

## Folded Horn Acoustic Guitar Patent # 10,177,172

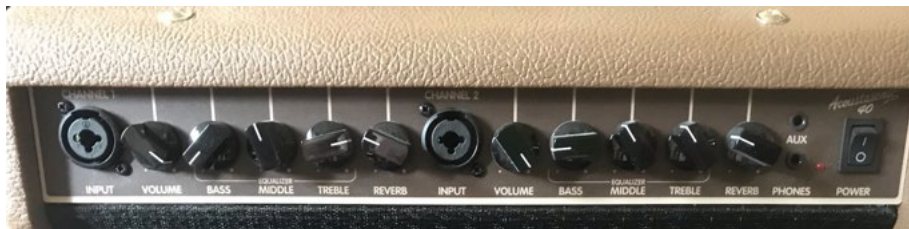


# Folded Horn Acoustic Guitar Patent # 10,777,172

How do I put this:



+



Inside of this:



To get a far more powerful acoustic guitar that rocks, can be played with less effort, and is battery powered – UNPLUGGED.



# Folded Horn Acoustic Guitar Patent # 10,177,172



=



Drivers

Solution: machine folded horns (waveguides) into a guitar body, add speakers and electronics. 4X the power!

All components not shown 3



## Folded Horn Acoustic Guitar Patent # 10,177,172





## Folded Horn Acoustic Guitar Patent # 10,177,172



Chamber divider  
(not shown) is  
placed on top of  
folded horns.

4/20/2023



Soundboard (not  
shown) is placed on  
top of guitar sides.

## Folded Horn Acoustic Guitar Patent # 10,177,172



Class D  
amplifier and  
battery pack  
placed here.

They fit –  
barely!



## Folded Horn Acoustic Guitar Patent # 10,777,172



Chamber divider

Front of  
soundboard

Back of  
soundboard  
CNC machined  
from one  
piece of Baltic  
Birch (except  
bridge support  
is glued).  
Moves like a  
speaker, light  
but very  
strong. I can  
move this  
thing  $\frac{1}{4}$ " with  
my hand. You  
try that with  
Sitka Spruce  
(which I love),  
it will snap.

## Folded Horn Acoustic Guitar Patent # 10,177,172





## Folded Horn Acoustic Guitar Patent # 10,777,172



## Folded Horn Acoustic Guitar Patent # 10,777,172

Zigged  
where I  
should  
have  
zagged.



Soundboard and  
body still need to be  
stained and polished.  
May not win a beauty  
contest, but will  
provide unmatched  
power.

Starting to drum sand the top in assembly to match the body.

Screwing soundboard on so it is removable, with access to chamber divider, speakers and electronics.

Drill out sound hole for magnetic pickup, and use piezo pickup under the bridge saddle.



## Folded Horn Acoustic Guitar Patent # 10,777,172



Decorative features are actually designed to give soundboard more flex/volume and still maintain strength.

(48) #4-40 screws with washers, each need to offset 4 lbs. of force from the strings (196 lbs. total). Screw and washer assembly is able to handle 4X this amount of force.

Guitar body wall section is 1/4" thick Rock Maple, enough room for screws. No glue required.

# Folded Horn Acoustic Guitar Patent # 10,777,172





Folded Horn Acoustic Guitar Patent # 10,777,172

(12) **United States Patent**  
**Katzenberger**

(10) **Patent No.:** **US 10,777,172 B1**  
(45) **Date of Patent:** **Sep. 15, 2020**

(54) **FOLDED HORN ACOUSTIC GUITAR**

(71) Applicant: **Joseph J. Katzenberger**,  
Crawfordsville, IN (US)

(72) Inventor: **Joseph J. Katzenberger**,  
Crawfordsville, IN (US)

(73) Assignee: **Joseph J. Katzenberger**,  
Crawfordsville, IN (US)

(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 0 days.

4,987,815 A 1/1991 Shockley

5,208,410 A 5/1993 Foley

5,333,527 A 8/1994 Janes

5,461,958 A 1/1995 Dresdner

5,442,986 A 8/1995 Cota

5,549,027 A 8/1996 Steinberger

5,567,896 A 10/1996 Gottschall

5,661,252 A 8/1997 Krawczak

5,682,003 A 10/1997 Jarowsky

4,995,293 A 11/1999 Anderson

6,040,510 A 3/2000 Yuan

6,124,536 A 9/2000 Hoshino

6,646,191 B1 11/2003 Martin

6,664,452 B1 12/2003 Teel

6,800,797 B2 10/2004 Steiger

6,833,501 B2 12/2004 Jagmin

(Continued)

(21) Appl. No.: **16/431,553**

(22) Filed: **Jun. 4, 2019**

(51) **Int. Cl.**  
**G10D 13/02** (2020.01)  
**G10D 3/02** (2006.01)  
**G10D 1/08** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **G10D 3/02** (2013.01); **G10D 1/08**  
(2013.01)

(58) **Field of Classification Search**  
CPC ..... G10D 3/02; G10D 1/08  
See application file for complete search history.

(56) **References Cited**  
U.S. PATENT DOCUMENTS

2,001,723 A 5/1935 Hammond, Jr.

2,228,463 A 6/1942 Kislingbury

3,194,870 A 7/1965 Tondreau et al.

3,549,775 A 12/1970 Kaminsky

3,612,741 A 10/1971 Marshall

3,656,395 A 4/1972 Kaman

3,892,159 A 7/1975 Houstma

4,464,967 A 8/1984 Trimborn

4,748,886 A 6/1988 De Byl

OTHER PUBLICATIONS

U.S. Appl. No. 10/686,839, filed Oct. 14, 2003, Henry Langeman.

U.S. Appl. No. 11/142,487, filed Jun. 1, 2005, Kenneth Preece.

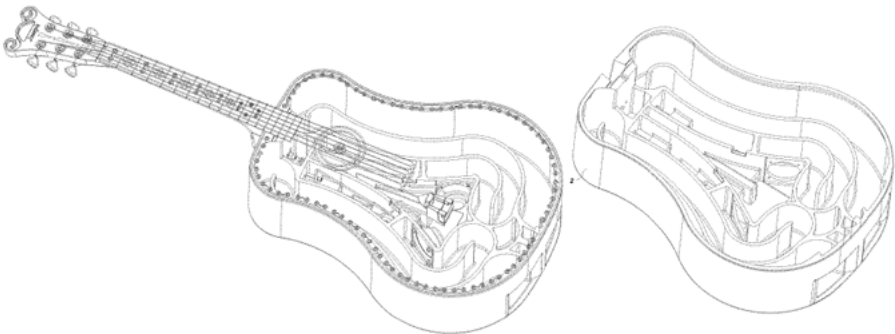
U.S. 11/810,948, filed Sep. 7, 2007, Jan Anders Linden.

Primary Examiner — Kimberly R Lockett

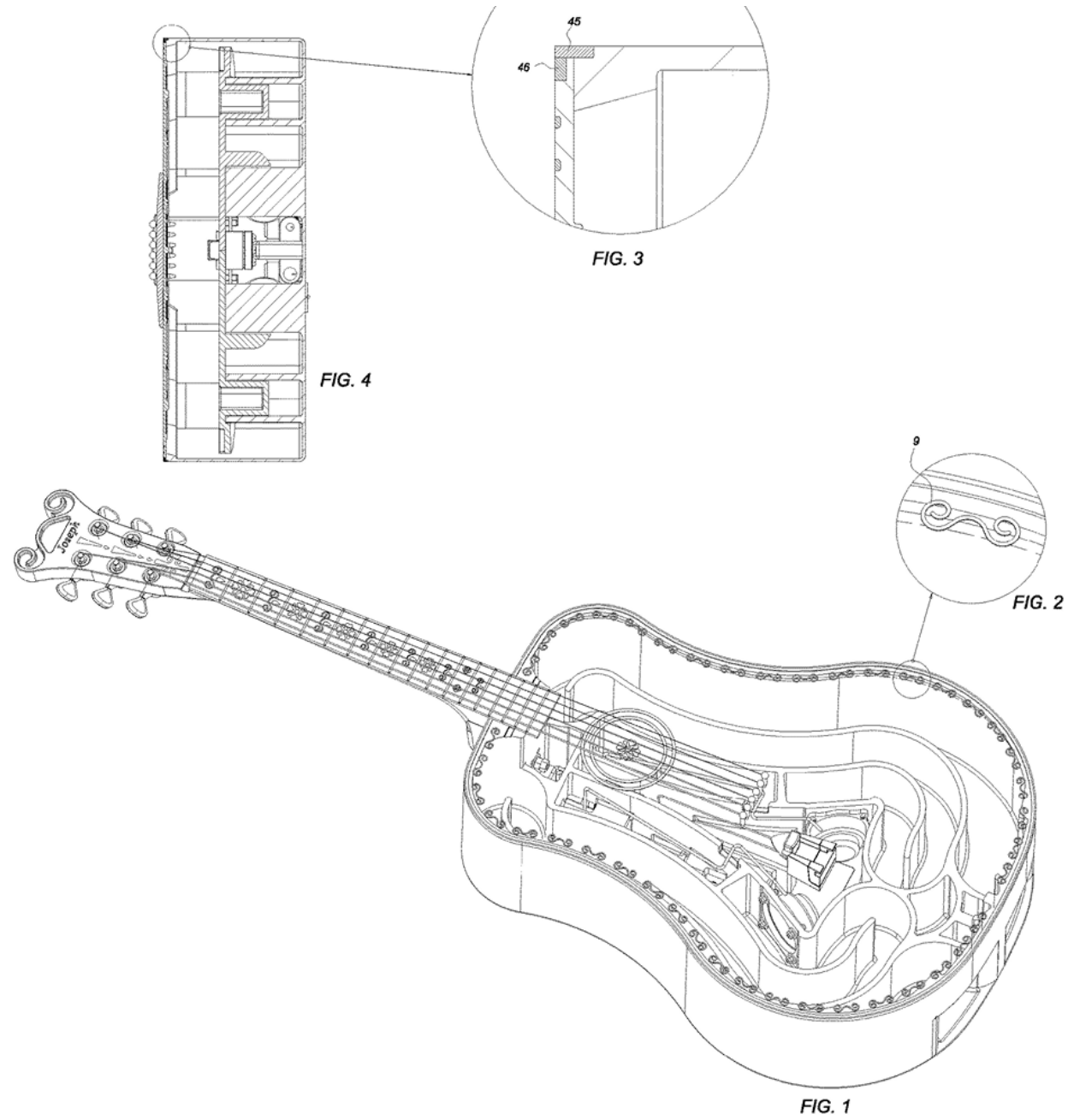
(57) **ABSTRACT**

This invention is an acoustic guitar with two internal folded horns built into the guitar body. Each left and right horn is five feet long. The natural acoustic sound inside the guitar is captured by a microphone (not a pickup under the strings), inside the guitar's upper chamber. It is then sent to an internal preamp, which sends the signal to left and right speakers, which are mounted to the compression chamber at the start of each folded horn. It then travels through the throat of each folded horn, which increases exponentially until it reaches the end of the horn. The sound waves are concentrated throughout this shape (does not lose sound energy), and are also directed to left and right exits out the end of the instrument. The material for the body is Rock Maple, and the other materials are Sitka Spruce, Rosewood and Mahogany.

