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# Guitar Tuning Nightmares Explained

## (Part 1 of 2)

**By Jack Endino**
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**(As printed in TapeOp, with minor corrections added)**

***Dislaimer:* This is not meant to be a technical paper. It's addressed to working/recording musicians, with whom I've spent most of my waking hours for 15 years, using a *conversational-rant* writing style. The intent is to enlighten and entertain. Musicians do not respond well to technical papers.**

Everyone who's had tuning nightmares during a recording session, raise your hand. Gee, that's just about everyone, isn't it?

As a guy who's been recording guitar bands for 14 years now, I have to admit to a problem: I have painfully accurate awareness of tuning. This means I hear tuning discrepancies some people might not notice consciously; other people might just feel slightly uncomfortable without knowing why. Many of us who are engineer/producers have this blessing/curse. As a wee lad, I would turn on the radio and find myself thinking "Wow... Hendrix is out of tune there!" or "Rod Stewart's way sharp on this whole song" or "Why is that organ part so out of tune with the guitars?" And some classical orchestra music drives me nuts for this reason. Yup, a curse.

In less-commercial pop music (i.e. "indy rock") you can get away with more, if you're good. Sonic Youth and Pavement just wouldn't be the same if they were always in perfect tuning... but not many bands are capable of trumping imperfect tuning with their sheer force of personality, and you shouldn't assume your band is one of them.

In the studio, of course, my ear for tuning is a blessing... but if I get fatigued, it can transform into the Beast That Ate The Session, as my ears start playing tricks on me. I resolved to learn as much as I could about potential "tuning nightmares" so I could better defend myself.

To begin with, it is essential to grasp one iron-clad fact, or you will go insane:

*It is impossible to ever get any fretted, stringed instrument "perfectly in tune". Nope. Can't be done.*

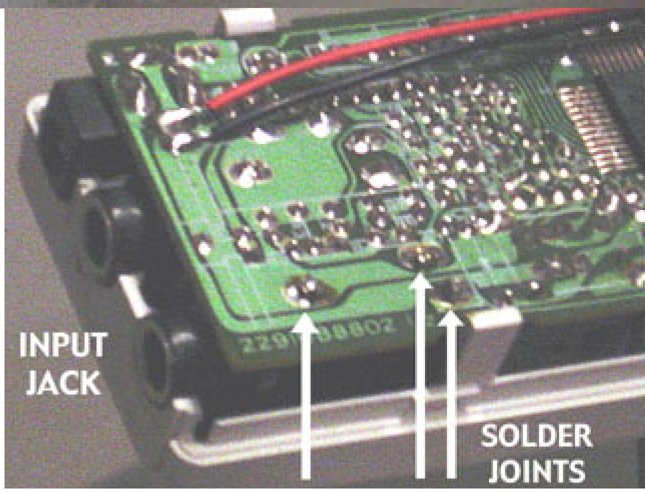
Once you understand this, you can start dealing with the implications. Your life will become easier. First, let's talk tuners!

### THE INFERNAL MACHINES

Once in a blue moon I still get a band that actually doesn't use 'em. Yeah, hard to believe, and this becomes tuning nightmare #1 when someone wants to do an overdub a few days later. Tuning by ear to the tape can be damned difficult, especially with the crazed noisy bands I often work with. I generally beg such a band to reconsider their tuner aversion, at least for the few days they are in the studio with me. Seems pretty obvious, right? (The single, amazing exception to this has been the band Zen Guerrilla, with whom I've made two albums entirely tunerless. Their tuning sense is so uncanny that I learned to just let 'em alone.)

I encounter three kinds of tuners: the kinds with little meters with needles that move (make sure you hold them horizontal!), the kind with rows of flashing LEDS, and those "strobe" types with a moving wheel and a flashing light. I haven't seen a strobe tuner in years, and never liked 'em much, though they work well if you can figure 'em out. Oh yeah, then there's those silly little "pitch pipes" like a mini-harmonica... avoid!

