SOME PRINCIPLES OF 'FINE-TUNING' GUITAR SOUND: PART 1 of 4

by Ervin Somogyi

Tom Blackshear asked me to make a presentation on the topic of how I "fine-tune" the sound of my guitars. The subject is, for me, incredibly broad and open-ended -- far more so than I can encapsulate in a few brief pages of script. It is further complicated by the fact that there are two separate types of "fine tuning". In one, you're talking about manipulating some accessible elements of an instrument that's already been created; in the other you're talking about the creating of something purposefully and intelligently as you go, from the ground up.

Obviously, it is easier to "fine-tune" a guitar which already exists and is operating/ sounding more or less as you want. Fine-tuning a guitar that does not have the sound you intended or hoped for is hopeless unless you're prepared to do major surgery, and you really need to go back to the drawing board.

Altogether, it seems to me that the topic of 'fine tuning' needs to be thought of broadly. It needs to include some context. It needs to include fundamental considerations of design. And it needs to include an understanding of the realistic possibilities of any particular design.

I say this out of my experience of having made guitars of all kinds, having listened to them, and having listened to their players talk, for over thirty years. There are many people who believe that a guitar is this kind or that kind or has this sound or that sound as a function of how the instrument was made -- as though a reality had thereby been cast in stone. Or rather, in this instance, in wood. There is considerable truth to this view, and there are guitars which do function just like this: they have their own voice and response which are so much themselves, and so inflexible in being themselves, that the player cannot overcome this quality and interject his own persona into the music through his technique.

But I also know that there are other guitars whose sounds and performances are also largely a function of how they are played, and by whom. While this may sound too fanciful and folk-tale-ish for some people to swallow, others will recognize that there is truth in this as well. Years ago I went to a party to which someone had brought a guitar; it was passed around and played by five people. Incredibly, to me, it sounded like five different guitars. I've spent a great deal of time since then analyzing and trying to understand this phenomenon.

I've learned that while the guitar is not a particularly complicated instrument [it has far fewer parts than the average tv set, or toaster, or telephone, or even bicycle] it is an endlessly subtle one in which everything connects and interacts with everything else. This being so, the intelligence of the luthier can be bent toward shaping guitars which are very different in the degree to which they bend to the will, style, and interpretive chops of the player.

Let us agree that an important line to draw in the matter of "fine tuning" has to do with whether you are approaching a completed instrument or whether you are still regulating the shaping of components of an instrument under construction. This is important for obvious reasons. There are some things that are relatively easy to do if the guitar parts are on the workbench in front of you; also, there is a separate range of modifications and alterations it is possible (or impossible) to do to a guitar once it has been completed. This is important because it bears on the matter of whether a guitar which is not fully satisfactory can be made to be so with a certain amount of labor and cost, or whether one should sell it and buy one that already has those qualities. Many guitarists face this sooner or later, and the best answers are always arrived at on a case-by-case basis.

What kinds of things are capable of being "fine tuned", however that phrase is defined? I can think of four broad categories. First, playability: adjustments, action tweaking, buzzing problems, etc. on completed guitars. These are the easiest to do. The work involves paying a certain amount of attention to strings, nut, saddle, neck and frets, and all repair shops do these procedures every day.

Second, there are problems of tone and response associated with what kinds of strings you put on the guitar. They do make a difference. But this is a no-brainer and it is solved by going out and buying new strings until you like how your guitar sounds.

Third, there are ergonomic problems such as those associated with neck size, shape and length. Neck size and shape can be altered with some amount of work, and then the neck and head will need to be refinished. Scale length cannot be changed without doing major surgery on the guitar. Sometimes a player will want a crowned fingerboard rather than a flat one: this can be done relatively easily as well. The shaping of the guitar neck and fingerboard are by themselves interesting and entirely separate topics which bring together the interrelationship between the contouring of the neck and the musculature and enervation of the human hand, wrist and forearm. If you have carpal tunnel problems, or arthritic aches and pains, this is a biggie. But also, I'll lay money on the supposition that each guitar player you know has different sized hands -- and who decided that one size and shape of guitar neck should fit them all?

Fourth and last, are the trickier, subtler "fine-tuning" problems associated with systemic, basic, aspects of tone and response. These are tricky because they force us to go to fundamental aspects of the mechanisms of dynamics of a soundbox. The factors involved are usually complex, interdependent, require experience and understanding to work with effectively, and usually need to be addressed prior to a guitar's being actually completed. As such, I do not consider these operations to properly belong in the area of "fine tuning" so much as belonging to the field of Design. I do an awful lot of this work, as does every luthier, and from this point on I will in fact be talking about the fine tuning of the design of the guitar.

Anyway, the elements of guitar design which can be fine-tuned or otherwise manipulated are (in order of decreasing importance) the face and its bracing, the bridge, the back and its bracing, the neck, and, lastly, the sides. The bridge is important because it has a dual function: it acts as a unique dynamic element [separate from everything else] and also as a main face brace [part of a system]. Each of these elements could easily become a separate topic of discussion if there were enough time. The face and its bracing could be treated as two separate topics theoretically, although in reality they are so interdependent that it is not possible to separate one from the other. These are, in fact, an easily appreciated microcosm of how the guitar really works: everything connects to everything else.

Since the topic of "fine-tuning" is so broad and open-ended for me, I intend to limit my remarks to the simple-sounding subject of the guitar bridge alone. It is in fact not simple at all, but for purposes of this discussion it has the virtue of being able to be "fine tuned" on the completed guitar (because it is so readily accessible) while at the same time it is an integral part of any guitar's overall design from the first day that guitar is begun to be built. I also need to tell you that, since I am a custom-maker of guitars, and I build most of my guitars for individual clients, I don't build most of my guitars exactly the same as the previous one. I initially fine-tune my lutherie work through conversations I have with my clients. I listen to them as they tell me what they want, what they have, what they don't want. Then I build accordingly. And my success/satisfaction rate is high. I build according to the principles I'm going to describe below (and which, in principle, apply to both steel string and nylon string guitars).

So, to begin. Some of you will be asking: what the heck is so important or complicated about the bridge? What does it do? And how?

We all know that the guitar bridge is that piece of wood on the face to which the strings attach. It is mostly taken for granted as a necessary part of the guitar, and not much attention is paid to it outside of whatever distinctive decorative styling it may have. Yet, it is at least as important a factor in the production of sound as the guitar's bracing, to which a great deal of attention is paid. In reality, it is not possible to understand the effect of bracing without recognizing that the bridge is, in effect, the main brace to which all the other braces are subordinate. An analogy may be helpful toward illustrating this point: if the guitar were like a business (whose task it is to make sound, rather than products) then (1) the strings would be the CEO and budget; (2) the braces, the face, and all the face's vibrational activities would be the different departments and their workers which actually produce results for the company; and (3) the bridge would be the office manager who sets task priorities, allocates "funds" (i.e., sets aside energy) for the workers, and coordinates and directs the specific flow of activity to the different sections of his work force.

