

state, band structure, Brillouin zones and a little about intermetallic compounds.

This is a formidable amount of material, especially when one sees what the author means when he writes in the preface that he wants to discuss inorganic systems "without simply stating results". He has certainly achieved this aim: there are three pages showing line by line how to pass from Cartesian to spherical polar coordinates in the expansion of ∇^2 ; and there are four pages in small type working in detail through the Kronig-Penney model of a lattice.

It is impossible in a book of this kind to keep a uniform mathematical level. Thus the calculus of variations, which is hard, comes on page 103, just ten pages before the use of an Argand diagram, which is easy. There does not seem to be much that is wrong, though someone new to the Dirac δ -function might be surprised to see it defined (page 131) by $f(x) = \int f(x) \delta(x-x) dx$. Almost inevitably there is a certain inelegance when so much ground has to be covered (for example, the proof of the Uncertainty Principle on page 158).

On the good side it must be said that most of the mathematics really is clear, and the diagrams are excellent, so that if a student were to take up this book and work steadily through it, without any doubt he would be able to learn a lot. It would be an excellent book, not so much for class use, but as a reference volume to which a student could be referred if he found his class lectures unpalatable. C. A. COULSON

Ornithological Statistics

The Visible Migration of Birds at Ottenby, Sweden. Edited by Carl Edelstam. Drawings by Harald Wiberg. Pp. 360. (Swedish Ornithological Association: Stockholm, 1972.) 95 Sw. cr.

THIS is an extraordinary book in several senses of the word. Teams at many bird observatories have counted the birds daily migrating past. In the few cases where analyses have been published it is usually stated that the original data have been deposited at some institute. The Ottenby team decided that this was not good enough and have deposited the original data in the reader's lap. Interpretation and commentary occupy less than a fifth of the book—a tenth, really, since each page is half English, half Swedish.

The data concern ten years, 1947 to 1956, June to October, and 1,509 observation days. The yearly totals for sixty species are presented in the form of histograms elegantly spaced over ten pages. These are then re-sorted into a further set of 10-day period histograms. Then the daily totals for each species

for each year are set out, again as histograms, over 180 pages. The monotony of page (36×22.5 cm) after page of black bars and white space is offset by an elegant line drawing of each species.

Next the hourly variations within each 10-day period are presented in the form of two seven-step ladders, on the rungs of which the histograms are mounted. The extravagance of the layout is even more apparent here, for in half the 70 species given a page apiece, the left or right hand ladder is completely empty.

The production is impeccable, the paper quality high, the draughtsmanship superb, the amount of work appalling. Yet what does it achieve? Certainly, as pointed out in the commentaries, impressions can be gained by visual inspection, but to test them recourse to the original numerical data is still needed. These could be extracted by measurement (the histograms are meticulously accurate) but it would have been simpler (and not much duller) to have the numbers themselves, and to use histograms to illustrate particular points that statistical analysis had shown to be valid.

There is little doubt that this book will remain unique. A wide sale cannot be forecast. G. V. T. MATTHEWS

Geometrical Optics

The Optics of Rays, Wavefronts and Caustics. By O. N. Stavroudis. Pp. xvi+313. (Academic: New York and London, October 1972.) \$18.

THIS interesting and unusual book on geometrical optics begins (after an historical introduction) by obtaining the concept of a ray path in a medium of continuously varying refractive index via the calculus of variations, and continues with an account of the differential geometry of curvature and torsion of generalized space curves. Then the Hilbert integral is defined and used to deduce the mathematical concepts of the wavefront as a transversal of a two-parameter family of rays and the caustic as the envelope of such a family. Snell's law is then derived for a medium of sectionally-continuous refractive index.

Contact with the bread-and-butter of geometrical optics is made in a discussion of ray tracing, but the treatment is at an esoteric level with no real mention of how to do ray tracing in cases of practical interest. It is probably fair to assume, however, that no neophyte in need of such advice would buy the book anyway.

Chapter seven establishes the general condition for the existence of a wavefront to a set of rays and Malus's theorem is formally proved. The chapter on "Generalized Raytracing" concerns the propagation of an element of wavefront through a system and represents, in effect, a generalized paraxial

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ray trace in which the optical axis is replaced by a skew finite ray.

The discussion on classical aberration theory includes Hamilton's characteristic function, Hertzberger's diaphragm theory, and an incomplete account of the Seidel aberrations. This is preceded by a partially successful attempt to produce the reverse of the well-known Luneburg derivation of the fundamental properties of geometrical optics from Maxwell's equations.

A radically different mechanism of image analysis is then studied in the form of Hertzberger's fundamental optical invariant and its scalar form the lens equation. This is a system of first-order partial differential equations involving ray coordinates and directions at the object and image planes. The book closes with a closely-reasoned but slightly tongue-in-cheek application of algebraic group theory to lenses—heady stuff for lens designers.

In summary, there is little in the book to cause the designer to rush to the coding sheet to rewrite his programs—it is not a book of that level. But for those of us who enjoy an occasional dip into the rigours of Luneburg there is much here to interest and stimulate, and the author succeeds in guiding us through the welter of mathematics with an entertaining and readable style. JOHN MACDONALD