

Musical Mathematics

ON THE ART AND SCIENCE OF ACOUSTIC INSTRUMENTS



Cris Forster

MUSICAL MATHEMATICS

ON THE ART AND SCIENCE OF ACOUSTIC INSTRUMENTS

MUSICAL MATHEMATICS

ON THE ART AND SCIENCE OF ACOUSTIC INSTRUMENTS

Text and Illustrations

by Cris Forster



CHRONICLE BOOKS

SAN FRANCISCO

Copyright © 2010 by Cristiano M.L. Forster

All Rights Reserved. No part of this book may be reproduced in any form without written permission from the publisher.

Library of Congress Cataloging-in-Publication Data available.

ISBN: 978-0-8118-7407-6

Manufactured in the United States.

All royalties from the sale of this book go directly to the Chrysalis Foundation, a public 501(c)3 nonprofit arts and education foundation.

www.chrysalis-foundation.org

Photo Credits:

Will Gullette, Plates 1–12, 14–16.

Norman Seeff, Plate 13.

10 9 8 7 6 5 4 3 2 1

Chronicle Books LLC
680 Second Street
San Francisco, California 94107

www.chroniclebooks.com

In Memory of Page Smith

my enduring teacher

And to Douglas Monsour

our constant friend

I would like to thank the following individuals and foundations for their generous contributions in support of the writing, designing, and typesetting of this work:

Peter Boyer and Terry Gamble-Boyer
The family of Jackson Vanfleet Brown
Thomas Driscoll and Nancy Quinn
Marie-Louise Forster
David Holloway
Jack Jensen and Cathleen O'Brien
James and Deborah Knapp
Ariano Lembi, Aidan and Yuko Fruth-Lembi
Douglas and Jeanne Monsour
Tim O'Shea and Peggy Arent
Fay and Edith Strange
Charles and Helene Wright

Ayrshire Foundation
Chrysalis Foundation

The jewel that we find, we stoop and take't,
Because we see it; but what we do not see
We tread upon, and never think of it.

W. Shakespeare

For more information about
Musical Mathematics: On the Art and Science of Acoustic Instruments
please visit:

www.chrysalis-foundation.org

www.amazon.com

www.chroniclebooks.com

CONTENTS

Foreword by David R. Canright	v
Introduction and Acknowledgments	vii
Tone Notation	ix
List of Symbols	xi
CHAPTER 1 MICA MASS	1
Part I Principles of force, mass, and acceleration	1
Part II Mica mass definitions, mica unit derivations, and sample calculations	14
Notes	24
CHAPTER 2 PLAIN STRING AND WOUND STRING CALCULATIONS	27
Part I Plain strings	27
Part II Wound strings	36
Notes	41
CHAPTER 3 FLEXIBLE STRINGS	44
Part I Transverse traveling and standing waves, and simple harmonic motion in strings	44
Part II Period and frequency equations of waves in strings	54
Part III Length, frequency, and interval ratios of the harmonic series on canon strings	59
Part IV Length, frequency, and interval ratios of non-harmonic tones on canon strings	69
Part V Musical, mathematical, and linguistic origins of length ratios	79
Notes	94
CHAPTER 4 INHARMONIC STRINGS	98
Part I Detailed equations for stiffness in plain strings	98
Part II Equations for coefficients of inharmonicity in cents	108
Part III General equations for stiffness in wound strings	113
Notes	115
CHAPTER 5 PIANO STRINGS VS. CANON STRINGS	118
Part I Transmission and reflection of mechanical and acoustic energy	118
Part II Mechanical impedance and soundboard-to-string impedance ratios	120
Part III Radiation impedance and air-to-soundboard impedance ratios	126
Part IV Dispersion, the speed of bending waves, and critical frequencies in soundboards	130
Part V Methods for tuning piano intervals to beat rates of coincident string harmonics	135
Part VI Musical advantages of thin strings and thin soundboards	141
Notes	143

CHAPTER 6 BARS, RODS, AND TUBES	147
Part I Frequency equations, mode shapes, and restoring forces of free-free bars	147
Part II Free-free bar tuning techniques	160
Part III Frequency equations, mode shapes, and restoring forces of clamped-free bars	174
Part IV Clamped-free bar tuning techniques	176
Notes	178
CHAPTER 7 ACOUSTIC RESONATORS	182
Part I Simple harmonic motion of longitudinal traveling waves in air	182
Part II Equations for the speed of longitudinal waves in solids, liquids, and gases	186
Part III Reflections of longitudinal traveling waves at the closed and open ends of tubes	189
Part IV Acoustic impedance and tube-to-room impedance ratio	196
Part V Longitudinal pressure and displacement standing waves in tubes	200
Part VI Length and frequency equations of tube resonators	203
Part VII Theory of cavity resonators	212
Part VIII Cavity resonator tuning techniques	219
Notes	223
CHAPTER 8 SIMPLE FLUTES	227
Part I Equations for the placement of tone holes on concert flutes and simple flutes	227
Part II Equations for analyzing the tunings of existing flutes	242
Part III Suggestions for making inexpensive yet highly accurate simple flutes	246
Notes	248
CHAPTER 9 THE GEOMETRIC PROGRESSION, LOGARITHMS, AND CENTS	253
Part I Human perception of the harmonic series as a geometric progression	253
Part II Logarithmic processes in mathematics and human hearing	257
Part III Derivations and applications of cent calculations	265
Part IV Logarithmic equations for guitar frets and musical slide rules	271
Notes	276
CHAPTER 10 WESTERN TUNING THEORY AND PRACTICE	280
Part I Definitions of prime, composite, rational, and irrational numbers	281
Part II Greek classifications of ratios, tetrachords, scales, and modes	284
Part III Arithmetic and geometric divisions on canon strings	291
Part IV Philolaus, Euclid, Aristoxenus, and Ptolemy	299
Part V Meantone temperaments, well-temperaments, and equal temperaments	334
Part VI Just intonation	365
Notes	460
CHAPTER 11 WORLD TUNINGS	485
Part I Chinese Music	485
Notes	504

Part II	Indonesian Music: Java	508
	Bali	522
	Notes	535
Part III	Indian Music: Ancient Beginnings	540
	South India	564
	North India	587
	Notes	600
Part IV	Arabian, Persian, and Turkish Music	610
	Notes	774
CHAPTER 12 ORIGINAL INSTRUMENTS		788
<i>Stringed Instruments:</i>		
	Chrysalis	788
	Harmonic/Melodic Canon	790
	Bass Canon	800
	Just Keys	808
<i>Percussion Instruments:</i>		
	Diamond Marimba	824
	Bass Marimba	826
<i>Friction Instrument:</i>		
	Glassdance	828
<i>Wind Instruments:</i>		
	Simple Flutes	833
CHAPTER 13 BUILDING A LITTLE CANON		834
	Parts, materials, labor, and detailed dimensions	834
	Epilog by Heidi Forster	839
Plate 1:	Chrysalis	845
Plate 2:	Harmonic/Melodic Canon	846
Plate 3:	Bass Canon	847
Plate 4:	String Winder (machine)	848
Plate 5:	String Winder (detail)	849
Plate 6:	Just Keys	850
Plate 7:	Diamond Marimba	851
Plate 8:	Bass Marimba	852
Plate 9:	Glassdance	853
Plate 10:	Glassdance (back)	854
Plate 11:	Simple Flutes	855
Plate 12:	Little Canon	856

Plate 13: Cris Forster with Chrysalis	857
Plate 14: Heidi Forster playing Glassdance	858
Plate 15: David Canright, Heidi Forster, and Cris Forster	859
Plate 16: Chrysalis Foundation Workshop	860
Bibliography for Chapters 1–9	861
Bibliography for Chapter 10	866
Bibliography for Chapter 11	871
Bibliography for Chapter 12	877
Appendix A: Frequencies of Eight Octaves of 12-Tone Equal Temperament	879
Appendix B: Conversion Factors	880
Appendix C: Properties of String Making Materials	882
Appendix D: Spring Steel Music Wire Tensile Strength and Break Strength Values	884
Appendix E: Properties of Bar Making Materials	885
Appendix F: Properties of Solids	888
Appendix G: Properties of Liquids	890
Appendix H: Properties of Gases	892
Index	895

Foreword

I met Cris Forster more than thirty years ago. Shortly thereafter, I saw him perform *Song of Myself*, his setting of Walt Whitman poems from *Leaves of Grass*. His delivery was moving and effective. Several of the poems were accompanied by his playing on unique instruments — one an elegant box with many steel strings and moveable bridges, a bit like a koto in concept; the other had a big wheel with strings like spokes from offset hubs, and he rotated the wheel as he played and intoned the poetry. I was fascinated.

Since that time, Cris has built several more instruments of his own design. Each shows exquisite care in conception and impeccable craftsmanship in execution. And of course, they are a delight to hear. Part of what makes them sound so good is his deep understanding of how acoustic musical instruments work, and part is due to his skill in working the materials to his exacting standards.

But another important aspect of their sound, and indeed one of the main reasons Cris could not settle for standard instruments, is that his music uses scales and harmonies that are not found in the standard Western system of intonation (with each octave divided into twelve equal semitones, called equal temperament). Rather, his music employs older notions of consonance, which reach back as far as ancient Greek music and to other cultures across the globe, based on what is called just intonation. Here, the musical intervals that make up the scales and chords are those that occur naturally in the harmonic series of overtones, in stretched flexible strings, and in organ pipes, for example.

In just intonation, the octave is necessarily divided into unequal parts. In comparison to equal temperament, the harmonies of just intonation have been described as smoother, sweeter, and/or more powerful. Many theorists consider just intonation to be the standard of comparison for consonant intervals. There has been a resurgence of interest in just intonation since the latter part of the twentieth century, spurred by such pioneers as Harry Partch and Lou Harrison. Even so, the community of just intonation composers remains comparatively quite small, and the subset of those who employ only acoustic instruments is much smaller still. I know of no other living composer who has created such a large and varied ensemble of high-quality just intoned acoustical instruments, and a body of music for them, as Cris Forster.

