HDP: 25 – 02

# The Sound of Wood Tops on a Banjo

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Replacing the typical mylar banjo head with thin wood produces qualitatively different sounds. Samples are presented here without any discussion of the physics. It is actually a simple, non-destructive, reversible, and inexpensive modification one can try with virtually any banjo. Instructions are included.

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## I. INTRODUCTION

There are string instruments around the world with drumhead tops that have sisters that look and play similarly but have thin wood for soundboards. Nomenclature is interesting but not worth fighting over. Rather, I present here some played examples and single string sounds with a variety of heads for comparison. It is offered as a banjo modification for the Do-It-Yourselfer that is simple, non-destructive, reversible, and inexpensive but yields a totally different instrument. It can be played like the original banjo but certainly invites exploration and innovation.

FIG. 1. three wood discs that easily replace the white mylar head and the wood-topped “hexagon”

## II. OUTLINE

In section §III, a short version of a tune is played on the original banjo (Remo top-frosted head at 91 on the DrumDial); on three wood 11″ discs of different thickness, each mounted on the same original banjo; and on an all wood construction, the "hexagon," which is strung with nylon fishing line strings. Section §IV contains carefully controlled single plucks — with all strings open and at the bridge with all strings damped. Section §V describes the easiest way to try it yourself.

## III. PLAYED TUNE

The tune is a brief version of a song that descended from a 1928 recording by Jim Jackson.[1] That song was saved from oblivion by Harry Smith in his 1952 *Anthology of American Folk Music*. It morphed substantially in the hands of Roger McGuinn, who included it in the 1968 *Dr. Byrds & Mr. Hyde*. Despite the rock arrangement, McGuinn's tune was clearly banjo-based. McGuinn began his professional music career playing banjo, and he has performed that song solo on banjo ever since.

On a banjo, it sounds much better frailed than plucked. I initially thought that the wood soundboards do much better plucked than frailed because their attack sound is actually very percussive even with bare finger tips. So, these played examples are plucked with bare fingers for a fair comparison. On the other hand, further exploration is warranted.

So, here they are. "Blue" is the tune. The original mylar head is labeled "remo." The three wood discs are a thinner solid spruce labeled "thin," a thicker solid spruce labeled "thick," and a 1/16″ 6-ply Baltic birch plywood labeled "ply." The all-wood hexagon is, of course, "hexagon."

The recording set-up and settings are the same for all five — at least as best I could. Among other things, that means that the relative loudnesses are represented reasonably well. Listening myself after the fact, I hear that I got the tempo and pitch pretty well-matched, but I can't swear about the playing itself. I wonder to what extent I subconsciously compensated for the inherent lower volumes. The single string wire breaks in section §IV are unbambiguous.

http://www.its.caltech.edu/~politzer/wood-tops/remo-blue.mp3 .

http://www.its.caltech.edu/~politzer/wood-tops/thin-blue.mp3 .

http://www.its.caltech.edu/~politzer/wood-tops/blue-thick.mp3 .

http://www.its.caltech.edu/~politzer/wood-tops/blue-ply.mp3 .

http://www.its.caltech.edu/~politzer/wood-tops/blue-hexagon.mp3 .

## IV. WIRE BREAK RESULTS

### A. the set-up

Looping thin magnet wire around a string at a particular location and pulling until it breaks provides a highly reproducible pluck. The slight variations from pluck to pluck are negligible compared to the difference of interest between different heads and different instruments more generally. So, I present one typical pluck for each head. I currently use #42 AWG (0.0026″D), which is ornery and nearly invisible, and I set the microphone 1″ from the bridge. Thinner wire would allow getting closer, which, from a physics standpoint, is a better measure of the motion of the head and bridge themselves, which is simpler to understand than the produced sound. I used to be able to do that. :(

The banjo is one of my retired reseach-grade Goodtimes, manufactured and donated by Greg Deering. In particular, it is the 2 3/4″ deep version of the trio described in ref.[2]. For the sake of this comparison, nothing was changed on that banjo except for the head. (The construction is described in section §V.) The hexagon has a similarly thin plywood soundboard, but it is a totally different instrument and has nylon fishing line strings for this example.

For the record, the thicknesses and masses for 11″ discs are as follows — Remo mylar: 0.009″ and 18 g (for the 11″ disc alone); thin: 0.066″ and 42 g; thick: 0.076″ and 47 g; and 1/6″ ply: 0.188″ and 141 g.

