to the finite element and finite difference methods followed by fundamental numerical aspects for static problems. After that, a long chapter deals with eigenvalue problems, with special attention to cyclic symmetric structures occurring in machine dynamics. Numerical integration techniques for dynamic analysis are also discussed. A special chapter at the end of the book deals with case studies, which are also partly included in the different previous chapters. All parts of the book contain both the fundamental theoretical foundations of the described methods as well as scientific and industrial applications.

The book is written for students of mechanical engineering interested in numerical methods for static and dynamic problems in applied mechanics. However, it is also a useful tool for scientists and engineers working in this field in industry and universities. For both, students and engineers, the book can be highly recommended as helpful support in the study of the fundamentals of numerical dynamics and the solution of related problems.

H. IRRETIER

ULTRASONICS—FUNDAMENTALS AND APPLICATIONS, 1992, by H. Kuttruff. London and New York: Elsevier Applied Science. 452+xiv pp. Price £87.00. ISBN 1-85166-553-6.

This book is a translation of *Physik und Technik des Ultraschalls*, which was published in 1988 by S. Verlag, Stuttgart, the original having been based on lectures given by the author to students of electrical engineering and physics. Using general acoustics as a basis, it sets out to examine the nature of sound of frequency >20 kHz. The book is consequently divided into two sections, the first (chapters 1–8) outlining the basis of ultrasonics, and the second dealing with the applications (chapters 9–15).

Following an Introduction, in which ultrasound is placed in the context of wave and materials science and historical, natural and physical perspectives are introduced (chapter 1), the basic concepts of acoustics are presented without systematic derivation of formulae (chapter 2). These include a discussion of the parameters which quantify an acoustic field, and of aspects of sound propagation (e.g., the wave equation, plane and spherical waves, energy density and intensity, and non-linear effects). The chapter concludes with descriptions of sound waves in solids, reflection and refraction, and Doppler effects. In almost all cases, detailed derivations and proofs are omitted, and the reader is urged to consult "any good textbook on acoustics", although none are specifically recommended within the body of the text. At the back of the book there is a bibliography of some 22 such textbooks, although no further indication is given as to their content or level. Although detailed proofs are generally omitted, this is not to say that the mathematical notation employed is elementary: for example, the first two examples in chapter 2 employ tensor and vector differential notation with minimum preamble.

Chapter 3 is concerned with the radiation and diffraction of sound, the latter being seen as a secondary radiation from objects of finite size. Attention is drawn to the specific aspects of these two phenomena as they relate to ultrasonic frequencies. The representation of linear systems in time and frequency is discussed, the author keeping the formulation general enough to apply to either acoustic or electrical signals. This is followed by an explanation of point source synthesis and radiation from a piston (transient and steady state radiation from a circular piston, uniform and non-uniform piston surface velocity). This exposition of the basics of acoustic radiation from vibrating surfaces lays the foundation for a detailed discussion of the generation of ultrasound, to which chapters 4 and 5 are devoted. Chapter 4 is a discussion of the exploitation of the piezoelectric effect through matrix representation and lattice displacement, and its application in transducers which may be matched, loaded or electrically resonant. Descriptions through formulation and materials science are complementary in this chapter, which closes with useful practical

hints on the design of piezoelectric ultrasonic generators. While the emphasis in chapter 4 is on the plane piezoelectric transducer operating in thickness mode, chapter 5 extends the topic of generation begun in chapter 4 to transduction techniques other than the piezoelectric (specifically magnetostrictive, electrostatic and mechanical techniques), and outlines other modes (e.g., bending) and also the variety of fields (e.g., very high frequency focused) and waves (shear, Rayleigh) that can be generated. These sections are more descriptive than mathematical.