Doing what he has done is not easy, far from it. The long process of developing his instruments has required endless experimentation and careful measurement, as well as intense study of the literature on acoustics of musical instruments. In this way Cris has developed deep and rich knowledge of how to design and build instruments that really work. Also, in the service of his composing, Cris has studied the history of intonation practices, not only in the Western tradition, but around the world.

This book is his generous offering of all that hard-earned knowledge, presented as clearly as he can make it, for all of you who have an interest in acoustic musical instrument design and/or musical scales over time and space. The unifying theme is how mathematics applies to music, in both the acoustics of resonant instruments and the analysis of musical scales. The emphasis throughout is to show how to use these mathematical tools, without requiring any background in higher mathematics; all that is required is the ability to do arithmetic on a pocket calculator, and to follow Cris' clear step-by-step instructions and examples. Any more advanced mathematical tools required, such as logarithms, are carefully explained with many illustrative examples.

The first part of the book contains practical information on how to design and build musical instruments, starting from first principles of vibrating sound sources of various kinds. The ideas are explained clearly and thoroughly. Many beautiful figures have been carefully conceived to illuminate the concepts. And when Cris gives, say, formulas for designing flutes, it's not just something he read in a book somewhere (though he has carefully studied many books); rather, you can be

sure it is something he has tried out: he knows it works from direct experience. While some of this information can be found (albeit in a less accessible form) in other books on musical acoustics, other information appears nowhere else. For example, Cris developed a method for tuning the overtones of marimba bars that results in a powerful, unique tone not found in commercial instruments. Step-by-step instructions are given for applying this technique (see Chapter 6). Another innovation is Cris' introduction of a new unit of mass, the "mica," that greatly simplifies calculations using lengths measured in inches. And throughout Cris gives careful explanations, in terms of physical principles, that make sense based on one's physical intuition and experience.

The latter part of the book surveys the development of musical notions of consonance and scale construction. Chapter 10 traces Western ideas about intonation, from Pythagoras finding number in harmony, through "meantone" and then "well-temperament" in the time of J.S. Bach, up to modern equal temperament. The changing notions of which intervals were considered consonant when, and by whom, make a fascinating story. Chapter 11 looks at the largely independent (though sometimes parallel) development of musical scales and tunings in various Eastern cultures, including China, India, and Indonesia, as well as Persian, Arabian, and Turkish musical traditions. As far as possible, Cris relies on original sources, to which he brings his own analysis and explication. To find all of these varied scales compared and contrasted in a single work is unique in my experience.

The book concludes with two short chapters on specific original instruments. One introduces the innovative instruments Cris has designed and built for his music. Included are many details of construction and materials, and also scores of his work that demonstrate his notation for the instruments. The last chapter encourages the reader (with explicit plans) to build a simple stringed instrument (a "canon") with completely adjustable tuning, to directly explore the tunings discussed in the book. In this way, the reader can follow in the tradition of Ptolemy, of learning about music through direct experimentation, as has Cris Forster.

David R. Canright, Ph.D.
Del Rey Oaks, California
January 2010

Introduction and Acknowledgments

In simplest terms, human beings identify musical instruments by two aural characteristics: a particular kind of sound or timbre, and a particular kind of scale or tuning. To most listeners, these two aspects of musical sound do not vary. However, unlike the constants of nature — such as gravitational acceleration on earth, or the speed of sound in air — which we cannot change, the constants of music — such as string, percussion, and wind instruments — are subject to change. A creative investigation into musical sound inevitably leads to the subject of musical mathematics, and to a reexamination of the meaning of variables.

The first chapter entitled “Mica Mass” addresses an exceptionally thorny subject: the derivation of a unit of mass based on an inch constant for acceleration. This unit is intended for builders who measure wood, metal, and synthetic materials in inches. For example, with the mica unit, builders of string instruments can calculate tension in pounds-force, or lbf, without first converting the diameter of a string from inches to feet. Similarly, builders of tuned bar percussion instruments who know the modulus of elasticity of a given material in pounds-force per square inch, or lbf/in², need only the mass density in mica/in³ to calculate the speed of sound in the material in inches per second; a simple substitution of this value into another equation gives the mode frequencies of uncut bars.

Chapters 2–4 explore many physical, mathematical, and musical aspects of strings. In Chapter 3, I distinguish between four different types of ratios: ancient length ratios, modern length ratios, frequency ratios, and interval ratios. Knowledge of these ratios is essential to Chapters 10 and 11. Many writers are unaware of the crucial distinction between ancient length ratios and frequency ratios. Consequently, when they attempt to define arithmetic and harmonic divisions of musical intervals based on frequency ratios, the results are diametrically opposed to those based on ancient length ratios. Such confusion leads to anachronisms, and renders the works of theorists like Ptolemy, Al-Fārābī, Ibn Sīnā, and Zarlino incomprehensible.

Chapter 5 investigates the mechanical interactions between piano strings and soundboards, and explains why the large physical dimensions of modern pianos are not conducive to explorations of alternate tuning systems.

Chapters 6 and 7 discuss the theory and practice of tuning marimba bars and resonators. The latter chapter is essential to Chapter 8, which examines a sequence of equations for the placement of tone holes on concert flutes and simple flutes.

Chapter 9 covers logarithms, and the modern cent unit. This chapter serves as an introduction to calculating scales and tunings discussed in Chapters 10 and 11.

In summary, this book is divided into three parts. (1) In Chapters 1–9, I primarily examine various vibrating systems found in musical instruments; I also focus on how builders can customize their work by understanding the functions of variables in mathematical equations. (2) In Chapter 10, I discuss scale theories and tuning practices in ancient Greece, and during the Renaissance and Enlightenment in Europe. Some modern interpretations of these theories are explained as well. In Chapter 11, I describe scale theories and tuning practices in Chinese, Indonesian, and Indian music, and in Arabian, Persian, and Turkish music. For Chapters 10 and 11, I consistently studied original texts in modern translations. I also translated passages in treatises by Ptolemy, Al-Kindī, the Ikhwān al-Ṣafā, Ibn Sīnā, Stifel, and Zarlino from German into English; and in collaboration with two contributors, I participated in translating portions of works by Al-Fārābī, Ibn Sīnā, Ṣafī Al-Dīn, and Al-Jurjānī from French into English. These translations reveal that all the above-mentioned theorists employ the language of ancient length ratios. (3) Finally, Chapters 12 and 13 recount musical instruments I have built and rebuilt since 1975.

I would like to acknowledge the assistance and encouragement I received from Dr. David R. Canright, associate professor of mathematics at the Naval Postgraduate School in Monterey,

California. David's unique understanding of mathematics, physics, and music provided the foundation for many conversations throughout the ten years I spent writing this book. His mastery of differential equations enabled me to better understand dispersion in strings, and simple harmonic motion of air particles in resonators. In Section 4.5, David's equation for the effective length of stiff strings is central to the study of inharmonicity; and in Section 6.6, David's figure, which shows the effects of two restoring forces on the geometry of bar elements, sheds new light on the physics of vibrating bars. Furthermore, David's plots of compression and rarefaction pulses inspired numerous figures in Chapter 7. Finally, we also had extensive discussions on Newton's laws. I am very grateful to David for his patience and contributions.

Heartfelt thanks go to my wife, Heidi Forster. Heidi studied, corrected, and edited myriad versions of the manuscript. Also, in partnership with the highly competent assistance of professional translator Cheryl M. Buskirk, Heidi did most of the work translating extensive passages from *La Musique Arabe* into English. To achieve this accomplishment, she mastered the often intricate verbal language of ratios. Heidi also assisted me in transcribing the Indonesian and Persian musical scores in Chapter 11, and transposed the traditional piano score of "The Letter" in Chapter 12. Furthermore, she rendered invaluable services during all phases of book production by acting as my liaison with the editorial staff at Chronicle Books. Finally, when the writing became formidable, she became my sparring partner and helped me through the difficult process of restoring my focus. I am very thankful to Heidi for all her love, friendship, and support.

I would also like to express my appreciation to Dr. John H. Chalmers. Since 1976, John has generously shared his vast knowledge of scale theory with me. His mathematical methods and techniques have enabled me to better understand many historical texts, especially those of the ancient Greeks. And John's scholarly book *Divisions of the Tetrachord* has furthered my appreciation for world tunings.

I am very grateful to Lawrence Saunders, M.A. in ethnomusicology, for reading Chapters 3, 9, 10, and 11, and for suggesting several technical improvements.

Finally, I would like to thank Will Gullette for his twelve masterful color plates of the Original Instruments and String Winder, plus three additional plates. Will's skill and tenacity have illuminated this book in ways that words cannot convey.

Cris Forster
San Francisco, California
January 2010

TONE NOTATION

	32'	16'	8'	4'	2'	1'	1/2'	1/4'	1/8'
--	-----	-----	----	----	----	----	------	------	------

1.	C ₀	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆	C ₇	C ₈
2.	C _∞	C _∞	C	c	c'	c''	c'''	c''''	c ^v
3.	C ₂	C ₁	C ₀	c ⁰	c ¹	c ²	c ³	c ⁴	c ⁵

