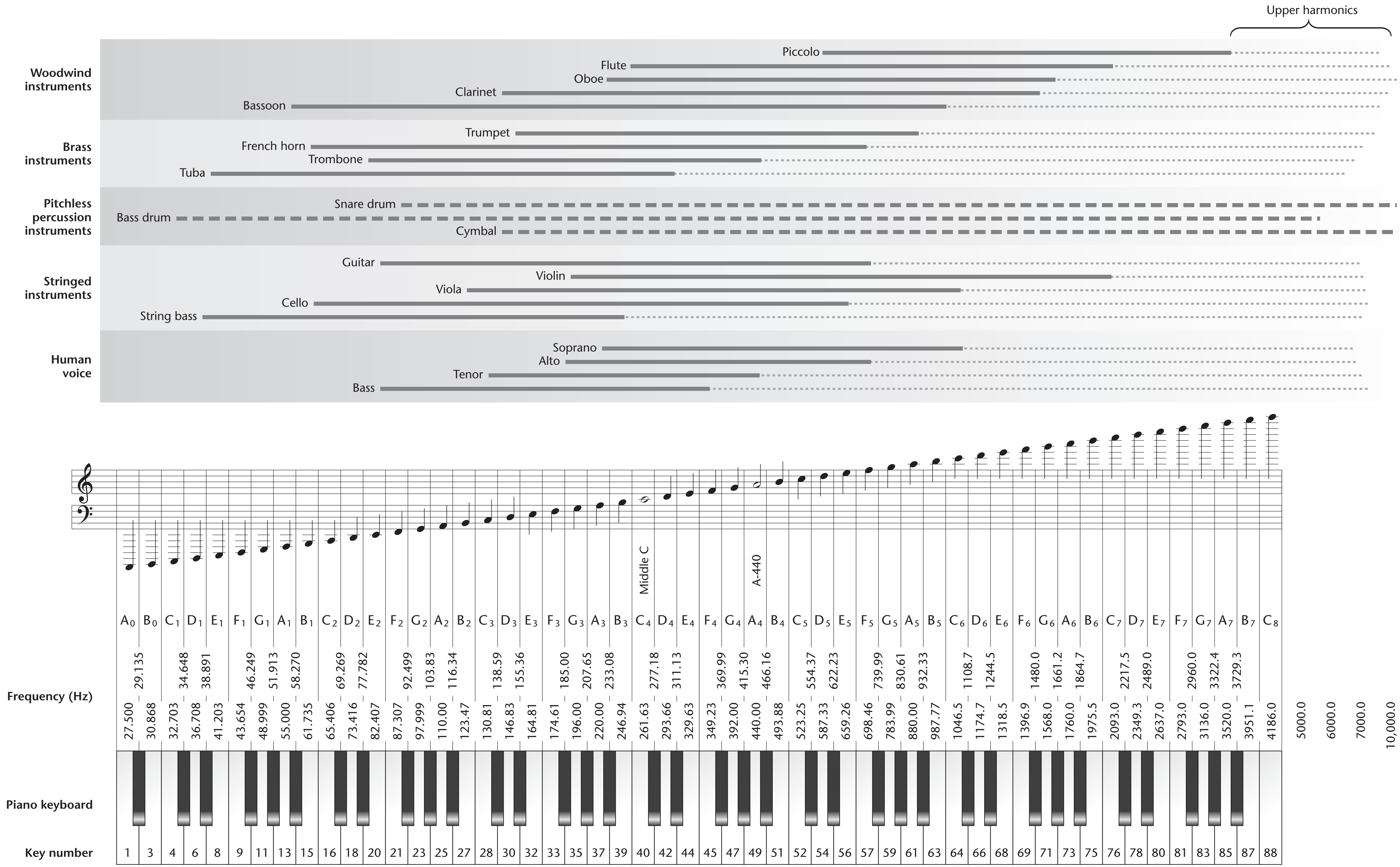
Audio in Media

10TH EDITION

Stanley R. Alten



Upper harmonics
Woodwind instruments
Piccolo
Flute
Oboe
Clarinet
Bassoon
Brass instruments
Trumpet
French horn
Trombone
Tuba
Pitchless percussion instruments
Snare drum
Bass drum
Cymbal
Stringed instruments
Guitar
Violin
Viola
Cello
String bass
Human voice
Soprano
Alto
Tenor
Bass
Middle C
A-440
A_0 B_0 C_1 D_1 E_1 F_1 G_1 A_1 B_1 C_2 D_2 E_2 F_2 G_2 A_2 B_2 C_3 D_3 E_3 F_3 G_3 A_3 B_3 C_4 D_4 E_4 F_4 G_4 A_4 B_4 C_5 D_5 E_5 F_5 G_5 A_5 B_5 C_6 D_6 E_6 F_6 G_6 A_6 B_6 C_7 D_7 E_7 F_7 G_7 A_7 B_7 C_8
Frequency (Hz)
29.135 34.648 38.891 46.249 51.913 58.270 69.269 77.782 92.499 103.83 116.34 138.59 155.36 185.00 207.65 233.08 277.18 311.13 369.99 415.30 466.16 554.37 622.23 739.99 830.61 932.33 1108.7 1244.5 1480.0 1661.2 1864.7 2217.5 2489.0 2960.0 3322.4 3729.3
27.500 30.868 32.703 36.708 41.203 43.654 48.999 55.000 61.735 65.406 73.416 82.407 87.307 97.999 110.00 123.47 130.81 146.83 164.81 174.61 196.00 220.00 246.94 261.63 293.66 329.63 349.23 392.00 440.00 493.88 523.25 587.33 659.26 698.46 783.99 880.00 987.77 1046.5 1174.7 1318.5 1396.9 1568.0 1760.0 1975.5 2093.0 2349.3 2637.0 2793.0 3136.0 3520.0 3951.1 4186.0 5000.0 6000.0 7000.0 10,000.0
Piano keyboard
Key number
1 3 4 6 8 9 11 13 15 16 18 20 21 23 25 27 28 30 32 33 35 37 39 40 42 44 45 47 49 51 52 54 56 57 59 61 63 64 66 68 69 71 73 75 76 78 80 81 83 85 87 88

Audio in Media

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Stanley R. Alten

Syracuse University

with contributions by **Douglas Quin**, Syracuse University

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To the sweetest sounds:
Claudette,
Ariane, and Renee

Brief Contents

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Preface

In audio production, technique and technology have always been inextricably linked: technique cannot be carried out without technology, and technology without technique is mindless. At no time in the history of audio has this been more evident than it is today. Advances in technology have made it possible to produce sound in an almost limitless variety of ways, increasing the possibilities for creative invention and aesthetic fulfillment. Moreover, these advances have made audio production accessible and affordable to just about anyone interested in the field whether professional or hobbyist. These advances notwithstanding, there are constants: basic principles in the behavior of sound and in the production and the evaluation of a high-quality product.

Through its more than three decades as the market-leading audio text, *Audio in Media* has tried to balance the relationship between technique and technology and continues to do so in this edition with the understanding that human creativity, vision, and "ears" are central to a production's ultimate success. It is up to the engineer to make a production sound good; it is up to the recordist to make it sound interesting.

Changes in the field occur almost daily. This makes it impractical to try to cover the amount of audio gear out there. Therefore the examples displayed throughout the book are to provide a sense of what is available at this writing. Because there are so many different types of computers and software programs in use in an ever-changing landscape, the relationship of computers to audio production is covered only as it applies to producing program materials and not to computer technology, software programs, or operational details. There are many books on the market that address these areas, to say nothing of the manuals provided with computers and software programs.