6 Claims, 5 Drawing Sheets

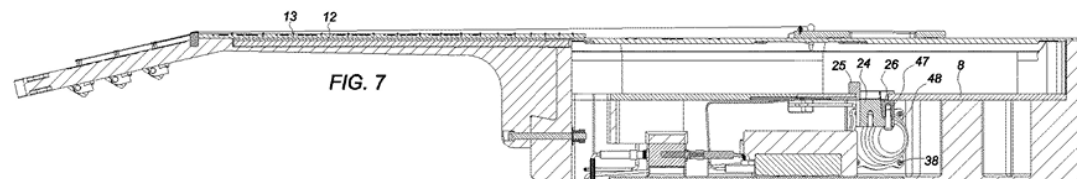
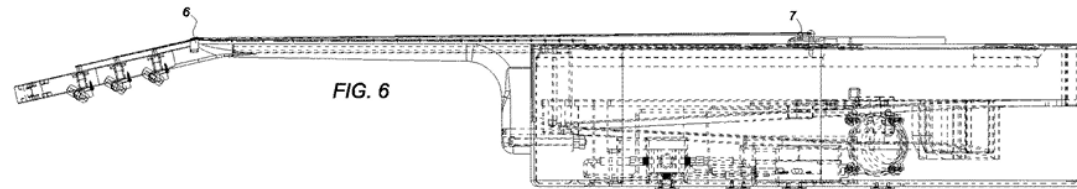
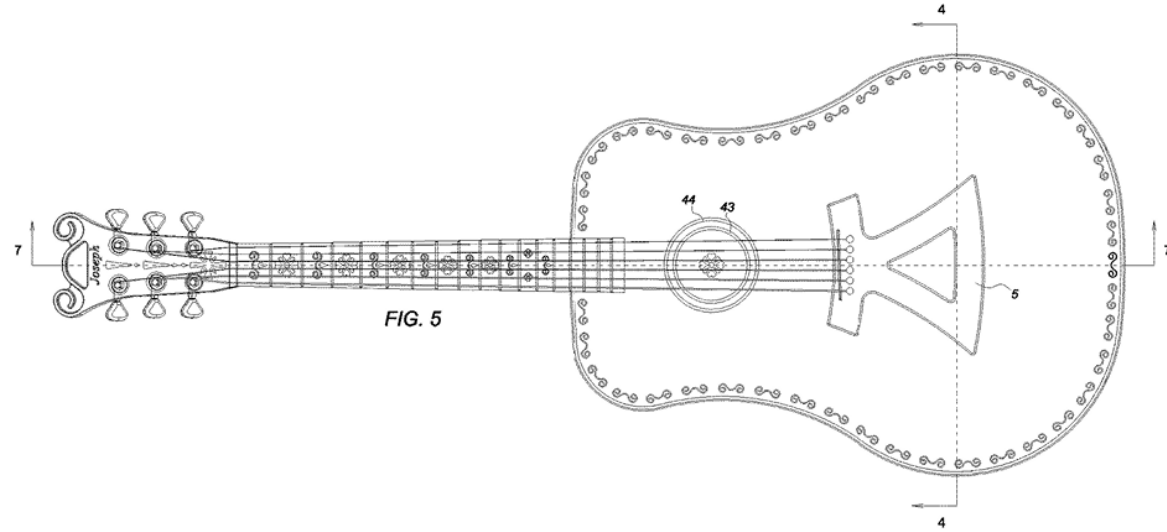


# Folded Horn Acoustic Guitar Patent # 10,777,172





# Folded Horn Acoustic Guitar Patent # 10,777,172



# Folded Horn Acoustic Guitar Patent # 10,777,172

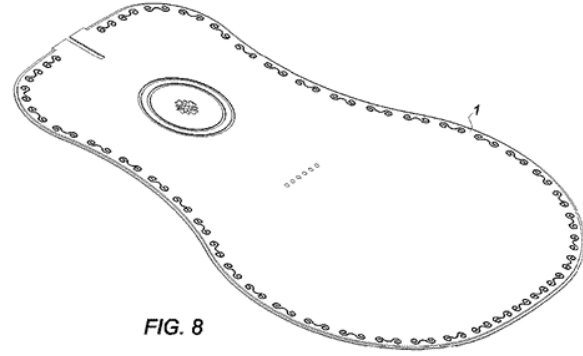


FIG. 8

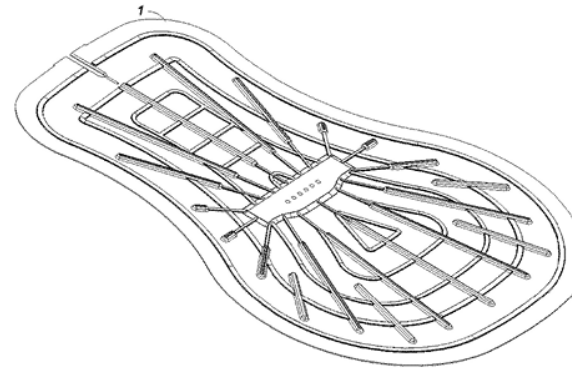


FIG. 9

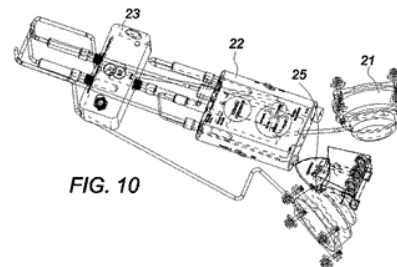


FIG. 10



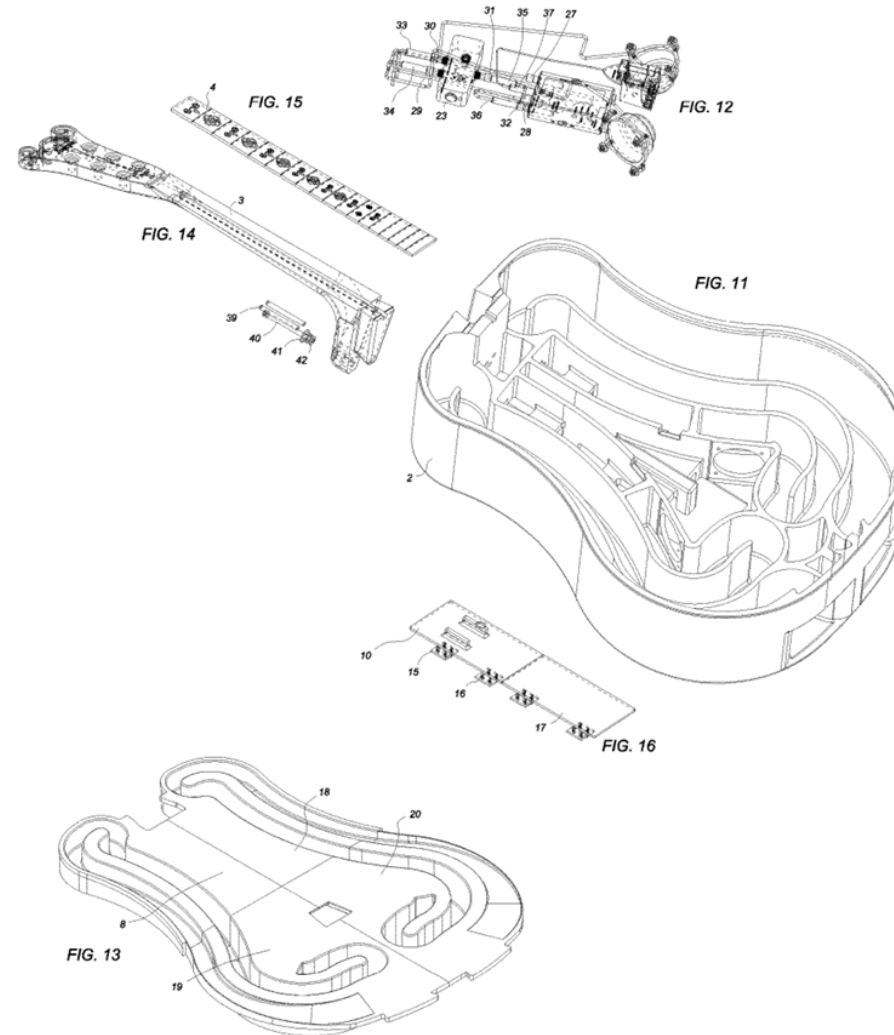
# Folded Horn Acoustic Guitar Patent # 10,777,172

U.S. Patent

Sep. 15, 2020

Sheet 4 of 5

US 10,777,172 B1



## Folded Horn Acoustic Guitar Patent # 10,777,172



Body wood is 100% Hard  
(Rock) Maple, same as a violin.



## Folded Horn Acoustic Guitar Patent # 10,777,172



CNC machine start.

## Folded Horn Acoustic Guitar Patent # 10,777,172



CNC machine about  
halfway through.



## Folded Horn Acoustic Guitar Patent # 10,777,172



CNC machine almost complete. I can cut the entire body and horns in about two full days, runs at night.

## Folded Horn Acoustic Guitar Patent # 10,777,172



Solid stock on the CNC machine.



Not final shape, but close!

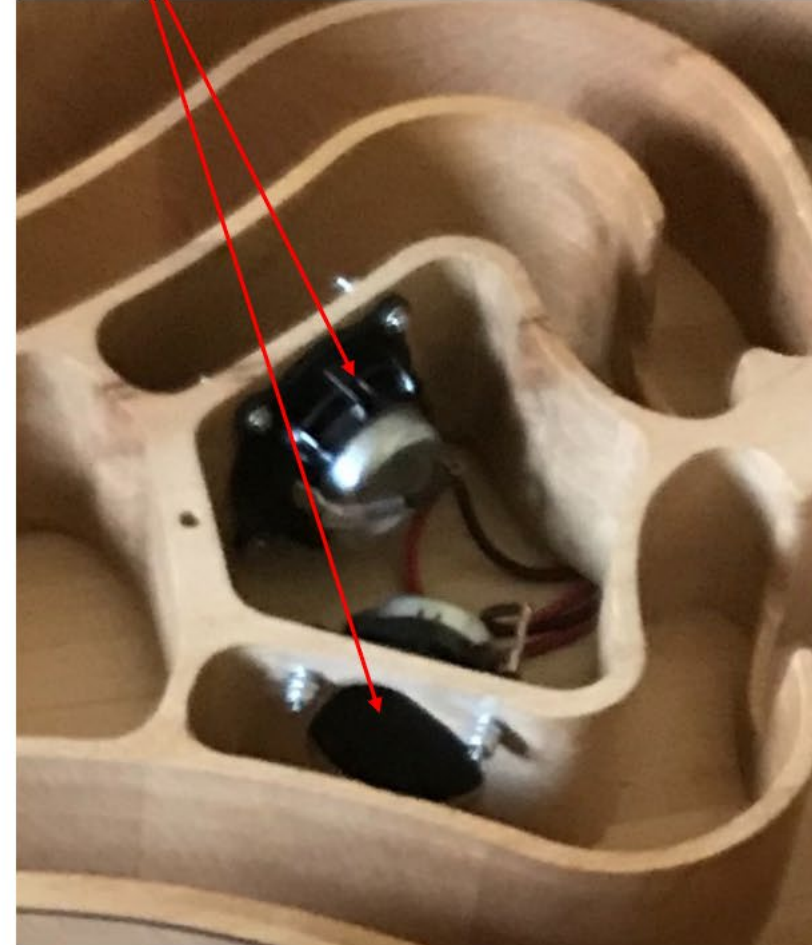


## Folded Horn Acoustic Guitar Patent # 10,777,172

This speaker  
not being  
used.



