The Art and Science of Mallet Instrument Tuning

BY BILL YOUHASS

The following are ideas and thoughts I have put together over some time. The ideas presented here are not too technical and definitely not complete, but should act as a catalyst to help percussionists listen in a different way to, and become closer with, their mallet-keyboard instruments.

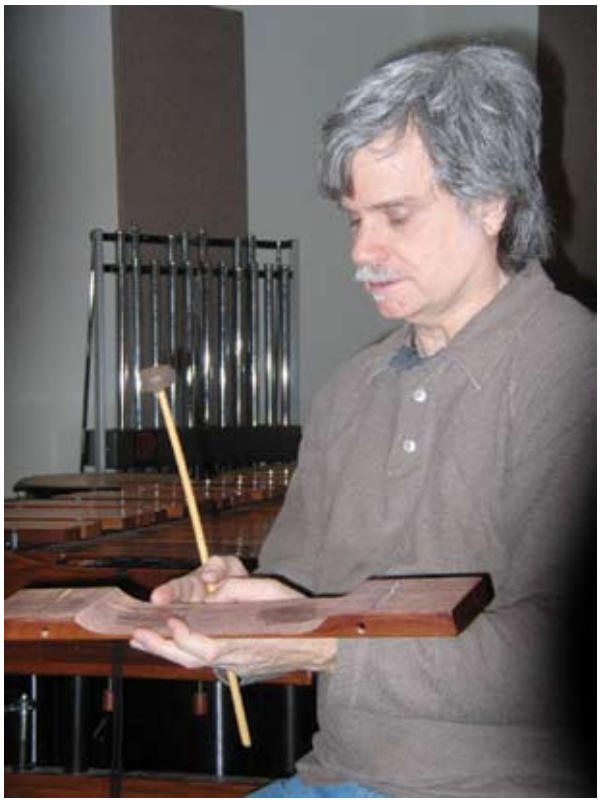
SOME BASICS

The best practical technique found so far to tune a fixed-pitch instrument in such a way that it can be played in all keys, or no key, is by "equal tempered" tuning. Because mallet percussion instruments are fixed-pitch, like a piano, they are always "out of tune," so tuning is both an art and a science. What sounds in tune is subjective, so the *art* is in tuning the bars in such a way that they sound in tune to the ears of most. The *science* is in understanding the acoustics of a rectilinear bar, and after making decisions about the bars sounding in tune, following through consistently from bar to bar and instrument to instrument. But then the art comes back again—sometimes subjective choices have to be made; sometimes art trumps science.

ENVIRONMENTAL CONDITIONS AND PITCH

How fast instruments go out of tune depends on the environmental conditions in which they are kept and, in the case of wood bars, the quality of the wood and the original drying process. Wood bars are more affected over a long period of time than metal or synthetic bars and need to be tuned more frequently. High humidity and heat cause bars to go flat, and low humidity and cold cause them to go sharp, regardless of the material. Ideal conditions are a consistent temperature and humidity. If instruments are undergoing constant changes in environment, there is much greater stress on the material, and the bars will be repeatedly expanding and contracting, absorbing and desorbing moisture. The pitch goes up and down repeatedly and ultimately the bars "forget where they belong." This is especially true of wood bars, so I recommend keeping the bars as close as possible to a constant environment of 72 degrees Fahrenheit and 40 to 60 percent humidity.\

Additionally, all the bars on one instrument are not affected the same. As I retune the same instrument over many years, I find the same bars move the same way each time! This F#5 always goes up a little; this A2 fundamental always drops a bit; the 10th partial on this D3 always moves this way. Instruments in Arizona often go sharp (dry and air-conditioned) and those in Seattle often go flat (wet, wet, wet, and maybe the spilled coffee).



OCTAVE STRETCHING

I would like to clarify several terms. "Harmonic" and "partial" are similarly defined and are used interchangeably throughout this discussion. The first harmonic or partial is the fundamental, the second harmonic or partial is the octave, the third is the 12th, etc. "Overtones" refers to pitches above the fundamental. I will refer to middle C as C4.