### B. single plucks

These are the sounds of a single representative wire-break pluck at the 14$^{\text{th}}$ fret with all strings open in double-C and recording set-up the same for all. The order is remo, thin, thick, ply, and hexagon.

http://www.its.caltech.edu/~politzer/wood-tops/1st-all-open-singles.mp3

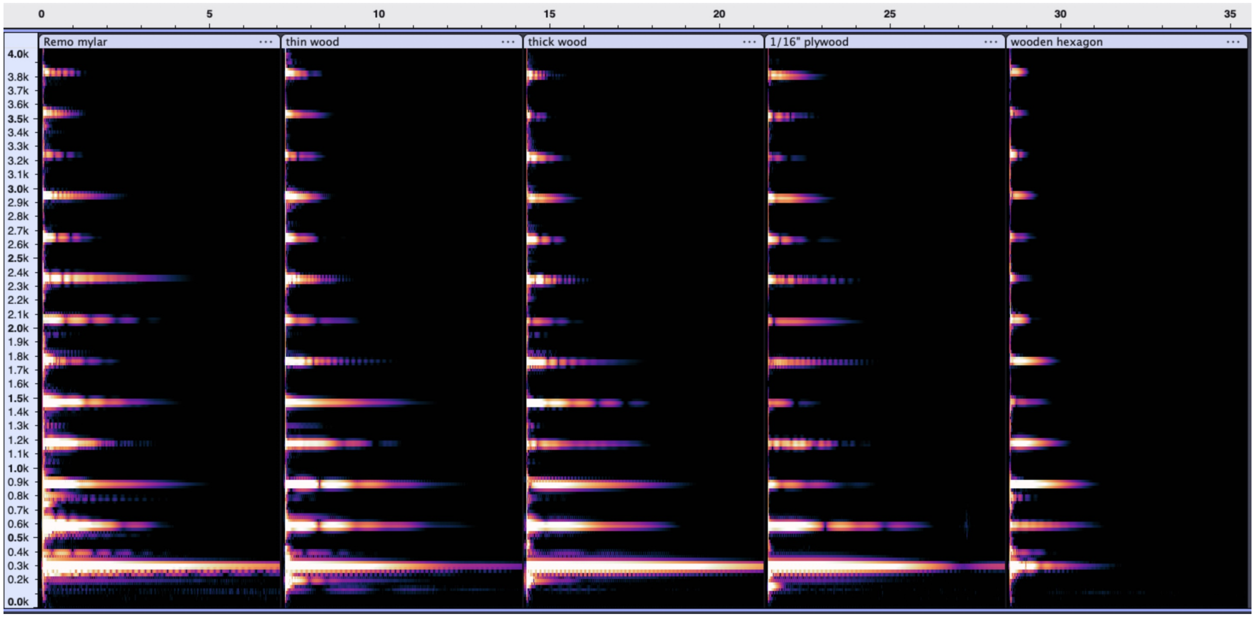


FIG. 2. a representative pluck for each top at original volume for 0 to 4000 Hz

The spectrograms in FIG. 2 show 0 to 4000 Hz. I think it's worth contemplating how perceptions compare to measurements of frequency amplitudes. One evident feature of the normal banjo is the presence of strong inharmonic partials. It was argued in earlier studies[3] that these are the origin of the ring of the banjo. Furthermore, they were identified as primarily due to the large initial motion of the whole bridge when a string is plucked, That motion excites all the other strings. There are also inharmonic partials coming from the modes of the head itself. The thinner of the wood tops also apparently has sufficient initial flex to excite inharmonic string partials.

Also of interest is the perception of loudness. Certainly, the hexagon is the quietest. But the story for the others is more complicated.

FIG. 3 shows spectrograms for the same recordings but going up to 16 kHz. The perceived percussive attack sound of all of the wood tops is clearly represented by initial strong sound at all frequencies — much more than occurs with the mylar drum head.

