book and comments are made upon their possible solutions. The book concludes with a reasonable discussion of the applications of electroluminescent devices and touches on the dismal subject of their possible failure.

There are a few 1966 references, but most of the work pertains to 1965 or earlier. Inevitably, therefore, in places the book is out of date. Thus the author states that efficiencies of electroluminescence from gallum phosphide are in the range 0.01–0.04% at room temperature, whereas in fact today they are roughly 100 times these values.

The field of electroluminescence is one of growing importance and almost certainly will have an impact on electronics technology because it can play a part at that point at which a man confronts his machine. The convenient visual display of information will clearly be valuable.

P. R. Thornton, who has spent three years in England at the Services Electronics Research Laboratory, an institution active in this field, and who now teaches material sciences at the University College of North Wales has given us a useful, critical and well written account of the physics of the subject. It is likely that it will find use for several years among those who are working in the field of electroluminescence and among those, presumably of stout heart, who propose to take it up.

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The reviewer has worked for several years at Bell Telephone Labs with emission of light from semiconductors.

Spinors and spaces

THE THEORY OF SPINORS. (Trans. from 1937 French edition) By Elie Cartan. 157 pp. MIT Press, Cambridge, Mass., 1966. $8.00

by Lawrence C. Biedenharn

Elie Cartan was one of the great mathematicians of this century; for physicists he is probably best known for his fundamental work on Lie groups. It is probably not well known that Cartan developed the *general* theory of spinors in 1913, a dozen years before Wolfgang Pauli made the spin-$^1/_2$ system a commonplace in physics (the name "spinor" stems from this latter application).

The present book is a translation (the the first in English) of Cartan's lectures on spinors in 1937—a classic of the mathematical literature. Cartan's purpose in these lectures is to develop the theory of spinors from a purely *geometrical* point of view, in contrast to earlier treatments, such as that of Weyl and Brauer. (A second motivation, for Cartan, was the desire to extend Paul Dirac's equations to general relativity; on this particular subject the present book is now somewhat out of date; the recent literature is cited in B. S. Dewitt, *Relativity, Groups and Topology*, Gordon and Breach, New York, 1965.)

The lectures were aimed at a general audience and develop the necessary techniques for linear representations of groups from the beginning by employing the (now familiar) method of infinitesimal generators. The work divides into two main parts: The first treats generalities on rotations and reflections in n-space, linear representations and the theory of spinors in 3-space; the second treats the theory of spinors in n-space including Minkowski space and Riemannian geometry.

Cartan's geometrical view of spinors can be best illustrated, for physicists nowadays, by reversing his order of presentation. Consider an arbitrary vector V in ordinary 3-space and the Pauli matrix vector σ. If we define a