As with previous editions, the tenth edition covers all the major audio and audio-related media: radio, television, film, music recording, game sound, the Internet, and, new with this edition, mobile media.

Content is designed for beginning- and intermediate-level study, yet the experienced practitioner will find the material valuable as a reference even after a course of study is completed. The organization facilitates reading chapters in or out of sequence, based on need and level of background, with little disruption to continuity.

This edition has been reorganized to better complement subject flow. Overall the chapters are more focused, to make the distribution of content easier to locate and assign. All chapters have been updated and refined. Several of the changes are in response to reviewers' recommendations.

Each chapter is preceded by an outline of its main headings and concluded with a list of its main points. Key terms are identified in ***bold italic*** and defined in the glossary. There are more than 100 new and revised illustrations.

The book's website features a variety of resources for students, including chapter summaries, flashcards, key terms, main points, a media glossary, information on occupations in audio media, and web links. For instructors there is a password-protected online *Instructor's Manual* to help guide discussion in the classroom, as well as additional exercises and test banks.

STRUCTURE OF THE BOOK

Part I: Principles

Chapter 1, "Sound in Production," introduces the role of audio in media and provides a context for evaluating the finished product.

Chapter 2, "Sound and Hearing," deals with the physical behavior of sound and its relationship to our psychophysical perception of sound stimuli. It also includes a section about the importance of caring for your ears and healthy hearing.

Chapter 3, "Acoustics and Psychoacoustics," develops the material in chapter 2 as it applies to the objective behavior of received sound, its subjective effect on those who hear it, and how these factors affect studio and control room design and construction. A new section covers project and home studios.

Part II: Technology

Chapter 4, "Loudspeakers and Monitoring," deals with the relationship between loudspeaker selection and control room monitoring, including expanded coverage of surround-sound monitoring, new material about monitoring with poor-quality loudspeakers, dynamic range tolerances, and monitor controllers. It also includes a revised section on headphones.

Chapter 5, "Microphones," discusses their principles, characteristics, accessories, and types. The chapter has been reorganized to improve subject flow by first covering basic principles and accessories and then discussing various types of microphones.

Chapter 6, "Mixers, Consoles, and Control Surfaces," has been reorganized to improve continuity. It adds mixers to the coverage of signal flow and design of broadcast and production consoles—analog and digital—and control surfaces. There is a revised section on sound in electrical form. Sections about meters, patching, and console automation are also included. Because of the many different types, models, and designs of consoles in use and their various purposes, the approach to the material in this edition is generic so that the basic principles are easier to grasp and apply.