The most common moving-needle types are the Boss Chromatic ones, and they're pretty good, but here's a tip: the input jack is soldered directly to the internal circuit board, and these solder joints ALWAYS crack eventually, which makes the tuner act "intermittent," with the needle jumping up and down. I have resoldered more of these in the studio than I can count; the plastic case comes apart easily, and you can resolder the jack in seconds. If you have one, check it: it may not be a "bad guitar cable" that's been frustrating you.


The little ones with flashing red and green LEDs that are often called "stage tuners" are rarely accurate enough for studio use; their only advantage is that you can read 'em without stooping and squinting. Hit that green LED, and you're done, right? Maybe. Some are OK. The cheaper moving-needle tuners are really not so great either. In my opinion the truly greatest innovation in tuners is the 19-inch-wide, single-rackspace multiple-LED type that you can read from clear across the stage. Korg makes some good ones. I finally had to buy one of these super-tuners for studio use; they are wonderful, deadly accurate machines. More on this in a moment.

## SOME TUNING TRICKS

Here's another tip to make your life easier. You know how when you plug a guitar in and pluck a string, sometimes the tuner needle (or LED display) wavers back and forth and drives you crazy? And you have to pluck it every which way before getting a "good reading" which finally "settles down?" Do these three things:

- 1) switch your guitar to its rhythm (neck) pickup, if it has one;
- 2) roll your guitar's tone knobs all the way off, to remove all the highs; and then
- 3) pluck the open string right over the twelfth fret, not over the pickup. Try it; you'll be amazed.

Why does this work? Here's a quick physics refresher. The sound of a string being plucked is composed of a fundamental tone (the "note" itself, which also happens to be the lowest and loudest tone made by the string) mixed with a series of increasingly higher-toned, lower-volume harmonics, starting with the octave (or "2nd harmonic") and then going on up to include higher tones that are NOT all octaves. Each harmonic corresponds to the length of the string divided by a whole number. The harmonic overtones are referred to by these numbers, and they correspond to those little "nodes" or dead spots on the strings where you can lightly place your fingers and get little chimey sounds. The 2nd harmonic or "octave" spot is exactly halfway along the string, right over 12th fret. The 3rd harmonic corresponds to one-third the length of the string, and can be found over frets 7 and 19, the 4th harmonic can be found over frets 5, 12 and 24 (or right over the neck pickup), the 5th harmonic over frets 4, 9 and 16, etc.

Several things to note:
1) The harmonics that are "powers of two" (2nd, 4th, 8th) are all octaves of the lowest, or "fundamental" note. To a tuner, they are the SAME note.
2) All the other harmonics represent DIFFERENT notes. It's the unique combination of fundamental plus these various harmonics that give any instrument it's particular character or timbre.
3) How you pluck the string, where you pluck the string, and where the pickup is located under the string, determines the blend of "fundamental vs. harmonics" that you hear. Pluck it near the bridge, and you get a twangy sound with lots of high tones. Pluck it near the middle, and you get mostly a deeper, more "pure" tone. Pluck it hard, and that initial burst of energy will cause more high harmonics. Put a pickup near the end of the string (at the bridge), and it will pick up more of those high harmonics; put it closer to the middle, and the fundamental tone will come through louder.

So... What is the tuner looking for? The fundamental note of the string, and nothing else! All the other tones made by the vibrating string "confuse" the tuner, making it indecisive. Roll off your highs, use the rhythm pickup, pluck near the middle... and just mail me a check, thank you very much. (Important: remember to switch everything BACK before you start playing the next song!)

Here's another tip for tuning acoustic guitars that don't have built-in pickups. Go find a pair of headphones, any old kind. AKG 240s work great. Put the headphones "on" the guitar body, sort of straddling it front-to-back, near the hole. Plug 'em into the input of the tuner. It looks silly, but the headphones will act like a microphone.

## THE REAL NIGHTMARE BEGINS

Consider a rock band with two guitars, bass and a keyboard guy with a Rhodes or Hammond. It is possible everyone will have their own tuner, and know how to use it. But after you roll tape, you discover that someone is out of tune. They all check their tuning and everyone announces that their tuning is fine. Then they all look at you (the engineer) accusingly. What to do? Start removing variables.