The bridge can function as office manager because it is the gateway to this activity. It is, first, the primary point of excitation of the face and calls many of the basic tonal shots, and, second, it functions as a mechanical coupler and can direct vibrational energies as a function of its shape, size and design. This is where the fine-tuning/design part comes in.

For purposes of this writing, I'm going to focus on the bridge in isolation from the rest of the system. This is highly artificial, but essential if we're going to get through this by this week. I'm going to avoid as entirely as I can the subject of top plate selection, treatment, thicknessing, shaping, tapering, or perforating [the soundhole placement and diameter each play a part]. Each of these could take many hours, if not days, to cover. I am also going to avoid as much as I can the legendarily complicated matter of bracing: the various styles patterns and schools of bracing such as Torres bracing, Hauser bracing and Kasha bracing [and all their variants]; bracewood selection and treatment; historical development of bracing in the German, French, Spanish and American schools; the physics and engineering of the most common bracing patterns; theories and practices of tapering and shaping of the materials; and, of course, the Magnum Bugaboos Of Guitar Discourse, the acoustics and dynamics of bracings and face-working in all their glory. It gets very complicated. And, to make matters worse, if you talk with six luthiers you'll get twelve different opinions -- many of them sounding plausible, if incomprehensible.

It can be appreciated that the location of the guitar's bridge would be an important factor toward determination of sound. Location is, in fact, critical to amount, possibilities and character of it. The best, richest sound will be gotten if the bridge is in the middle of the face, from where it can command both high and low pitched vibrational activity. Think of a drumhead: the place where you tap it (the point of excitation) determines the quality of the tone produced. If you excite a drumhead at or near its edge you can expect to get a high pitched sound, because the perimeter will be relatively rigid and can be expected to be capable of little movement. Hence, it will respond to being driven by vibrating in a high frequency/low amplitude manner and will make a high pitched, bright sound. If you instead tap the drumhead in the middle you can expect it to respond in a high-amplitude/low frequency manner -- with a lower, more open sound --because the middle of the drum is looser than the perimeter and is capable of greater excursion (movement). That's only part of the story, though. Energy at the center invariably travels to the perimeter and excites it also. Thus, tapping a drumhead in its center can simultaneously excite the edges and create those higher pitched components of response, overtones. These secondary sounds are a bit as though a bridge were placed at the edge of the face as well as in the middle. In the guitar, which higher components you get depends partly on the bracing structure that carries the vibrational excitations from the center of the plate to its edge, and partly on which strings and which frets/positions are being played on. [Disclaimer: obviously, top plate treatment and bracing are of major importance to these phenomena, but, for purposes of this discussion, as I said above, I'm not going to go into these.]

The importance of the information in the above paragraph rests not in the suggestion that we go around changing the location of the bridge in order to change a guitar's sound -- that would be ludicrous, and you'd have to change the neck and fingerboard right along with it. It is, rather, that the size and shape of the guitar, in tandem with the desired scale, will determine the location of the bridge with respect to the face's perimeter. A small guitar with a long scale will have an off-center bridge. As will a large guitar with a short scale. In other words, bridge position is "fine tuned" only at a fundamental level of design which must take these factors into account at the outset. Once you've decided on a body size and scale length the position of the bridge is a done deal.

O.K.,you say. But, regardless of where the bridge is, what can it do and how can it do it? I'm glad you asked. The guitar bridge effects and regulates tone in three ways: (1) by virtue of its position, (2) through its dynamics: that is, through its movements and its coupling efficiency (or inefficiency), and (3) through its design, size, mass and height. Let's examine these one at a time. I've already touched on the importance of position; let's look at bridge movements next.

THE BRIDGE: PRACTICALLY SPEAKING, IS IT RIGHT UP THERE WITH A BIG MAC HAPPY MEAL? OR IS IT REALLY MORE LIKE BOEUF STROGANOFF?

by Ervin Somogyi

In yesterday's installment of this discussion I ventured the opinion that the guitar bridge is an underrated and much-taken-for-granted part of the guitar which is much more important in its functions of coupling and regulation of vibrational activity than most people realize. I began to outline the thesis that this simple looking piece of wood in the middle of the guitar face is a sort of gateway to top plate activity.

This plate activity occurs in the following ways:

THE MODES OF MOVEMENT OF THE BRIDGE

The guitar bridge is capable of physical movement in three ways. (1) It moves up and down, pumping like a bellows or piston; (2) it seesaws back and forth sideways around the centerline of the guitar, each wing rising as the other falls;

and (3) it rocks backwards and forwards along its own axis, in the direction of the strings' pull. Being glued to a flimsy plate of softwood, the bridge really can't do anything else than these things. Well, all right: four ways, if you count being pulled off the face by string tension. But while the bridge is attached it's these main three – and complex variations of them.

Physicists and acousticians who have studied guitar top motion and bracing systems have determined that the guitar's three most important vibrational modes are identical to the movements of the bridge. That is, the guitar top moves (1) up and down as a unit, acting as a bellows or piston. It (2) teeter-totters sideways around the instrument's longitudinal center line. And (3) it seesaws up and down in front of and in back of the bridge as this rocks backward and forward. The technical names for these are, respectively, the **monopole**, the **cross dipole** and the **long dipole**. [I cannot include diagrams in this writing, so try to imagine these modes of movement: it's important to what I'm going to be talking about next.] From the guitarmaker's point of view, his biggest challenge is to make an instrument in which these modes of activity are balanced; that is, that there's not too much of one and not too little of another. This is, of course, a gross oversimplification in the service of getting a concept across. And while it may sound easy, this simple sounding ideal is complex enough that it cannot be completely explored in a lifetime of instrument making. I'm still learning what refinements in my own bridge design are useful and, yes, after 30 years, I still make changes in it.

You might want to flesh out your own understanding of guitar top movement and get a hands-on feel for these materials the next time you go to your friendly neighborhood luthier's workshop -- by actually handling some guitar tops. Carefully. You will notice that the softwoods which are used for this purpose have a grain structure which stiffens the material differentially along different axies. Guitar tops are much stiffer the long way [with the grain] than from side to side [perpendicular to the grain]. Some tops are remarkably stiffer or looser than others of the same thickness. Almost without exception side-to-side flexion is greater than long-axis flexion. It is important, if you want to make guitars, to develop a sense of just how much stiffness or looseness there is, compared to something else. This has clear implications for ease of (or resistance to) movement of the plate in the ways described above. Luthiers work with these factors every day to shape them and incorporate them into their guitars' sound.