Chapter 7, "Recording," has also been reorganized to improve subject flow. It covers basic digital theory; recording systems; digital audio workstations; CDs, DVDs, and high-density optical formats; and film audio formats. New material includes smartphone and tablet recording apps, connectors, and digital audio for video recording.

Chapter 8, "Synchronization and Transfers," covers these fundamental aspects of production and postproduction.

Chapter 9, "Signal Processors," discusses their general principles—both stand-alone and plug-ins—and their effects on sound. There are new sections about overdependence on signal processing in production and specialized plug-ins.

Chapter 10, "Audio and the Internet," covers Internet sound quality. It includes a new section on cloud computing and discussions of online collaborative recording and podcasting.

Part III: Production

Chapter 11, "The Speaking Voice, Voice-Overs, and Narration," focuses on the delivery and the signification of nonverbal speech. Coverage includes speech intelligibility, basic considerations in miking and recording speech, and factors in the delivery, production, and functions of voice-overs and narration.

Chapter 12, "Dialogue," deals with production recording and automated dialogue replacement of recordings made in the studio and on-location. It includes a refined section on the importance of dialogue recording and a new section on the production recording crew.

Chapter 13, "Studio Production: Radio and Television," covers microphone and production techniques as they apply to studio programs in radio and television.

Chapter 14, "Field Production: News and Sports," concentrates on producing news and sports on-location and includes new material about mobile news gathering and the growing use of the smartphone and the computer tablet in data collection, production, and transmission. Several of the illustrations related to sports production have been updated.

Chapter 15, "Sound Design," introduces the nature and the aesthetics of designing sound, the basic structure of sonic communication, the sound/picture relationship, and strategies for designing sound. It includes a section on the importance of having "ears"—the ability to listen to sound with judgment and discrimination. The chapter also serves as a foundation for the two chapters that follow, "Sound Effects" and "Music Underscoring."

Chapter 16, "Sound Effects," has been expanded and includes the functions of sound effects; types of sound effects; prerecorded sound-effect libraries; and producing and recording sound effects in the studio and in the field, with updated examples. The new section on the types of sound effects includes hard, Foley, ambience, electronic, and design effects.

Chapter 17, "Music Underscoring," addresses music's informational and emotional enhancement of visual content. Sections that include examples of film underscores, customized music programs, and organizing a music library have been updated. There is a new section that considers composing original scores.

Chapter 18, "Production for Mobile Media," is new. It covers the particular production and aesthetic challenges of producing audio today when so many listeners are hearing the sound through mobile devices such as smartphones and tablets.

Chapter 19, "Game Sound," introduces the preproduction, production, and postproduction of audio for games and how they are similar to and different from handling audio for television and film.

Chapter 20, "Music Recording," focuses on studio-based recording of live music. It includes the characteristics of musical instruments, ways to mike them, and various approaches to miking ensembles for stereo and surround sound.

Part IV: Postproduction

Chapter 21, “Editing,” describes the techniques of digital editing. It also addresses the differences between editing sound and editing picture; organizing the edit tracks; drive and file management; the aesthetic considerations that apply to editing speech, dialogue, music, and sound effects; and the uses of transitions.

Chapter 22, “Mixing: An Overview,” is the first of four grouped chapters covering mixing. This chapter introduces the final stage in audio production, when sounds are combined and processed for mastering, final duplication, and distribution. It includes coverage of mixing for the various media, the role of metering in assessment, troubleshooting, and new material on technical standards and delivery requirements when mixing for broadcast networks and film studios.

Chapter 23, “Premixing and Rerecording for Television and Film,” includes coverage of the procedures for the premix and rerecording stages; spatial imaging of stereo and surround sound; dialnorm; the CALM Act; dynamic range control; and stereo-to-mono and surround-to-stereo compatibility.

Chapter 24, “Music Mixdown,” is devoted to processing and mixing a music recording for stereo and surround sound.

Chapter 25, “Mixing for Mobile Media,” is new. It covers the considerations in signal processing and aesthetics when mixing for audio heard through media such as smartphones and tablets.

ACKNOWLEDGMENTS

The success of *Audio in Media* over the years has been due in large part to the interest, advice, and guidance of teachers and practitioners in the field who have been so forthcoming with their expertise. Whatever success the tenth edition enjoys is due in no small measure to their continued guidance and good advice.

To the following reviewers of the tenth edition, I offer my sincere gratitude for their insightful suggestions that helped direct this revision: Caryn Clippert, Towson State University; Matt Holmes, Hennepin Technical College, Eden Prairie Campus; Steven Keeler, Cayuga County Community College; John S. Klotz, Temple University; Mark Pfaff, Indiana University–Purdue University Indianapolis; Heather Polinsky, Central Michigan University; and Paul Schneider, University of Houston.

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Continued thanks go to Nathan Prestopnik, multimedia developer, for drafting the original material on game sound in the previous two editions that remains current.