When I got my first "TEST CD" (a handy thing everyone should have) it had some tuning reference tones which were pure A440Hz, etc. By running these pure notes into some typical guitar tuners, I discovered that, aside from some tuners having more "slop" in them, they can also have have slight calibration variations. Yes, one tuner's "A" may be slightly different from another tuner's. (Close enough for "live," you understand.) **Lesson:** in the studio, have everyone use the same tuner. It slows things down a bit, but it's worth it.

OK, suppose you make the band do this, but one guitarist is still consistently out of tune on the recording. He checks again, and says everything is fine. You borrow the guitar and check it yourself with the same tuner, and it looks wrong to you. Who's right?

The problem is that different people, using the same tuner, can tune in different ways. In order to see why, you need to understand another bit of the physics of vibrating strings. It took me years to realize this. Plug a guitar into any old-school moving-needle tuner, and pluck a string. You'll see the needle shoot up and OVERSHOOT the note and then settle back down. I always assumed that it was just a bit of springiness in the meter itself. It's not! The string itself is actually SHARP in the first instant after you pluck it. This is NOT some artifact of the tuner detecting the extra harmonic content during the initial attack of the note. No -- it's actually the fundamental note of the string that goes sharp!

This effect was explained to me once, though I don't recall the detailed "why" of it. However, those giant rack-mount LED super-tuners reveal it clearly. The essence of it is these things:

**1) the harder you pluck a string, the sharper the note of the initial attack will be;**
**2) the lower the tension on the string, the greater this effect; and,**
**3) the higher up the neck you go on the frets, the less this effect.**

High strings hardly do it. Low E on the guitar will do it like crazy. Bass strings can be hell. Thinner gauge strings tuned to a given note will do it more than thicker strings tuned to the same note, because they have less tension on them. If you listen, you can hear it when you pluck a low E string hard: you can hear it go "BWOWWWW" as you watch those flashing LEDS shoot all the way over to the right and then pull slowly back over to the middle. By the time the note has truly, completely "settled down," it has almost died away.

A hell of a lot is implied by this universal behavior of a vibrating string. First of all, which part of the string's sound should you be trying to tune to? Somewhere right after the pick attack? Or somewhere right near the end, when it has settled down? If one guitarist is an impatient sort, and tunes near the beginning of the plucked note when it has barely settled down, and the other guy tunes using the very end of the decay of the note, the impatient guy will end up sounding flatter, at least on his low strings. There's no right answer to this, except to be consistent -- or have the same person tune all the band's instruments using one single tuner. Sometimes, in the studio, that person is me; it's easier than trying to explain all this.

There's another implication. Imagine you're a rock guitarist or bassist. You're playing some fast punk rock tunes, with lotsa 16th notes. Your picking hand is going chug-chug-chug-chug, or gung-gung-gung-gung, on the strings, rapidly and forcefully, for maybe an entire song. **So... which part of the note are people hearing the whole time? Just the SHARP part, the initial attack.** No string ever rings long enough to "settle down" to that note you were seeing on the tuner. The only time that "in tune" note will ever exist is at the very end of the final ringing power chord at the end of the song! If you're a heavy-handed pick player on the guitar or bass, you are going to sound slightly sharp the whole time. If you use light gauge strings, you will be even sharper. A heavy-handed pick player on the bass can easily be 10 or 15 cents sharp the whole time, no matter how carefully he uses the tuner! (I find this to be the case about 40% of the time when recording rock bands.)

And, because the low strings do this "sharping-on-the-initial-attack" thing more than the high strings, the harder you play, the more out of tune the guitar will sound with itself. Since it's hard to tune to the "attack" of the notes though (cuz that sharp instant goes by so fast) a solution I have employed often (with aggressive rock players) is to intentionally flat the E string a slight amount, and maybe the A string a slightly lesser amount. Strum the guitar gently, and it sounds wrong. But SCHWANG on it really hard, repeatedly, and it will sound dead in tune each time, at least until you let it ring for more than a few seconds. It's important to know how it is going to be played!

