Preface

The purpose of this book is to introduce the reader to the acoustic wave concepts required for the design of a wide range of acoustic devices, and to discuss some of these devices in detail. My aim has been to describe a wide range of classical and more recently developed theoretical methods, such as perturbation and coupled wave theories, and to show how these concepts are applied to understanding the wide range of acoustic devices now being used in practical applications. The subjects covered in this book reflect my own research interests during the last ten years. Many of the new results are due to the original work of myself and my colleagues Bert Auld, Marvin Chodorow, Pierre Khuri-Yakub, John Shaw, and Cal Quate, and our research associates and students in the Ginzton Laboratory at Stanford University. Most of the text was first developed for class notes and taught by me, at Stanford, in two separate one-quarter graduate courses, "Theory of Acoustic Devices" and "Analog Signal Processing."

Chapter 1 introduces the reader to the basic concepts of wave propagation in piezoelectric and nonpiezoelectric media, and deals with the theory of piezoelectric transducers in some detail. To keep the theory simple, I have used one-dimensional theories and theories for isotropic media wherever possible. When necessary, it is shown how the theory must be modifed to take account of anisotropic piezoelectric media and to relate the constants used in the one-dimensional theory to the properties of anisotropic materials.

Chapter 2 is concerned with the theory of wave propagation in finite media, waveguide and surface waves. The basic theory of surface wave transducers is dealt with there, as well as concepts of leaky waves and wedge transducers. Again, the theory deals mainly with isotropic media, and it is shown how the results can be modified to take account of anisotropic piezoelectric materials. In this chapter, the reader is introduced to several important and powerful theoretical techniques, such as perturbation, normal mode theory, and the network theory for interdigital transducers.

Chapter 3 deals with diffraction and imaging. The basic theory of diffraction is developed and applied to piston transducers and focused beams, with the acoustic microscope as the prime example. The effects of using short pulses are dealt with, and it is shown how short-pulse-excited systems can be extremely useful in medical and nondestructive testing applications. Electronic focusing with transducer arrays, holography, and tomography are discussed in the last part of the chapter.

Chapter 4 is application-oriented to all kinds of analog signal processing devices. Various ways in which surface acoustic wave devices can be used in practice as filters for taking Fourier transforms in real time, for correlation of signals, for pulse compression, and so on, are discussed. Basic concepts of radar signal processing and spread spectrum communications are also described. It is shown how the same concepts cna be applied for use with other transversal filters such as charge-coupled devices and fiber-optic and superconductive delay lines. Considerable attention is paid to applications of charge-coupled devices. The last part of the chapter is devoted to acousto-optic devices and shows how these devices can be used to realize many of the concepts developed earlier in the chapter.

Many have helped me with this book and deserve thanks for doing so. I began teaching the first course on which this book is based in 1976; since then, many of my students have pointed out errors and made helpful suggestions. There have been so many, in fact, that by singling out some for praise, I am bound to neglect others who deserve equal mention, and so I thank all of them. Those whom I particularly remember as having made major contributions are Rick Baer, Tim Corle, Mindy Garber, Jonathan Green, Steve Hessel, Didier Husson, Robert Joly, Lou Lome, Kent Peterson, Alan Selfridge, and Fred Stanke.

I would also like to thank my friends and colleagues Eric Ash, Bert Auld, Marvin Chodorow, John Shaw, and Cal Quate for many stimulating discussions on acoustic concepts, as well as Simon Bennett, whose detailed comments enhanced my discussion of imaging and microscopy. I owe special thanks to Pierre Khuri-Yakub for the many research ideas we have generated together over the years, and for his helpful suggestions at all stages of the text.

I am grateful to Ching-Hua Chou, who calculated several of the graphs in this book, and to Alan Selfridge, who provided the material for several of the tables in Appendix B.

I would like to thank Melinda Sterling, who typed some of the early drafts, as well as Ingrid Tarien, who has spent many hours, in the years she has worked for me, occupied with the book manuscript and class notes.

I would like to thank my wife, Dorothy, for patiently bearing with me for the several years that it took to create this book.

Finally, I am extremely grateful to my daughter, Carol, who delayed her own

career plans to edit the book and put it in final form for the publishers. She made the text far more readable, caught numerous errors, and despite my many distractions, kept me working hard on the manuscript. Without her, I doubt that this book would ever have been completed.

Gordon S. Kino
Stanford, California