To the folks at Wadsworth Cengage Learning go my sincere gratitude for their support and high standards: Michael Rosenberg, publisher, for his enlightened supervision; Megan Garvey, associate development editor for being caring, capable, and a pleasure to work with in shepherding this edition; Rebecca Donahue, editorial assistant, for always helping smooth the way; and Michael Lepera, senior content project manager, for his assistance coordinating the departments involved in pulling the book together.

As always, I continue to be impressed by the considerable talents and the good sense of project manager and art director Gary Palmatier and copyeditor Elizabeth von Radics of Ideas to Images. I have been so fortunate over the years to have been the beneficiary of their indispensable contributions, which have been a key reason for the success of *Audio in Media*.

Stanley R. Alten

The great power of our craft . . . comes from the fact that we are not tied to the literal "truth" of an event. We are free to re-associate sounds and images, and the power of cinema is such that the audience will be inclined to accept them. This metaphoric sound should strive to create a purposeful and fruitful tension between what is on the screen and what is kindled in the mind of the audience.

—Walter Murch, Academy Award–winning sound designer and editor

I will always sacrifice a technical value for a production value.

—Bruce Swedien, music producer/sound engineer

Murphy's Law of Recording:
Anything that can sound different will.

—Anonymous

PART

I

Principles

1

Sound in Production

IN THIS CHAPTER

Sound brings the world into a person; the ear points inward. Sight takes a person into the world; the eye points outward. What we hear affects what we see. Sound and sight are not alternatives, however. The senses function as a democracy—a concept that has been lost because of the dominance of the eye. Each sense serves its own "constituency" and is uniquely suited to its role in the sensorial realm. The senses are also interdependent. To overlook the function of one is to miss their overall impact on a human being's relationship to, and perception of, the physical world, particularly when it comes to the contributions of audio in media.

THE IMPORTANCE OF SOUND IN PRODUCTION

Sound is elemental. It affects people in ways they do not realize. It is integral to much of what we know and feel. Sound provides all sorts of information related to the mental processes of knowledge, reasoning, memory, judgment, and perception and to emotion, feeling, and mood.

Sound is omnidirectional; it is everywhere. It can be layered and simultaneous—one sound can be added to another without displacement. It is attention demanding. Comprehending and assimilating aural information requires active listening. Sound communication is a dynamic activity. "Listening with the ear is inseparable from listening with the mind."[1]

1. Michael Chion, *Audio-Vision: Sound on Screen,* trans. and ed. Claudia Gorbman (New York: Columbia University Press, 1994), p. 33.

What also enhances the power of sound, paradoxically, is its visual component. As one sage observed, "He who has ears to hear sees!" For decades radio drama created pictures in the "theater of the mind." Sound adds a visual dimension to radio news and documentary. Songs stir images. Sound in visual media, even from off-screen, often excites an image. A shot can show a cowboy sauntering down a street in the Wild West, but the sounds of a blacksmith's hammering, a saloon's player-piano, and horses' hooves put a town around the cowboy in the mind's eye.

Try watching a program or film without the sound. Then close your eyes and only listen to the sound. On average you will find that it is the sound that provides more of the information and impact than the picture.

When it comes to production values, sound works its magic in many ways. Consider how well-crafted audio in any medium engages and transports us. Disregarding the influence of sound can lead to problems that become disconcerting and distracting, if not disturbing, to audiences. Attention to sound is too often overlooked, or left to the last minute, to the detriment of a production; it is an effective and relatively low-cost way to improve production values and help ensure artistic success.

EVALUATING THE FINISHED PRODUCT

Before beginning the journey through the basics of sound and audio production, it may be useful to provide a context as to what the sonic goals should be in producing the end product.

What makes good sound? Ask 100 audio specialists to evaluate the same material and undoubtedly you will get 100 different responses. That is one of the beauties of sound: it is so personal. Who is to tell you that your taste is wrong? If it satisfies you as a listener, that is all that matters. When sound is produced for an audience, however, professional "ears" should temper personal taste. To this end there are generally accepted standards that audio pros agree are reasonable bases for artistic judgment.

Before discussing these standards, a word about the monitor loudspeakers is in order. Remember that the sound you evaluate is influenced by the loudspeaker reproducing it (and the acoustics of the room). You must therefore be thoroughly familiar with how the loudspeaker affects sonic reproduction. If a sound is overly bright or unduly dull, you have to know whether that is the result of the recording or the loudspeaker. Remember, a good way to familiarize yourself with a loudspeaker's response is to listen on the monitor system to a few test discs and well-produced commercial recordings with which you are thoroughly familiar until you are confident about its response characteristics (see chapter 4 for an in-depth discussion of loudspeakers and monitoring).

Intelligibility

It makes sense that if there is narration, dialogue, or song lyrics, the words must be intelligible. If they are not, meaning is lost. But when working with material over a long period of time, the words become so familiar that it might not be apparent that they are muffled, masked, or otherwise difficult to distinguish. In evaluating intelligibility it is therefore a good idea to do it with fresh ears—as though you were hearing the words for the first time. If that does not give you the needed distance from the material, ask someone else if the words or lyrics are clear.

