

ACOUSTICS

WOODWIND ACOUSTICS

by Lars Kirmser

One of life's real joys is savoring that first cup of cappuccino every morning while sorting through my e-mail and reading all the latest postings in the musical instrument lists on the Internet. I find this activity to be very stimulating and often, a real source of inspiration. The diversity of ideas and opinions presented often allows me to look at a situation in a manner never before considered. As a result, I grow, my universe expands, I feel glad that I chose to be involved in the music industry.

One of the wonderfully liberating aspects of the Internet is that it is a totally democratic forum for virtually anyone who wants to convey their thoughts. And naturally, you must expect this forum to be a mix of truth, fiction, subjectivity, objectivity, intelligence, ignorance, and yes, even a little bovine excrement. I personally can forgive all of these categories except perhaps the last, albeit does provide some entertainment value from time to time.

One of the topics toward which I tend to gravitate (as I scroll down the postings) is any discussion relating to the acoustics of musical instruments. This topic has been of particular interest to me ever since my father helped me prepare a science project in 7th grade (MCMLVII) demonstrating the physical reasons for tone differentiation among the musical instruments of the modern orchestra. Later on in my career, from 1979 – 1997, I had the good fortune to teach a course in Musical Acoustics (108 hour) to adult students at a technical college. During these 18 years I had extraordinary fun exploring many of the important works on acoustics. I based my curriculum on three well known and readily available texts: THE ACOUSTICAL FOUNDATIONS OF MUSIC by John Backus, THE SCIENCE OF SOUND by Thomas Rossing, and FUNDAMENTALS OF MUSICAL ACOUSTICS by Arthur Benade. These three books, by the way, are absolute musts for anyone interested in getting the facts.

I should warn you, however. If you intend upon becoming a serious student of Musical Acoustics, you MUST be willing to let go all your ill-founded "gut" feelings and anecdotal opinions relating to musical acoustics. This is a luxury only the blissfully ignorant may hold onto. In fact, I would categorize approximately 90% of the opinions expressed on the Internet (relating to musical acoustics anyway) as falling into this realm. It reminds me of an interesting observation John Backus made in the introduction to his book:

" . . . what we know about the science of music has not spread very far, particularly among musicians. As a result, when a musician tries to give an acoustical explanation for something he has observed, he is almost invariably wrong. This is not surprising since, as we have already stated, there are so many more wrong ways than right ways of explaining something. However, the consequence is that music (like other fields of human endeavor) is burdened with fallacies and superstitions it could better do without If this provokes discussion and argument from musicians who find some of their cherished beliefs under attack, this will also be good; the author can use a few good enemies."

Backus' final comment was in reference to an earlier statement:

"[One] way of dealing with errors is to have friends who are willing to spend the time necessary to carry out a critical examination of the experimental design beforehand and the results after the experiments have been

completed. An even better way is to have an enemy. An enemy is willing to devote a vast amount of time and brain power to ferreting out errors both large and small, and this without compensation. The trouble is that really capable enemies are scarce; most of them are only ordinary. Another trouble with enemies is that they sometimes develop into friends and lose a good deal of their zeal."

One mistake we often make is that we will take as gospel the opinions (relating to musical acoustics) of persons who may otherwise be considered to be masters in vastly different disciplines within the music industry (i.e. musical instrument builders, repairers, teachers). Often these individuals engage in the regurgitation of grossly inaccurate myths, propagated by their own early mentors. What we are delving into here is not unlike the conundrums of religion or politics. In both religion and politics, never have so many, based so much faith, upon such little evidence; some insist in fact that it must be the result of a conspiracy, or at the very least mass hysteria. I believe that it is no different regarding musical acoustics.

"Please don't confuse my closely held beliefs with facts or reason!"