How does one regulate these modes of vibration and achieve an optimum balance of them in such inconsistent materials? Well, in a number of ways. It's analogous to there being many ways to prepare a fine dinner using the same ingredients: you need to develop a sense of how much of one thing goes well with how much of another. In this way both cooking and guitarmaking are similar, learned processes -- although it doesn't hurt at all to have some native ability at this. The "ingredients" in guitarmaking are things like the design, the woods, and the bracings and their stiffness' in relation to (i.e., facilitation or inhibition of) the above vibrational modes. An important basic ingredient in preparing a "meal of sound", as it were, is the design of the bridge. A rather small body of literature exists on the relation between bridge design and guitar sound and, to date, it all relates to classical guitars. But the principles of top motion as they are driven by bridges apply to steel string guitars as well.

Let's take a closer look at the modes of top motion, one at a time. It will constitute a short detour from our examination of the bridge alone. But it will be a useful detour that will put the bridge into a usable context for us to think about.

THE MODES OF MOVEMENT OF THE GUITAR FACE

FIRST MODE, OR MONOPOLE:

The ability of the guitar face to move in monopole mode is a measure of how well it can act as a unit. It is a function how the top is connected to itself and it has everything to do with wood selection, top thicknessing and bracing, and bridging. Monopole activity is responsible for low, open sound: that is, bass response.

A traditional technique for reinforcing the monopole is to make the guitar's face thinner around the edges so as to lessen resistance to movement as a unit, while simultaneously tying the center of the face together with the bridge and bracing so as to facilitate such movement. One can fine-tune this in a thousand ways -- by thinning and/or tapering the face and/or the braces selectively -- but the basic rules are always the same: more wood produces a brighter sound and less wood produces a bassier sound.

One can also beef up the stiffness of the face by arching or doming it, and one can loosen the face by flattening it, a process analogous to tensing the face up by increasing the torque on it as a function of increased string height at the bridge, and lessening the stiffness of the face by attaching a lower-torque, lower-height bridge. The point is that, however one tries to manipulate the structure of the face toward making it capable of working as a unit, the bridge ties and connects it all together. Clearly the footprint, height and mass of the bridge, in relation to the system as a whole, become factors to think about. No matter how big or small, domed or flat, heavily or lightly braced, thick or thin, etc. the face is, the bridge will drive it.

SECOND MODE, OR CROSS DIPOLE:

The ability of the guitar face to rock sideways is a function of how little resistance there is to this motion. Classic guitars favor the cross dipole because its fan bracing is usually parallel to the grain, and offers no resistance to sideways rocking. In comparison, a steel string guitar's "X" brace does resist this movement.

A traditional way of enabling cross dipole movement is to thin the face only on its right and left wings -- at either end of the bridge -- but not in the middle. This can also be done with the bracing also, as when braces at the wings of the face are made smaller than the braces in the middle. Again, this is common practice in classic guitarmaking. Active cross dipole motion correlates with loudness in a guitar. Good flamenco guitars usually have a more dominant cross dipole mode than classic guitars do.

These things being so, the length of the bridge in relation to the size of the guitar is a significant factor in the facilitation or inhibition of sideways rocking. A clear example of this differential and intentional coupling function can be seen in the Gendai Guitar Book 6 [The Gendai Guitar, Kabushiki Gaisya 1 - 11, Chihaya-Cyou, Tosima-Ku, Tokyo 171, Japan], in which a Smallman guitar with a very short bridge in proportion to the guitar body size can be seen opposite a Somogyi with a very long bridge in proportion to its body size. These are both remarkable compared to other bridges in the same book. Both of these guitars work, but the thinking and dynamics behind them are different. Everything else being equal, the Smallman bridge will favor better cross dipole activity; the Somogyi bridge will favor the long dipole.

THIRD MODE, OR LONG DIPOLE:

The ability of the guitar face to engage in long dipole motion is a function of how much or how little resistance there is to rocking back and forth. This is traditionally accomplished by tapering the face and the braces along the long axis until stiffness or springiness is "just right" as judged by the experience of the maker. Long dipole movement is important to the very high frequency response of the guitar, for reasons too complicated to go into here. It is associated with carrying power, rather than mere loudness in the immediate vicinity of the guitar.

The bridge can help control long dipole activity if it is made higher, because the higher the strings are over the face the more torque acts on it, and the more easily back-and-forth rocking motion can occur. Long dipole movement is further enhanced as the bridge is made longer and narrower. Contrarily, if one lowers the bridge and makes it wider the opposite will happen: as the strings get closer to the face and exert less torque on it, the sound produced becomes less bright. If anything, a fatter footprint helps to drive the monopole.

These modes of movement are systemic. That is, they describe the fundamental and simultaneous workings of several components [the face, the bracing, the bridge] of a guitar top. The principles regulating these apply to steel string guitars as well, although, to my knowledge, no one in the field of acoustic guitar building besides me incorporates this kind of thinking into their bridge design work.

MEANWHILE, BACK AT THE BRIDGE . . .

Once again, let me underline that we're describing the entirely artificial situation of the bridge acting as though it were behaving independently of the rest of the system. Properly speaking, the movements described above pertain to the guitar face, whether or not it's acting in tandem with the bridge.

Still, we may ask, can we not identify any design elements pertaining to the bridge which affect its functioning in the monopole, cross dipole and long dipole modes all by itself? Well, yes. While it is true that bridge size and shape go hand in hand with monopole, cross dipole and long dipole movement, there are five independent elements of bridge design worth mentioning.

SOME PRINCIPLES OF 'FINE-TUNING' GUITAR SOUND, PART 3 OF 4

by Ervin Somogyi

In yesterday's segment I spoke of how the guitar bridge and face each move in three principal ways: pumping up and down as a unit, teeter-tottering across the longitudinal center line, and pivoting backwards and forwards around the long axis of the bridge. These are called a number of things in what available literature there exists on this topic, but my preferred labels are the monopole, cross dipole and long dipole, respectively.

For today's discussion I want to focus on what elements in bridge design, by themselves, could conceivably act to facilitate or hinder these movements.

To my thinking, there are five. I'll discuss the first two today, and the rest tomorrow.

[1] BRIDGE MASS:

The mass of the bridge can make a difference to response regardless of what mode of vibration it is designed to facilitate. A heavy bridge will have more inertia, and will take some milliseconds longer to start to move than a lighter weight one. A few milliseconds can be all it takes to give notes a short, bright character or a longer, more rounded one. Technically, this has to do with manipulation of the rise-time-to-peak of a note, and it likewise can effect sustain (decay time).