Tonal Balance

Bass, midrange, and treble frequencies should be balanced; no single octave or range of octaves should stand out. Be particularly aware of too much low end that muddies and masks sound; overly bright upper midrange and treble that brings out sibilance and noise; absence of brilliance that dulls sound; and too much midrange that causes the harshness, shrillness, or edge that annoys and fatigues.

The timbre of the voice, sound effects, and acoustic instruments should sound natural and realistic. Music and sounds generated by electric and electronic instruments do not necessarily have to sound so, unless they are supposed to.

Ensemble sound should blend as a whole. As such, solos and lead voicings should be sonically proportional in relation to the accompaniment.

Definition

Each element should be clearly defined—identifiable, separate, and distinct—yet, if grouped, blended so that no single element stands out or crowds or masks another. Each element should have its position in, and yet be a natural part of, the sound's overall spectral range and spatial arrangement.

Spatial Balance and Perspective

All sonic elements in aural space—stereo or surround sound—should be unambiguously localized; it should be clear where various sounds are coming from. Their relationships—front-to-back and side-to-side—should be in proper perspective: dialogue spoken from the rear of a room should sound somewhat distant with appropriate ambience; an oboe solo should be distinct yet come from its relative position in the orchestra; a vocal should not be too far in front of an ensemble or buried in it; background music should not overwhelm the announcer; and crowd noise should not be more prominent than the sportscaster's voice.

Positional and loudness changes should be subtle and sound natural. They should not jar or distract the listener by jumping out, falling back, or bouncing side-to-side (unless the change is justified in relation to the picture). There should be no holes in the spatial imaging, nor should sounds be overly concentrated, creating sonic imbalance, masking, reduced definition, or a mishmash.

Dynamic Range

Dynamic range is the range between the loudest and the softest signals a system can produce without distortion. Therefore the audio should be as wide as the medium allows, making sure that the softest sounds are easily audible and the loudest sounds are not distorted.

If compressed, sound should not seem squeezed, nor should it surge from quiet to loud and vice versa.

Clarity

A clear recording is as noise-free and distortion-free as possible. Hum, hiss, leakage, phasing, smearing, blurring from too much reverberation, and distortion—all muddle sound, adversely affecting clarity.

Airiness

Sound should be open and airy. It should not seem isolated, stuffy, muffled, closed-down, dead, lifeless, overwhelming, or oppressive.

Acoustical Appropriateness

Acoustics, the properties of a room that affect the quality of sound, obviously must be good, but they must also be appropriate. With picture the space in which a character is seen and the acoustic dimension of that space must match. With music the acoustics should complement the type of music being played. Classical music and jazz sound most natural in an open, relatively spacious environment. Acoustics for rock-and-roll can range from tight to open. In radio most on-air talent belongs in a drier acoustic environment to complement the lip-to-ear intimacy of the medium.

Source Quality

When a recording is broadcast, downloaded, or sent on for mastering, there is usually some loss in sound quality. This occurs with both analog and digital sound. For example, what seems like an appropriate amount of reverberation when listening to a scene or a song in a studio may be barely discernible after transmission or transfer. As a general guideline, be aware that a source recording should have higher resolution than its eventual release medium.

PRODUCTION VALUES

In dealing with production and production values, director Francis Ford Coppola uses a triangle to explain what the priorities should be. The top of the triangle says "Good." The bottom-left side says "Quick." The bottom-right side says "Cheap." You can connect only two of the sides but not all three. If the production is good and quick, it will not be cheap. If is good and cheap, it will not be quick. And if the production is quick and cheap . . .

The degree to which you are able to develop and appraise production values is what separates the mere craftsperson from the true artist. Production values relate to the material's style, interest, color, and inventiveness.

Production values are the most difficult part of an evaluation to define or quantify because response is qualitative and intuitive. Material with excellent production values grabs and moves you. It draws you into the production, compelling you to forget your role as objective observer; you become the audience. When this happens it is not only the culmination of the production process but its fulfillment.

MAIN POINTS

- Sound brings the world into a person; the ear points inward. Sight takes a person into the world; the eye points outward.
- Sound provides all sorts of information related to the mental processes of knowledge, reasoning, memory, judgment, and perception and to emotion, feeling, and mood.
- Disregarding the influence of sound can lead to problems that become disconcerting and distracting, if not disturbing, to audiences. Attention to sound is too often overlooked, or left to the last minute, to the detriment of a production.
- In evaluating a final product, factors that should be considered include intelligibility, tonal balance, definition, spatial balance and perspective, dynamic range, clarity, airiness, acoustical appropriateness, and source quality.
- Production values relate to the material's style, interest, color, and inventiveness.
- Material with excellent production values grabs and moves you, drawing you into the production and compelling you to forget your role as objective observer. When this happens it is not only the culmination of the production process but its fulfillment.