Same speaker



Speaker in cabinet, 117 dB max, bass  
is OK, but obviously missing a woofer.

Speaker in guitar 125 dB max, very strong bass.



## Folded Horn Acoustic Guitar Patent # 10,777,172



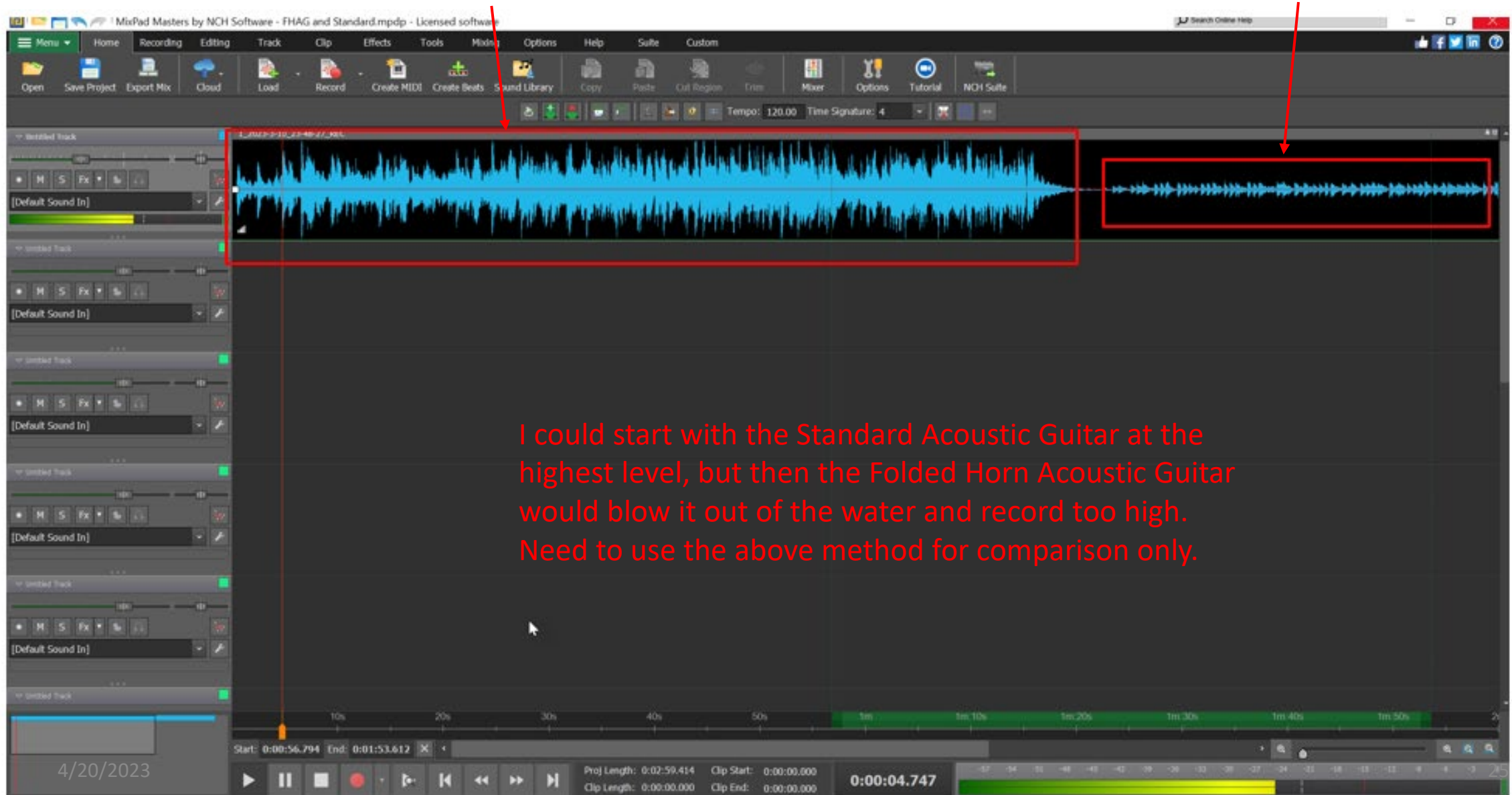
I was pleasantly surprised by this Bose Waveguide CD player. It is only 14" across, and does indeed fill a 15' x 15' room with sound, bass was pretty good. Speakers are almost exactly the same physical size as mine, and dB was also similar, encouraging.

My waveguides are much longer. The Bose waveguide is 27" long, one only. I have two five foot long waveguides, and you can hear the richer bass in mine, capturing  $\frac{1}{4}$  wavelength of about 80 Hz.

## Folded Horn Acoustic Guitar Patent # 10,777,172

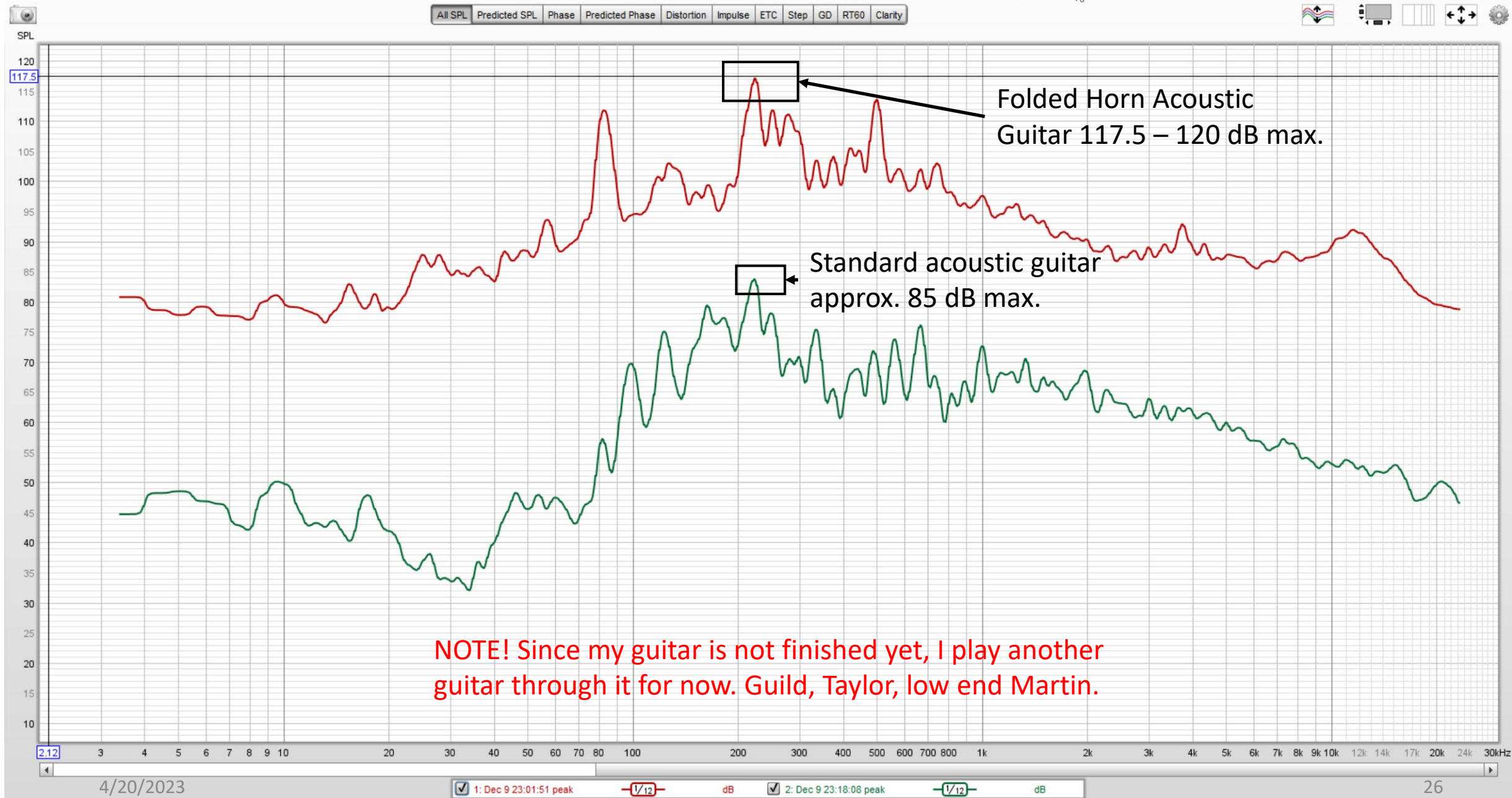
Folded Horn Acoustic Guitar at highest recording level without clipping.

Standard Acoustic Guitar at same recording level.



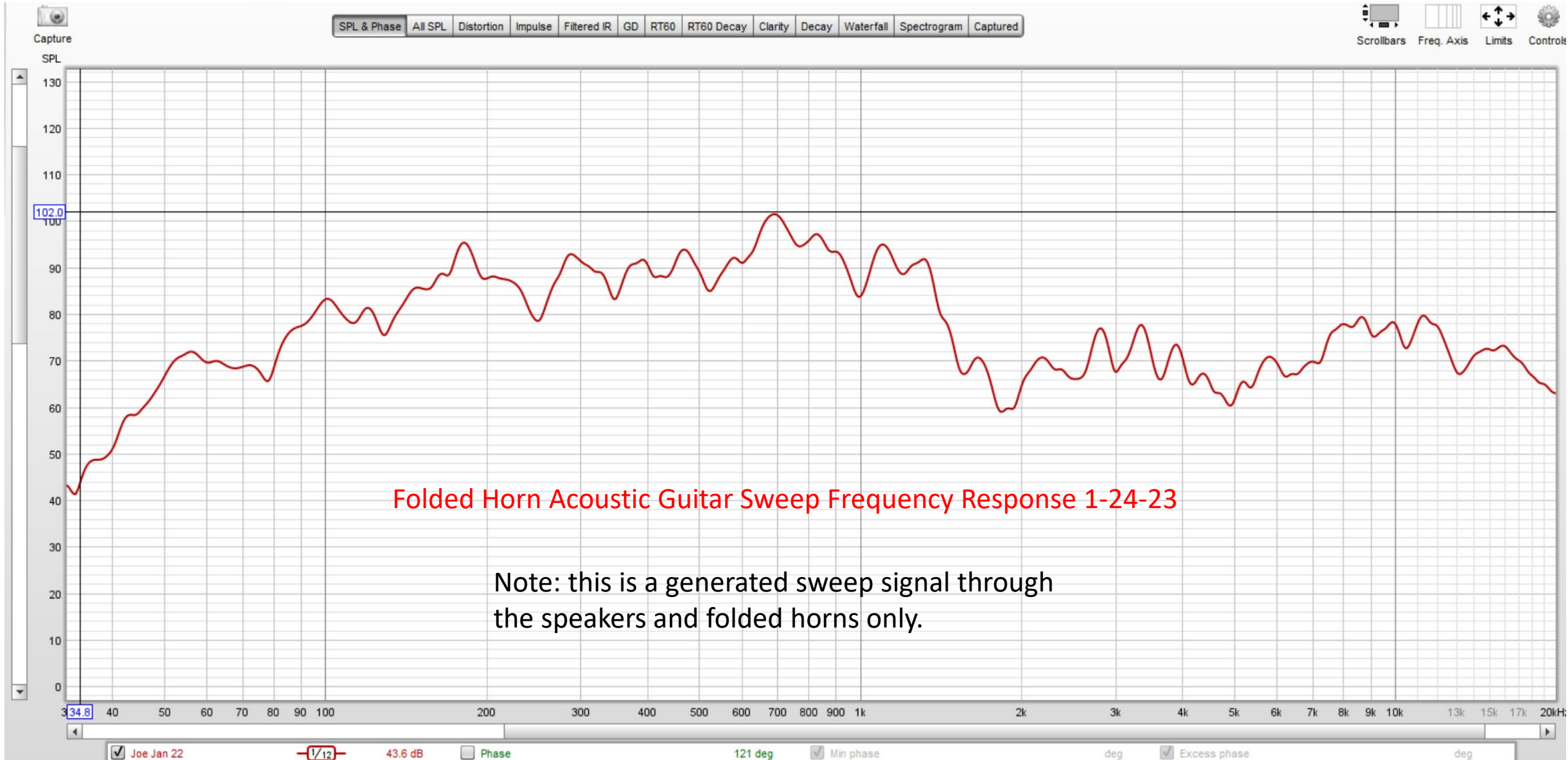
# Folded Horn Acoustic Guitar Patent # 10,777,172