A pattern I have observed repeatedly through rock music history: guitars and vocals, the loudest musical components, will seem fine, but bass will be sharp, and the keyboards will seem flat. Wind instruments may seem flat too. If you listen to a lot of garage records from the 60s, and even a lot of well-known classics from the 70s and 80s, you will notice this over and over, now that I've called your attention to it. (Sorry!) What's actually happening is, the keys are fine, the guitars are sharp, and the bass is sharper. Keyboard instruments, for the most part, do not respond to attack the way strings do, except acoustic pianos to a very small extent (cuz they do have strings!). Many, many times, when overdubbing vintage keyboard parts later on top of guitar rock, I have had to slow the tape speed by several cents to bring the recorded guitars down into tune with the keys. Modern Studers and Otaris are great for precise varispeeding. ADATs can do it too. ProTools (at this writing, at v5.1) can do it, but hides it under "session setup". Thankfully, modern electronic keyboards have fine-tuning controls on them.

If I'm faced with a planned non-live situation where everyone is counting on serious overdub architecture, I'll try to save doing the keeper bass track until after all the guitar tracks have been laid down. Do you want to have to retune each of the 14 guitar tracks by ear to match a pre-existing badly-tuned bass, or retune 1 bass to match 14 pre-existing guitars? This completely goes against my preference for keeping the "live" rhythm tracks when possible, but sometimes that's just how the cookie crumbles. These days I take it for granted that the bass might end up sounding sharp, no matter what tuning contortions I go through in advance. You don't know until there are other instruments, actually playing the song, to compare with. I just accept it, and then we tune the bass to the track by ear later and recut it, or run the "live" bass track through a harmonizer and bring it down a few cents. ("Of course, now with ProTools you can blah blah blah..." Yeah, I know.)

If you ever work with one of those bands who tune their guitars down impossibly low and use light strings, you can lose your mind, because the tuning becomes a continuously moving target. And that doesn't even take into account that the harder the strings are squeezed against the neck, the sharper they can sound, or that some people pull back on the neck when they play chords, flexing the neck backwards and sharping all the strings.

Here's another tip, just to compound the confusion: many guitars will change their tuning very slightly depending on whether the player is sitting down or standing up. Sit down, and the neck is sticking out, being pulled downward by gravity. Tune it. Leave it plugged into the tuner. Now stand up, and make an E chord with your hand. While doing this, check the tuning of the E string on the tuner. If it's any kind of bolt-on neck like a Strat, you may see the low E string go visibly flat as soon as you stand up!! The middle of the guitar actually "sags" a tiny bit as you support some of the weight at the end of the neck with your fretting hand. It doesn't mean the neck is loose -- it means guitars are more flexible than you realized.

All of this is enough to make the producer/engineer very gray indeed. But we're not done... (end of part 1)

# Guitar Tuning Nightmares Explained

## (Part 2 of 2)

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**(As printed in TapeOp, with minor corrections added)**

### ...FURTHER TUNING NIGHTMARES

Strings are supposed to slide smoothly through the notches in the guitar nut as you turn the tuning keys. With many guitars, though, they "stick". You can tell because as you turn the tuning key to sharp the string, the tuner will show no change, and then suddenly you hear a tiny squeak, and now the tuner shows you have overshot the mark and are too sharp. You reverse, and the same thing happens. Sometimes I see people twisting their tuning keys back and forth vigorously, overshooting this way and that until they hit the mark by sheer chance. Later, they go to bend a string, and it immediately goes flat. There's a better way!

If you constantly give a little tug on the string each time you turn the tuning key, you will always "unstick" the string from the slot in the nut... just enough for it to go where it would have gone a minute after you started playing. But, tug on the strings too hard, and you might find they go sharp later on instead of flat. Learn to do this the right amount and you can tune much more efficiently.

Another factor is how a player squeezes the strings. With tall frets, a fretted string may not actually touch the wood of the neck. The string will be suspended between the two frets that are on either side of your fingertip. But if you have strong fingers OR light strings, that bit of string is bent downward until it touches the wood. This, of course, stretches the string and pulls it a bit sharp! Even worse, some people tend to slide the strings sideways a bit, sharping them more.

A double-whammy tuning nightmare is when someone sits down and carefully tunes, and then clamps a capo on the guitar neck. These apply some serious pressure to the strings, and the guitar may go slightly sharp. Then they try to retune it, but with the capo on. And you thought that strings sticking in the nut were bad!