1. American System, used throughout this text.
2. Helmholtz System.
3. German System.

LIST OF SYMBOLS

Latin

12-TET	12-tone equal temperament
a	Acceleration; in/s^2
a.l.r.	Ancient length ratio; dimensionless
B	Bending stiffness of bar; $\text{lbf}\cdot\text{in}^2$, or $\text{mica}\cdot\text{in}^3/\text{s}^2$
B'	Bending stiffness of plate; $\text{lbf}\cdot\text{in}$, or $\text{mica}\cdot\text{in}^2/\text{s}^2$
B_A	Adiabatic bulk modulus; psi , lbf/in^2 , or $\text{mica}/(\text{in}\cdot\text{s}^2)$
B_I	Isothermal bulk modulus; psi , lbf/in^2 , or $\text{mica}/(\text{in}\cdot\text{s}^2)$
b	Width; in
ϵ	Cent, 1/100 of a “semitone,” or 1/1200 of an “octave”; dimensionless
$\bar{\epsilon}$	Coefficient of inharmonicity of string; cent
c_B	Bending wave speed; in/s
c_L	Longitudinal wave speed, or speed of sound; in/s
c_T	Transverse wave speed; in/s
c.d.	Common difference of an arithmetic progression; dimensionless
c.r.	Common ratio of a geometric progression; dimensionless
cps	Cycle per second; $1/\text{s}$
D	Outside diameter; in
D_i	Inside diameter of wound string; in
D_m	Middle diameter of wound string; in
D_o	Outside diameter of wound string; in
D_w	Wrap wire diameter of wound string; in
d	Inside diameter, or distance; in
E	Young’s modulus of elasticity; psi , lbf/in^2 , or $\text{mica}/(\text{in}\cdot\text{s}^2)$
F	Frequency; cps
F_c	Critical frequency; cps
F_n	Resonant frequency; cps
\bar{F}_n	Inharmonic mode frequency of string; cps
f	Force; lbf , or $\text{mica}\cdot\text{in}/\text{s}^2$
f.r.	Frequency ratio; dimensionless
g	Gravitational acceleration; 386.0886 in/s^2
h	Height, or thickness; in
I	Area moment of inertia; in^4
i.r.	Interval ratio; dimensionless
J	Stiffness parameter of string; dimensionless
K	Radius of gyration; in
k	Spring constant; lbf/in , or mica/s^2
L	Length; in , cm , or mm
ℓ_M	Multiple loop length of string; in
ℓ_S	Single loop length of string; in
l.r.	Length ratio; dimensionless
lbf	Pounds-force; $\text{mica}\cdot\text{in}/\text{s}^2$
lbm	Pounds-mass; 0.00259008 mica

$M/u.a.$	Mass per unit area; mica/in ² , or lbf·s ² /in ³
$M/u.l.$	Mass per unit length; mica/in, or lbf·s ² /in ²
m	Mass; mica, or lbf·s ² /in
n	Mode number, or harmonic number; any positive integer
P	Pressure; psi, lbf/in ² , or mica/(in·s ²)
p	Excess acoustic pressure; psi, lbf/in ² , or mica/(in·s ²)
psi	Pounds-force per square inch; lbf/in ² , or mica/(in·s ²)
q	Bar parameter; dimensionless
R	Ideal gas constant; in·lbf/(mica·°R), or in ² /(s ² ·°R)
r	Radius; in
S	Surface area; in ²
SHM	Simple harmonic motion
T	Tension; lbf, or mica·in/s ²
T_A	Absolute temperature; dimensionless
t	Time; s
U	Volume velocity; in ³ /s
u	Particle velocity; in/s
V	Volume; in ³
v	Phase velocity; in/s
W	Weight density, or weight per unit volume; lbf/in ³ , or mica/(in ² ·s ²)
w	Weight; lbf, or mica·in/s ²
Y_A	Acoustic admittance; in ⁴ ·s/mica
Z_A	Acoustic impedance; mica/(in ⁴ ·s)
Z_r	Acoustic impedance of room; mica/(in ⁴ ·s)
Z_t	Acoustic impedance of tube; mica/(in ⁴ ·s)
Z_M	Mechanical impedance; mica/s
Z_b	Mechanical impedance of soundboard; mica/s
Z_p	Mechanical impedance of plate; mica/s
Z_s	Mechanical impedance of string; mica/s
Z_R	Radiation impedance; mica/s
Z_a	Radiation impedance of air; mica/s
z	Specific acoustic impedance; mica/(in ² ·s)
z_a	Characteristic impedance of air; 0.00153 mica/(in ² ·s)

Greek

Δ	Correction coefficient, or end correction coefficient; dimensionless
$\Delta\ell$	Correction, or end correction; in, cm, or mm
δ	Departure of tempered ratio from just ratio; cent
γ	Ratio of specific heat; dimensionless
θ	Angle; degree
κ	Conductivity; in
Λ	Bridged canon string length; in
Λ_A	Arithmetic mean string length; in
Λ_G	Geometric mean string length; in
Λ_H	Harmonic mean string length; in

λ	Wavelength; in
λ_B	Bending wavelength; in
λ_L	Longitudinal wavelength; in
λ_T	Transverse wavelength; in
μ	Poisson's ratio; dimensionless
Π	Fretted guitar string length; mm
π	Pi; ≈ 3.1416
ρ	Mass density, or mass per unit volume; mica/in ³ , or lbf·s ² /in ⁴
τ	Period, or second per cycle; s

BIBLIOGRAPHY

Chapters 1–9

- Askenfelt, A., Editor (1990). *Five Lectures on The Acoustics of the Piano*. Royal Swedish Academy of Music, No. 64, Stockholm, Sweden.
- Askill, J. (1979). *Physics of Musical Sound*. D. Van Nostrand Company, New York.
- Baines, A. (1967). *Woodwind Instruments and Their History*. Dover Publications, Inc., New York, 1991.
- Barbera, A., Translator (1991). *The Euclidean Division of the Canon: Greek and Latin Sources*. University of Nebraska Press, Lincoln, Nebraska.
- Barker, A., Translator (1989). *Greek Musical Writings*. Two Volumes. Cambridge University Press, Cambridge, Massachusetts.
- Bell, A.J., and Firth, I.M. (1986). The physical properties of gut musical instrument strings. *Acustica* **60**, No. 1, pp. 87–89.
- Benade, A.H., and French, J.W. (1965). Analysis of the flute head joint. *Journal of the Acoustical Society of America* **37**, No. 4, pp. 679–691.
- Benade, A.H. (1967). Measured end corrections for woodwind toneholes. *Journal of the Acoustical Society of America* **41**, No. 6, p. 1609.
- Benade, A.H. (1976). *Fundamentals of Musical Acoustics*. Dover Publications, Inc., New York, 1990.
- Berliner, P.F. (1978). *The Soul of Mbira*. University of California Press, Berkeley, California, 1981.
- Blevins, R.D. (1979). *Formulas for Natural Frequency and Mode Shape*, Reprint. Krieger Publishing Company, Malabar, Florida, 1993.
- Boehm, T. (1847). *On the Construction of Flutes, Über den Flötenbau*. Frits Knuf Buren, Amsterdam, Netherlands, 1982.
- Boehm, T. (1871). *The Flute and Flute-Playing*. Dover Publications, Inc., New York, 1964.
- Boyer, H.E., and Gall, T.L., Editors (1984). *Metals Handbook, Desk Edition*. American Society for Metals, Metals Park, Ohio, 1989.
- Bray, A., Barbato, G., and Levi, R. (1990). *Theory and Practice of Force Measurement*. Academic Press, San Diego, California.
- Burkert, W. (1962). *Lore and Science in Ancient Pythagoreanism*. Translated by E.L. Minar, Jr. Harvard University Press, Cambridge, Massachusetts, 1972.
- Cadillac Plastic Buyer's Guide*. Cadillac Plastic and Chemical Company, Troy, Michigan, 1986.
- Campbell, M., and Greated, C. (1987). *The Musician's Guide to Acoustics*. Schirmer Books, New York, 1988.
- Capstick, J.W. (1913). *Sound*. Cambridge University Press, London, England, 1932.
- Chapman, R.E., Translator (1957). *Harmonie universelle: The Books on Instruments*, by Marin Mersenne. Martinus Nijhoff, The Hague, Netherlands.

- Cohen, H.F. (1984). *Quantifying Music*. D. Reidel Publishing Company, Dordrecht, Netherlands.
- Coltman, J.W. (1979). Acoustical analysis of the Boehm flute. *Journal of the Acoustical Society of America* **65**, No. 2, pp. 499–506.
- Cremer, L., Heckl, M., and Ungar, E.E. (1973). *Structure-Borne Sound*, 2nd ed. Springer-Verlag, Berlin and New York, 1988.
- Cremer, L. (1981). *The Physics of the Violin*, 2nd ed. The MIT Press, Cambridge, Massachusetts, 1984.
- Crew, H., and De Salvio, A., Translators (1914). *Dialogues Concerning Two New Sciences*, by Galileo Galilei. Dover Publications, Inc., New York.
- D’Addario Brochure (2007). “[Catalog Supplement/String Tension Specifications](#).” Online publication, pp. 1–14. J. D’Addario & Company, Inc., Farmingdale, New York.
- Den Hartog, J.P. (1934). *Mechanical Vibrations*. Dover Publications, Inc., New York, 1985.
- Den Hartog, J.P. (1948). *Mechanics*. Dover Publications, Inc., New York, 1984.
- D’Erlanger, R., Bakkouch, A.A., and Al-Sanūsi, M., Translators (Vol. 1, 1930; Vol. 2, 1935; Vol. 3, 1938; Vol. 4, 1939; Vol. 5, 1949; Vol. 6, 1959). *La Musique Arabe*. Librairie Orientaliste Paul Geuthner, Paris, France.
- Diels, H. (1903). *Die Fragmente der Vorsokratiker, Griechisch und Deutsch*. Three Volumes. Weidmannsche Verlagsbuchhandlung, Berlin, Germany, 1951.
- D’Ooge, M.L., Translator (1926). *Nicomachus of Gerasa: Introduction to Arithmetic*. The Macmillan Company, New York.
- Dunlop, J.I. (1981). Testing of poles by using acoustic pulse method. *Wood Science and Technology* **15**, pp. 301–310.
- Du Pont Bulletin: “Tynex 612 Nylon Filament.” Du Pont Company, Wilmington, Delaware.
- Düring, I., Translator (1934). *Ptolemaios und Porphyrios über die Musik*. Georg Olms Verlag, Hildesheim, Germany, 1987.
- Einarson, B., Translator (1967). *On Music*, by Plutarch. In *Plutarch’s Moralia, Volume 14*. Harvard University Press, Cambridge, Massachusetts.
- Elmore, W.C., and Heald, M.A. (1969). *Physics of Waves*. Dover Publications, Inc. New York, 1985.
- Fenner, K., *On the Calculation of the Tension of Wound Strings*, 2nd ed. Verlag Das Musikinstrument, Frankfurt, Germany, 1976.
- Fishbane, P.M., Gasiorowicz, S., and Thornton, S.T. (1993). *Physics for Scientists and Engineers*. Prentice-Hall, Englewood Cliffs, New Jersey.
- Fletcher, H., Blackham, E.D., and Stratton, R.S. (1962). Quality of piano tones. *Journal of the Acoustical Society of America* **34**, No. 6, pp. 749–761.
- Fletcher, H. (1964). Normal vibration frequencies of a stiff piano string. *Journal of the Acoustical Society of America* **36**, No. 1, pp. 203–209.
- Fletcher, N.H., and Rossing, T.D. (1991). *The Physics of Musical Instruments*, 2nd ed. Springer-Verlag, Berlin and New York, 1998.

