The Technical Committee on Musical Acoustics (TCMU) is made up of scientists and engineers interested in the application of science and technology to the study of music and musical instruments. Members of the committee are interested in the underlying science of how humans make and perceive music, including music created by the human voice. Topics of interest include the physics of musical sound production, the perception and cognition of music, the analysis and synthesis of musical sounds and composition, and the classification of music and musical instruments. A review of publications in the area of musical acoustics reveals work relating to a wide variety of instruments. There are reports of several investigations of the human voice and many familiar western orchestral instruments, but one can also find reports of more unfamiliar instruments such as the Southeast Asian khaen (Cottingham, 2011) and the Nigerian slit log drum (Cannaday, et al., 2012).

Interestingly, the vast majority of scientists who are working in the field of musical acoustics were not trained as acousticians. Most come to the field of musical acoustics from a variety of other scientific disciplines. Therefore, the TCMU is an eclectic mix of scientists with a wide array of backgrounds. At a meeting of the TCMU it is not unusual to find someone trained in high-energy physics discussing the physics of the trumpet with a colleague who was trained in nonlinear optics. This mix of backgrounds gives the TCMU a unique character that enhances both personal and professional interactions, and results in each person approaching the field from a slightly different perspective.

As one would expect, there are some musical acousticians who were trained in acoustics. This is more prevalent with the members living in Europe, where the field is supported financially by governmental organizations. However, we are beginning to see more young people from the United States studying musical acoustics. This increase can probably be attributed to the interesting and challenging problems presented to those who study the physics of musical instruments, as well as the welcoming attitude that the members of the TCMU have toward people new to the field.

Although the community of musical acousticians encompasses a wide variety of research topics, there are a few that have been receiving significant attention recently. There are also several topics that would be receiving attention if adequate funding was available. One of the research areas that fits in the former category concerns the ability to distinguish the quality of musical instruments deterministically. It is common for musicians to believe that one make or model of an instrument is better than another one that appears almost identical, and they often agree on which instruments are superior. Unfortunately, the goal of evaluating the quality of a musical instrument quantitatively has been elusive. The inability to objectively determine the quality of a musical instrument is partly due to the musician’s inability to express the important qualities of an instrument in scientific language. It is also partly due to the acoustician’s inability to determine what quantities to measure and how to measure them (see, for example, Campbell, 2013). The problem...
is exacerbated by the personal preferences and preconceived notions of many musicians. A prime example of the power of preconceived notions was recently published in *Proceedings of the National Academy of Sciences* by Claudia Fritz and her colleagues at Lutheries-Acoustique-Musique in Paris (Fritz, 2014). They reported that in double-blind tests professional musicians cannot distinguish between high quality modern violins and similar instruments made by Guarneri and Stradivari in the 18th century. Although the conclusions seem well supported, many musicians have been critical of the research simply because of the well-established bias toward violins made by the 18th century masters.

Another topic receiving significant attention concerns the effect of structural vibrations on the sound produced by wind instruments. Structural vibrations are clearly important in producing the sound of string and percussion instruments. The importance of structural vibrations on the sound produced by wind instruments, however, has been debated for over a century. Recent experimental results indicate that structural vibrations are important in producing the unique sound of some brass wind instruments, e.g., trumpets and trombones (Kausel, et al., 2010), but the effects are likely insignificant in woodwind instruments, e.g., flutes and clarinets (Nederveen and Dalmont, 1999). The current work in this area is primarily directed toward achieving a theoretical understanding of the processes governing the interaction between the structural vibrations and the air column that produces the sound in these instruments. The issue is complicated by the necessity of the human interaction with the instrument during performance, which means that the structural vibrations can affect the sound field directly or they may feed back to the lips of the player. Additionally, the player may unconsciously compensate for the effects of structural vibrations. Separating these effects and determining the physics of the coupling mechanism is a non-trivial problem that is currently being addressed by musical acousticians in several countries.

Research on the synthesis of musical sounds is another area in which a large number of musical acousticians are involved. The goal of such work is to model the full physical system of a musical instrument and produce an accurate simulation of the sound in real time. Current work in this area includes a wide range of instruments, but regardless of the instrument under investigation the effort always necessitates extensive theoretical, experimental and computational work (see, for example, Smith, 2010; Chabassier, et al., 2013). Although significant progress has been made over the past decade in real-time simulation of musical instruments, there is still much to learn. Many musical instruments are so poorly understood that there is not even enough information to begin constructing an algorithm that will result in an accurate simulation of the sound.

As was pointed out by Murray Campbell in a recent plenary address to the ASA, there is one area that is critical to the advancement of our understanding of music and musical instruments but has yet to be seriously addressed: the quantitative characterization of the vocabulary that musicians use (Campbell, 2013). Not only has this topic not been adequately addressed, there seems to be no consensus on how to address it. Musicians use such terms as dark, rich, resistance, powerful, etc. when describing a musical instrument or its sound, but the meanings of these terms are not clear. It is not even clear that musicians are using the same definitions, although surprisingly they often agree on the description of an instrument using such terms. An accurate translation of the vocabulary that musicians use to describe instruments into scientific terms would revolutionize the field of musical acoustics, however, it currently appears to be many years away. Unfortunately, until such a lexicon can be constructed the divide between the musician and the acoustician will never be adequately bridged.