One of the common misconceptions is: the average musician is completely unaware that each family of musical instruments has its own unique set of acoustical rules under which it must operate. Each is separate and, in fact unique. The Woodwinds, Brasswinds, Violin Family, Fretted Strings, Percussion, all behave differently and to varying degrees with regard to the natural laws of physics. For example, the material from which a member of the violin family is made is indeed critical to its tonal output; the material of a woodwind instrument is not critical to its tonal output. How could this be! Well, in order for the material to affect the tonal output, it must couple significantly with the vibrating air column and become part of the vibrating system. In a woodwind, except for the initial 5 – 10% of its length, the material exhibits little or no sympathetic vibration; there is just not enough energy generated at the mouthpiece of a Woodwind instrument to cause the body to be set into vibration. In the Brasswinds, the material and treatment of that material from which they are made will indeed affect the final tone quality. Why? Because the metal body does in fact vibrate sympathetically and couples acoustically with the vibrating column of air. This question of the affect of material on tonal output is even more pronounced in instruments of the violin and guitar families.

With regard to the Woodwind family John Backus writes:

"The belief in the importance of material to woodwind tone probably arises from the observation that when the instrument is played, there are sometimes vibrations in its body that can be felt by the fingers. It is then assumed that the vibrations of the walls can also affect the internal standing wave and change its quality. However, recent work has shown that the sound radiated from the walls is negligible compared with the sound normally radiated by the instrument, and that the effect of the wall vibrations on the internal standing wave is also negligible." [Effect of Wall Material on the Steady State Tone Quality of Woodwind Instruments: Journal of the Acoustical Society of America 1971]

Backus continues:

"It follows that the material of the instrument is not a factor of its tone; if a gold flute sounds different from a silver one, it is because of differences in the structural dimensions and not because of the difference in the metal. In short, the material of the wind instruments may be chosen for its working qualities and not for any imagined effect on its tone."

Arthur Benade writes concerning woodwind acoustics:

"The question of whether or not the playing properties of wind instruments are influenced by the material from which it is made has been the subject of curiously bitter controversy for at least 150 years. . . . Since 1958 I have made several studies of the possible difference in damping that can be made by using copper, silver, brass, nickel silver, or various kinds of wood as the air-column wall material. If the walls are thick enough not to vibrate and if they are smooth and nonporous, experiment and theory agree that switching materials will make changes in the damping that are generally less than the two-percent change that most musicians are able to detect."

Murray Campbell and Clive Greated state in their book The Musician's Guide to Acoustics:

"Traditional Clarinets are made of wood, African Blackwood being used for good quality modern instruments. It is often said that the clarinet has a woody sound, but this is due to the shape of the bore and finger holes together with the end condition imposed by the reed, rather than anything to do with the material. . . . It is generally accepted that the construction material has only a secondary influence on tone quality, the dimensions of the resonating tube being the dominant factor which determines this (Coltman 1971) Generally more expensive instruments are made to a far higher standard of craftsmanship, which may be of more significance than the material itself."

Understandably, I may have ruffled the feathers of a number of my readers. Nevertheless, my purpose is only meant to offer a challenge to those of you who have been inclined to continue spewing the popular myths of musical acoustics about. I believe that unless an individual makes an effort to study the published data; unless he makes a responsible effort to become aware of the 150 years of research that is freely available to anyone with a library card, then they are simply NOT entitled to an opinion. The solution: Begin by reading the three books that I recommended at the beginning of this article (at least). Think about the material (a lot). Discuss it with other intelligent inquiring minds. Then, and only then, will you will you be able to offer a valid, intelligent contribution to the discussion. Otherwise, you will only be contributing to the confusion by sharing ignorance.

Other Recommended Reading:

- The Physics of Sound by Richard E. Berg & David G. Stork (1982)
- Music, Physics and Engineering by Harry F. Olson (1967)
- On the Sensations of Tone by Hermann Helmholtz (1877)
- The Science of Music by Sir James Jeans (1937)
- Problems for Musical Acoustics by William R. Savage (1977)
- The Musician's Guide to Acoustics by Murry Campbell & Clive Greated (1987)
- Musical Acoustics an Introduction by Donald E. Hall (1980)
- The Science of Sound by Thomas D. Rossing (1982)
- Fundamentals of Musical Acoustics by Arthur H. Benade (1976)
- The Acoustical Foundations of Music by John Backus (1977)