Overlays





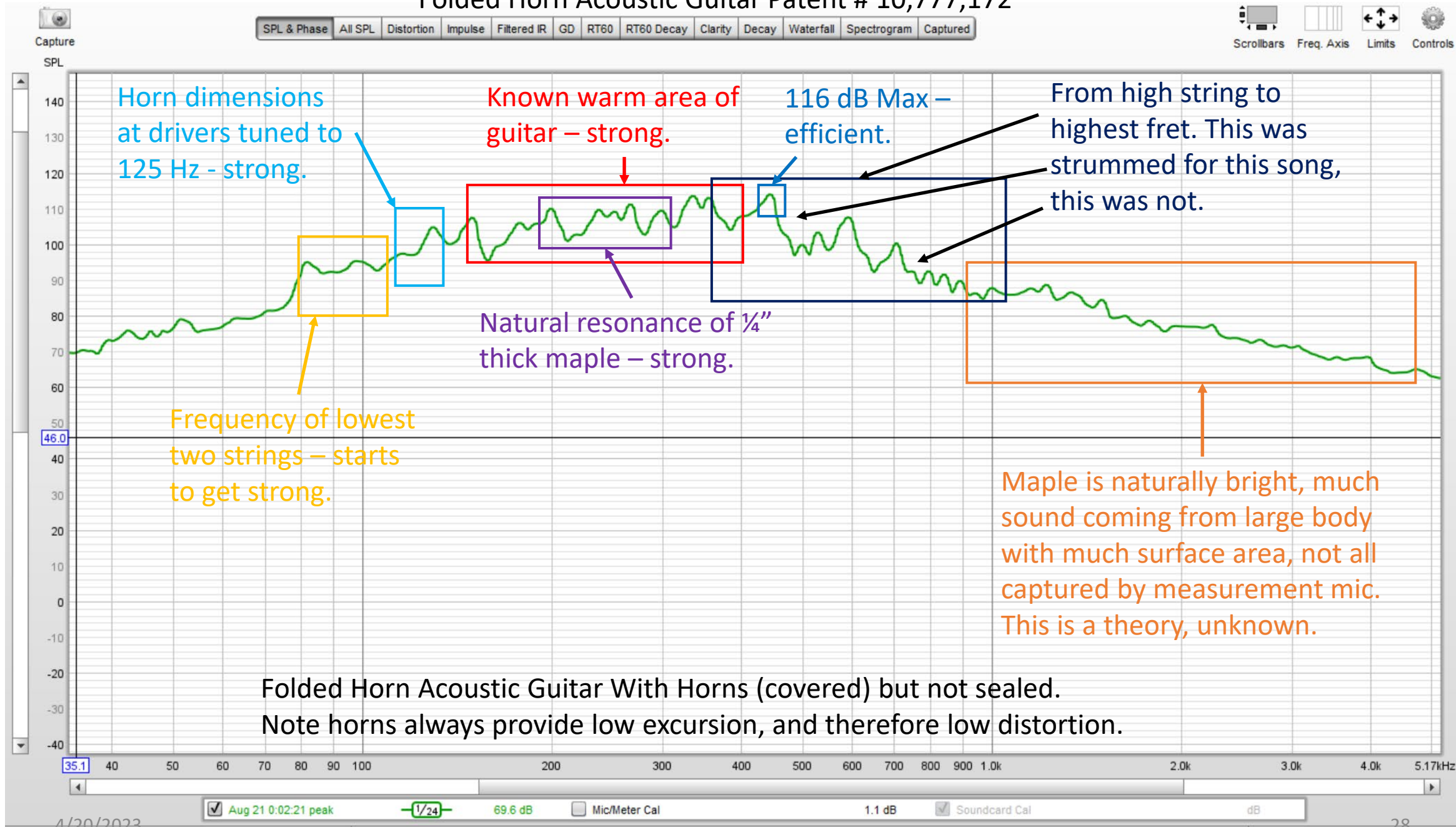
# Folded Horn Acoustic Guitar Patent # 10,777,172



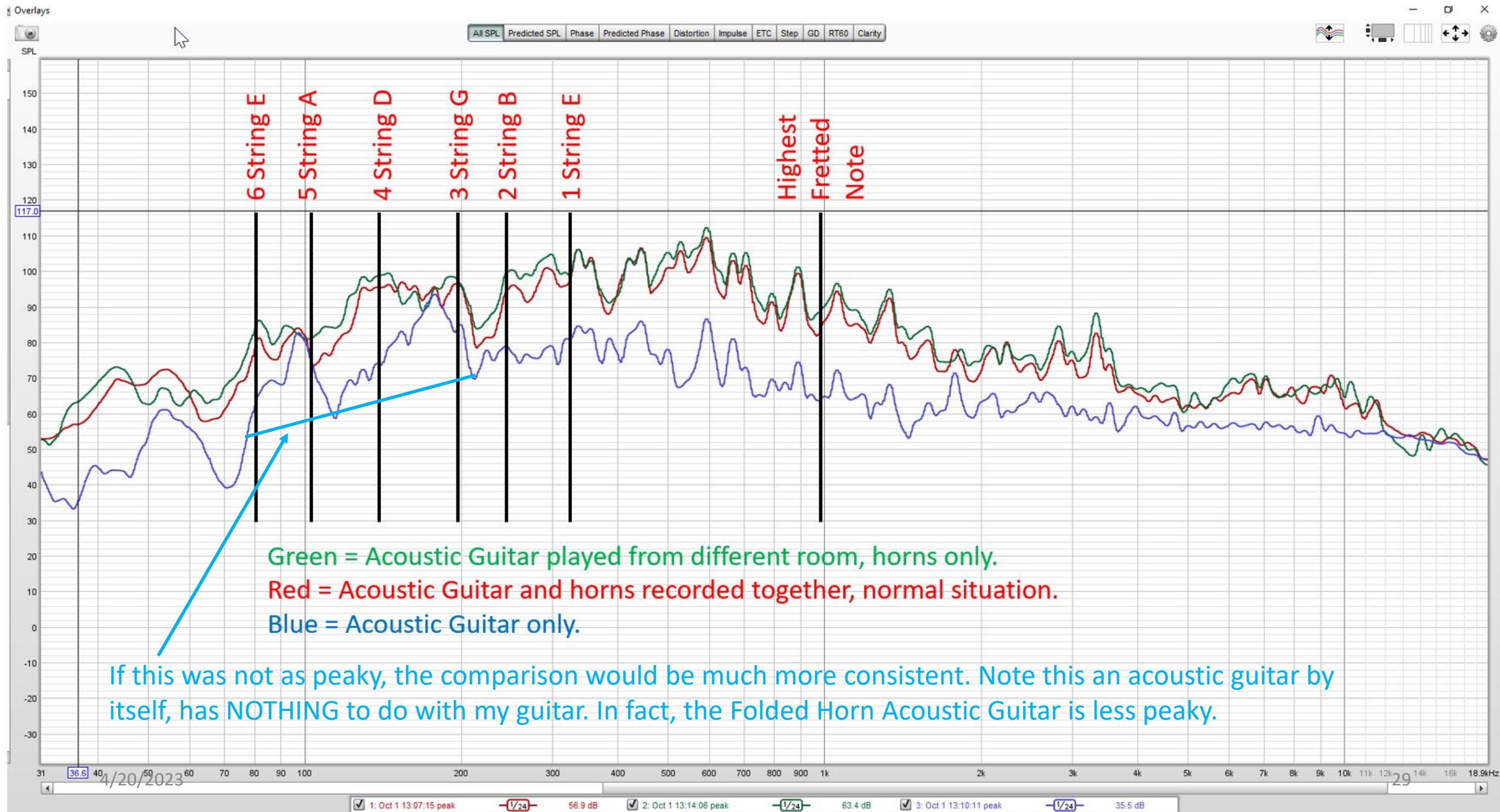
Folded Horn Acoustic Guitar Sweep Frequency Response 1-24-23

Note: this is a generated sweep signal through the speakers and folded horns only.