The mass of the bridge is determined by choice of wood (or other material), and the design/shaping of the bridge as seen from the standpoint of how many grams it weighs in its ready-to-glue form. Think of the possible extremes: a bridge made out of Styrofoam vs. a bridge made out of lead: the Styrofoam bridge will kick into movement instantly and probably stop quickly; the lead bridge will take longer to get going, and also longer to stop. These small things make a difference, and any luthier worth his salt ought to be able to tell you the mass of his bridges.

It goes without saying that the mass of the bridge is only important in relation to the design and mass of the braced face. The typical classic guitar bridges range in mass from around 15 to around 40 grams while the typical braced classic guitar face ranges from around 150 to around 350 grams. Of course, the numbers are different for steel string guitars.

Luthier Richard Schneider once made a flamenco guitar bridge that weighed out at nine grams, which is close to nothing, and any amateur can discern that there's a difference in weight between an ebony bridge and a rosewood or maple one. Obviously, altering the mass of a bridge on a heavy face is not as likely to make an audible difference as it might on a lighter one. Again, check in with your friendly neighborhood luthier for hands-on information.

[2] COUPLING FUNCTIONS OF THE BRIDGE AND ITS COMPONENTS:

The bridge acts as a mechanical coupler between the strings and the soundbox. It also acts in a second important way: as an acoustic coupler. It is here, and at all points where a connection between two materials is made, that energies can be lost or captured for use in sound production.

Why should this be particularly important? Well, the guitar is a rather inefficient tone generator, in that only three to six percent of the energy which drives it (string movement) actually becomes sound: the other 94% to 97% goes into mechanical vibration of the woods and is otherwise lost to heat, internal and external friction, damping, and poor couplings. That is, of any strings' action, only about 5% of this energy makes it to become sound. It's a little bit like only one sperm out of millions making it to the ovum; in both cases you need lots of bang to get a buck, as it were -- and, while only one sperm has to make it all the way to the egg in nature, in the guitar the points of potential loss or gain of sound energy merit a careful look because we want the strings on our guitars to deliver more sound than the other guy's guitars can.

The important features of the bridge as coupling elements are (l) the nature of the glue joint between the bridge and the guitar face, (2) the contact characteristics between string and the bridge saddle that they pass over, and (3) the contact characteristics between the saddle and the bridge itself. That significant energy can be lost at coupling points has been proven experimentally and can be illustrated by the fact that a guitar with a sloppily or loosely fitting nut and/or saddle will sound audibly quieter than the same guitar with tight fittings. The more adventurous of you who are reading this can demonstrate this effect for yourselves if you take the trouble to simply insert a poorly fitting plastic saddle, gotten from your nearest music store, into your guitar bridge tonight, and hear the difference which this one factor alone makes. Or, if you already have a poorly fitting plastic saddle, get a tight-fitting bone one installed. Saddles are not glued in and come out easily, so this is not hard to do. I guarantee you'll hear a difference; it may be so slight on the average guitar that you can't be sure, but I guarantee it will be so on responsive, sensitive ones. And as to glue joints, you'll be surprised at how many bridges are poorly glued on, especially on lower end factory guitars.

A very important element of coupling design is the longitudinal rigidity and stability of the bridge, either as a function of materials choice, or bridge shape, or both. This goes to the above discussion of energy loss. If the bridge is flimsy and floppy, it will flex and bend along with the face, and it will have one kind of dynamic. If, on the other hand, it manages to be a comparatively rigid member then it will likely not take up much string energy in flexing and bending, but will most likely shunt the strings' energies into the soundox directly and with less loss. Remember: if the guitar only "captures" some 5% of the strings' energies in the form of sound, then even a few percent loss or gain of string energy at the bridge may make a difference.

For this reason, some luthiers put thought into the shape of their bridge profiles. Traditional classic guitar bridges have a wing on each side of the saddle mound and tie block. If you look at this construct from an engineering standpoint you will appreciate that the nexus between the center and the wings -- the point where the thick part of the bridge connects to the skinny part -- is where flexion is most likely to occur. The nexus is a "weak" spot. This spot is thinner and weaker still in those traditional classic guitar bridges which have been scooped/arched to conform to the dome of the face: the nexus is made thinner by the removal of wood from the bottom of the bridge. Next time you go to a guitar store with any good selection of guitars look at their bridges: the ends of the wings are often thicker than the nexus points, for just this reason! Now, you may want a bridge that has such a design and such a dynamic. But if you don't, then an intelligent thing to do is to reverse the thick and thin spots on the wings and beef up the flexpoints. This is what luthiers like John Gilbert have done: make a bridge which doesn't necessarily weigh any more than the traditional bridge, but which is much stiffer on its long axis and less subject to flexing, by making it equally stiff along its entire length.

Choice of materials plays a part in energy transfer or loss, too, because some materials will soak up energy and deaden it, while others are lively. The technical name for the cause of this is "internal damping". Brazilian rosewood, wenge, and others have very little internal damping. They are "live" woods which don't soak up energy but rather give you a sound or tone when you tap them. Marimbas were made out of Brazilian rosewood: imagine, a wood that rings like crystal when you hit it! So a bridge made out of such a material would not damp out very much of the energy that the strings give over to them. Other woods have greater internal damping. These simply do not have a comparable tap tone: maple, walnut, ebony, etc. all sound considerably more dead, and make a "thunk" or "thud" rather than a "ping" when you tap them.

Imagine a bridge made of superball material: you know, those kids' balls that bounce forever when you drop them from a height? The energy from the fall is analogous to string energy in the guitar, The object is to get a sustaining amount and level of activity on the bridge end. Now imagine dropping an orange from the same height. It will have virtually no sustain, as the orange will absorb the energy of the fall and not bounce back. Bridges behave in ways analogous to superballs and oranges, although not to so extreme a degree, and the choice of what material you want to use becomes one more place to exercise judgment.

But aside from all these things I want to redirect our attentions to the coupling function of the bridge, mentioned previously, which is of such overwhelming and critical importance that it cannot be overstated. It ties everything (bracing, top wood, doming, etc.) in the face together and connects it all to the strings. A fuller discussion of this function is outside the scope of this writing at this time, but it is a minor art form unto itself and is fully capable of supporting years of study, experimentation, variation, and refinement.

SOME PRINCIPLES OF 'FINE-TUNING' GUITAR SOUND, PART 4 OF 4

by Ervin Somogyi

This is the fourth and final part of my contribution to the "fine tuning" discussion. Tomorrow and the day after I'll be available on the chat site to answer questions.