2

Sound and Hearing

IN THIS CHAPTER

The term *sound* refers to three basic occurrences: the physical phenomenon of vibrations that set into motion longitudinal waves of compression and rarefaction propagated through molecular structures such as gas, liquids, and solids; the psychophysical perception of sound stimuli; and the physiological phenomenon that stimulates the sense of hearing.

THE SOUND WAVE

Sound is produced by vibrations that set into motion radiating waves of compression and rarefaction propagated through a range of media such as gases, liquids, and solids.

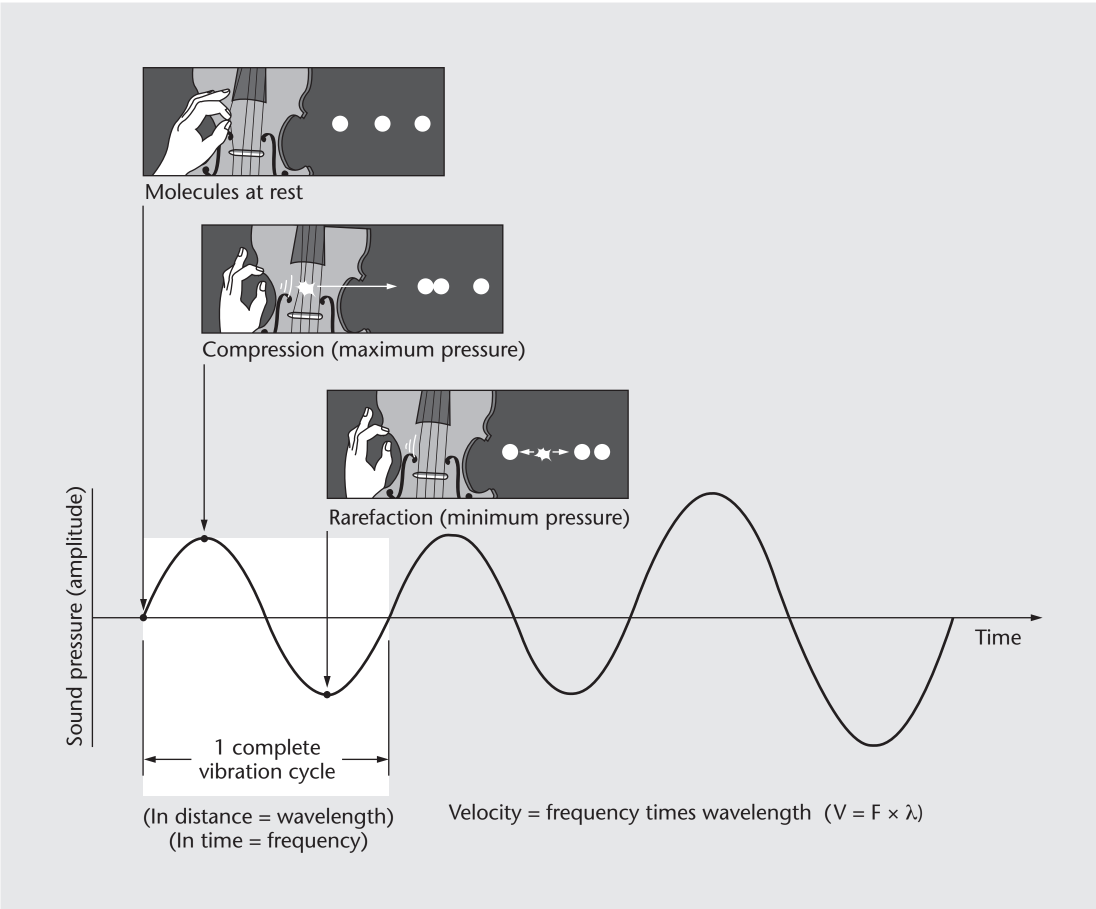
Hearing occurs when these vibrations are received and processed by the ear and sent to the brain by the auditory nerve.

Sound begins when an object vibrates and sets into motion molecules in the air closest to it. These molecules pass on their energy to adjacent molecules, starting a reaction—a ***sound wave***—which is much like the waves that result when a stone is dropped into a pool. The transfer of momentum from one displaced molecule to the next propagates the original vibrations longitudinally from the vibrating object to the hearer. What makes this energy transfer possible is a medium with the property of elasticity—whether gas, liquid, or solid. ***Elasticity*** is the phenomenon whereby a displaced molecule tends to pull back to its original position after its initial momentum has caused it to displace nearby molecules.

As the energy from a vibrating object moves outward, it compresses molecules closer together, increasing pressure. ***Compression*** continues away from the object as the momentum of the disturbed molecules displaces the adjacent molecules, producing a crest or peak in the sound wave. When a vibrating object moves inward, it pulls the molecules farther apart and thins them, creating a ***rarefaction***. This rarefaction also travels away from the object in a manner similar to compression except that it decreases pressure, thereby producing a trough or valley in the sound wave (see 2-1). As the sound wave moves away from the vibrating object, the individual molecules do not advance with the wave; they vibrate at what is termed their *average resting place* until their motion stills or they are set in motion by another vibration. To understand wave motion, we need to examine the components that make up a sound wave: frequency, amplitude, velocity, wavelength, and phase (see 2-1, 2-2, and 2-9).