The complementary problem of the detection of ultrasound is the subject of chapter 6. After an initial mathematical discussion of the use of a reversible piezoelectric plate, the principles of reciprocity and calibration are introduced. The chapter describes sensors which utilize a range of phenomena in the detection of ultrasound (piezoelectric, electrostatic, mechanical, thermal and optical, the latter including techniques for visualization of the field). The specific problem of the detection of hypersound (frequency >1 GHz) in solids, also called "microwave acoustics", is discussed in chapter 7. The distinction of hypersound from ultrasound arises because at such high frequencies quantum effects become noticeable. Parallels are made with optics to more easily discuss such phenomena as coherent and incoherent hypersound, and phonon behaviour and energy. These ideas are extended to discuss optoacoustics interactions, and the generation/detection of hypersound through thermal and superconduction interactions. The first part of the book closes in chapter 8 with a discussion of the absorption of ultrasound in gases, liquids and solids. The various mechanisms are outlined: for liquids the importance of viscous and thermal effects are outlined with a discussion of conduction, molecular relaxation and molecular association effects; for solids the additional dissipative effects due to polycrystalinity, dislocations, polymer, phonon and electron effects due to polycrystallinity, dislocations, polymer, phonon and electron effects are described through a mainly qualitative exposition. Chapter 8 ends with a quantative and practical discussion of the measurement of ultrasonic sound speed and attenuation.

The second part of the book opens with a discussion of the application of signal processing and measurement to the field of ultrasonics (chapter 9). Acoustic delay lines exhibiting monomode or muti-mode propagation, Rayleigh wave filters and other Surface Acoustic Wave devices, optical interactions (Debye–Sears and Bragg diffraction) and Doppler applications are discussed. A description of the importance of method (e.g., transmission/reflection, impulse/continuous wave, resonance techniques, etc.) and of wave, transducer, display and material type to non-destructive materials testing by low power ultrasound (chapter 10) lay the foundation for a series of practical examples of flaw detection.

The use of ultrasound as an (ideally) non-invasive tool for medical diagnosis is the topic of chapter 11. A survey of impulse echo technology follows a brief description of the acoustic properties of biological tissue at MHz frequencies. Issues covered include transducer and display types, scanning procedures and applications. The chapter concludes with a description of Doppler sonography.

The exploitation of ultrasound not as simply a diagnostic tool but as a method of producing sharp images is explored in chapter 12. The importance to microscopy of phase information, the limitations in frequency imposed by resolution and attenuation requirements, and the consideration which must be given to the design of transducer and lens and to the coupling medium, are discussed. The principles of acoustic holography and tomography are introduced.

Ultrasonically induced cavitation is the subject of chapter 13. After a description of the dynamics of an idealized single spherical bubble, where the behaviour is categorized by the division between "gaseous" and "hard" cavitation, the phenomena of cavitation nucleation, erosion, sonoluminescence and sonochemistry are introduced. Although the salient

features are covered, space limitations prohibit a comprehensive review of these processes.

Various applications of high intensity ultrasound are discussed in chapter 14, specifically cleaning, joining/welding, machining and the production of dispersions. The mechanisms for action are described, the relative merits of the ultrasonic and competing techniques are compared (e.g., for cost and range of application), and the practical details of apparatus, geometry, acoustic parameters and procedure are expounded. Other applications (e.g., degassing, diffusion acceleration and inclusion aggregation) are briefly mentioned, and the chapter concludes with an introduction to therapeutic ultrasound, although space prohibits mention of the more recent advances.

The possibility of an ultrasonically induced health risk is the topic of the final chapter. The author concentrates on airborne and diagnostic ultrasound, for the latter specifically investigating the risks arising through thermal, mechanical and cavitational mechanisms. For these three the author performs rudimentary calculations in support of a time-average intensity of 0·1 W/cm^2, below which ultrasound may be considered to be harmless. Space does not allow for a review of the very considerable body of literature on the current experimental and legislative work in this field. Throughout this book there are examples of topics which are not discussed to the limit of current knowledge, and it would not be reasonable to expect a text of this type (based as it is on a student lecture course) to cover them. Reflecting this, there are only a small number of references given at the end of each chapter, and some of these refer to German language publications, again reflecting the origins of the book.

The book generally comprises good written descriptions incorporating physical understanding and practical experience, appealing where necessary to quoted mathematics of a level which would at times require considerable familiarity with basic reference texts to understand its source and basics. Therefore, while it is an excellent book for those who already have a foundation in acoustics, it would not be appropriate for the complete novice as a stand-alone text.

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