Yesterday's topic was the specific design considerations of the guitar bridge which facilitate or hinder its ability to engage in monopole, cross dipole and long dipole motion. I'd described these important modes of vibration in my contribution to this topic from two days ago. Yesterday we examined the first two of what I consider the most important design considerations for the bridge: [1] its mass and [2] its coupling action as a function of its components, design and materials. Today I'll discuss the remaining three.

[3] COUPLING ACTION OF THE BRIDGE AS A FUNCTION OF ITS FIT AND

THE FACE/GLUE JOINT:

The coupling/fitting of the bridge itself to the guitar face merits the same kind of attention in acoustic guitars that it has always had from the makers of archtops: that is, you want a the best fit possible. The rage in acoustic guitarmaking these days is in creating domed faces, as you can observe by looking at the next Taylor, Fox, etc. guitar that you see. You can probably also see, next time you're in the audience at a guitar performance and the stage lights bounce off the guitar's faces and allow you to clearly observe this doming, that there are dimples at the edges of the bridges. One can also occasionally see this in classic guitars – which have traditionally had slightly domed faces for far longer than steel string guitars have. This dimpling is an indicator of a flat bridge having been glued onto an arched face, with the attendant deformation of the more yielding material and consequent flattening of the dome in a critical location. If you believe that a certain degree of facial arching will benefit your guitars, you ought to arch the bridges accordingly so as to maintain this significant dynamic and design feature. Many individuals already do exactly this so as to not introduce unforeseen and uncontrolled variables into their carefully crafted sound-producing boxes. In manufacturing, however, it is too easy to subordinate the needs of the soundbox to the needs of manufacturing efficiency.

In the final analysis, putting a flat bridge on a domed face both flattens and weakens the face and also negates some of the advantages of having domed it in the first place. I think a flat bridge-area on a dome will more easily be driven in long dipole mode, because there will be less longitudinal arching to inhibit this movement. Also, I think the dimpling of the face at the bridge wings -- which represents interruptions in the load-bearing capacity of an otherwise evenly curved arch -- facilitates its cross-dipole movement: there is less to hold it back.

[4] BRIDGE HEIGHT AND TORQUE:

I've already mentioned the importance of recognizing that the higher the bridge, the more torque acts on the face so as to stiffen it and brighten up the tonal response. Conversely, the lower the bridge, the opposite. In fact, a low bridge will help produce a lower, fundamental sound less colored by overtones, and in general helps the monopole mode. The higher the bridge the more tendency there is toward long dipole movement.

The importance of this element of bridge design has long been recognized by those guitar makers who take great pains to set their necks so as to achieve a specific, precise and consistent string height at the bridge on every guitar they make. This is different than simply aiming at a workable action. Before he retired, for example, guitarmaker John Gilbert was adamantly meticulous about setting his strings at the same precise height above the face every time because of his recognition of the fact that changing this one thing alone can have an audible effect on sound. For those guitarmakers who have not yet understood the importance of having the same torque on every guitar they make the question is: how could they know what effect a change in bracing has, for instance, if you also change the driving/energy from guitar to guitar at the same time? It's a recipe for producing guitars with lack of consistency of sound, and for muddying what you could learn from your results.

[5] PROPORTIONALITY OF SIZE:

An important design implication of the above mentioned principles of bridge activity is one of proportionality: that is, that one should expect to see bridges sized in proportion to the size of the soundbox they are driving. In theory you shouldn't expect to see normal, big bridges automatically put on small guitars, although this is commonly seen on the different size instruments made by commercial manufacturers for whom one-size-fits-all thinking dominates. A normal bridge on a small guitar is the equivalent of a larger bridge on a normal sized guitar -- a pairing which, while undoubtedly convenient for the production maker, is not necessarily the most intelligent use of the materials if management of sound is your goal. If you've been following my argument to this point you will by now be in a position to suspect that paying insufficient attention to the raw size of the bridge may well have some effect on one or another of the guitar's principal vibrational modes.

[6] LOCATION:

While location of the bridge was the very first thing I mentioned in the first part of this discussion, I wanted to come back to it to make the point (for those of you that might be wondering why I haven't mentioned this) that location is not a design variable of the bridge, and hence doesn't belong in this part of the discussion. Location is a relational and systemic function, not a design one.

Neither are the aesthetics nor ornamentation of the bridge relevant to how it works, if these don't impact its size, weight or stiffness.

TO SUM UP:

These are the factors I work with, in each of my guitar bridges, to assure that my guitars are as close as possible to what I understand my clients to want. I pay attention to my bridges to the extent of subjecting each of them to thirteen "fine-tuning" procedures in addition to all the necessary normal shaping, sanding and contouring ones, with an end to making each bridge a customized integral part of the guitar it is intended for.

And, as I said above, this is for the bridges only. There's a great deal of separate work that goes into all the other parts of my guitars. It's challenging, meticulous work, and I keep on telling people that lutherie is not for everybody.

Cutting To The Chase: are any of these factors significant or dramatic by themselves alone? I tend to doubt it. But in the aggregate -- if you gain or lose a little bit at each of these junctures, or if you stop unintended gains and losses by doing consistent and appropriate work, and if you connect the making of the bridge with other design elements -- it will almost certainly make enough of a difference that someone can hear.

My advice to luthiers reading this is that if you are simply aware of these factors, and work with them for a little while, and talk about this work with your clients, then you'll probably come off as a more serious, experienced and professional luthier. You'll certainly make a better impression on your clients, and probably a better guitar. You'll likely feel more confident in your work. You will in fact become a better luthier. And you may make a sale which you would not otherwise have made.

My advice to guitarists reading this is that you approach your local friendly neighborhood luthier with some respect if you want to bug him about his woods, his bridges, his designs, etc. He will be busy trying to make a living and his time is valuable. Offer to pay him something for educating you and don't waste his time gratuitously. Please recognize that he is your target of choice expressly because he is convenient and accessible. You cannot visit your friendly neighborhood guitar factory and waste its time in asking beginner's questions about how much its guitar bridges weigh or how they select their top woods. Factories are busy places and are not set up to be bothered with such questions, and they'll throw you out for being a nuisance. I would, if I were a factory. Nor is it certain that you will be able to get useful real information from your friendly neighborhood music retailer, although you might luck out. Stores are open to invite the public in and answer its questions as a matter of business, in the daily hope that they can make a sale. Good luck. And visit my website at www.esomogyi.com

Q1

> *I've already mentioned the importance of recognizing that the higher the*
> *bridge, the more torque acts on the face so as to stiffen it and brighten up*
> *the tonal response. Conversely, the lower the bridge, the opposite. In*
> *fact, a low bridge will help produce a lower, fundamental sound less colored*
> *by overtones, and in general helps the monopole mode. The higher the bridge*
> *the more tendency there is toward long dipole movement.*

And what about the distance and angle of the strings from the tie block to the saddle bone? Of course we cannot have too low of a breakover angle or we'd all be playing sitars, but do the same rules of torque apply to some degree to the breakover angle?   Ken

A1
Hello, Ken:

Yes, break angle of the strings is yet another design variable for luthiers to use in their "recipe mix" of sound and response.

