

Engineering Metrology by G. G. Thomas, Halsted Press, 1974, 420 pages, \$17.50.

REVIEWED BY R. A. DASKIVICH¹

This book is written for readers with divergent interests. The first half treats the physics and mathematics of optical metrology while the final chapters include topics familiar to the practicing metrologist. Subject matter will be reviewed in order of appearance in the text.

Interferometers of various types are effectively presented in Chapter 1 through the use of many examples. Perhaps too much emphasis is placed on the physics of laser action in underlining the importance of this device as a coherent source. Once introduced, the laser is extensively discussed in the second chapter.

Fourier transform theory is used to present the concepts of spatial and temporal coherence in Chapter 2. The section on laser design and an exhaustive listing of various laser types are unexpected in a book addressing metrology. This level of detail continues in the following chapter on holography.

Fundamental principles of holography incorporate a mathematical development usually found in a graduate course in coherent optics. Holographic interferometry is discussed to the point of exploring the photochemical processes characteristic of various recording media. The object of this discussion is to provide an understanding of the resolution now obtainable with interferometric holograms. Factors which limit the uses of holography are the final topic in Chapter 3.

Moire fringes are easier to produce than holograms and the point is made early in Chapter 4 that most engineering measurements do not require precision to a fraction of a light wavelength. An analytical treatment of diffraction gratings accompanies the material on moire fringes. Details of diffraction grating manufacture (including a section on ruling engines) convey an appreciation for sources of error in optical gratings. This completes the optical metrology material, and the balance of the book encompasses subjects on the mechanics of metrology.

Length and diameter discussions commence with the SI definition of the meter in Chapter 5. Gauge blocks and the mysteries of wringing are treated thoroughly at the expense of diameter standards which receive only two pages. Instruments from the micrometer to 3-axis measuring machines are included with the notable omission of air gauges.

The chapter on angle measurement uses many developments from the National Physical Laboratory to illustrate calibration techniques. An extensive treatment of grating prisms is followed by an effective presentation of the autocollimator. Applications of the sine bar, radial gratings, and miscellaneous procedures of angle metrology round out this section.

While angle measurement requires no absolute reference standard, straightness is the fundamental form in metrology. Chapter 7 cites straightness measurement techniques from the knife-edge and theodolite to numerous applications of the alignment telescope including marine engine bearing alignment and nuclear power station

layout. The author's broad industrial experience is further indicated by an illustration of the Rodolite to qualify a gear hobbing machine. This statement from the three pages on flatness illustrates the meager knowledge generally available on this concept: "Surface finish is a feature of flatness which is functional."

In Chapter 8 surface texture is addressed with emphasis on principles and history of instrumentation at the expense of current industrial practice. The relation between function, production costs, and surface texture permeates the text. The Opitz classification scheme for surface function serves as an outline for treating surface interactions during elastohydrodynamic lubrication, running-in, and solid-to-solid contact. Surface texture instruments surveyed include optical, electron-optical, interferometric, surface adsorption, capacitance and stylus devices. A brief history of the E-system and M-system precedes an enumeration of statistical parameters used to specify surface roughness. Present problems in surface texture measurement are succinctly stated at the end of the chapter. This and the succeeding chapter on roundness are most useful for the metrologist-engineer.

Departures from roundness have presented some of the greatest measuring challenges in metrology. The final chapter of the book contains a complete overview of the importance of roundness, the instrumentation used and the standards employed. A subtle distinction is made between roundness and circularity. The advantages and limitations of rotating spindle vs rotating part instruments are clearly delineated. A section on the interpretation of polar charts is well done, but more attention to reference centers might be warranted. Details of the least-squares center predominate the discussion although the minimum radial separation center is preferred in the U.S. Mention of several commercially available roundness instruments and material on calibration and accuracy end the book.

In summary, the first half of *Engineering Metrology* stresses the physics and mathematics of optical metrology. The format uses subject headings and well-placed line drawings effectively. The British standards cited throughout the text are most useful to those involved with engineering in the United Kingdom. As a whole, the book is a useful reference for metrologists and precision engineers. Finally, the chapters on surface texture and roundness provide a basis in metrology for students and practicing engineers alike.

Modern Developments in Lubrication Mechanics, J. A. Walowit and J. N. Anno, Halsted Press, 1975, \$31.50.

REVIEWED BY B. J. HAMROCK¹

The text treats three selected developments in lubrication mechanics; elastohydrodynamic lubrication, metalworking lubrication, and foil bearing operation. In giving a treatment of these three areas

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the authors attempt to unify various modes of boundary deformation with lubrication theory. The author's objective in preparing this book was to fill the gap between works on elastohydrodynamic lubrication and the other modes of boundary deformation that occur in metalworking lubrication and foil bearing operation.

In order to give the reader the proper background to deal with the subject matter in these three specialized areas, background information in hydrodynamics, elastic and plastic theory is covered in the text. This material is presented not only to make the text self-contained but also to present a modern treatment of these topics as they relate to lubrication theory.