Octave stretching on mallet instruments is done for several reasons. One is that the "Western" human ear tends to hear "perfect" octaves, double octaves, etc. in higher registers as flat and is generally happier when higher octaves are "sharp." Another grows out of the physical characteristics of piano strings. Because piano strings are very hard and are stretched tightly, the overtones in a given string are sharp, and they get sharper as the strings get shorter and are under increasing tension. This is called "inharmonicity." Simply stated, in order for the ear to perceive octaves as being "in tune," which generally means without any (or with very slow) "beats," a piano tuner must theoretically tune the fundamental on a given string to match the 2nd partial on the string one octave lower, or be very close. This usually results in tuning that higher octave "sharp" to match the lower string's 2nd partial.

For my own work, I have developed an octave stretching system that is a compromise, as is all stretching, because there is no *right* way. Many years ago, I spoke with and acoustically analyzed the playing of many musicians, from violinists, flutists, clarinetists, and oboists to jazz guitarists. I also consulted with piano tuners, analyzed the tuning of some fifty pianos from tiny spinets to nine-foot grands, and read materials on the theory and practice of piano tuning, especially the question of stretching.

Even though there are differences in the acoustic properties of piano harmonics and mallet percussion harmonics, there must be a similarity in the tuning of the two if they are played together. However, while I have a consistent stretching system in use today, the final sound of the bars on each

If a marimba is not tuned for a long period of time, it doesn't go out of tune any faster than if it is tuned more frequently; it just gets more painful to listen to.

instrument is what is most important. So, again the subjective nature of art comes back and what *should* work doesn't always.

HARMONICS

Until about 1926, mallet percussion instruments were tuned without any intentionally tuned overtones. There was one pitch tuned on each bar (the first mode of vibration or the fundamental) and each bar contained whatever overtones happened to occur as a result of cutting the arch to tune the fundamental pitch. At this time the J.C. Deagan Company began tuning marimbas with a harmonic two octaves above the fundamental (4th partial), which revolutionized the sound of mallet percussion in regards to color and intonation. Deagan also began tuning vibraphones with a 4th partial and xylophones with a 3rd partial—an octave and a 5th above the fundamental. (You may have a four-octave xylophone with the lowest 5th or octave tuned in octaves, but I have to stop somewhere.)

If you listen to these post-1925 marimbas (see "Assignment" at the end of this article), you may also hear a pitch approximating the 10th partial, but *not* the naturally occurring 10th partial in the harmonic series, which would have been an octave and a major third. Rather, you will hear a pitch that will usually vary from a sharp minor 3rd to a flat major 3rd. On most post-1925 marimbas you will find at least one tuned partial in addition to the fundamental between the range of C2 (or lower) and somewhere between C5 and A5.

Contrary to the older Deagan and Leedy marimbas, most manufacturers today tune a major third, the "true" 10th partial. (Several makers are also now tuning the 20th partial, which is an octave above the 10th partial where possible.) There is a definite, striking difference in timbre in these different ways of tuning.

One very important issue in tuning the overtones on a given bar is that they must match the same pitches on higher bars (this does not refer to those "in between" 10th partials on older Deagans, etc.). For example, C4, the 4th partial of C2 (the lowest C on a five-octave marimba), must match the fundamental of the C4 bar; the 10th partial, E5, must match the fundamental on the E5 bar *and* the 4th partial on the E3 bar.

It would be thought provoking to see what interest there would be in offering instruments with the older "in between 10th partial" tuning, as there are strong arguments that this older tuning avoided some of the pitfalls of "true" 10th partial tuning.

OTHER HARMONICS

There are also other harmonics that occur naturally. "Torsional" and "out of phase transverse harmonics" are two examples. These various "extra" harmonics are popularly known as *edge tone*, *side-tone*, *wolf tone*, etc. They are most significantly a problem on marimbas in several ranges—C2 to A3, from about E4 to B4, and from about F6 to C7, on vibes from F3 to G4, and on xylophones from about C4 to C5 and from about F7 to C8. On glockenspiels there sometimes can be problems between about C5 to F5.

Don't take these ranges too seriously as they all depend on the bar dimensions and density. Whenever possible, these harmonics must be tuned in such a way that they do not interfere with the perceived tuning of the bar.