This is the sound of the same recordings where the wood top sounds have been amplified by the amounts shown on the top of each column in FIG. 4, i.e., 6, 9, 12, and 15dB respectively. The goal was to allow focus on the timbre differences. Of course, for anything but

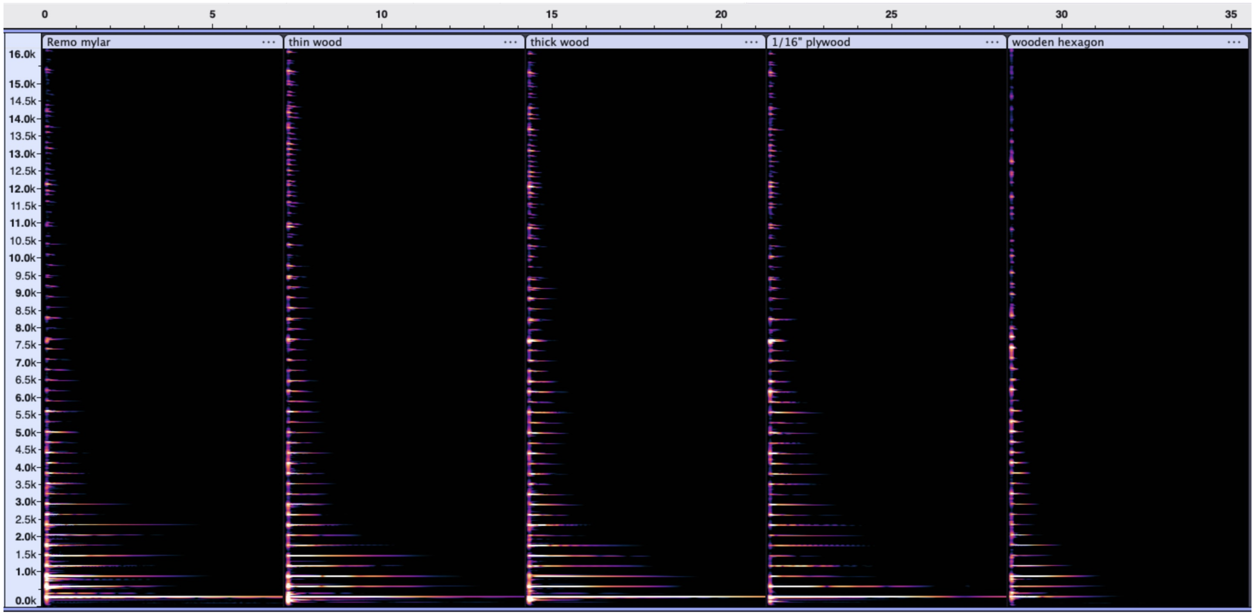


FIG. 3. a representative pluck for each top at original volume for 0 to 16,000 Hz

a pure, steady, single frequency tone, loudness is a complex issue. So, the dB amounts are just guess at something that might be useful for the comparisons.

http://www.its.caltech.edu/~politzer/wood-tops/1st-all-open-singles-amplified.mp3