- Fogiel, M., Editor (1980). *The Strength of Materials & Mechanics of Solids Problem Solver*. Research and Education Association, Piscataway, New Jersey, 1990.
- Goodway, M., and Odell, J.S. (1987). *The Historical Harpsichord, Volume Two: The Metallurgy of 17th- and 18th-Century Music Wire*. Pendragon Press, Stuyvesant, New York.
- Gray, D.E., Editor (1957). *American Institute of Physics Handbook*, 3rd ed. McGraw-Hill Book Company, New York, 1972.
- Halliday, D., and Resnick, R. (1970). *Fundamentals of Physics*, 2nd ed. John Wiley & Sons, New York, 1981.
- Hamilton, E., and Cairns, H., Editors (1963). *The Collected Dialogues of Plato*. Random House, Inc., New York, 1966.
- Helmholtz, H.L.F., and Ellis A.J., Translator (1885). *On the Sensations of Tone*. Dover Publications, Inc., New York, 1954.
- Hoadley, R.B. (1980). *Understanding Wood*. The Taunton Press, Newtown, Connecticut, 1981.
- Hubbard, F. (1965). *Three Centuries of Harpsichord Making*, 4th ed. Harvard University Press, Cambridge, Massachusetts, 1972.
- Ingard, U. (1953). On the theory and design of acoustic resonators. *Journal of the Acoustical Society of America* **25**, No. 6, pp. 1037–1061.
- Ingard, K.U. (1988). *Fundamentals of Waves and Oscillations*. Cambridge University Press, Cambridge, Massachusetts, 1990.
- Jan, K. von, Editor (1895). *Musici Scriptores Graeci*. Lipsiae, in aedibus B.G. Teubneri.
- Jerrard, H.G., and McNeill, D.B. (1963). *Dictionary of Scientific Units*, 6th ed. Chapman and Hall, London, England, 1992.
- Jones, A.T. (1941). End corrections of organ pipes. *Journal of the Acoustical Society of America* **12**, pp. 387–394.
- Kinsler, L.E., and Frey, A.R. (1950). *Fundamentals of Acoustics*, 2nd ed. John Wiley & Sons, Inc., New York, 1962.
- Klein, H.A. (1974). *The Science of Measurement*. Dover Publications, Inc., New York, 1988.
- Land, F. (1960). *The Language of Mathematics*. Doubleday & Company, Inc., Garden City, New York.
- Lemon, H.B., and Ference, M., Jr. (1943). *Analytical Experimental Physics*. The University of Chicago Press, Chicago, Illinois.
- Levin, F.R., Translator (1994). *The Manual of Harmonics, of Nicomachus the Pythagorean*. Phanes Press, Grand Rapids, Michigan.
- Liddell, H.G., and Scott, R. (1843). *A Greek-English Lexicon*. The Clarendon Press, Oxford, England, 1992.
- Lide, D.R., Editor (1918). *CRC Handbook of Chemistry and Physics*, 73rd ed. CRC Press, Boca Raton, Florida, 1992.
- Lindeburg, M.R. (1988). *Engineering Unit Conversions*, 2nd ed. Professional Publications, Inc., Belmont, California, 1990.

- Lindeburg, M.R. (1990). *Engineer-in-Training Reference Manual*, 8th ed. Professional Publications, Inc., Belmont, California, 1992.
- Lindley, M. (1987). "Stimmung und Temperatur." In *Geschichte der Musiktheorie, Volume 6*, F. Zaminer, Editor. Wissenschaftliche Buchgesellschaft, Darmstadt, Germany.
- McLeish, J. (1991). *Number*. Bloomsbury Publishing Limited, London, England.
- Moore, J.L. (1971). *Acoustics of Bar Percussion Instruments*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.
- Morse, P.M., and Ingard, K.U. (1968). *Theoretical Acoustics*. Princeton University Press, Princeton, New Jersey, 1986.
- Nash, W.A. (1957). *Strength of Materials*, 3rd ed. Schaum's Outline Series, McGraw-Hill, Inc., New York, 1994.
- Nederveen, C.J. (1969). *Acoustical Aspects of Woodwind Instruments*. Frits Knuf, Amsterdam, Netherlands.
- Nederveen, C.J. (1973). Blown, passive and calculated resonance frequencies of the flute. *Acustica* **28**, pp. 12-23.
- Newton, R.E.I. (1990). *Wave Physics*. Edward Arnold, a division of Hodder & Stoughton, London, England.
- Norton, M.P. (1989). *Fundamentals of Noise and Vibration Analysis for Engineers*. Cambridge University Press, Cambridge, Massachusetts.
- Oberg, E., Jones, F.D., Horton, H.L., and Ryffel, H.H. (1914). *Machinery's Handbook*, 24th ed. Industrial Press Inc., New York, 1992.
- Olson, H.F. (1952). *Music, Physics and Engineering*, 2nd ed. Dover Publications, Inc., New York, 1967.
- Pierce, A.D. (1981). *Acoustics*. Acoustical Society of America, Woodbury, New York. 1991.
- Pierce, J.R. (1983). *The Science of Musical Sound*. Scientific American Books, W.H. Freeman and Company, New York.
- Pikler, A.G. (1966). Logarithmic frequency systems. *Journal of the Acoustical Society of America* **39**, No. 6, pp. 1102-1110.
- Rao, S.S. (1986). *Mechanical Vibrations*, 2nd ed. Addison-Wesley Publishing Company, Reading, Massachusetts, 1990.
- Richardson, E.G. (1929). *The Acoustics of Orchestral Instruments and of the Organ*. Edward Arnold & Co., London, England.
- Rossing, T.D. (1989). *The Science of Sound*, 2nd ed. Addison-Wesley Publishing Co., Inc., Reading, Massachusetts, 1990.
- Sadie, S., Editor (1984). *The New Grove Dictionary of Musical Instruments*. Macmillan Press Limited, London, England.
- Schlesinger, K. (1939). *The Greek Aulos*. Methuen & Co. Ltd., London, England.
- Schuck, O.H., and Young, R.W. (1943). Observations on the vibrations of piano strings. *Journal of the Acoustical Society of America* **15**, No. 1, pp. 1-11.

- Sears, F.W., Zemansky, M.W., and Young, H.D., *University Physics*, 7th ed. Addison-Wesley Publishing Company, Reading, Massachusetts, 1988.
- Skudrzyk, E. (1968). *Simple and Complex Vibratory Systems*. Pennsylvania State University Press, University Park, Pennsylvania, 1981.
- Smith, D.E. (1925). *History of Mathematics*. Two Volumes. Dover Publications, Inc., New York, 1958.
- Standards Handbook, Part 2 — Alloy Data, Wrought Copper and Copper Alloy Mill Products*, Eighth Edition, Copper Development Association, Inc., Greenwich, Connecticut, 1985.
- Stauss, H.E., Martin, F.E., and Billington, D.S. (1951). A piezoelectric method for determining Young's modulus and its temperature dependence. *Journal of the Acoustical Society of America* **23**, No. 6, pp. 695–696.
- Steinkopf, O. (1983). *Zur Akustik der Blasinstrumente*. Moeck Verlag, Celle, Germany.
- Stiller, A. (1985). *Handbook of Instrumentation*. University of California Press, Berkeley, California.
- Suzuki, H. (1986). Vibration and sound radiation of a piano soundboard. *Journal of the Acoustical Society of America* **80**, No. 6, pp. 1573–1582.
- Thompson, S.P. (1910). *Calculus Made Easy*, 3rd ed. St. Martin's Press, New York, 1984.
- Timoshenko, S., and Woinowsky-Krieger, S. (1940). *Theory of Plates and Shells*, 2nd ed., McGraw-Hill Book Company, New York, 1959.
- Timoshenko, S.P. (1953). *History of Strength of Materials*. Dover Publications, Inc., New York, 1983.
- Towne, D.H. (1967). *Wave Phenomena*. Dover Publications, Inc., New York, 1988.
- Tropfke, J. (1921). *Geschichte der Elementar-Mathematik*. Seven Volumes. Vereinigung Wissenschaftlicher Verleger, Walter de Gruyter & Co., Berlin and Leipzig, Germany.
- U.S. Business and Defense Services Administration (1956). *Materials Survey: Aluminum*. Department of Commerce, Washington, D.C.
- Weaver, W., Jr., Timoshenko, S.P., and Young, D.H., *Vibration Problems in Engineering*, 5th ed. John Wiley and Sons, New York, 1990.
- White, W.B. (1917). *Piano Tuning and Allied Arts*, 5th ed. Tuners Supply Company, Boston, Massachusetts, 1972.
- Wogram, K. (1981). Akustische Untersuchungen an Klavieren. Teil I: Schwingungseigenschaften des Resonanzbodens. *Das Musikinstrument* **24**, pp. 694–702, 776–782, 872–879. English translation: Acoustical research on pianos. Part I: Vibrational characteristics of the soundboard. In *Musical Acoustics: Selected Reprints*, T.D. Rossing, Editor, pp. 85–98. American Association of Physics Teachers, College Park, Maryland, 1988.
- Wolfenden, S. (1916). *A Treatise on the Art of Pianoforte Construction*. The British Piano Museum Charitable Trust, Brentford, Middlesex, England, 1975.
- Wood, A.B. (1930). *A Textbook of Sound*. The Macmillan Company, New York, 1937.
- Wood, A. (1940). *Acoustics*. Dover Publications, Inc., New York, 1966.

Young, R.W. (1952). Inharmonicity of plain wire piano strings. *Journal of the Acoustical Society of America* **24**, No. 3, pp. 267–272.