FREQUENCY AND PITCH

When a vibration passes through one complete up-and-down motion, from crest to trough, it has completed one cycle. The number of cycles that a vibration completes in one second is expressed as its ***frequency***. If a vibration completes 50 ***cycles per second (cps)***, its frequency is 50 ***hertz (Hz)***; if it completes 10,000 cps, its frequency is 10,000 Hz, or 10 ***kilohertz (kHz)***. Every vibration has



2-1 Components of a sound wave. The vibrating object causes compression in sound waves when it moves outward (causing molecules to bump into one another). The vibrating object causes rarefaction when it moves inward (pulling the molecules away from one another).

a frequency, and humans with excellent hearing may be capable of hearing frequencies from 20 to 20,000 Hz. The limits of low- and high-frequency hearing for most humans, however, are about 35 to 16,000 Hz. Frequencies just below the ***low end*** of this range, called ***infrasonic,*** and those just above the ***high end*** of this range, called ***ultrasonic,*** are sensed more than heard, if they are perceived at all.

These limits change with natural aging, particularly in the higher frequencies. Generally, hearing acuity diminishes to about 15,000 Hz by age 40, to 12,000 Hz by age 50, and to 10,000 Hz or lower beyond age 50. With frequent exposure to loud sound, the audible frequency range can be adversely affected prematurely.

Psychologically, and in musical terms, we perceive frequency as ***pitch***—the relative tonal highness or lowness of a sound. The more times per second a sound source vibrates, the higher its pitch. Middle C (C4) on a piano vibrates 261.63 times per second, so its fundamental frequency is 261.63 Hz. The A note above middle C has a frequency of 440 Hz, so the pitch is higher. The ***fundamental*** frequency is also called the *first harmonic* or *primary frequency.* It is the lowest, or basic, pitch of a musical instrument.

The range of audible frequencies, or the ***sound frequency spectrum,*** is divided into sections, each with a unique and vital quality. The usual divisions in Western music are called octaves. An ***octave*** is the interval between any two frequencies that have a tonal ratio of 2:1 (refer to the inside front and back covers of the book).

The range of human hearing covers about 10 octaves, which is far greater than the comparable range of the human eye; the visible light frequency spectrum covers less than one octave. The ratio of highest to lowest light frequency visible to humans is barely 2:1, whereas the ratio of the human audible frequency spectrum is 1,000:1.

Starting with 20 Hz, the first octave is 20 to 40 Hz; the second, 40 to 80 Hz; the third, 80 to 160 Hz; and so on (see inside back cover). Octaves are grouped into ***bass, midrange,*** and ***treble*** and are further subdivided as follows.

- **Low bass**—first and second octaves (20 to 80 Hz). These are the frequencies associated with power, boom, and fullness. While there is generally little musical content in the lower part of this range, rap and hip-hop music in particular make effective use of this part of the frequency spectrum. In the upper part of the range are the lowest notes of the piano, organ, tuba, and bass and the fundamental of the bass (kick) drum. (As mentioned previously, a fundamental is the lowest, or basic, pitch of a musical instrument; see “Timbre” later in this chapter.) Sounds in these octaves need not occur often to maintain a sense of fullness. If they occur too often or at too loud a level, the sound can become thick or overly dense. With the exception of subwoofers, which are designed to handle low-end program material, most loudspeakers are capable of reproducing few, if any, of the first-octave frequencies. Loudspeakers capable of reproducing second-octave frequencies often do so with varying loudness levels.

- **Upper bass**—third and fourth octaves (80 to 320 Hz). Most of the lower tones generated by rhythm and other support instruments such as drums, piano, bass, cello, and trombone are in this range. They establish balance in a musical structure. Too many frequencies from this range make it sound boomy; too few make it thin. When properly proportioned, pitches in the second, third, and fourth octaves are very satisfying to the ear because we perceive them as giving sound an anchor, that is, fullness or bottom. Too much fourth-octave emphasis, however, can muddy sound. Frequencies in the upper bass range serve an aural structure in the way the horizontal line serves a visual structure—by providing a foundation. Almost all professional loudspeakers can reproduce the frequencies in this range.

- **Midrange**—fifth, sixth, and seventh octaves (320 to 2,560 Hz). The midrange gives sound its intensity. It contains the fundamental and the rich lower harmonics and overtones of most sound sources. It is the primary treble octave of musical pitches. The midrange does not necessarily generate pleasant sounds. Although the sixth octave is where the highest fundamental pitches reside, too much emphasis here is heard as a hornlike quality. Too much emphasis of seventh-octave frequencies is heard as a hard, tinny quality. Extended listening to midrange sounds can be annoying and fatiguing.