The first chapter of the text is devoted to providing the reader with background information. Information is also provided about Cartesian tensors. The authors then develop in Chapter 2 the background information for the hydrodynamic theory of lubrication. The Navier-Stokes equations are first presented which are reduced first to the boundary layer equations and then the Reynolds equations. Simple examples of slider and journal bearings are presented to illustrate the use of the Reynolds equation. The chapter concludes with the presentation of the energy equation.

Chapter 3 derives the basic mathematical principles of elasticity as they relate to the boundary deformation of a lubrication contact. Within the chapter the Hertzian contact problem is presented which determines the size of the contact zone and the pressure for a given geometry, elastic properties and load.

Having developed the Reynolds and elasticity equations, the authors then couple these effects in Chapter 4 to give the elastohydrodynamic lubrication of line contacts as first derived by Grubin. Dowson and Higginson's minimum film thickness formula for line contacts is also presented. The chapter concludes with a discussion of thermal elastohydrodynamic lubrication including design curves and experimental results. The reviewer found this chapter inadequate since it does not cover developments of the last ten years on lubricant starvation, elastohydrodynamic lubrication of low elastic modulus materials, and point lubrication.

Chapter 5 briefly describes the principles of plasticity as they relate to lubrication theory. Chapter 6 then makes use of these principles to describe metalworking lubrication. Within this chapter the sheet rolling process and the axisymmetric deformation processes are presented. The material presented in this chapter represents the first complete presentation of metalworking lubrication in a text and therefore represents a major contribution by the authors.

The final chapter is devoted to foil bearing theory. Within the chapter the authors cover the perfectly flexible and the elastic foil types, as well as the bending-dominated foil bearing. Design curves are also presented.

In conclusion the reviewer feels that the book would be a good addition to the library of the lubrication engineer. In particular it is felt that the chapters on metalworking and foil bearing operations will be of great use. Furthermore, the background chapters on hydrodynamic lubrication, elasticity and plasticity should also be helpful. However, the reviewer feels that the chapter on elastohydrodynamic lubrication does not adequately describe the subject matter.

Modern Lubricating Greases, C. J. Boner, Scholium International Inc., Flushing, New York, July 15, 1976, 339 pp., \$27.00.

REVIEWED BY G. L. HARTING¹

A review of lubricating grease technology entitled, *Modern Lubricating Greases* has recently been introduced by Scientific Publi-

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cations Ltd. This text was authored by C. J. Boner and is essentially an addendum to his *Manufacture and Application of Lubricating Greases* which was published in 1954. Boner's new book is primarily based on literature and patent sources which appeared between 1955 and 1974.

In assessing the merits of *Modern Lubricating Greases* it is important at the outset to state that the book does not contain any original contributions to lubricating grease technology. If the reader is hoping to find any new insights into how greases function or the mechanisms by which grease compositions influence performance, he will be sorely disappointed. The author simply presents a compendium of literature references which had been previously published and makes no attempt to translate this information into any unified theories of grease technology.

Modern Lubricating Greases is an expanded bibliography of the technical literature related to grease technology which has appeared within the last 20 years and as such constitutes a useful reference for both grease formulators and lubrication engineers. The text covers a wide range of subjects from the microstructure of greases to advice on practical applications and is well footnoted so that the reader can easily refer to the original sources of any item of interest for additional details. The author has concentrated on those contributions to grease technology which were most significant and has not included subjects of marginal importance. In *Modern Lubricating Greases* the author has also simplified the text by avoiding the use of detailed grease formulations and has relied on more general descriptions of grease compositions.

However, as a bibliography *Modern Lubricating Greases* is not without its faults, the most serious of which is a lack of organization. An example of poor organization is found in the second chapter of the text in which the author reviews the influence of various components on finished grease properties. The chapter opens with summaries of the ways in which both base fluids and soap gellants contribute to the properties of a grease. At this point, however, the text abruptly digresses into discussions of definitions of various grease properties, the dielectric constants of greases, friction reduction, etc. Only later does the text return to the initial topic, the influence of components on properties, by reviewing the influence of inorganic gellants, polymers and additives. This interruption of the primary topic of the chapter made the text less readable than it might have been.

Poor textual organization was also evidenced by the occasional inclusion of topics in chapters which were not appropriate to their subject matter. For instance, a discussion of the factors which influence the performance of greases in rolling element bearings is located in a chapter entitled "Containers, Equipment and Methods for Application." This topic would have been more appropriately placed in the subsequent chapter in which Application Recommendations were discussed. A carefully detailed Index might have served to compensate for this poor topical organization. Unfortunately, the Index is not extensive and consequently is of little help in locating topics in the text.

Overall, *Modern Lubricating Greases* successfully distills 20 years of grease literature into a single volume, and, if the reader can decode the logic of its organization, it could be a useful reference book for the grease technologist.

Principles of Tribology, J. Halling (editor), Scholium International Inc., 130 East 31 Street, New York, NY 11354, 401 pages, 1976, \$22.50.

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The field of tribology is still in a developmental stage where textbooks come and go rapidly. A few years ago a treatment of lubrication would have dealt almost exclusively with hydrodynamic bearings, and

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