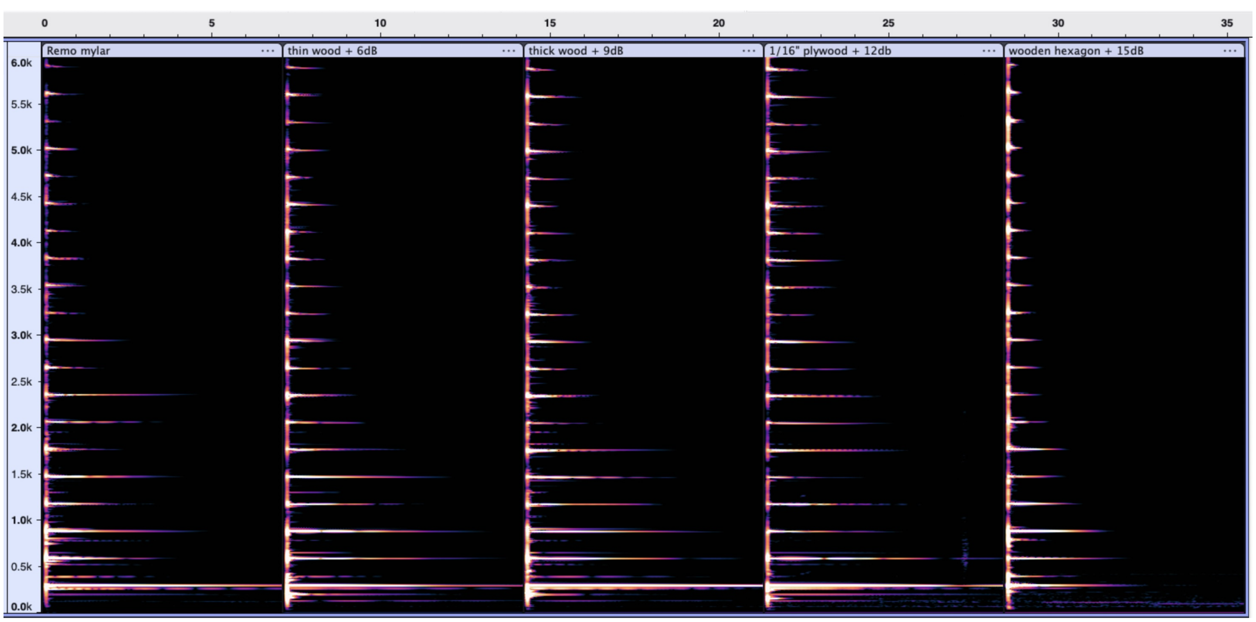


FIG. 4. a representative pluck for each top for 0 to 6000 Hz, amplified as indicated

### C. bridge taps

With all strings damped (including the tail strings behind the bridge), wire breaks at the bridge provide an impulse, always with the same force, like a well-controlled tap. The produced near-field sound is a crude measure of the consequent bridge motion. This has long been studied for wood-topped instruments and more recently for banjos.[4] Here are representative recorded sounds at 1″ for the five instruments in the same order: http://www.its.caltech.edu/~politzer/wood-tops/bridge-tap-comparison.mp3 . There is no extra amplification here. All are recorded with the same set-up and settings.

FIG. 5 is a graph of their spectra, and FIG. 6 are spectrograms going up to 2000 Hz. (FIG. 5 was calculated with relatively low frequency resolution becasue that is what is generally relevant to sound production from the strings.)