# Folded Horn Acoustic Guitar Patent # 10,777,172

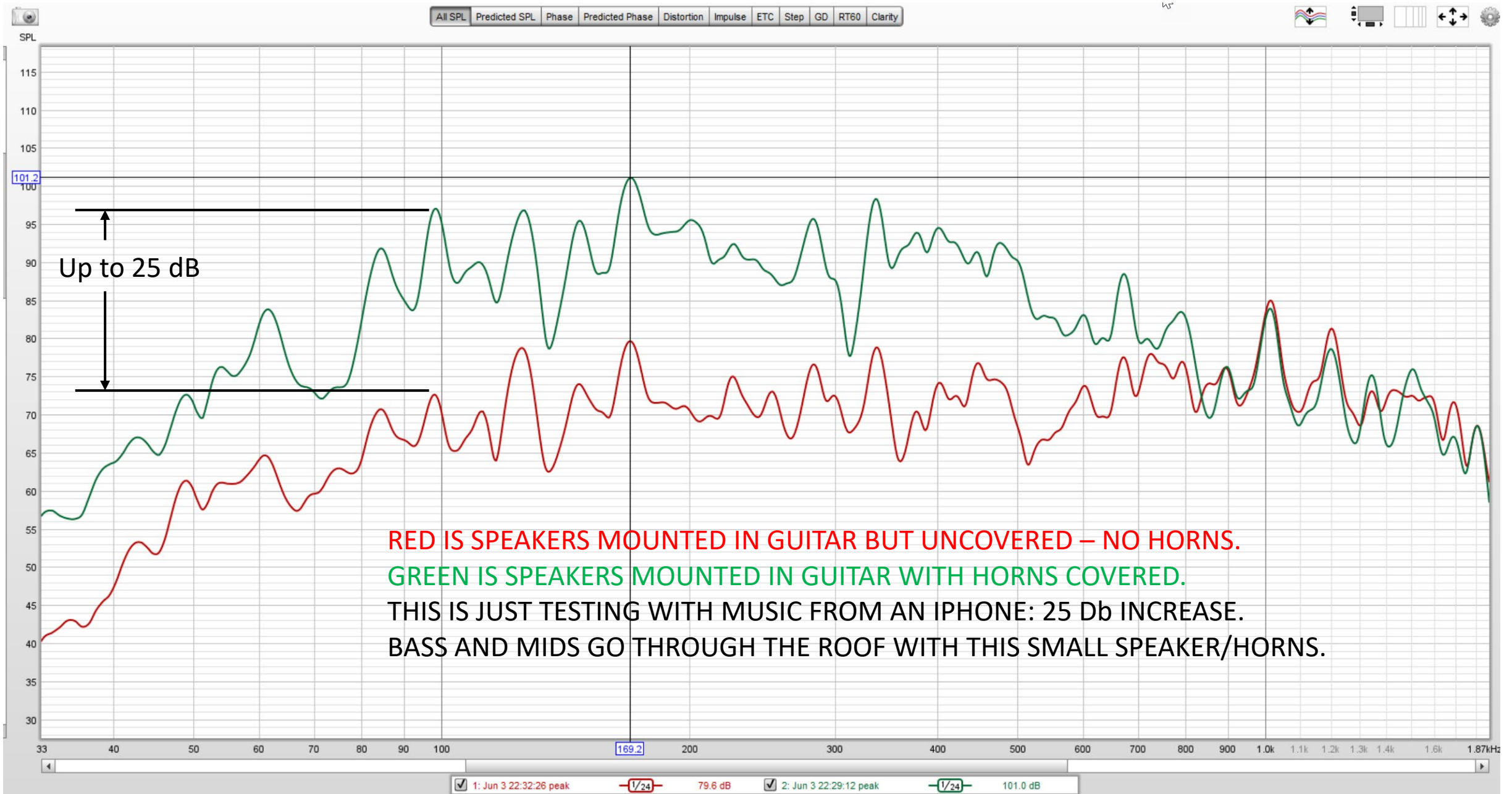


# Folded Horn Acoustic Guitar Patent # 10,777,172





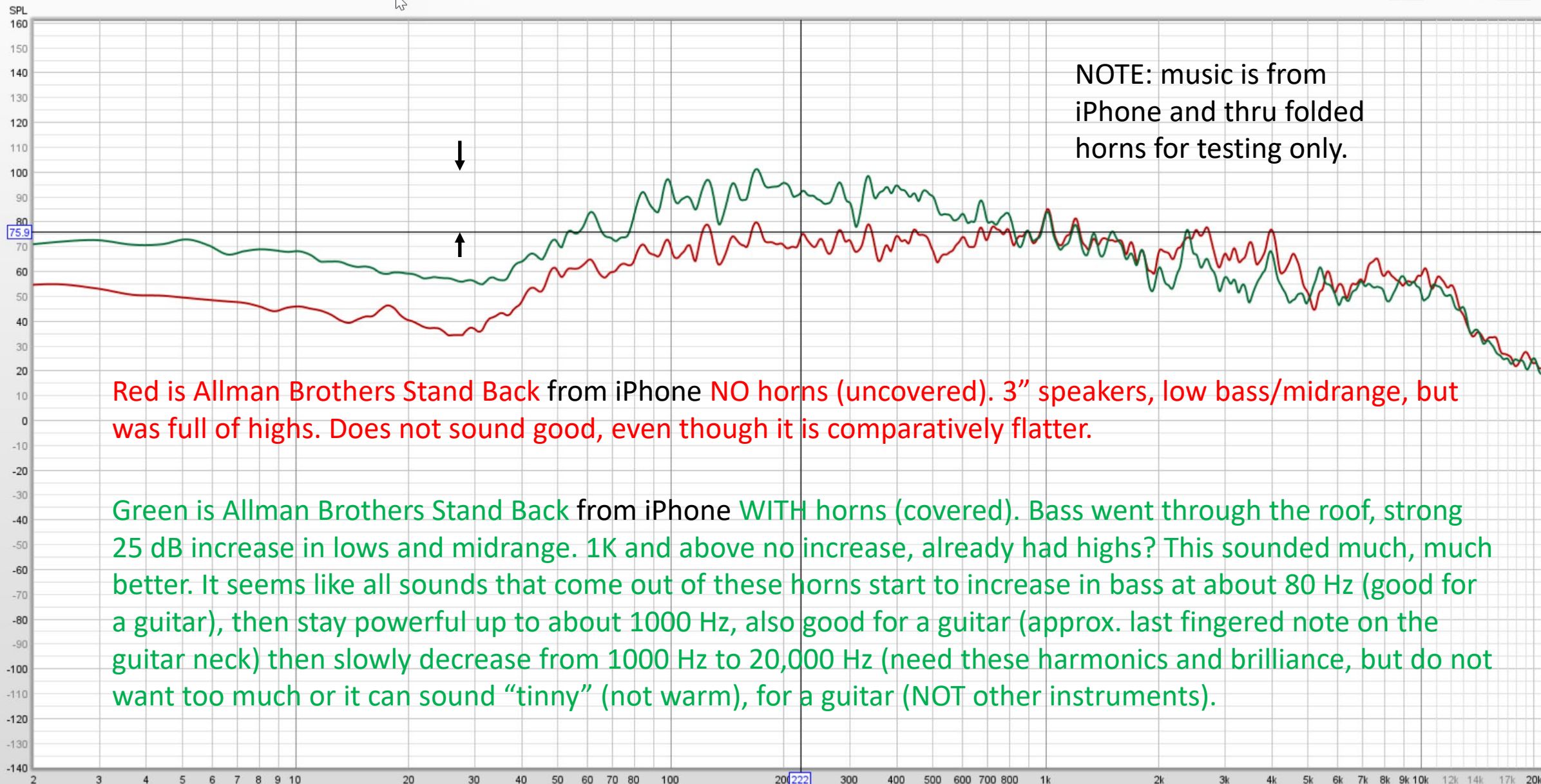
# Folded Horn Acoustic Guitar Patent # 10,777,172



# Folded Horn Acoustic Guitar Patent # 10,777,172

Overlays

All SPL Predicted SPL Phase Predicted Phase Distortion Impulse ETC Step GD RT60 Clarity



NOTE: music is from iPhone and thru folded horns for testing only.

Red is Allman Brothers Stand Back from iPhone NO horns (uncovered). 3" speakers, low bass/midrange, but was full of highs. Does not sound good, even though it is comparatively flatter.

Green is Allman Brothers Stand Back from iPhone WITH horns (covered). Bass went through the roof, strong 25 dB increase in lows and midrange. 1K and above no increase, already had highs? This sounded much, much better. It seems like all sounds that come out of these horns start to increase in bass at about 80 Hz (good for a guitar), then stay powerful up to about 1000 Hz, also good for a guitar (approx. last fingered note on the guitar neck) then slowly decrease from 1000 Hz to 20,000 Hz (need these harmonics and brilliance, but do not want too much or it can sound "tinny" (not warm), for a guitar (NOT other instruments).

4/20/2023

1: Jun 3 22:32:26 peak

1/24

73.9 dB

2: Jun 3 22:29:12 peak

1/24

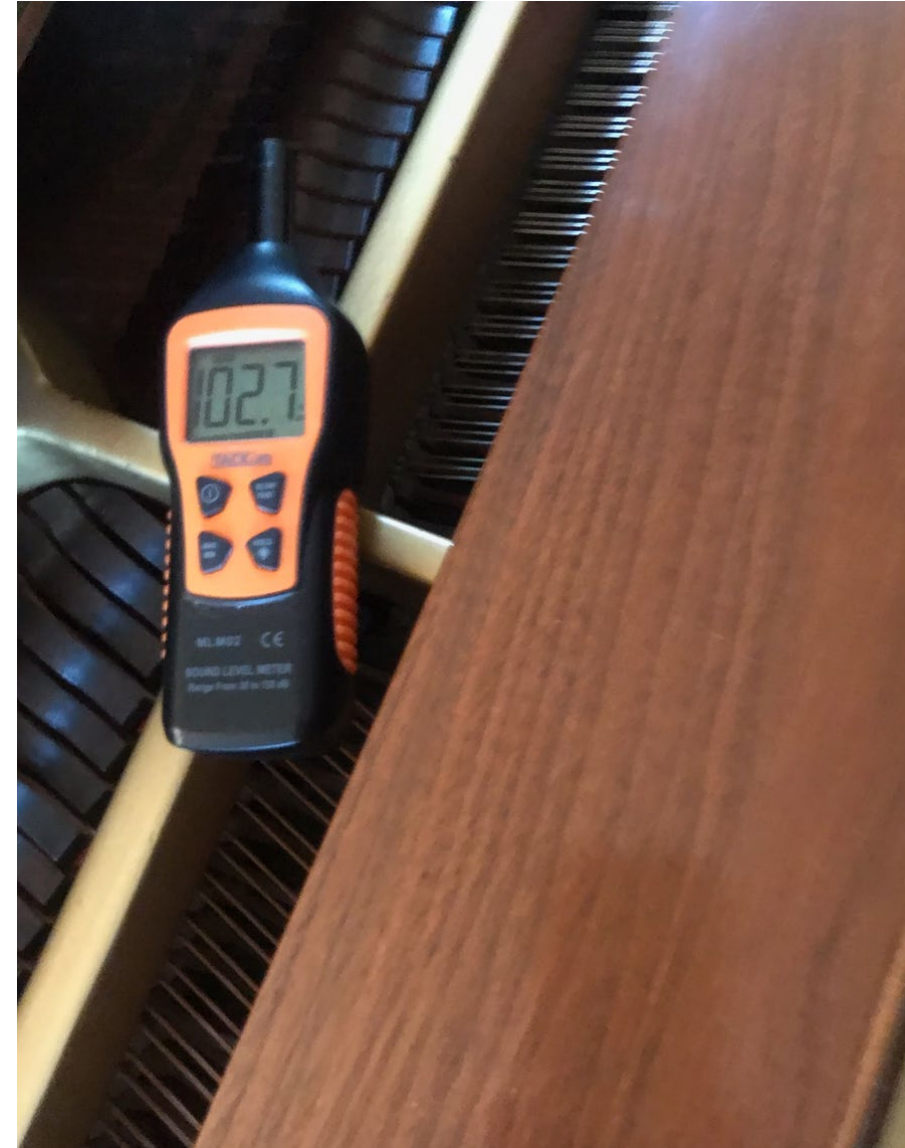
91.5 dB

31

## Folded Horn Acoustic Guitar Patent # 10,177,172

### COMMON SCALE LENGTHS

Guitar	# frets	scale
Classical short	20	650 mm
Classical long	20	660 mm
Fender 25-1/2" Stratocaster & Telecaster	21 - vintage 22 - modern	25.500"
Fender Jaguar	22	24.000"
Fender DuoSonic & Mustang	19	22.500"
Fender Bajo Sexto Baritone Telecaster	24	30.1562"
Gibson 24-3/4"	22	Varies, see above
Gibson 'Byrdland'	22	23.500"
Gibson long scale (used on acoustics)	20	25.300"
Guild acoustics 25-5/8"	20	25.625"
Guild electrics 24-3/4"	21 or 22	24.750"
Martin standard 25.4" (Dreadnought, OM)	20	25.340"
Martin short 24.9" (0, 00, 000)	20	24.840"
National	20	25.000"
Paul Reed Smith	22 or 24	25.000"