There are many interesting problems in musical acoustics that relate to singing and the perception of songs by listeners. The scope of the research is impressive, which is not surprising given the prevalence of sung music in cultures worldwide. Research on the process of singing ranges from imaging vocal folds to electroglottography (see, for example, Bailly, et al., 2010; Bernardoni, et al., 2014). Research on the perception of sung music is similarly broad and involves investigations across the fields of physics, physiology and psychology. The study of sung music overlaps significantly with the study of human speech, but it has recently been shown that the two fields may be more closely coupled than one may suspect. Work by Diana Deutsch and her colleagues at the University of California, San Diego has revealed that when a spoken phrase is listened to several times in succession the listener perceives the phrase as being sung (Deutsch, 2011). Most musical acousticians came to the field because of an abiding interest in music and the science of music. Many still maintain active research programs in other fields of physics and engineering while approaching musical acoustics as an

*Continued on page 60*
Review by: Joe W. Posey
121 Breezy Point Drive, Yorktown, Virginia 23692

The subject of this book is aircraft noise. It is a collection of notes from a graduate-level course taught by the author over the past few decades. He assumes no previous exposure to the study of acoustics by the students. Even though the text is brief, the scope is very broad, going from the fundamentals of acoustic theory to computational aeroacoustics (CAA).

The introduction, chapter 1, addresses acoustic propagation and noise metrics, then moves on to very brief discussions of the nature of aircraft noise, types of vehicular horns, and music theory. The next chapter covers the fundamental types of noise sources: monopoles, dipoles, and quadrupoles. Chapter 3 discusses Lighthill’s 1952 paper including his “equation of sound” and his acoustic analogy. Chapters 4 and 5 are concerned with subsonic jet noise while the next chapter, the longest in the book (46 pages), is an exploration of various CAA schemes, concluding with short discussions of propeller and helicopter noise prediction. Supersonic jet noise, “sound at solid boundaries” (airframe noise?), combustion noise, and sonic booms are dealt with in 11 pages in chapter 7 before it concludes with 8 pages on measurement techniques and noise reduction.

Clearly, the author wishes to share the information he collected throughout his career which is related to aircraft noise, plus a few other aspects of acoustics. As the title indicates, the book is intended to be an introduction to the subject, and that is a reasonable description of the contents. It could be used to show the student a sampling of work done in the area, but not to provide a foundation for further study. While the density of equations suggests rigorous treatment, the breadth of coverage and the brevity of the book necessitate cursory discussions of the many aspects of aircraft acoustics. Anyone seriously interested in the field would be well advised to first take a course in acoustics and then to study a systematic survey of the field such as that compiled by Hubbard (Aeroacoustics of Flight Vehicles, Theory and Practice–Volume 1: Noise Sources; Volume 2: Noise Control, edited by Harvey H. Hubbard, Acoustical Society of America, 1994) which was stringently reviewed.

The work chosen for presentation by Bose is curious indeed. Many of the references are non-refereed conference papers and theses or dissertations. For example, the only references for the extensively researched topic of propeller noise are a 1970 Jet Propulsion Laboratory report and an unspecified 1996 “time-domain calculation.” Lengthy quotations from the references are given throughout the book, but they are usually taken out of context so that the reader has no basis for establishing the limitations or generality of the quote.

Nomenclature and symbology are not only unconventional, but often contradictory and confusing. For example, instead of using $f$ (Hz) for frequency in cycles per second, $v$ is used and given the dimension of $1/s$ when it is clearly intended to be cycles/s. Further, even though the traditional $\omega$ is used for radial frequency, it is given the units of radians/s rather than $1/s$. In the discussion on standing waves in tubes, $\alpha$ is given two different definitions. The second is called “spatial radian frequency” and defined as $\omega/c$, which is traditionally called the wave number and given the symbol $k$. In fact, in the same discussion, $\omega/c$ is set equal to $v$, $\omega$, and finally $k$ in the space of little more than a page. To compound the confusion, the accompanying Fig. 1.4 erroneously shows pressure antinodes and velocity nodes at the open ends of a tube. All of this discussion and pointless collection of equations clouds one of the simplest concepts in acoustics, resonant frequencies of tubes. One need only note that a closed-closed tube will resonate at frequencies having an integral number of half wavelengths in the tube due to the requirement for a pressure node at each end.

Continued on next page
velocity node at each end. Similarly, an open-closed tube resonates with an odd number of quarter wave lengths due to the requirement for a pressure node at the open end and a velocity node at the closed end. Such obfuscation is typical of the entire book.

Nonsensical passages are found throughout the text. For example, here is a run-on sentence from section 1.8 talking about ducted fan noise: “It has been found that pressure noise distribution is less effective can decay [sic] exponentially in their passage through the duct, whereas in a supersonically spinning mode the noise distribution is less effective upstream and is zero under choking conditions.” Unfortunately, this and a short, equally cloudy discussion near the end of the book are the only inclusions of duct acoustics material, a very important consideration in turbofan noise prediction and control. For large, modern turbofan-powered transport aircraft, fan noise often is larger than jet noise, especially during landing approach.

Unfortunately, organization is also a major problem. For example, the brief section on “Measurement Techniques” includes an unrelated discussion of airframe noise sources as well as a paragraph on the increasing role of air traffic controllers in airport community noise reduction, including the imposition and enforcement of curfews.

So, this introduction to aerodynamic noise may have an audience, but it should not include anyone with a serious interest in establishing a foundation for the practice of aircraft noise control engineering.

Musical Acoustics
Continued from page 58

unfunded sideline. Some have no active research effort in musical acoustics but are merely interested in the physics and physiology associated with making and listening to music. The TCMU acts as a professional home for all of these people.

Biosketch

Thomas Moore is the Archibald Granville Bush Professor of Science and a Professor of Physics at Rollins College in Winter Park, Florida. He is the former chair of the Technical Committee on Musical Acoustics and has an active research program investigating the physics of musical instruments.

References