CORRECTING OVERTONES

When retuning existing bars, ideally the tuner would like to be able to tune all the above-mentioned harmonics correctly, or to at least eliminate any dissonance that strong out-of-tune harmonics may cause.

On post-1925 instruments, this is frequently possible with the "other" harmonics, almost always possible with 1st, 3rd (xylophones), and 4th partials, and sometimes possible with 10th partials. It depends on the quality of the original tuning. This is not a big problem on the better, newer instruments (and I emphasize "the better"), as these makers have very good in-house tuners and small corrections can be made. However, a number of companies are not as careful when tuning overtones because, well, it just takes too long. Sometimes these mistakes can be corrected and sometimes they cannot.

Pre-1926 instruments are a different situation. For example, those great pre-1926 Deagan and Leedy xylophones had no intentionally tuned overtones, as mentioned above. Sometimes it is possible to tune a pitch to the 3rd partial ("5ths" or so-called "quint" tuning) but again, it depends. There is also a certain character

to not having the overtones "correctly" tuned.

Whether or not to tune these 5ths is an issue to consider, as it is not necessarily wise to correct them. For instance, on the old Leedy #992 xylophones I usually recommend *not* trying to bring the "5th" in tune because the bars are quite small (even compared to a Deagan #870), and removing the amount of wood necessary can often reduce the rich tonal quality of the bars.

When, on a xylophone, those 5ths *can* be tuned, whether "body" will be lost depends on how close the harmonics are and the size of the bars. There can be: (1) no loss of body, (2) some loss, or (3) a great deal of loss. The same concept holds true for trying to tune 4th partials on pre-1926 marimbas such as the earlier Deagan #35x series. Ultimately there should be a discussion between player and the tuner, and the tuner needs to know your preferences and express to you his expectation of what is likely to happen.

WHEN TO TUNE

There is no single answer to this question, so this is really up to the player. I cannot say, for example, "Marimbas should be tuned every two or three years," because mallet instruments are not like pianos. If pianos are not tuned regularly, considerable and sometimes irreparable damage can be done to the structural components such as the strings, frame, and pin block. This situation is not true with mallet percussion. If a marimba is not tuned for a long period of time, it doesn't go out of tune any faster than if it is tuned more frequently; it just gets more painful to listen to and won't blend in with other instruments. Also, as it slowly goes out of tune, you may become gradually used to it, which not a good idea! If your ears can stand it, more power to you, because mine can't.

For schools and orchestras it would be ideal to tune all of the mallet instruments at the same time. If it is affordable, that is the best procedure, and you will hear the difference in your mallet section. However, if this is not a possibility, I recommend a systematic schedule for having the instruments tuned in order to assure all are tuned frequently enough to preserve the integrity of the entire section. For personal instruments, have them tuned when you feel they need it (or when someone else complains).

ASSIGNMENT

The following is a suggested assignment for tuning your ear into your bars. Try to hear the 4th and 10th partials on your marimba, assuming, of course, that you have a post-1926 marimba made by a company that actually tuned both notes. Use the lower bars, C2 to G3, as it's easier to hear.

First, play the bar as you normally would to get the fundamental in your ear. Then place a finger lightly in the center of a bar to lessen the prominence of the fundamental. Depending on the bar, use a medium rubber mallet and play about one-half to two-thirds of the way toward one of the cords. You should hear the 4th partial.

Next, place a couple of fingers on the top of the bar near one end. Play again in the center, then near each edge. You should hear another pitch, *hopefully* just one, and something around a major or minor 10th partial. What do you find?

IN CONCLUSION

I believe the greatest single leap in the ongoing evolution of mallet instrument tuning was the discovery by the Deagan tuners some 80 years ago of the advantage to tuning 4th partials on marimbas and vibraphones and 3rd partials on xylophones. This revolutionized the sound of these instruments. There have been a number of advances since that time, especially in the past fifteen years, that have further refined the art tuning of bars, and there are more to come, I am sure.

Bill Youhass is a former Artist-in-Residence at the Cincinnati College-Conservatory of Music. He was a founding member of The Percussion Group Cincinnati and taught percussion at Ithaca College. He is the owner of Fall Creek Marimbas. **PN**