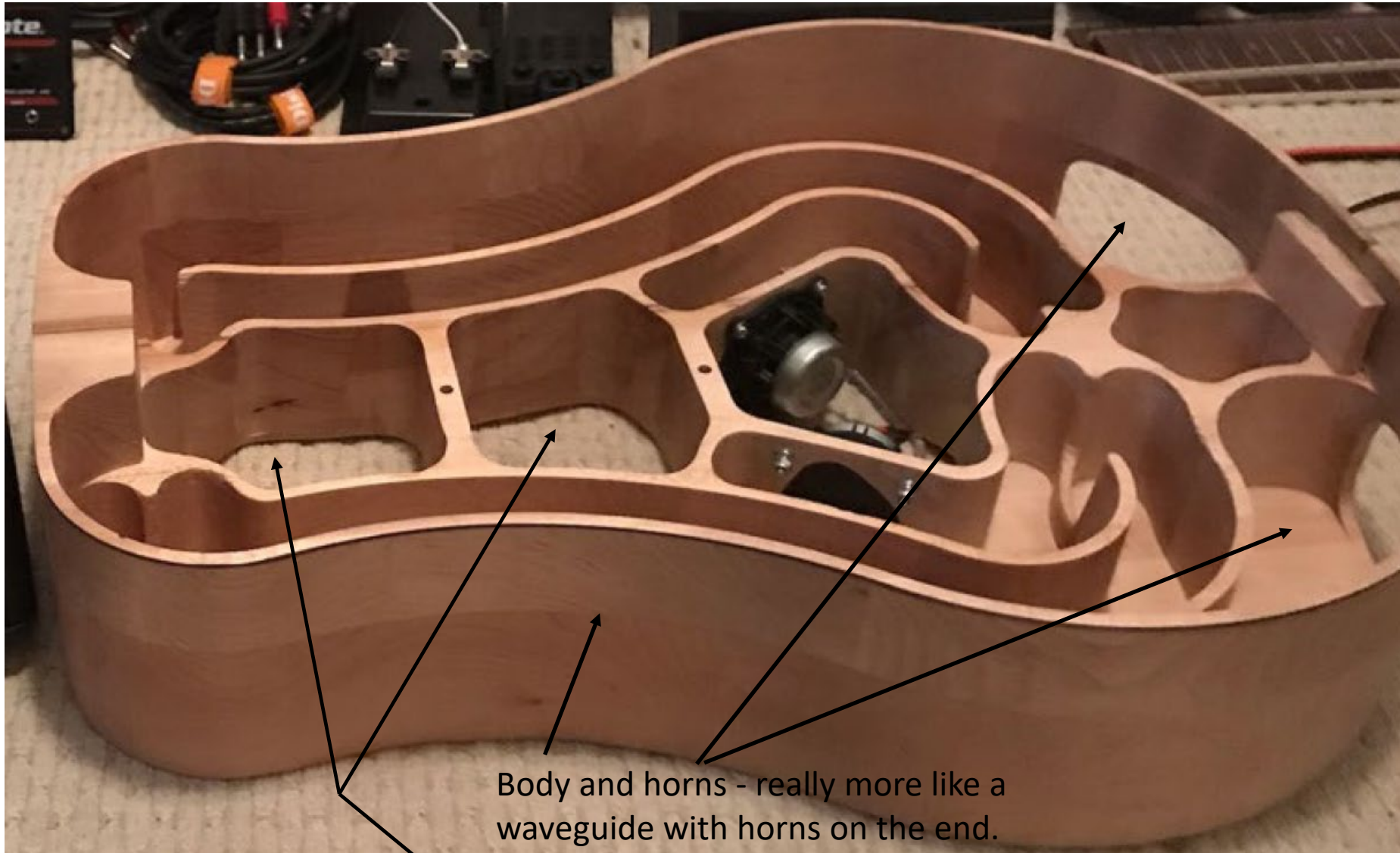


## Folded Horn Acoustic Guitar Patent # 10,177,172



18" x 24" Rock Maple used for guitar body and folded horns. This is a smaller scale prototype for one half of body only. Wood is very stable, even after much is cut away with CNC machining.

## Folded Horn Acoustic Guitar Patent # 10,177,172



Body and horns - really more like a waveguide with horns on the end. Speakers shown, amp and battery pack go here (charge at night like your iPhone).



## Folded Horn Acoustic Guitar Patent # 10,177,172





## Folded Horn Acoustic Guitar Patent # 10,177,172



4/20/2023

Dovetail neck fit is great! CNC machining is accurate to  $\frac{1}{5}$  the thickness of a human hair (.001"). Straight as an arrow.

## Folded Horn Acoustic Guitar Patent # 10,177,172



Leave this on full volume Master and Gain, for more than a second and your ears will split of course.

4/20/2023



Try this at full volume Master and Gain, with 1/4" Baltic Birch, and IF you find the right spot, it will feedback like a mother.



Try this at full volume Master and Gain, with 1/2" Baltic Birch, and it WILL NOT feedback at any position!

1/2" Baltic Birch is being used for the chamber divider to prevent feedback.

(12) **United States Patent**  
**Katzenberger**

(10) **Patent No.: US 10,777,172 B1**  
(45) **Date of Patent: Sep. 15, 2020**

---

- 1) The guitar body and soundboard on this guitar are three inches longer, so the soundboard is louder. The soundboard is made from light yet strong material (Baltic Birch Laminate), so it moves more, which also makes it louder. The natural sound of the acoustic guitar provides much of the great tone of this guitar, in addition to speakers and folded horns.
- 2) Two folded horns are built into the guitar body for true stereo sound.
- 3) Each folded horn is five feet long, which captures the lowest frequency of the guitar (80 Hz). This can not be done with small speakers only, that need to fit inside guitar, without these horns.
- 4) An 80 Hz wavelength is actually (14) feet long. The speed of sound is 1,125 feet per second, divided by this frequency of 80 Hz gives us a 1/4 wavelength of (3.50) feet. Horns that are (5) feet long easily capture this wavelength, with room for side ports, and still will not break this critical 1/4 wavelength rule. The 1/4 wavelength rule is a truth in physics and acoustic engineering. If you do not capture this, the sound will be greatly diminished. Do not take my word for it, Google it!



- 5) The folded horns (also known as waveguides, if not tapered) provide sound directivity, and does not lose sound energy. It is not possible to amplify a sound wave once it is in air, but it is possible to prevent sound loss, by directing sound to a desired source.
- 6) Battery powered. Can use standard batteries or Lithium Ion batteries, similar to what Tesla and all other Electric Vehicles use.
- 7) The guitar body is cut from a 6" thick maple block, and the walls are ¼" thick, which resonates more like a piano than a standard acoustic guitar that has very thin walls (needed for traditional bending of the sides).
- 8) The vibrations are so powerful, you can feel them in your body as you play, similar to a violinist that can feel the vibration of the instrument through their neck.
- 9) A piano is powerful due to a large soundboard, thick wood and substantial size. This guitar has a larger soundboard, thicker wood, and a more substantial size than a standard dreadnought guitar.

10) A violin, which is approx. 1/3 the size of a guitar, produces greater volume because it is bowed, not plucked or strummed like a guitar. Also the soundboard has only one brace and a bass bar, which allows it to vibrate more.

11) Soundboard and chamber divider are made of Baltic Birch. This ¼" thick wood is laminated with (5) pieces of Birch, each one having the grain 90 degrees from piece below it, for exceptional strength. This is NOT plywood, it is solid Birch on every laminate. The soundboard is machined down to a much thinner size, while leaving braces in solid. This requires only two CNC machining processes (top and back sides). This provides great soundboard movement, which increases natural acoustic volume, before the sound is captured and fed into the folded horns. Many harps have Baltic Birch sound boards due to strength required on such a large soundboard, with tremendous amounts of string pressure.

12) The nut is pocketed and floats for ease of removal. The saddle and nut can be easily removed, and both replaced with different heights of nut and saddle. This allows action adjustment at the nut, and also the saddle/bridge. Action height combinations are available in many combinations not seen previously with standard acoustic guitars.

13) The volume of this guitar body (wood only, not air inside), is 270 cubic inches, which is approx. 4X more volume than a standard dreadnought acoustic guitar (due to waveguides and also ¼" thick walls). This provides resonance far greater than any other acoustic guitar can produce, even without the speakers and electronics. Then include speakers and electronics, and the resonance is unmatched by a factor of 5X sustain (5 seconds sustain vs. 25 seconds sustain – tested with a strummed E chord).



## Folded Horn Acoustic Guitar Patent # 10,177,172

### Testimonials #1:

What a remarkable, beautiful bit of work you've put into this! And CNC skills *to the moon!* Wow. Can you see how green I am?

Unbelievable work.

I HATE !!!! the fact I did not think of this, I play guitar and would love to hear this, it's a great idea. So very fricken cool !!!!!

Done right, I would think this to be a revolutionary instrument.

Jaw-dropping just to see part of it.

Beyond impressive!

Beautiful, a work of Art.

This is frigging wild, awesome, crazy cool!

Intriguing acoustic design.

Wild idea, flying close to the sun.

I'd like to see the guitar. Do It. Play it.

Very, very interesting.

Cant wait to hear this thing, and please have someone with a slide rip a riff, love the concept!

I love the creativity of your project.

If its a success tonally then I'd expect a good audience for such an instrument.

The patent is notably well written. Much of it is a re-cap of the guitar's weaknesses and a teaching of new fabrication technology for complex but natural shapes.

## Folded Horn Acoustic Guitar Patent # 10,177,172

### Testimonials #2:

If it is truly better and takes over the world, that is a blessing for all. But if sales are tiny until 2039, Joseph gets little to no compensation for his effort. The telephone, the electric car, the vacuum tube, burbled in small sales for most of their patent periods.

Very cool and great job sticking with your idea!

## Folded Horn Acoustic Guitar Patent # 10,177,172 7-16-22 Updates

It's going to sound a little bit weird, but sound takes on the characteristics of the surfaces that it strikes. As a good example, sit in your car in your driveway and shut the engine off and leave your stereo on. Listen to that sound, that's glass sound. Most of the surfaces in your car are glass so you're going to get a really good idea of what glass sound is. If you have a tone control, turn the low frequency all the way down, maximize the treble and really listen to the reflections in your car. You won't be able to stand it for too long nor should you.

Why? The natural materials on this planet produce the best sound. All the materials that the Earth produces or that we produce from the Earth make the best sound. Synthetics like plastics and glass are no good. Wood with its cost, ease of manufacturing, ease of build and selection, and there are so many great woods to choose from. Woods can be easily stained and sealed, they're readily available in all parts of North America that I'm familiar with so it's a good choice. Some other softwoods such as alder, pine, and birch work well and are economical.

The purpose of materials used in instruments (which '**produce**' sound) and those used in audio playback devices (which '**reproduce**' sound) are different.