The chief advance of the modern classical guitar bridge over the previous incarnation of such an object -- the lute bridge -- which was only a tie block, is precisely that there is a saddle in front of the tie block. The reason that this is important is (1) that the strings' pull on a tie block alone is exclusively along the straight line of string tension -- sort of like tying a rope to a car bumper and pulling on it directly; but (2) the tie block divides the string tension which is acting on the bridge into two components: (a) a direct one, in line with the strings, and also (b) one in which the strings' pull is upwards, away from the face, along the line determined by the difference in height between the saddle and the tie-block. This bifurcation of pulls creates (c) a resultant force acting in a downward direction. This is a much more efficient energy path toward excitation of a plate. You'll get more sound out of a drumhead, for example, if you excite it by displacing it downwards than by pulling on it from its side. (c) force also has torque, but it's the downward component of bridge movement which is the important one.

The break angle of the string is the chief culprit/agent in this, and one winds up looking at the factors responsible for this angle: the distance between the saddle slot and the tie block; the difference in height between them; and the strings' tensions. If the string angle is too steep [insufficient distance, too great height differential] then you'll be loading the guitar down with more torque in downward movement. This will favor the long dipole at the expense of the monopole. If the angle is too shallow [insufficient difference in height between saddle and tie block] then there is not much break-angle pressure of the string on the saddle, and tone suffers: you lose the highs and emasculate the lows.

One of the very important things about the modern classical guitar bridge, and one which is a real advance in dynamics over previous stringed instrument bridges, is that it offers play-room to work with this important variable. More recently some luthiers' attempts to control break-angle height have resulted in the double-hole bridge design [the tie block has twelve string holes rather than six], where the string anchors at the BOTTOM of the tie block and increases the angle to the saddle. As far as I know I was the first one to do this back in the seventies, but it's one of the many unknown facts about me. The idea has caught on since. Interestingly, it is more difficult to manipulate this variable on steel string guitars because the design of the bridge offers less string-angle varying space.

Cheers! Ervin Somogyi

Q2

>Ervin wrote: While location of the bridge was the very first thing I
>mentioned in the first part of this discussion, I wanted to come back to it
>to make the point (for those of you that might be wondering why I haven't
>mentioned this) that location is not a design variable of the bridge, and
>hence doesn't belong in this part of the discussion. Location is a
>relational and systemic function, not a design one.

Neither are the aesthetics nor ornamentation of the bridge relevant to how it works, if these don't impact its size, weight or stiffness.<<<<

There are several things I notice in relation to the top to bridge function, and I'm wondering what you think about it. First, when I copy a famous Spanish maker's instrument, I get the impression that there is a certain area they place the bridge for optimal results. Second is that there is a curve on the bridge bottom while there may not be a dome on the top, whereby the bridge, when glued, pulls the top into it causing the slight dimples at the ends of the bridge arms. I've seen this phenomena on the Conde guitars as well as having a slight dome on the Rodriguez, but with a deeper curve on the bottom of the bridge to pull the top into it. This seems to have an effect on the sound, and I have thoughts about how the top with less dome might function better for sustain, etc. by just pulling it into the heavier curve on the bridge. This does put certain stresses on the top, but it may
be necessary for certain responses from the top gain in sound. What do you think? Regards, Tom Blackshear

A2

Hi, Tom:

Good question, and one you're sure to get varying opinions about, depending on whom you ask. You know: five luthiers -- ten opinions. Top doming is an art form all unto itself, and has lots to do with plate integrity, tonal and dynamic functioning, etc. It shapes the guitar's sound, no doubt about it, depending on how much doming there is, whether it's planar-perimeter or spherical-perimeter doming, whether it's spherical doming as a unit or whether it's differential doming within the footprint of the guitar face, whether the face is tapered as well, how it's braced, and so on. I'm already tired just thinking about this.

Here's my take on [at least part of] it:

The early Spanish makers domed their guitar faces. They found this to be an efficient and effective solution to the tonal and mechanical challenges they were faced with in creating this new stringed instrument which had to accomplish certain given musical tasks. One of the principal of these was to play at the range of the human voice so that it could accompany it and still maintain its own integrity: that is, not be drowned out by it, and not compete with the singer to his detriment.

The early makers worked hard at refining their design so that these guitars did these things. The use of dished workboards [called SOLERAS], the frequent absence of rigid molds, and the use of individual lining segments [TENTELLONES, PRONOUNCED TEN-TAY-YONES] enabled luthiers to make quick on-the-spot changes in guitar shape and design in response to an idea or inspiration, or possibly request. Their work was flexible.

Once guitars became objects that you could make a living at making [that is, the market expanded] many of the Southern Spanish makers went to Madrid, the big city. This is no different than how American blues players from the South migrated to Chicago, Detroit, St. Louis, etc. because they knew they could make a living in these places. Once in Madrid, the famous houses got established and, as we all know, began to make lots of guitars [compared with former production levels]. Some of these learned that they could make guitars faster by making them with flat tops: they began to dispense with the soleras, which had enabled makers to dome their guitar faces to the domings that they preferred. [Soleras were all hand made, and each was specific to their maker and model; they weren't standardized, like the modern radiused workboards you can now buy at any luthier's supply business.] Making this concession to efficiency and intentional quality certainly facilitated production: it's what any manufacturer tries to do to as great a degree as he can. But the dome was lost, and with it, an important dynamic component of the guitar. Many modern Spanish guitars have flat faces, or nearly flat faces. It's faster and easier to make a guitar like this.

According to Eugene Clark, noted authority, the Spanish guitar lost its voice when this transition was made. According to Richard Brune, noted authority, plenty of Spanish guitars sound great no matter how they're made.

If you support Eugene Clark's opinion, press one. If Richard Brune's position appeals to you, press two.

There's an excellent interview with contemporary American luthiers in the previous-to-last issue of American Lutherie Magazine [contact Guild of American Luthiers, 8222 South Park Ave., Tacoma, Washington, to get a back copy] which casts some light on this aspect of guitarmaking work. The current issue has an excellent interview with Eugene Clark. I'm still trying to get them to interview me, but they don't return my calls. (joke).