- **Upper midrange**—eighth octave (2,560 to 5,120 Hz). We are most sensitive to frequencies in the eighth octave, a rather curious range. The lower part of the eighth octave (2,560 to 3,500 Hz) contains frequencies that, if properly emphasized, improve the intelligibility of speech and lyrics. These frequencies are roughly 3,000 to 3,500 Hz. If these frequencies are unduly emphasized, however, sound becomes abrasive and unpleasant; vocals in particular become harsh and lispy, making some consonants difficult to understand. The upper part of the eighth octave (above 3,500 Hz), on the other hand, contains rich and satisfying pitches that give sound definition, clarity, and realism. Listeners perceive a sound source frequency in this range (and also in the lower part of the ninth octave, up to about 6,000 Hz) as being nearby, and for this reason it is also known as the *presence range*. Increasing loudness at 5,000 Hz, the heart of the presence range, gives the impression that there has been an overall increase in loudness throughout the midrange. Reducing loudness at 5,000 Hz makes a sound seem transparent and farther away.

- **Treble**—ninth and tenth octaves (5,120 to 20,000 Hz). Although the ninth and tenth octaves generate only 2 percent of the total power output of the sound frequency spectrum, and most human hearing does not extend much beyond 16,000 Hz, they give sound the vital, lifelike qualities of brilliance and sparkle, particularly in the upper-ninth and lower-tenth octaves. Too much emphasis above 6,000 Hz makes sound hissy and brings out electronic noise. Too little emphasis above 6,000 Hz dulls sound.

Understanding the audible frequency spectrum's various sonic qualities is vital to processing spectral balances in audio production. Such processing is called *equalization* and is discussed at length in chapters 9 and 24.

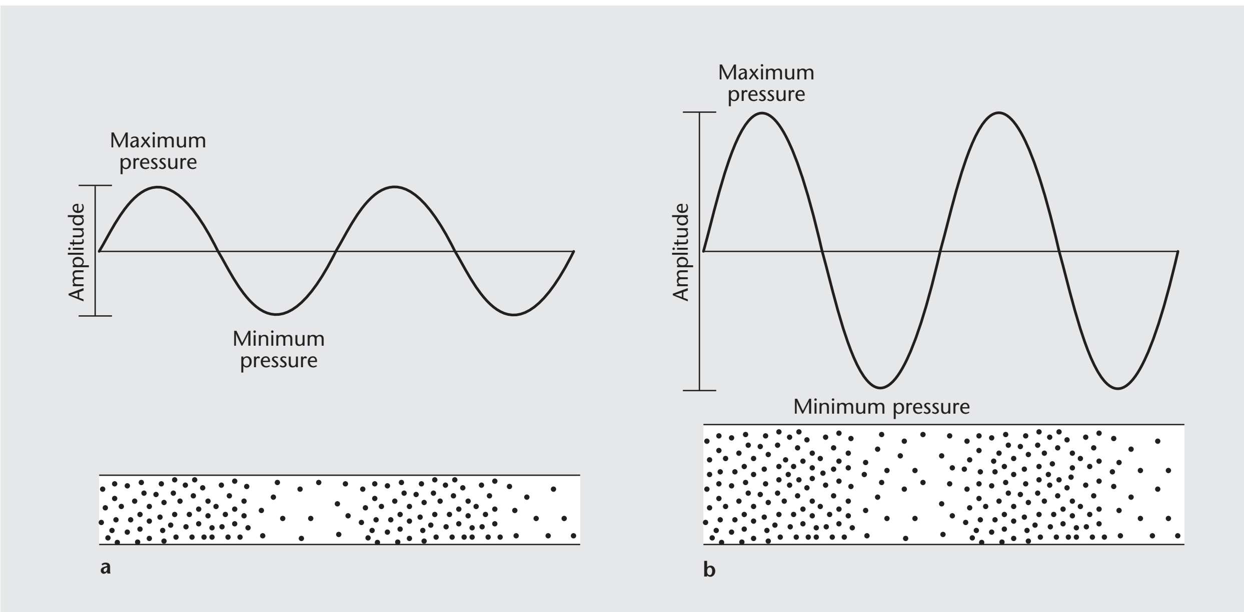
AMPLITUDE AND LOUDNESS

We have noted that vibrations in objects stimulate molecules to move in pressure waves at certain rates of alternation (compression/rarefaction) and that rate determines frequency. Vibrations not only affect the molecules' rate of up-and-down movement but also determine the number of displaced molecules that are set in motion from equilibrium to a wave's maximum height (crest) and depth (trough). This number depends on the intensity of a vibration; the more intense it is, the more molecules are displaced.

The greater the number of molecules displaced, the greater the height and the depth of the sound wave. The number of molecules in motion, and therefore the size of a sound wave, is called ***amplitude*** (see 2-2). Our subjective impression of amplitude is a sound's loudness or softness. Amplitude is measured in decibels.

The Decibel

The ***decibel (dB)*** is a dimensionless unit and, as such, has no specifically defined physical quantity. Rather, as a unit of measurement, it is used to compare the ratio of two quantities usually in relation to acoustic energy, such as



2-2 Amplitude of sound. The number of molecules displaced by a vibration creates the amplitude, or loudness, of a sound. Because the number of molecules in the sound wave in (b) is greater than the number in the sound wave in (a), the amplitude of the sound wave in (b) is greater.