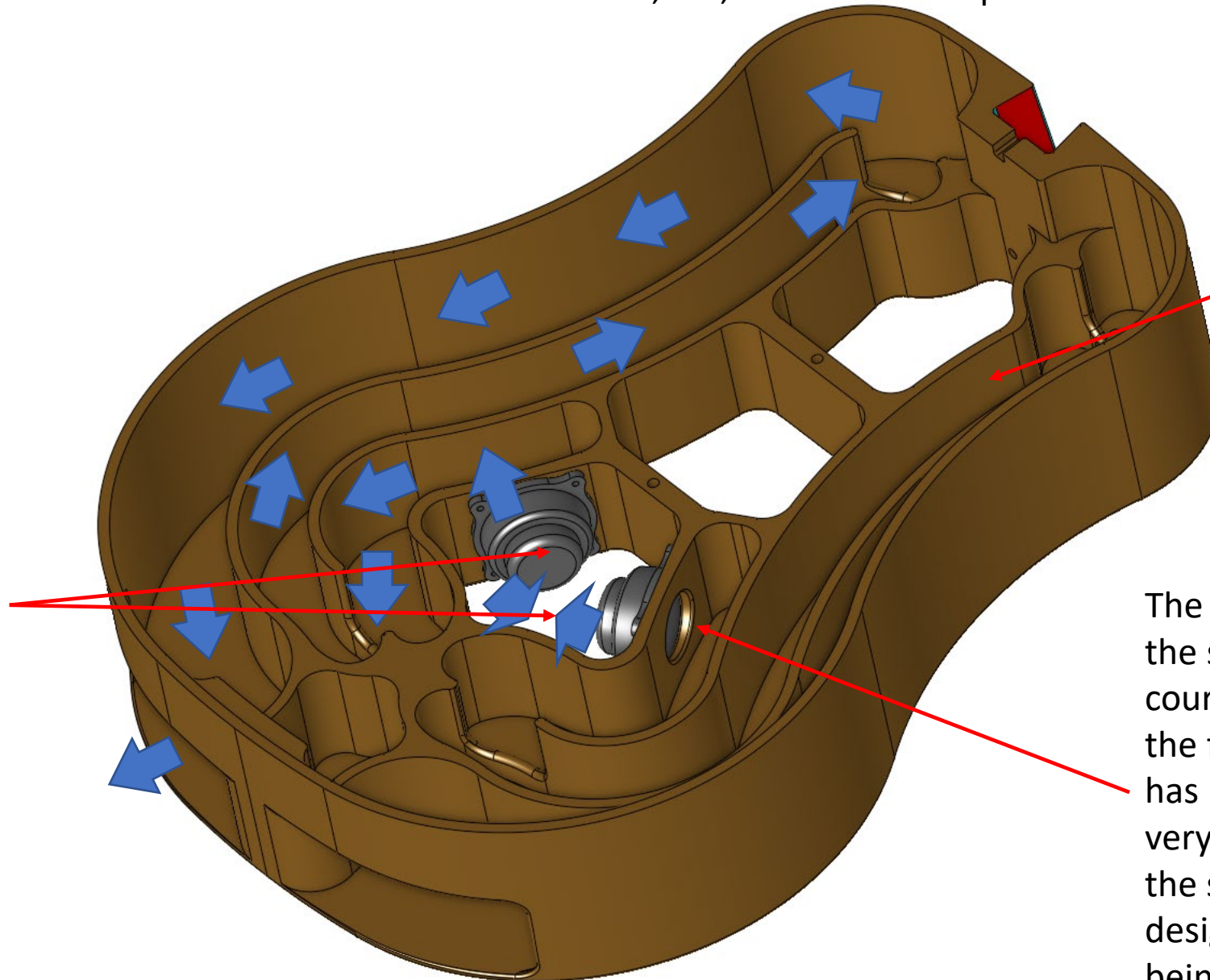
Please pay attention to bold words. "Produce" and "Reproduce" have rather completely different meanings. You see, wood, brass and some other chosen materials are selected in instruments because they react to various physical forces (from vibration, airflow friction, brute force, etc) and make interesting sound based on their properties.

But for playback devices, the main purpose of materials containing transducers is prevent unwanted sound from the transducers (because they cannot physically perfectly transfer electronic signal into physical sound wave.) So, for speakers and headphones, we have to deal with enclosures/damping materials. For the purpose, materials with good acoustic absorption and highly resonance-resistant are highly desired for the job.



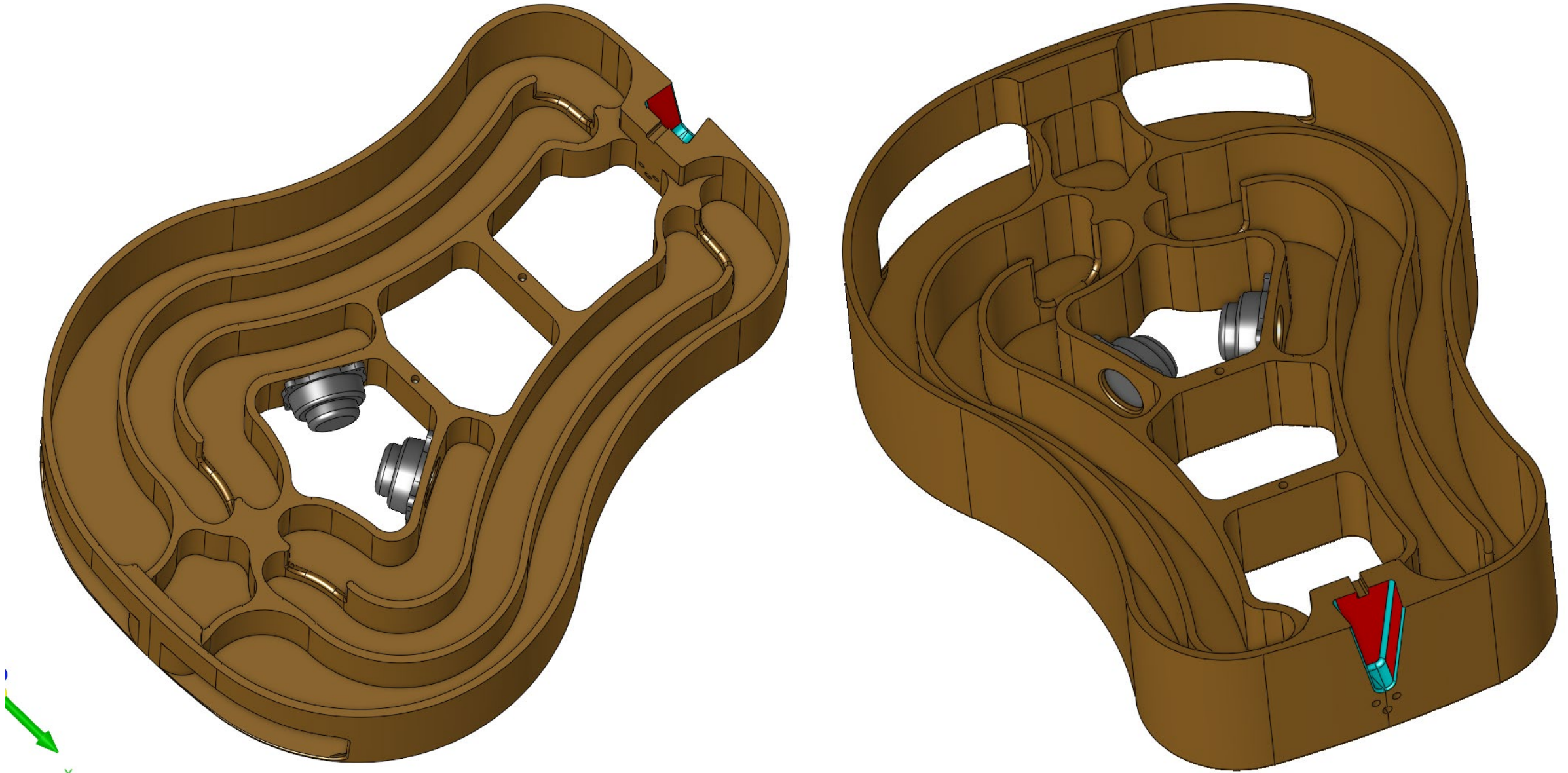
The sound coming from the back of the speakers is constructive interference with each other (no loss of sound) due to design.

The sound from the back of the speakers goes out the back of the guitar, and is covered on the top, to provide a pressurized air chamber.

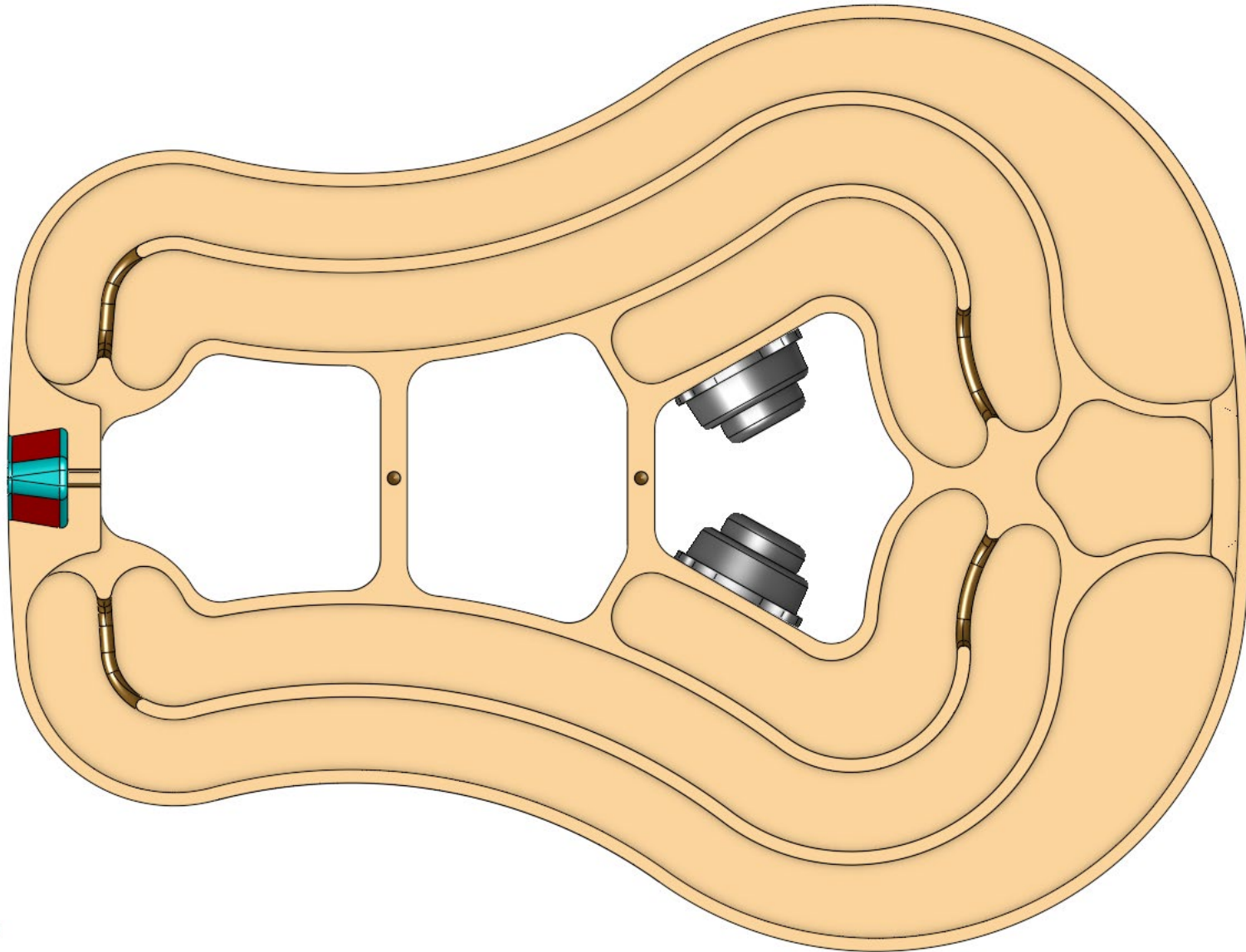


Please note the waveguides are shown uncovered for clarity, they are fully covered at final assembly.