Here's another tip: when you first replace the strings on a stringed instrument, the new strings stretch a bit for the first 20 minutes or so before they settle down. I always tell a band to change their strings the night before coming to the studio. That way, the stretching happens overnight, and when they come in the next day and tune up, the guitars stay in tune better. (I tell drummers the same thing about changing heads.)

Heavy strings in general are a Good Thing for tuning:

1. The initial attack doesn't go as sharp when you hit 'em hard.
2. Your crappy amateur vibrato (i.e. bad 80's metal) will be harder to do.
3. Your undisciplined fingers will have a harder time bending them out of tune.
4. They stay in tune longer (they don't "stretch" as quickly).
5. They make a fatter, richer sound come out of the pickups.

Result? Everyone will think you are a better player. (Even though you won't be able to play "Eruption" anymore.)

Floating Bridges are like the anti-Christ if you are a stickler for tuning. Bend one string sharp, and all the others go flat. If one string goes flat by itself, the act of sharping it back up to correct pitch will cause all the other strings to go flat. Rest your hand on the bridge to mute 'em slightly and go "chunk chunk chunk," and they all go very sharp. (You can hear this on many, many thrash metal records.) Break one string, and all the others instantly go so sharp that you have to stop the song. For solos, it's cool. Dive-bombing, man... zowee. But for actual chords and rhythm playing, it's the closest you can get to a guitar that is actually, literally untunable. (At least, for more than a few seconds at a time.) I will usually wedge something under the bridge to fix it in place long enough for us to cut all the rhythm tracks. I have to be careful what I say, because the inventor lives here in Seattle (and has made some serious bank from his invention), but I thank the Tuning Gods that I don't see these things much anymore.

## INTONATION HELL

"Intonation" of stringed instruments is a truly black art, and like tuning, no two people do it the same way, and for the same reasons: they don't know how the instrument is going to be played. When a guitar is not intonated right, a chord will sound good at one point on the neck, but out of tune at another point. The goal of intonation is to make the instrument play "in tune" all the way up the neck, or at least as far as it can be expected to be played (at least to the 16th fret or so).

I ask people, when possible, to get their guitars "intonated" by an expert before coming to the studio... but far too often, I still have to re-intonate them myself. "Lemme find a screwdriver and an allen wrench... you guys go have a smoke." Sometimes I'm amazed how far off they are... then I remember how badly I used to do it years ago when I thought I knew what I was doing. The process involves moving the bridge saddles back and forth, effectively changing the length of each string until the frets are in the best positions under the string (easier than moving the frets around!), and also adjusting the curvature of the neck with the truss rod (too curved, and you will have to push the strings too far to get to the frets in the middle of the neck, and they'll be sharp) and adjusting the height of the bridge overall (too high, and fretted strings go sharp, but with the whole neck, not just the middle; too low, and they buzz and rattle). To do it right, you have to know how hard the guitar is going to be played, and keep in mind that sharp-on-the-initial-attack thing I mentioned in Part 1.

Sometimes, you will sadly conclude that the damned frets are simply not in the right places, and you just gotta live with it. You do the best you can, and tell the band to go forth and rock. Probably no one will ever hear it but you.

Guitars have other problems. I've found that with some guitars, the nut is too tall. This means that as you get closer to the nut, you have to press harder to bend the string down toward the fret... just the opposite of what you'd expect. This means that any note played on the first fret will be very sharp. Check this on a few guitars with a precise tuner and you will be very, very scared. A "zero fret," like some Gretsches have, was one designer's solution. A currently hyped, copyrighted/patented new "tuning system" (which will remain nameless here) has as one of its components the slight adjustment of the position of the nut to move it a bit closer to the first fret. It's a fudge, but it can compensate somewhat for the problem.

## MORE MATH: THERE WILL BE A QUIZ IN THE MORNING

I've got to get back to physics and theory again to deal with the last of the tuning bogeys which bedevil our studio lives (if "studio lives" is not an oxymoron). Every few years, Guitar Player magazine reprints an article entitled "The Harmonic Tuning Myth". I saved it last time I saw it, and wave it at people occasionally.