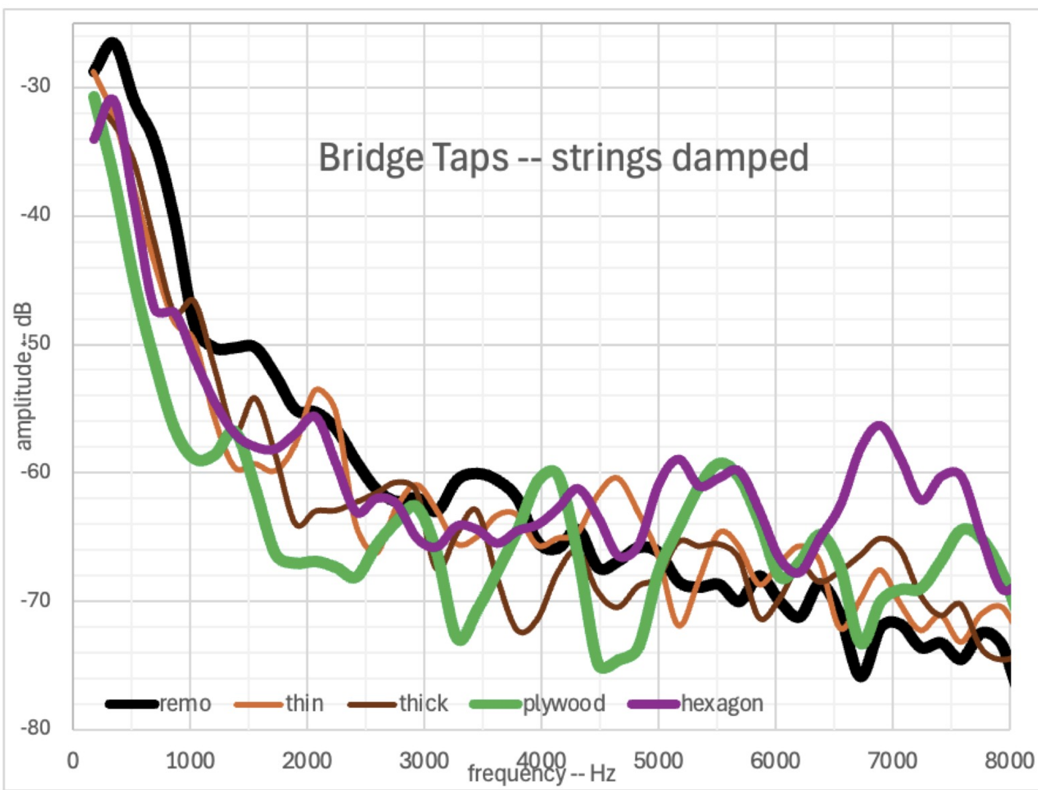


FIG. 5. spectra of the near sound due to bridge taps with strings damped

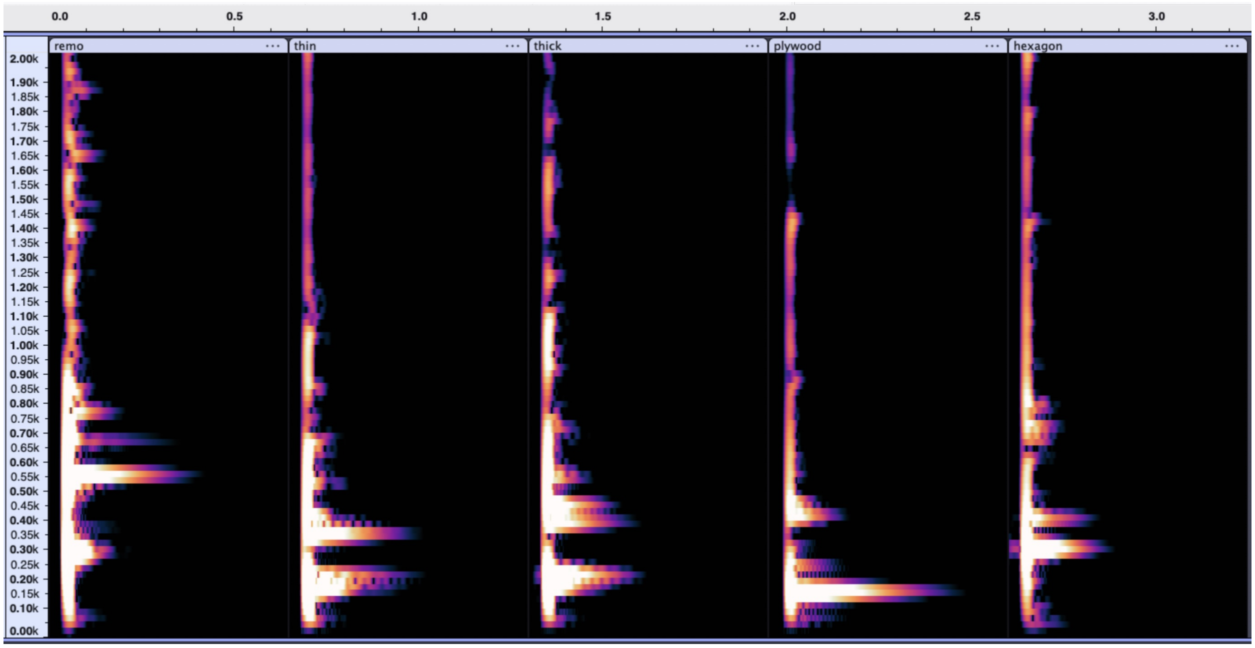


FIG. 6. spectra of the near sound produced by bridge taps with strings damped

## V. CONSTRUCTION TIPS

### A. wood disks & mounting technique

To make one for yourself, you need a thin wood disk that's the diameter of the head it's replacing. For the banjo used here, that was 11″. The two thin solid spruce disks were a serendipitous find — left over from someone else's extensive experimentation that included a variety of bracing. I picked two without any bracing because they're the simplest. (See section §C below.) 1/16″ plywood is readily available, maybe not in hardware or lumber yards but from craft suppliers or other specialty stores. (Michael's has some on-line. I used left-overs from an earlier project, and the supplier was a specialized outfit in a neighboring county that sold, among other things, Keller drum shells.)

The simplest way that actually worked to mount the wood disks relied on starting with a regular Remo head. I used one that was very worn and actually stretched out from some sort of previous abuse. Trace a 10″D centered circle and cut it out. The wood sits in its place, and your existing hooks and tension ring hold it down. (Common sense is required in tensioning.) The result is shown in the photo on page 1.

### B. the height issue

If the disk simply sits on top of your existing rim, it will raise the bridge. You could use a shorter bridge. More significantly, it will raise the tension ring, and that might interfere with the strings. Before I did anything with the 1/16″ disk, the strings could not be fretted above the 17th. But I like the 22nd. Removing wood from the top of the rim is irreversible and *not* recommended. Much easier is a trick incorporated for many years on Goodtimes by Greg Deering. The holes in the rim for the hanger bolts are elongated slightly, which allows a range of heights over which the neck can be set. A bit of Dremeling was all that was needed. And it works! If you're paranoid like me, you can put an appropriately sized slice of dowel in the hole (no glue needed) where the hanger bolt isn't. The same idea, i.e., elongated holes, is what allows a height adjustment on the Goodtime tailpiece.