The sound from the back of the speaker (which of course is out of phase from the front of the speaker) has no interference (or very little) with the front of the speaker due to guitar design and waveguides being covered.

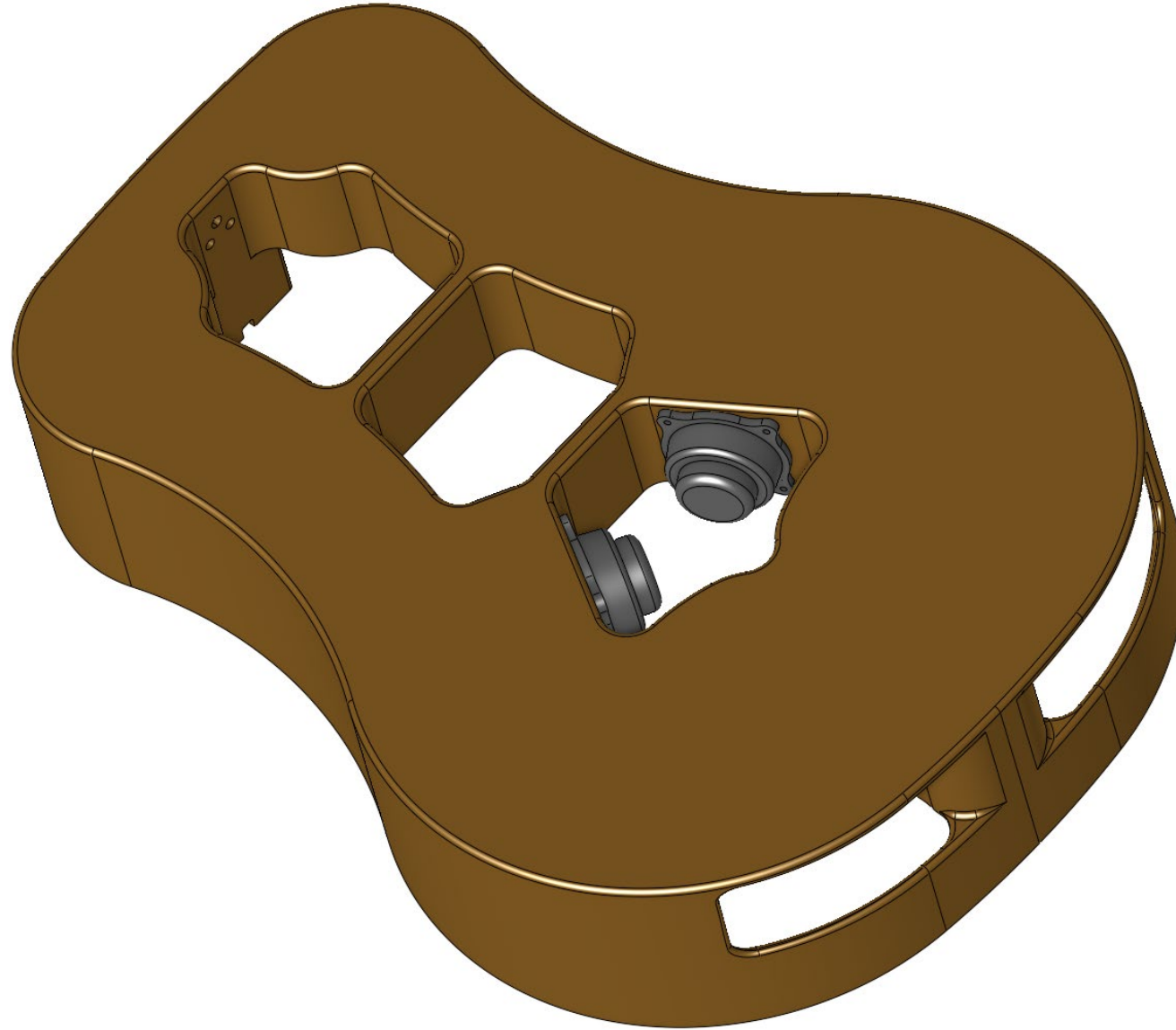


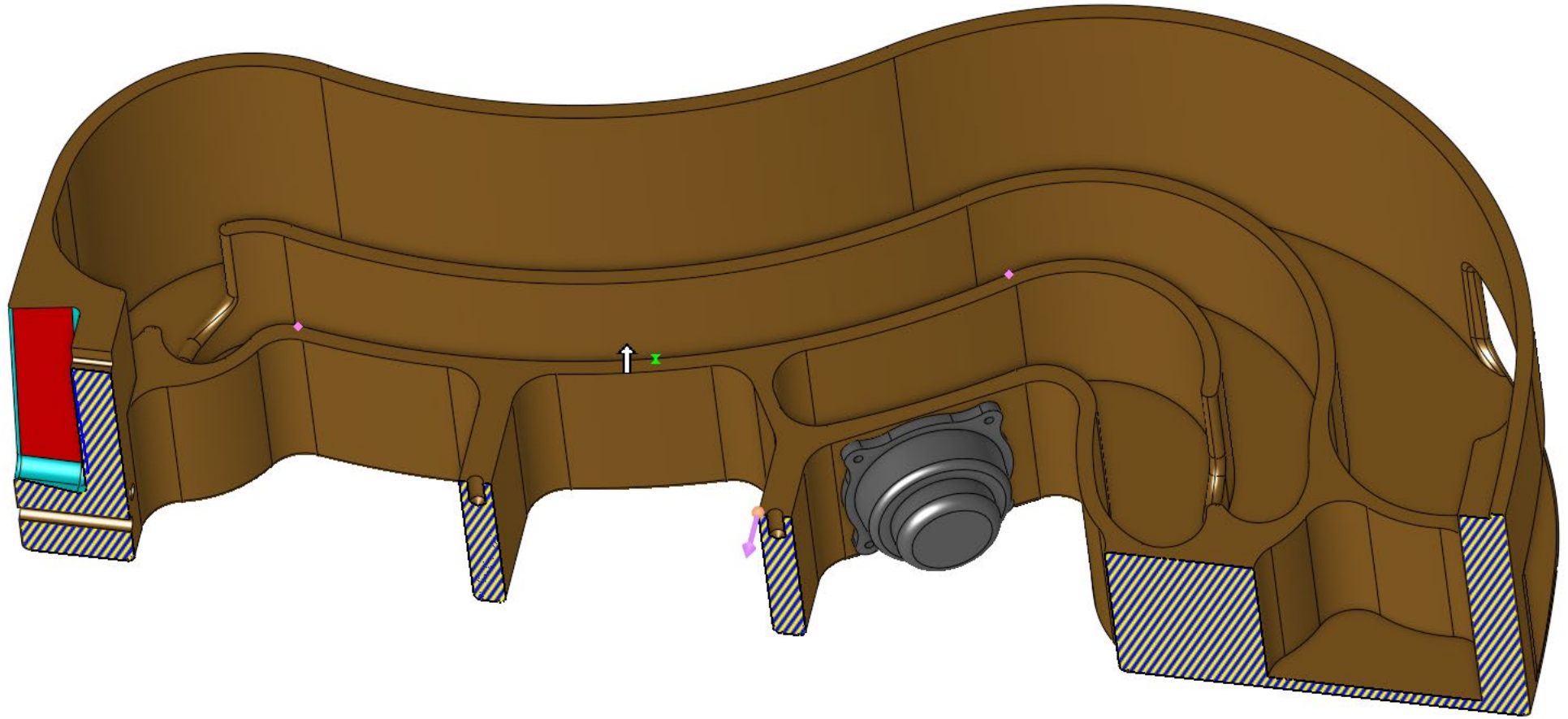




x

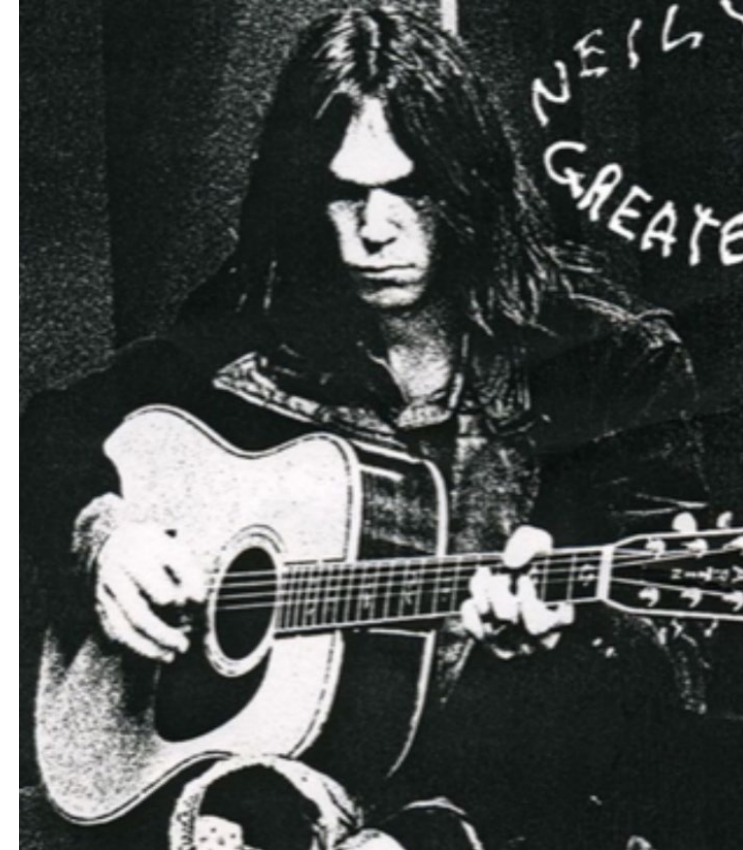
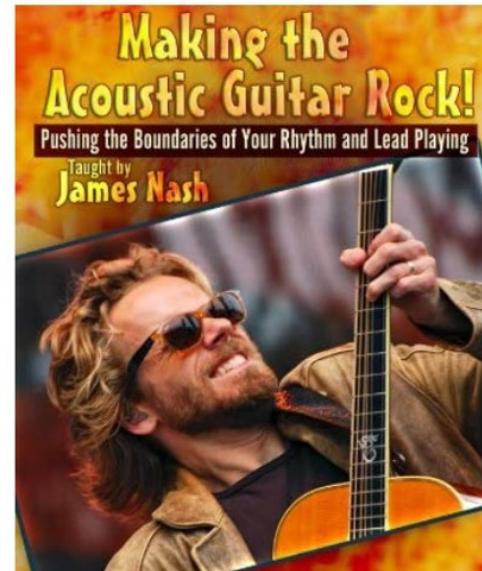






More of this:

Less of this:





What did I learn?

Happiness lies not in the victory...but in the struggle (Benjamin Franklin).

Experience is the name we give...to our mistakes (Oscar Wilde).

The world is in constant conflict...be happy when things go well (Joe Katzenberger).

The Folded Horn Acoustic Guitar can really rock, play softly, and all points in between.