You've seen the method: someone will tune their low E or A string, either with a tuner or with that old standard, a Tuning Fork. Then they will lightly chime the 4th harmonic (above the 5th fret) and compare that note with the 3rd harmonic (above the 7th fret) on the next string up. These are thought to be the same note. The problem is, they're not exactly. To explain why means we must delve into the "equal-tempered scale", but the essence of it that if you tune your guitar this way, an additive error is introduced with each string. By the time you get to the high E string, you are no longer quite in tune with the low E string. Nonetheless this method is close enough to get the tuning in the ballpark... but not always close enough for the studio.

Brute-force explanation of equal-temperament:

1) Two different notes sound "good" together only if their frequencies are simple integer fractional multiples of each other; i.e. four wavelengths of one note equals three wavelengths of the other, or five equals four, or seven equals five. [For example, E at 660 Hz, has a 3/2 ratio to A at 440 Hz. Three waves of that E are the same physical length as two waves of that A.] For an octave, the ratio is a simple as it gets: two wavelengths of the higher note equal one wavelength of the lower one. [For example, two A notes: 880 Hz and 440 Hz, a ratio of 2 to 1.]

2) "Chords" represent stacked ratios of these wavelengths; for instance, seven wavelengths of the high note will equal five wavelengths of the next one down, or four wavelengths of the lowest note. The notes are all "in tune" with each other when these ratios are exact.

3) The western musical scale is made of 12 notes per octave that are equally spaced apart. This allows you to play in any key without having to stop and adjust your tuning for each key (this will become clearer in a moment). Each of the 12 notes is about 5.946% higher in frequency than the one below it. If you take A 440, and multiply it by exactly 1.05946, you get the frequency of A sharp, which is 466.162 Hz. Multiply that again by 1.05946 eleven more times, and you reach 880 Hz, the A an octave higher. In the studio, where sometimes you have to change tape speeds for tuning purposes, you can just remember it as "6% speed change equals one half-step" (or one fret on the guitar). Six percent is ballpark... then finetune by ear. (Also... each of the 12 notes in an octave is divided into 100 tiny intervals called "cents". So... one "cent" is about .06%. An octave is 1200 cents. Hey, I didn't invent this stuff...)

So far so good? Get out your old TI calculator and try multiplying anything by 1.05946, 12 times, and watch the number end up doubled. It happens that 1.05946 is the "twelfth root of two". This evil number, which we are stuck with, has caused tuning nightmares for entire civilizations.

The G (and B) string drives people crazy on the guitar. They tune it, then play a C chord or A minor chord, but the G string sounds wrong. Fuzz and distortion makes the wrongness even more apparent. So they tune the G string by ear so that chord is in tune... and then all the other chords they play sound wrong. Way down there at the first fret, all your intonation acrobatics (which mostly affect the other end of the string!) will be of little use, so what do you do? Sigh wearily... and look for another guitar, which might fix the problem... sorta.

The explanation won't make you happy. In the "first position," meaning for chord shapes that are mostly on the first couple frets on the guitar, the G string is often used for the upper part of a musical interval called a "third," either major or minor third. (This musical term is not to be confused with "third harmonics;" it's a totally different thing.) In an ideal world, a "major third" is two notes (a "diad") whose frequencies are in a ratio of 5 to 4, or 1.25, while a "minor third" is in a ratio of 6 to 5, or 1.2. If those ratios are true, these diads (note pairs) sound wonderfully in tune and harmonious.

Here's where it gets hairy. In our 12-tone Western scale, where all the notes are equally spaced, no pair of them are exactly in a 1.2 or 1.25 ratio. If you pull out your calculator and multiply 1.05946 by itself a few times, you'll land on 1.189 and, next, 1.2599! The first one is actually 15 cents flat from where your ears will want a minor third to be, and the second is 14 cents sharp from where a major third should be! So if you tune a chord that includes a major third "by ear" until it sounds perfect, that same chord with a minor third substituted in it will be 29 cents out of tune... almost a third of a half-step. (Cue: wailing and gnashing of teeth.)