The only reason I can think of to put a scooped bridge on a flat face is to try to retrofit a semblance of a dome into a guitar face. This, of course, will produce the characteristic dimpling that you've mentioned. It also does nothing to stabilize the face against the torquing of the bridge which wants to push the soundhole down and pull the topwood in back of the bridge up. It's one of the critical functions of the dome to stabilize the face against this pull. Can such a guitar sound good? Yes. Is it a better design? Not as far as I can see: it's a cut corner. Is it stable? Not as likely, in the long run. Is it what they want to make as a function of their design concept and the sound they want to create? They'll certainly tell you so.

Will these guitars sell, no matter who thinks or says anything about them? You bet.

I hope this answers your question.

Cheers! Ervin Somogyi

Q3

In response to Tom's email I've noticed that traditional Spanish makers used much more curve than most modern makers and Europeans. Hopf guitars are an example where very little curve is used: maybe 1mm . I've built guitars with 3-4 mm curve which seemed to slow the guitar down and not give a full bass. The way I see it is that with less curve the top can move more freely from being static to the first modes where it is moving in and out. With more curve, it seems to restrict an even balance between in and out. Though having said that the string tension will make the top biased anyway. Colin

A3

Hello, Colin:

People have tried all kinds of things as alternative materials and designs of saddles. The principal function of the saddle is to be a clear and unambiguous "starting point" for the string as it jumps off into space. So one consideration is that the material be hard and non-damping of any string energy. Wood and the soft plastics have an index of energy absorption which make them unattractive for use. The more vitreous the material the less the energy loss, but simultaneously the greater the permeability of the sound energy into those parts of the saddle that are expected to carry the information from neighboring strings: that is, sound is thought to "spill over" onto neighboring strings' territory, and muddy the overall sound.

John Gilbert pioneered, as far as I know, the separation of string sound as a function of how the saddles were shaped. At first he undercut the bottoms of his saddles between each of the strings, so that his saddles looked like Roman aqueducts. This left a clear energy path from each string down through the saddle and into the bridge. This arrangement also increased the longitudinal flexibility of his saddles so they could flex with the movements and settlings-in of the bridge over time. Later he devised individual saddles so as to keep the input from each string as separate from the others' inputs as much as possible. It is thought by some that this separation reduces the overtone/interplay-of-high-frequency mixes which contribute so much to the lush tonal character some guitars have, and gives Gilbert's guitars the "neutral" sound that he ascribes to his instruments.

I've found that a saddle that is embedded in a slot in the saddle mound to about half depth [of the bridge] gives the most satisfying sound. If it's less than that there may be mechanical problems later on, and hence transfer-of-energy problems. If the saddle is too deep and there's very little bridge wood left under it, it weakens the bridge; over time the strings' forward-push will push the two halves of the saddle mound apart [using the saddle itself as a lever or crowbar], creating a space and sometimes deforming the front of the bridge. This, of course, makes the guitar a spectacularly less efficient tool, as energy transfer at the saddle is largely a function of the tight mechanical fit of the parts which no amount of saddle hardness will rectify. Also, I once built a guitar with a saddle slot so deep [my thinking was that the deeper the saddle slot the more contact area between saddle and bridgewood, and the better the sound] that he front of the bridge eventually broke off.

I must say that I've learned more from my failures than from my successes... although my clients do tend to want to celebrate my successes. Funny, how people are like that.

Cheers! Ervin Somogyi

Great job Ervin! Here are my questions:

Q4.
Regarding the modes of vibration.
Do the three modes occur at specific frequencies, or do they happen at the same time? David Schramm

A4.
Hi, David Schramm:

Great questions. And ones it could take hours to answer. Let me grab a beer before I start this. aaaahhhh. That's so much better.

Regarding the modes of vibration of the face: it is my position that the monopole, cross dipole and long dipole are the most important modes of movement of the face. I think I'm right; but authorities such as Graham Caldersmith think that a fourth, the cross tripole, is also very important. Actually, there are many modes -- so many that you really can't catalogue or make sense of many of them, even though they can be observed to exist. Also, many of these are limited, restricted, not very active (in that they don't displace much air), and otherwise easy to think of as probably not being significant.

The wording of your first question is confusing to me, but I think you're asking about whether or not these modes occur simultaneously at the same frequency. (?) They do occur simultaneously, but usually not at the same frequency. This touches, in fact, the fundamental task of the luthier -- whether he is working by gut and instinct, or by formula and science.

According to the literature that I'm aware of [there may be a lot more out there that I don't know about] in which "good" guitars have been studied scientifically, it has been found that the monopole on these is active at around 90 to 100 cps; the cross dipole is consistently active at around the 200 to 220 cps range, and the long tripole is active at around the 350 – 400 cps level. Something about these modes occurring at these peaks works to make what people can agree on as being a successful guitar.

There are endless ways for the luthier to "tweak" or even radically affect any one or all these modes, and for luthiers such as myself the effort requires years of "getting a feel" for the materials. You learn to feel obscure things like "this is enough", or "this is a bit too much" . . . things that are difficult to explain in a short-term format lutherie class. The backup plan is to hook up tone generators and oscilloscopes, etc, to these woods and get a reading on them in this manner. And it's much quicker than developing this amorphous feel for the materials. But you may imagine that a bit more or less wood here and there will hinder this activity, but facilitate that one; or, more true to real life, will hinder this one but will hinder that one even more, producing a net gain for one mode at the expense of another.

The long and the short of it is that the principlal modes of vibration of the face do not necessarily occur at specific frequencies. They can be all over the map, and often are. But on BETTER guitars, they tend to be found at these peaks, or near them.

Q5.
Regarding the Cross Dipole mode:

If the cross dipole affects loudness it seems that a symmetrical bracing (7-fan Torres, Hauser, M.Ramirez, Santos, even lattice Smallman,etc)would be advantageous. Assuming that it would give an even side to side cross dipole motion. Assymetrical bracing (6-fan with an added diagonal transverse bar i.e.

older J.Ramirez, older Gilbert, some Mig.Rodriguez, etc) would throw that balance off by being stiff on one side. The balance being thrown off by possibly having more amplitude on the less stiff side and less amplitude on the stiff side. What are your thoughts or observations? David Schramm

A5.
I absolutely agree with you that symmetrically-braced faces are the most easy to regulate as regards vibrational activity. It seems to me intuitively obvious that asymmetrical bracing would tend to throw the face off balance. Yet, the fact is that both symmetrically- and asymmetrically-braced guitars have been made which are generally considered to sound good. Until the quantity "sounds good" is analyzed and broken into better defined components, no better answer will be found, in my opinion, than that both symmetrically braced and asymmetrically braced guitars can work just fine.