Zanoncelli, L., Translator (1990). *La Manualistica Musicale Greca*. Angelo Guerini e Associati, Milan, Italy.

Zebrowski, E., Jr. (1979). *Fundamentals of Physical Measurement*. Duxbury Press, Belmont, California.

Chapter 10

Adkins, C.D. (1963). *The Theory and Practice of the Monochord*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.

Al-Faruqi, L.I. (1974). *The Nature of the Musical Art of Islamic Culture: A Theoretical and Empirical Study of Arabian Music*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.

Asselin, P. (1985). *Musique et Tempérament*. Éditions Costallat, Paris, France.

Barbera, C.A. (1977). Arithmetic and geometric divisions of the tetrachord. *Journal of Music Theory* **21**, No. 2, pp. 294–323.

Barbera, A., Translator (1991). *The Euclidean Division of the Canon: Greek and Latin Sources*. University of Nebraska Press, Lincoln, Nebraska.

Barbour, J.M. (1933). The persistence of the Pythagorean tuning system. *Scripta Mathematica*, Vol. 1, pp. 286–304.

Barbour, J.M. (1951). *Tuning and Temperament*. Da Capo Press, New York, 1972.

Barker, A., Translator (1989). *Greek Musical Writings*. Two Volumes. Cambridge University Press, Cambridge, England.

Barnes, J. (1979). Bach's keyboard temperament. *Early Music* **7**, No. 2, pp. 236–249.

Beck, C., Translator (1868). *Flores musice omnis cantus Gregoriani*, by Hugo Spechtshart [von Reutlingen]. Bibliothek des Litterarischen Vereins, Stuttgart, Germany.

Bower, C.M., Translator (1989). *Fundamentals of Music*, by A.M.S. Boethius. Yale University Press, New Haven, Connecticut.

Briscoe, R.L., Translator (1975). Rameau's "Démonstration du principe de l'harmonie" and "Nouvelles réflexions de M. Rameau sur sa démonstration du principe de l'harmonie:" *An Annotated Translation of Two Treatises by Jean-Philippe Rameau*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.

Brun, V. (1964). Euclidean algorithms and musical theory. *L'Enseignement Mathématique* **X**, pp. 125–137.

Burkert, W. (1962). *Lore and Science in Ancient Pythagoreanism*. Translated by E.L. Minar, Jr. Harvard University Press, Cambridge, Massachusetts, 1972.

Chalmers, J.H., Jr. (1993). *Divisions of the Tetrachord*. Frog Peak Music, Hanover, New Hampshire.

Chandler, B.G., Translator (1975). Rameau's "Nouveau système de musique théorique:" *An Annotated Translation with Commentary*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.

- Chapman, R.E., Translator (1957). *Harmonie universelle: The Books on Instruments*, by Marin Mersenne. Martinus Nijhoff, The Hague, Netherlands.
- Coelho, V., Editor (1992). *Music and Science in the Age of Galileo*. Kluwer Academic Publishers, Dordrecht, Netherlands.
- Cohen, H.F. (1984). *Quantifying Music*. D. Reidel Publishing Company, Dordrecht, Netherlands.
- Compact Edition of the Oxford English Dictionary*. Oxford University Press, Oxford, England, 1974.
- Crew, H., and De Salvio, A., Translators (1914). *Dialogues Concerning Two New Sciences*, by Galileo Galilei. Dover Publications, Inc., New York.
- Crocker, R.L. (1963). Pythagorean mathematics and music. *The Journal of Aesthetics and Art Criticism* **XXII**, No. 2, Part I: pp. 189–198, and No. 3, Part II: pp. 325–335.
- Crocker, R.L. (1966). “Aristoxenus and Greek Mathematics.” In *Aspects of Medieval and Renaissance Music: A Birthday Offering to Gustave Reese*, J. LaRue, Editor. Pendragon Press, New York.
- Crone, E., Editor; Fokker, A.D., Music Editor; Dikshoorn, C., Translator (1966). *The Principal Works of Simon Stevin*. Five Volumes. C.V. Swets & Zeitlinger, Amsterdam.
- Crookes, D.Z., Translator (1986). *Syntagma musicum II: De organographia, Parts I and II*, by Michael Praetorius. The Clarendon Press, Oxford, England.
- Daniels, A.M. (1962). *The De musica libri VII of Francisco de Salinas*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.
- De Haan, D.B., Publisher (1884). *Vande Spiegeling der Singconst*, by Simon Stevin. Amsterdam.
- D’Erlanger, R., Bakkouch, A.A., and Al-Sanūsī, M., Translators (Vol. 1, 1930; Vol. 2, 1935; Vol. 3, 1938; Vol. 4, 1939; Vol. 5, 1949; Vol. 6, 1959). *La Musique Arabe*, Librairie Orientaliste Paul Geuthner, Paris, France.
- Diels, H. (1903). *Die Fragmente der Vorsokratiker, Griechisch und Deutsch*. Three Volumes. Weidmannsche Verlagsbuchhandlung, Berlin, Germany, 1951.
- D’Ooge, M.L., Translator (1926). *Nicomachus of Gerasa: Introduction to Arithmetic*. The Macmillan Company, New York.
- Dupont, W. (1935). *Geschichte der musikalischen Temperatur*. C.H. Beck’sche Buchdruckerei, Nördlingen, Germany.
- Düring, I., Editor (1930). *Die Harmonielehre des Klaudios Ptolemaios*. Original Greek text of Ptolemy’s *Harmonics*. Wettergren & Kerbers Förlag, Göteborg, Sweden.
- Düring, I., Translator (1934). *Ptolemaios und Porphyrios über die Musik*. Georg Olms Verlag, Hildesheim, Germany, 1987.
- Farmer, H.G. (1965). *The Sources of Arabian Music*. E.J. Brill, Leiden, Netherlands.
- Farmer, H.G., Translator (1965). *Al-Fārābī’s Arabic-Latin Writings on Music*. Hinrichsen Edition Ltd., New York.
- Fend, M., Translator (1989). *Theorie des Tonsystems: Das erste und zweite Buch der Institutioni harmoniche (1573)*, von Gioseffo Zarlino. Peter Lang, Frankfurt am Main, Germany.
- Fernandez de la Cuesta, I., Translator (1983). *Siete libros sobre la musica*, by Francisco Salinas. Editorial Alpuerto, Madrid, Spain.

- Flegg, G., Hay, C., and Moss, B., Translators (1985). *Nicolas Chuquet, Renaissance Mathematician*. D. Reidel Publishing Company, Dordrecht, Holland.
- Forster, C. (2015). “[The Partch Hoax Doctrines](#).” Online article, pp. 1–19. The Chrysalis Foundation, San Francisco, California.
- Gossett, P., Translator (1971). *Traité de l'harmonie* [Treatise on Harmony], by Jean-Philippe Rameau. Dover Publications, Inc., New York.
- Green, B.L. (1969). *The Harmonic Series From Mersenne to Rameau: An Historical Study of Circumstances Leading to Its Recognition and Application to Music*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.
- Guthrie, K.S., Translator (1987). *The Pythagorean Sourcebook and Library*. Phanes Press, Grand Rapids, Michigan.
- Hamilton, E., and Cairns, H., Editors (1966). *The Collected Dialogues of Plato*. Random House, Inc., New York.
- Hawkins, J. (1853). *A General History of the Science and Practice of Music*. Dover Publications, Inc., New York, 1963.
- Hayes, D., Translator (1968). *Rameau's Theory of Harmonic Generation; An Annotated Translation and Commentary of "Génération harmonique" by Jean-Philippe Rameau*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.
- Heath, T.L., Translator (1908). *Euclid's Elements*. Dover Publications, Inc., New York, 1956.
- Heath, T. (1921). *A History of Greek Mathematics*. Dover Publications, Inc., New York, 1981.
- Hitti, P.K. (1937). *History of the Arabs*. Macmillan and Co. Ltd., London, England, 1956.
- Hubbard, F. (1965). *Three Centuries of Harpsichord Making*, 4th ed. Harvard University Press, Cambridge, Massachusetts, 1972.
- Hyde, F.B. (1954). *The Position of Marin Mersenne in the History of Music*. Two Volumes. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.
- Ibn Sīnā (Avicenna): *Auicene perhypatetici philosophi: ac medicorum facile primi opera in luce redacta...* This Latin translation was published in 1508. Facsimile Edition: Minerva, Frankfurt am Main, Germany, 1961.
- Jacobi, E.R., Editor (1968). *Jean-Philippe Rameau (1683–1764): Complete Theoretical Writings*. American Institute of Musicology, [Rome, Italy].
- James, G., and James, R.C. (1976). *Mathematics Dictionary*, 4th ed. Van Nostrand Reinhold, New York.
- Jorgensen, O. (1977). *Tuning the Historical Temperaments by Ear*. The Northern Michigan University Press, Marquette, Michigan.
- Jorgenson, D.A. (1957). *A History of Theories of the Minor Triad*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.
- Jorgenson, D.A. (1963). A résumé of harmonic dualism. *Music and Letters* **XLIV**, No. 1, pp. 31–42.
- Kastner, M.S., Editor (1958). *De musica libri VII*, by Francisco Salinas. Facsimile Edition. Bärenreiter-Verlag, Kassel, Germany.
- Kelleher, J.E. (1993). *Zarlino's "Dimostrazioni harmoniche" and Demonstrative Methodologies in the Sixteenth Century*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.