For comparison, a "fourth," the frequency span from A down to E, should be in a ratio of 4 to 3, or 1.3333... and in our Western scale, it lands on 1.3348. Damn close... only 2 cents sharp. A "fifth" (E to B, the ultimate punk rock interval; one string over, 2 frets up) should be 3 to 2, or 1.5000, but it lands on 1.4983 in our scale... 2 cents flat. Fourths and fifths are definitely close enough for rock and roll.

But... pile on a bunch of fuzz/distortion (which nakedly reveals tuning problems) and place those "third" notes right on the pesky first fret of the guitar, and you can have the ultimate homicidal-suicidal tuning nightmare. There's not much you can do. When a musician with a song including lots of first position complex chords notices this problem, he (and you) can go nuts trying to get his guitar in tune. There are actually chord progressions that simply cannot be played completely in tune on some guitars, period; you have to tune by ear for part of the chord progression, record it, then retune for the other part of the chord progression, and punch all those parts in... with very fast fingers. Or get another guitar... and hope!

You can try to suggest transposing the chord to some other part of the neck. Sometimes it works, if you can convince the musician. I had one client with a beat-to-hell Strat and a song with a first-position chord sequence that could not be tuned. No way, no how. We almost went insane, because he WOULD not use another guitar. It was a simple song, yet we spent hours trying to get a track done that did not sound horribly sour.

What could I do? Nothing... except try to learn why. That started me on the journey which led to this article. Thanks for reading, and good luck in the future... with all those keyboards, loops and samples! Hey, electric guitar's not dead, it just smells funny...

# Guitar Tuning Nightmares: Web Bonus Part 3

I encourage the reader to go forth and do some research on the nature of our 12-toned equal-tempered scale. I did, and the scales fell from my eyes [sorry]. Suffice it to say that I am so confident now of my guitar-tuning abilities that I actually commissioned a luthier to custom-build me an electric guitar fretted to play a 19-tones-per-octave musical scale... and I can actually get it in tune for minutes at a time, though just how the hell to do this is another subject!

Once I had made this preposterous guitar, word got around, and several people pointed me in the direction of pioneering author/composer **Harry Partch**, whose book "Genesis of a Music" pretty much blew my mind. Heavily mathematical at times, it's pretty dense going, but taken slowly, you can see he was way ahead of everyone in his explorations of non-equal-tempered or "just-intonation" musical scales. He comes out in favor of a 53-note scale (!), which would be pretty hard to realize on any fretted instrument, cuz the frets would just be too close together! The 19-notes-per-octave scale is about as far as you would want to take this idea for a guitar, and with my large fingers, it's pretty useless above the, er, 19th fret (I was gonna say "12th"...). Why 19? This scale is sort of the next-one-up in subdividing an octave, that has any potential usefulness. If you do the math using the 19th-root of 2 (where's my calculator? OK, it's 1.0371... the frequencies are 3.7% apart), you find out that in this scale, some different notes are closer to ideal. The minor third comes out to 1.2000 (perfect 6/5!), and the major third to 1.2447 (only 7 cents off, much closer to 5/4 than the 12-tone scale, which gives 1.2599 or 15 cents off). Much better on that G string! But the fourth, which should be 4/3, is 1.3389 or 7 cents sharp (compared to 2 cents in 12-tone), the fifth, which should be 3/2, is 1.4938 or 7 cents flat (compared to 2 cents in 12-tone), but the sixth: 1.6665 or an almost perfect 5/3 (compared with 1.6817 or 15 cents sharp in 12-tone). So, with a 19-tone scale, you've got just-OK 4ths and 5ths, but near-perfect minor 3rds and major 6ths. I figured it would be interesting to see what my fingers might do on such a guitar neck...and it is. But I have yet to actually use it for anything (like, who do I jam with?), nor have I spent the time on the instrument that it deserves. I like to leave it around studios I frequent, to the great bafflement of clients who casually pick it up without looking too closely at it! Boy are they pissed... their reactions are priceless to watch, especially when I pick it up and rip out a "scale". So... it's good for something!

*(Jack Endino is a Seattle-based freelance producer/engineer who has made 400+ records in 13 countries since 1985.)*