### C. bracing & break angles

I opted for no bracing on any of the wood disks, imagining I might include an intelligent discussion of admittance in comparison to the drumhead. But that didn't happen. Even the thinner of the two solid spruce disks held up well enough under the down-pressure of the strings that it could be played. However, its long-term prospects in that configuration were questionable. In the aftermath of all recordings, I have opted to keep the 1/16″ plywood on the instrument. It might be tough enough to withstand on its own. But, just in case, I installed one of Joel Hooks' mutes — at least for storage — https://banjothimble.com/banjo-mutes. (See FIG. 7.)

More generally, wood soundboards are louder if the wood is thinner. Thinner simply moves more under the force of the strings. Some break angle and down force is generally considered necessary. So, something must be done to avoid collapse of the sound board. Usually, a compromise is struck between top thickness and additional bracing. Any bracing obviously reduces certain motions of the soundboard. Its dimensions and placing allow selectivity in what is damped the most. So, decisions are tangled up with the question of what sounds "best."

The hexagon was a kit marketed by the long-defunct Hughes Dulcimer Co. of Denver, CO. I think I made mine around 1990. Michael Miles, a world-class professional clawhammer player includes his hexagon in performances that involve multiple banjos. And one has been on display for many decades at McCabe's Guitar Shop in Santa Monica, CA.

The hexagon top was pieced together using smaller (therefore cheaper) pieces. The joints were reinforced, and those reinforcements also serve as bracing – visible in FIG. 8.

FIG. 7. one of Joel Hooks' mutes installed to brace the plywood top

FIG. 8. hexagon back view

### D. break angle misconceptions

Banjos, the violin family, most mandolins, and many guitar have floating bridges. A common misconception is that the break angle of the strings going over the bridge is essential for getting good volume out of the instrument. However, it is common knowledge in the banjo world that too large a break angle suppresses the sound. Also, reducing the break angle allows the soundboard to move more and generate more sound. It turns out that the only impediment to making break angles smaller and smaller is that the strings lose contact with the bridge when they vibrate upwards and may even jump out of their slots.

In fact, the zero break angle "problem" can be addressed, and perfectly playable instruments can be made with zero break angles. I built one specifically to compare its sound to a 13° angle.[5] I once saw (but lost track since) photos of an acoustic guitar with a bridge and saddle that drove vibrations in the guitar top without producing any static, equilibrium down force — effectively with zero break angle.

Break angles have an enormous impact on timbre. In particular, floating bridges all produce a formant with a frequency range that is enhanced relative to above and below. The break angle controls its lower reach. Taking the angle to zero turns the formant into a low-pass filter.

Because a guitar bridge and saddle can be far more substantial than a banjo bridge, making a zero break angle guitar is much simpler than what is required for a banjo. Hence, I made no attempt for this investigation.

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[1] *Jim Jackson, v. 1, The Complete Recorded Works in Chronological Order, 1927 to 1928*, Document Records DOCD-5114, https://www.document-records.com/

[2] My 2013 report, https://www.its.caltech.edu/ politzer/TheOpenBackOfTheOpenBack.pdf, discussed the back and sound hole of open-back banjos. The three banjos used for demonstrations were identical except for their rim heights: 2″, 2 3/4″, and 5 5/8″.

[3] see July 2023 to May 2024 at https://www.its.caltech.edu/~politzer/

[4] *Acoustics of the Banjo: measurements and sound synthesis & theoretical and numerical modelling*, J. Woodhouse, D. Politzer, and H. Mansour, Acta Acustica, **5**, 15 and 16 (2021) https://doi.org/10.1051/aacus/2021009 and https://doi.org/10.1051/aacus/2021008) and *Pickers' Guide to* Acoustics of the Banjo, D. Politzer, J. Woodhouse, and H. Mansour, HDP: 21 – 01, http://www.its.caltech.edu/~politzer – APRIL 2021

[5] https://www.its.caltech.edu/~politzer/zero-break/zero-break.pdf. The math there was wrong and was corrected in https://www.its.caltech.edu/~politzer/parametric.pdf. A more likely scenario is given in refs. [4], but the phenomenon underlying banjo ring was confirmed in refs. [3].