- Lawlor, R. and D., Translators (1978). *Mathematics Useful for Understanding Plato*, by Theon of Smyrna. Wizards Bookshelf, San Diego, California, 1979.
- Levin, F.R., Translator (1994). *The Manual of Harmonics, of Nicomachus the Pythagorean*. Phanes Press, Grand Rapids, Michigan.
- Lindley, M. (1984). *Lutes, Viols and Temperaments*. Cambridge University Press, Cambridge, England.
- Litchfield, M. (1988). Aristoxenus and empiricism: A reevaluation based on his theories. *Journal of Music Theory* **32**, No. 1, pp. 51–73.
- Mackenzie, D.C., Translator (1950). *Harmonic Introduction*, by Cleonides. In *Source Readings in Music History*, O. Strunk, Editor. W. W. Norton & Company, Inc., New York.
- Macran, H.S., Translator (1902). *The Harmonics of Aristoxenus*. Georg Olms Verlag, Hildesheim, Germany, 1990.
- Marcuse, S. (1964). *Musical Instruments: A Comprehensive Dictionary*. W. W. Norton & Company, Inc., New York, 1975.
- Maxham, R.E., Translator (1976). *The Contributions of Joseph Sauveur to Acoustics*. Two Volumes. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.
- Mersenne, M. (1636–37). *Harmonie universelle contenant la théorie et la pratique de la musique*. Three Volumes. Facsimile Edition. Éditions du Centre National de la Recherche Scientifique, Paris, France, 1963.
- Meyer, M.F. (1929). *The Musician's Arithmetic*. Oliver Ditson Company, Boston, Massachusetts.
- Miller, C.A., Translator (1993). *Musica practica*, by Bartolomeo Ramis de Pareia. Hänssler-Verlag, Neuhausen-Stuttgart, Germany.
- Niven, I. (1961). *Numbers: Rational and Irrational*. Random House, New York.
- Palisca, C.V. (1961). "Scientific Empiricism in Musical Thought." In *Seventeenth Century Science and the Arts*, H.H. Rhys, Editor. Princeton University Press, Princeton, New Jersey.
- Palisca, C.V. (1985). *Humanism in Italian Renaissance Musical Thought*. Yale University Press, New Haven, Connecticut.
- Palisca, C.V., Translator (2003). *Dialogue on Ancient and Modern Music*, by Vincenzo Galilei. Yale University Press, New Haven, Connecticut.
- Partch, H. (1949). *Genesis of a Music*, 2nd ed. Da Capo Press, New York, 1974.
- Rameau, J.P. (1722). *Traité de l'harmonie reduite à ses principes naturels*. Facsimile Edition. Biblioteca Nacional de Madrid, Spain, 1984.
- Rasch, R., Editor (1983). *Musicalische Temperatur*, by Andreas Werckmeister. The Diapason Press, Utrecht, Netherlands.
- Rasch, R., Editor (1984). *Collected Writings on Musical Acoustics*, by Joseph Sauveur. The Diapason Press, Utrecht, Netherlands.
- Rasch, R., Editor (1986). *Le cycle harmonique (1691), Novus cyclus harmonicus (1724)*, by Christiaan Huygens. The Diapason Press, Utrecht, Netherlands.
- Reichenbach, H. (1951). *The Rise of Scientific Philosophy*. The University of California Press, Berkeley and Los Angeles, California, 1958.

- Roberts, F. (1692). A discourse concerning the musical notes of the trumpet, and the trumpet-marine, and of the defects of the same. *Philosophical Transactions of the Royal Society of London* **XVII**, pp. 559–563.
- Rossing, T.D. (1989). *The Science of Sound*, 2nd ed. Addison-Wesley Publishing Co., Inc., Reading, Massachusetts, 1990.
- Sadie, S., Editor (1980). *The New Grove Dictionary of Music and Musicians*. Macmillan Publishers Limited, London, England, 1995.
- Shirlaw, M. (1917). *The Theory of Harmony*. Da Capo Press Reprint Edition. Da Capo Press, New York, 1969.
- Solomon, J., Translator (2000). *Ptolemy Harmonics*. Brill, Leiden, Netherlands.
- Soukhanov, A.H., Executive Editor (1992). *The American Heritage Dictionary of the English Language*, 3rd ed. Houghton Mifflin Company, Boston, Massachusetts.
- Stephan, B. (1991). *Geometry: Plane and Practical*. Harcourt Brace Jovanovich, Publishers, San Diego, California.
- Truesdell, C. (1960). *The Rational Mechanics of Flexible or Elastic Bodies: 1638–1788*. Orell Füssli, Zürich, Switzerland.
- Wallis, J. (1677). Dr. Wallis' letter to the publisher, concerning a new musical discovery. *Philosophical Transactions of the Royal Society of London* **XII**, pp. 839–842.
- West, M.L. (1992). *Ancient Greek Music*. The Clarendon Press, Oxford, England, 1994.
- White, W.B. (1917). *Piano Tuning and Allied Arts*, 5th ed. Tuners Supply Company, Boston, Massachusetts, 1972.
- Wienpahl, R.W. (1959). Zarlino, the *Senario*, and tonality. *Journal of the American Musicological Society* **XII**, No. 1, pp. 27–41.
- Williams, R.F., Translator (1972). *Marin Mersenne: An Edited Translation of the Fourth Treatise of the "Harmonie universelle."* Three Volumes. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.
- Williamson, C. (1938). The frequency ratios of the tempered scale. *Journal of the Acoustical Society of America* **10**, pp. 135–136.
- Winnington-Ingram, R.P. (1932). Aristoxenus and the intervals of Greek music. *The Classical Quarterly* **XXVI**, Nos. 3–4, pp. 195–208.
- Winnington-Ingram, R.P. (1936). *Mode in Ancient Greek Music*. Cambridge University Press, London, England.
- Winnington-Ingram, R.P. (1954). "Greek Music (Ancient)." In *Grove's Dictionary of Music and Musicians, Volume 3*, 5th ed., E. Blom, Editor. St. Martin's Press, Inc., New York, 1970.
- Zarlino, R.M.G. (1571). *Dimostrazioni harmoniche*. Facsimile Edition, The Gregg Press Incorporated, Ridge-wood, New Jersey, 1966.
- Zarlino, R.M.G. (1573). *Istitutioni harmoniche*. Facsimile Edition, The Gregg Press Limited, Farnborough, Hants., England, 1966.

Chapter 11

Chinese Music

- Apel, W., Editor (1944). *Harvard Dictionary of Music*, 2nd ed. Harvard University Press, Cambridge, Massachusetts, 1972.
- Gulik, R.H., Translator (1941). *Poetical Essay on the Lute*, by Hsi K'ang. In Gulik's *Hsi K'ang and His Poetical Essay on the Lute*, Sophia University, Tokyo, Japan.
- Kaufmann, W. (1967). *Musical Notations of the Orient*. Indiana University Press, Bloomington, Indiana.
- Kaufmann, W. (1976). *Musical References in the Chinese Classics*. Detroit Monographs in Musicology, Detroit, Michigan.
- Kuttner, F.A. (1965). A musicological interpretation of the twelve lüs in China's traditional tone system. *Journal of the Society for Ethnomusicology* **IX**, No. 1, pp. 22–38.
- Lieberman, F., Translator (1977). *The Mei-an Ch'in-p'u*, by Hsü Li-sun. In Lieberman's *The Chinese Long Zither Ch'in: A Study Based on the Mei-an Ch'in-p'u*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.
- Lieberman, F., Translator (1983). *The Mei-an Ch'in-p'u*, by Hsü Li-sun. In Lieberman's *A Chinese Zither Tutor*. University of Washington Press, Seattle, Washington.
- Lui, T. (1968). A short guide to *ch'in*. *Selected Reports* **I**, No. 2, pp. 180–201. Publication of the Institute of Ethnomusicology of the University of California at Los Angeles.
- Needham, J. (1962). *Science and Civilization in China, Volume 4, Part I*. Cambridge University Press, Cambridge, England.
- Reinhard, K. (1956). *Chinesische Musik*, 2nd ed. Im Erich Röth-Verlag, Kassel, Germany.
- Robinson, K. (1980). *A Critical Study of Chu Tsai-yü's Contribution to the Theory of Equal Temperament in Chinese Music*. Franz Steiner Verlag GmbH, Wiesbaden, Germany.
- Sachs, C. (1940). *The History of Musical Instruments*. W. W. Norton & Company, Inc., New York.
- Sadie, S., Editor (1980). *The New Grove Dictionary of Music and Musicians*. Macmillan Publishers Limited, London, England, 1995.
- Wang, L., and Needham, J. (1955). Horner's Method in Chinese Mathematics: Its origins in the root-extraction procedures of the Han Dynasty. *T'oung Pao Archives* **XLIII**, No. 5, pp. 345–401. Leiden, Netherlands.
- Wang, K. (1956). *Chung-kuo yin yueh shih*. Taipei, Formosa: Chung hua shu chu.

Indonesian Music

- Apel, W., Editor (1944). *Harvard Dictionary of Music*, 2nd ed. Harvard University Press, Cambridge, Massachusetts, 1972.
- Blom, E., Editor (1954). *Grove's Dictionary of Music and Musicians*, 5th ed. St. Martin's Press, Inc., New York, 1970.
- Hood, M. (1954). *The Nuclear Theme as a Determinant of Paçet in Javanese Music*. Da Capo Press, Inc., New York, 1977.

- Hood, M. (1966). *Sléndro and pélog redefined. Selected Reports I*, No. 1, pp. 28–48. Publication of the Institute of Ethnomusicology of the University of California at Los Angeles.
- Lentz, D.A. (1965). *The Gamelan Music of Java and Bali*. University of Nebraska Press, Lincoln, Nebraska.
- Martopangrawit, R.L. (1972). *Catatan-Catatan Pengetahuan Karawitan [Notes on Knowledge of Gamelan Music]*, translated by M.F. Hatch. In *Karawitan, Volume 1*, J. Becker and A.H. Feinstein, Editors. Center for South and Southeast Asian Studies, The University of Michigan, 1984.
- McDermott, V., and Sumarsam (1975). Central Javanese music: The *paṭet* of laras *sléndro* and the *gendèr barung*. *Journal of the Society for Ethnomusicology* **XIX**, No. 2, pp. 233–244.
- McPhee, C. (1966). *Music in Bali: A Study in Form and Instrumental Organization in Balinese Orchestral Music*. Yale University Press, New Haven, Connecticut.
- Ornstein, R.S. (1971). *Gamelan Gong Kebjar: The Development of a Balinese Musical Tradition*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.
- Poerbapangrawit, R.M.K. (1955). *Gendhing Jawa [Javanese Gamelan Music]*, translated by J. Becker. In *Karawitan, Volume 1*, J. Becker and A.H. Feinstein, Editors. Center for South and Southeast Asian Studies, The University of Michigan, 1984.
- Rai, I. W. (1996). *Balinese Gamelan Semar Pagulingan Saih Pitu: The Modal System*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.
- Randel, D.M., Editor (1986). *The New Harvard Dictionary of Music*, 6th ed. The Belknap Press of Harvard University Press, Cambridge, Massachusetts, 1993.
- Sadie, S., Editor (1984). *The New Grove Dictionary of Musical Instruments*. Macmillan Press Limited, London, England.
- Schaareman, D., Editor (1992). *Balinese Music in Context: A Sixty-fifth Birthday Tribute to Hans Oesch*. Amadeus Verlag, Winterthur, Switzerland.
- Sindoesawarno, K. (1955). *Ilmu Karawitan [Knowledge About Gamelan Music]*, translated by M.F. Hatch. In *Karawitan, Volume 2*, J. Becker and A.H. Feinstein, Editors. Center for South and Southeast Asian Studies, The University of Michigan, 1987.
- Sumarsam (1975). *Gendèr barung, its technique and function in the context of Javanese gamelan. Indonesia* **20**, pp. 161–172.
- Sumarsam (1992). *Gamelan: Cultural Interaction and Musical Development in Central Java*. The University of Chicago Press, Chicago, Illinois, 1995.
- Surjodiningrat, W., Sudarjana, P.J., and Susanto, A. (1972). *Tone Measurements of Outstanding Javanese Gamelans in Jogjakarta and Surakarta*, 2nd ed. Gadjah Mada University Press, Jogjakarta, Indonesia.
- Tenzer, M. (2000). *Gamelan Gong Kebyar: The Art of Twentieth-Century Balinese Music*. The University of Chicago Press, Chicago, Illinois.
- Toth, A.F. (1975). The Gamelan Luang of Tangkas, Bali. *Selected Reports II*, No. 2, pp. 65–79. Publication of the Institute of Ethnomusicology of the University of California at Los Angeles.
- Toth, A.F. (1993). “Selera Yang Selaras: Papatutan Gong Ditinjau Dari Segi Akustika dan Estetika.” *Mudra: Jurnal Seni Budaya*, pp. 92–117. Edisi Khusus.

Indian Music

- Aiyar, M.S.R., Translator (1932). *Svaramēlakalānidhi*, by Rāmāmātya. The Annamalai University, India.
- Ayyar, C.S. (1939). *The Grammar of South Indian (Karnatic) Music*. Smt. Vidya Shankar, Madras, India, 1976.
- Bhandarkar, R.S.P.R. (1912). Contribution to the study of ancient Hindu music. *The Indian Antiquary* **XLI**, pp. 157–164, pp. 185–195, pp. 254–265.
- Bhandarkar, R.S.P.R. (1913–1914). Kuḍimiyāmalai inscription on music. *Epigraphia Indica* **XII**, No. 28, pp. 226–237.
- Bhatkhande, V.N. (1930). *A Comparative Study of Some of the Leading Music Systems of the 15th, 16th, 17th, and 18th Centuries*. Indian Musicological Society, Baroda, India, 1972.
- Bhise, U.R., Translator (1986). *Nārādīyā Śikṣā*, by Nārada. Bhandarkar Institute Press, Poona, India.
- Coomaraswamy, A.K. (1930). The parts of a *vīṇā*. *Journal of the American Oriental Society* **50**, No. 3, pp. 244–253.
- Gangoly, O.C. (1935). *Rāgas and Rāginīs*. Nalanda Publications, Bombay, India, 1948.
- Ghosh, M., Translator (Vol. 1, Ch. 1–27, 1950; Vol. 2, Ch. 28–36, 1961). *The Nāṭyaśāstra*, by Bharata. Bibliotheca Indica, The Asiatic Society, Calcutta, India.
- Iyer, T.L.V. (1940). The scheme of 72 *mēlas* in Carnatic Music. *The Journal of the Music Academy* **XI**, Parts I–IV, pp. 80–86, Madras, India.
- Jairazbhoy, N.A. (1971). *The Rāgs of North Indian Music*. Wesleyan University Press, Middletown, Connecticut.
- Jairazbhoy, N.A. (1975). An interpretation of the 22 *śrutis*. *Asian Music* **VI**, Nos. 1–2, pp. 38–59.
- Junius, M.M. (1974). *The Sitar*. Heinrichshofen's Verlag, Wilhelmshaven, Germany.
- Kaufmann, W. (1968). *The Rāgas of North India*. Indiana University Press, Bloomington, Indiana.
- Kaufmann, W. (1976). *The Rāgas of South India*. Indiana University Press, Bloomington, Indiana.
- Krishnaswamy, A. (1981). *Mēlakarta and Janya Rāga Chart*. Sakthi Priya Publication, Madras, India.
- Lath, M., Translator (1978). *A Study of Dattilam: A Treatise on the Sacred Music of Ancient India*. Impex India, New Delhi, India.
- Marcotty, T. (1974). *Djovari: Giving Life to the Sitar*. This essay on how to make a parabolic *sitar* bridge is in *The Sitar*, by Manfred M. Junius. Heinrichshofen's Verlag, Wilhelmshaven, Germany.
- Nijenhuis, E.W., Translator (1970). *Dattilam: A Compendium of Ancient Indian Music*. E. J. Brill, Leiden, Netherlands.
- Powers, H.S. (1958). *The Background of the South Indian Rāga-System*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.
- Ramachandran, K.V. (1938). The *mēlakarta* — a critique. *The Journal of the Music Academy* **IX**, Parts I–IV, pp. 31–33, Madras, India.
- Ramachandran, K.V. (1950). Carnatic *rāgas* from a new angle — *Śaṅkarābharaṇa*. *The Journal of the Music Academy* **XXI**, Parts I–IV, pp. 88–99, Madras, India.

- Ramachandran, K.V. (1950). Carnatic *rāgas* and the textual tradition. *The Journal of the Music Academy* **XXI**, Parts I–IV, pp. 99–106, Madras, India.
- Ramachandran, K.V. (1950). *Apurva rāgas* of Tyāgarāja's songs. *The Journal of the Music Academy* **XXI**, Parts I–IV, pp. 107–109, Madras, India.
- Ramachandran, N.S. (1938). *The Rāgas of Karnatic Music*. University of Madras, Madras, India.
- Rao, T.V.S. (1945 and 1946). The *rāgas* of the Sangita Saramita. *The Journal of the Music Academy* **XVI**, Parts I–IV, pp. 45–64, and **XVII**, Parts I–IV, pp. 104–134, Madras, India.
- Rowell, L. (1981). Early Indian musical speculation and the theory of melody. *Journal of Music Theory* **25.2**, pp. 217–244.
- Roy, H.L. (1937). *Problems of Hindustani Music*. Bharati Bhavan, Calcutta, India.
- Sachs, C. (1940). *The History of Musical Instruments*. W. W. Norton & Company, Inc., New York.
- Sadie, S., Editor (1980). *The New Grove Dictionary of Music and Musicians*. Macmillan Publishers Limited, London, England, 1995.
- Sadie, S., Editor (1984). *The New Grove Dictionary of Musical Instruments*. Macmillan Press Limited, London, England.
- Sambamoorthy, P. (1960). *History of Indian Music*. The Indian Music Publishing House, Madras, India.
- Sambamoorthy, P. (Vol. 1, A–F, 1952; Vol. 2, G–K, 1959; Vol. 3, L–N, 1971). *A Dictionary of South Indian Music and Musicians*. The Indian Music Publishing House, Madras, India.
- Sastri, S.S. (1931). Venkaṭamakhi and his twelve notes. *The Journal of the Music Academy* **II**, No. 1, pp. 22–23, Madras, India.
- Sathyanarayana, R., Editor (1957). *Kuḍimiyāmalai Inscription on Music*. Śrī Varalakshmi Academies of Fine Arts, Parimala Press, Mysore, India.
- Shankar, R. (1968). *My Music, My Life*. Simon and Schuster, New York, New York.
- Sharma, P.L., Editor and Translator (Vol. 1, Ch. 1, 1992; Vol. 2, Ch. 2–6, 1994). *Brhaddeśi* of Śrī Mataṅga Muni. Indira Gandhi National Centre for the Arts in association with Motilal Banarsidass Publishers, Delhi, India.
- Shringy, R.K., and Sharma, P.L., Translators (Vol. 1, Ch. 1, 1978; Vol. 2, Ch. 2–4, 1989). *Saṅgītaratnākara*, by Sārṅgadeva. *Volume 1*, Motilal Banarsidass, Delhi, India; *Volume 2*, Munshiram Manoharlal, New Delhi, India.
- Sorrell, N., and Narayan, R. (1980). *Indian Music in Performance*. New York University Press, New York, New York. This book comes boxed with an excellent cassette tape recording.
- Widdess, R. (1995). *The Rāgas of Early Indian Music*. The Clarendon Press, Oxford, England.

Arabian, Persian, and Turkish Music

- Al-Faruqi, L.I. (1974). *The Nature of the Musical Art of Islamic Culture: A Theoretical and Empirical Study of Arabian Music*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.
- Al-Faruqi, L.I. (1981). *An Annotated Glossary of Arabic Musical Terms*. Greenwood Press, Westport, Connecticut.

- Avenary, H., Translator (1974). The Hebrew version of Abū l-Ṣalt's treatise on music. *Yuval III*, pp. 7–82.
- Barker, A., Translator (1989). *Greek Musical Writings*. Two Volumes. Cambridge University Press, Cambridge, England.
- Cowl, C., Translator (1966). Al-Kindī's essay on the composition of melodies. *The Consort*, No. 23, pp. 129–159.
- Crookes, D.Z., Translator (1986). *Syntagma musicum II: De organographia, Parts I and II*, by Michael Praetorius. The Clarendon Press, Oxford, England. The first edition of this work was published in 1618.
- D'Erlanger, R., Bakkouch, A.A., and Al-Sanūsī, M., Translators (Vol. 1, 1930; Vol. 2, 1935; Vol. 3, 1938; Vol. 4, 1939; Vol. 5, 1949; Vol. 6, 1959). *La Musique Arabe*, Librairie Orientaliste Paul Geuthner, Paris, France.
- Dieterici, F., Translator (1858–1890; 16 Volumes). *Die Philosophie der Araber im IX. und X. Jahrhundert n. Chr. aus der Theologie des Aristoteles, den Abhandlungen Alfarabis und den Schriften der Lautern Brüder*. The quoted passage on music is in *Volume 6*, entitled: *Die Propaedeutik der Araber im zehnten Jahrhundert*. E.S. Mittler und Sohn, Berlin, Germany, 1865.
- El-Hefny, M., Translator (1931). *Ibn Sinā's Musiklehre* [Ibn Sinā's teaching on music]. Ph.D. dissertation printed by Otto Hellwig, Berlin, Germany.
- Farhat, H. (1965). *The Dastgāh Concept in Persian Music*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.
- Farhat, H. (1990). *The Dastgāh Concept in Persian Music*. Cambridge University Press, Cambridge, England.
- Farmer, H.G. (1925). Clues for the Arabian influence on European musical theory. *The Journal of the Royal Asiatic Society*, First Quarter, pp. 61–80.
- Farmer, H.G. (1928). Ibn Khurdādhbih on musical instruments. *The Journal of the Royal Asiatic Society*, Third Quarter, pp. 509–518.
- Farmer, H.G. (1929). *A History of Arabian Music*. Luzac Oriental, London, England, 1994.
- Farmer, H.G. (1953–1954). The song captions in the *Kitāb al-aghānī al-kabīr*. *Transactions of the Glasgow University Oriental Society XV*, pp. 1–10.
- Farmer, H.G. (1954). "Ūd." In *Grove's Dictionary of Music and Musicians, Volume 8*, 5th ed., E. Blom, Editor. St. Martin's Press, Inc., New York, 1970.
- Farmer, H.G. (1957). "The Music of Islam." In *New Oxford History of Music, Volume 1: Ancient and Oriental Music*, E. Wellesz, Editor. Oxford University Press, London, England, 1960.
- Farmer, H.G. (1965). *The Sources of Arabian Music*. E.J. Brill, Leiden, Netherlands.
- Farmer, H.G., Translator (1965). *Al-Fārābī's Arabic-Latin Writings on Music*. Hinrichsen Edition Ltd., New York.
- Farmer, H.G. (1965). The old Arabian melodic modes. *Journal of the Royal Asiatic Society*, Parts 3 & 4, pp. 99–102.
- Farmer, H.G. (1978). *Studies in Oriental Musical Instruments, First and Second Series*. Longwood Press Ltd., Tortola, British Virgin Islands.
- Hitti, P.K. (1937). *History of the Arabs*. Macmillan and Co. Ltd., London, England, 1956.

- Lachmann, R. and El-Hefni, M., Translators (1931). *Risāla fī hubr tā'lif al-alḥān* [Über die Komposition der Melodien], by Al-Kindī. Fr. Kistner & C.F.W. Siegel, Leipzig, Germany.
- Lewis, B., Editor (1976). *Islam and the Arab World*. Alfred A. Knopf, New York.
- Maas, M. and Snyder, J.M. (1989). *Stringed Instruments of Ancient Greece*. Yale University Press, New Haven, Connecticut.
- Marcus, S.L. (1989). *Arab Music Theory in the Modern Period*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.
- Marcus, S.L. (1992). Modulation in Arab music: Documenting oral concepts, performance rules and strategies. *Ethnomusicology* **36**, No. 2, pp. 171–195.
- Muallem, D. (2010). *The Maqām Book: A Doorway to Arab Scales and Modes*. OR-TAV Music Publications, Kfar Sava, Israel.
- Racy, A.J. (1977). *Musical Change and Commercial Recording in Egypt, 1904–1932*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.
- Racy, A.J. (1978). “Music.” In *The Genius of Arab Civilization*, 2nd ed., J.R. Hayes, Editor. MIT Press, Cambridge, Massachusetts, 1983.
- Ribera, J. (1929). *Music in Ancient Arabia and Spain*. Translated and abridged from the Spanish by Eleanor Hague and Marion Leffingwell. Stanford University Press, Stanford University, California.
- Ronzevalle, P.L., Translator (1913). *Un Traité de Musique Arabe Moderne*, by Mikhā'il Mashāqah. *Mélanges de la Faculté Orientale* **VI**, pp. 1–120. Université Saint-Joseph, Beirut, Lebanon.
- Sachs, C. (1940). *The History of Musical Instruments*. W. W. Norton & Company, Inc., New York.
- Sadie, S., Editor (1984). *The New Grove Dictionary of Musical Instruments*. Macmillan Press Limited, London, England.
- Shiloah, A. (1972). The *simsimīyya*: A stringed instrument of the Red Sea area. *Asian Music* **IV**, No. 1, pp. 15–26.
- Shiloah, A., Translator (1978). *The Epistle on Music of the Ikhwān Al-Ṣafā*. Tel-Aviv University, Tel-Aviv, Israel.
- Shiloah, A. (1979). *The Theory of Music in Arabic Writings (c. 900–1900)*. G. Henle Verlag, München, Germany.
- Shiloah, A. (1981). The Arabic concept of mode. *Journal of the American Musicological Society* **XXXIV**, No. 1, pp. 19–42.
- Signell, K.L. (1973). *The Turkish ‘Makam’ System in Contemporary Theory and Practice*. Ph.D. dissertation printed and distributed by University Microfilms, Inc., Ann Arbor, Michigan.
- Signell, K.L. (1986). *Makam: Modal Practice in Turkish Art Music*. Da Capo Press, New York, New York.
- Smith, E., Translator (1847). *A Treatise on Arab Music*, by Mikhā'il Mashāqah. *Journal of the American Oriental Society* **I**, No. 3, pp. 173–217. Boston, Massachusetts.
- Touma, H.H. (1996). *The Music of the Arabs*. Amadeus Press, Portland, Oregon.
- Wright, O. (1966). Ibn al-Munajjim and the early Arabian modes. *The Galpin Society Journal* **XIX**, pp. 27–48.

Chapter 12

Writings on Cris Forster

- Editors. "Cris Forster." In *Für Augen und Ohren*, Magazine of the Berlin Music Festival. January–February, 1980, pp. 16–17. Dr. Ulrich Eckhardt, Publisher. Berlin, Germany.
- Mahlke, S. "Barde mit zwei Saitenspielen." *Der Tagesspiegel*. January 25, 1980. Berlin, Germany.
- Garr, D. "The Endless Scale." *Omni*. March, 1981, p. 48. New York, New York.
- McDonald, R. "Cris Forster: Making Music." *San Diego Magazine*. September, 1982, pp. 136–139, 198, 228. San Diego, California.
- Fleischer, D. "Sounds of Infinity." *Connoisseur*. August, 1983, pp. 102, 105. New York, New York.
- Levine, J. "Expanded Musical Palette Is Inventor's Note-able Goal." *The Tribune*. September 6, 1983. San Diego, California.
- Brewster, T. "A Medley of New Instruments: A Wheel Like the Wind." *Life*. November, 1983, p. 142. New York, New York.
- Editors. "Klingen wie der Wind." *Stern*. January, 1984, pp. 146–148. Hamburg, Germany.
- Davies, H. (1984). "Microtonal Instruments," pp. 656–657. In *The New Grove Dictionary of Musical Instruments, Volume 2*, S. Sadie, Editor. Macmillan Press Limited, London, England.
- Drye, S.L. (1984). *The History and Development of the Musical Glasses*, pp. 46–49. Master's thesis, North Texas State University.
- Arnautoff, V. "Hill Musician Composes, Builds Own Instruments." *The Potrero View*. November, 1985, p. 5. San Francisco, California.
- Editors. "This Californian and His Bearings Are Making Beautiful Music Together." *Precisionist: A Publication of the Torrington Company*. Summer, 1987, pp. 14–15. Torrington, Connecticut.
- Bowen, C. "Making Music from Scratch." *Métier*. Fall, 1987, p. 7. San Francisco, California.
- Snider, J. "Chrysalis: A Transformation in Music." *Magical Blend*. April, 1989, pp. 98–102. San Francisco, California.
- Hopkin, B. "Review." *Experimental Musical Instruments*. April, 1990, p. 4. Nicasio, California.
- Editors. "Forster, Cris." *PITCH for the International Microtonalist I*, No. 4, Spring 1990, p. 142. Johnny Reinhard, Editor. New York, New York.
- Canright, D. "Performance: Concert in Celebration of the Chrysalis New Music Studio — Instruments and Music by Cris Forster." *1/1, the Journal of the Just Intonation Network* **11**, No. 4. Spring, 2004, pp. 19–20. San Francisco, California.
- Seven extensive reviews of *Musical Mathematics: On the Art and Science of Acoustic Instruments*.
http://chrysalis-foundation.org/Musical_Mathematics_Reviews.htm
- Kaliss, J. "Cris Forster's 'Just' Musical Menagerie." *San Francisco Classical Voice*. July 23, 2013. San Francisco, California. (See [San Francisco Classical Voice Article](#).)

Spaulding, B. "How Math Is Helping One Man Push the Boundaries of Acoustic Music." *PTC Product Lifecycle Report*. January 4, 2016. Needham, Massachusetts. (See [PTC Mathcad Article](#).)

Forster, H. "Support the Evolution of Acoustic Music." *Kickstarter Project*. November 29, 2016–January 15, 2017. Brooklyn, New York. (See [Kickstarter Article](#).)

Videos on Cris Forster

Gaikowski, R., Videographer and Editor (1988). *Musical Wood, Steel, and Glass: A video featuring Cris Forster, composer, musician, inventor*. Production by One Way Films/Videos, San Francisco, California.

Noyes, E., Videographer and Editor; Forster, H., Producer and Writer (2006). *A Voyage in Music: A retrospective of Cris Forster's work over the past thirty years*. Production by Alligator Planet, San Francisco, California.

Video performances of solo and ensemble compositions at the Chrysalis New Music Studio.
<http://www.youtube.com/user/CrisForster/feed>

Thomas, R., Videographer and Editor; Forster, H., Writer (2016). *Support the Evolution of Acoustic Music*. Production by [Sponsored Films](#), San Francisco, California.