Having said that, I call your attention to how rigorously you might define "symmetrical". One could argue, in the light of the information in the previous paragraph, that a guitar with four braces on one side of the center line but only three on the other side of the center line is not all that badly asymmetric. Certainly not compared to, say, a Kasha-braced guitar. Now, that's real asymmetry! A great deal of negative criticism has been leveled at the Kasha guitars over the past twenty five years for a variety of reasons, all centering around the judgment that they don't sound all that good by one standard or another. Luthier Richard Scheider made it his life's work to promote these instruments, and his students have carried on this commitment after Richard died.

I'd agree with most of what I've heard, myself, about how problematic and unsatisfying the Kasha guitars and their sound are. Except that I've also heard and played the Kasha-design nylon string guitars made by Boaz El-Kayam, who was probably Schneider's last student. Boaz's guitars are unbelievably powerful compared with a standard guitar, whether it's symmetrically braced or not.

Does this mean that asymmetrical bracing works or doesn't work? The question is a red herring. The a priori fact is that vibrating plates move in certain ways; I believe that they are the same modes on all guitars. It's just that Boaz, out of his talent and inspiration and "sense of the wood" has found the right levels and mixes of the Kasha factors to make them work in the form of a guitar face. His Kasha braced faces work very well under the load of six nylon strings, to accomplish musical tasks which every guitar is trying to meet. I bet you'd find, if you examined them closely, that they have a very efficient monopole, cross dipole, and long dipole. The proof is always in the pudding, if we will trust our faculties.

Q6.
Could you expand on the Long Dipole and it's relation to carrying power?
David Schramm

A6.
I believe it does it through a principle which has not been much recognized. Right up there with Newton' Laws of Motion, stiffness-to-weight coefficients of wood and other materials, and the Prime Axioms of Helmholtz Resonances, is the Somogyi Small Yappy Dog Principle. The SSYDP is based in the recognition that low frequency sound pulses will travel far if there is enough energy behind them to carry them long distances -- as with those automobile bass-blasting boomboxes that you can hear from two blocks away; and also with large dogs that bark so powerfully they can be heard from down the block.

Low frequency sound can project powerfully; but it will simply not carry without the power to push it. However, high frequency sound will travel just as far with much less energy behind it. This is why you can hear a cheap, shrill battery operated radio the size of a cigarette pack from across the street, and why you can hear such unbelievably eardrum splitting sound from small dogs which cannot possibly weigh more than twelve pounds: it's the small yappy dog principle. High frequency sound will travel far, and it doesn't take much money to get it there. It's a cheap date, as it were.

So, armed with this ridiculous analogy, how does a guitar generate such high frequency sounds, when other frequency-gobbling modes are ready to suck the energy from them? How does the guitar make any small amounts of energy available at all, with which to push these high-frequency messengers away into space? I think the long dipole supports this. I think it does so because it's the path of least resistance to such frequency activity, given that the monopole and the cross dipole are busy at lower frequency levels.

I think of it as this. Supposing you have a guitar string vibrating at 100 cps [cycles per second]. That means that the string goes through one complete cycle from resting state to maximum displacement in one direction, back through resting state to maximum displacement in the opposite direction, and back to resting state again. Think sine wave: a line moves above the zero line to a peak, down an equal amount to an equal negative peak, and back to zero.

From the standpoint of physical, mechanical movement, each such cycle of 100 excursions per second contains TWO episodes of the string being stretched maximally [points of maximum excursion] alternating with periods of "being at rest". In other words, each 100 string movements sends 200 enegry pulses to the bridge, for it to do something with. This is high-frequency information. And it's not going to ignore it: the bridge is a conduit and receiver for string energies [remember the analogy of the office manager, in part 1 of my ramblings?] and will assign this high-frequency pulse somewhere for discharging into the rest of the system. Suppose that you are playing an A 440; the bridge is also getting 880 information simultaneously. Whenever you play, say, 1225 cps the bridge is getting a 1450 cps pulse-message. The bridge is getting very high frequency information with each note you play ... and the guitar, like a small yappy dog, will be able to "throw" this kind of sound out with very little effort [energy].

The fact that we are dealing with high-frequency information also means that we are dealing with low-amplitude response. They go hand in hand. High frequency sound comes out of the stiffest portion of a vibrating system, one which doesn't move very much -- only quickly. The principle is: If it moves a lot [has greater excursion] it will take more energy up in this movement and it will respond at a lower frequency of this [greater] movement. So we will find high-frequency activity in the stiffest, lowest amplitude capacity part of a guitar face. This is, obviously, at the perimeter, which is very stiff indeed, but also along the path of the guitar's bracing. The guitar is usually looser across, perpendicular, to the braces. But it's stiffest with them. In fact, it's their job to stiffen that part of the guitar in just such a way. They are reinforcing the stiffening function of the wood's own grain structure.

Q7.

Regarding the longer and narrower bridge and the long dipole. I can see how the longer bridge would be advantageous, but narrower? Is that because it would produce less amplitude a characteristic of high frequency? David Schramm

A7.

So, we come to that part of the bridge's design which will work hand in hand with allowing some slight rocking motion in this stiffest of all possible directions of a guitar face: along the grain. It seems to me that if we have a bridge with a wide footprint it will, to some small degree, hinder this high-speed but minimal-displacement rocking. It seems logical to help it along by making the bridge narrower, so it can "fulcrum" with a bit more ease.

Q8.

Regarding gluing of the bridge. Have you found that adhesives make a difference? I know the Gilberts have been using "System Three" epoxy for over 20 years and they have never had any failures. Part of their reason is that there is no moisture in epoxy thus affecting wood movement. To John and Bill a few thousandths is the Grand Canyon. What are your thoughts regarding the use of epoxy for attaching bridges? David Schramm

A8.

Yep, to the Gilberts a few thousandths of an inch is like the Mare Imbrium.

I don't know that the type of glue one uses on the bridge makes as much difference as they think. One of the considerations I think a luthier ought to have in mind is the longevity of his instruments, and the ease or difficulty with which they can be worked on in the future. An epoxied joint can be pried apart, but it's messy and it's hard not to damage the wood. The same is true for titebond. Hide glue will come apart the most cleanly, and is, in my opinion, the most responsibly user-friendly glue that I know of.

One of the unspoken subtexts of this discussion, and all others like it, is how the luthier in question has been trained and HOW HE IS INFORMED about the fine points of his craft. Virtually no one (that I know of) in this culture is trained in traditional techniques and attitudes; almost everyone is on the best-newest-modern-better bandwagon. While there is much truth in this, one of the prices we have collectively paid is considerable loss of an appreciation of the long-term integrity of the objects we create. Epoxy is used because it works, period. And no one had it before a few years ago, and it's been pointed out that everyone would have used it in the past if it had been available. But it works in a more permanent way than glues that existed previously and there is room to consider that this isn't the whole story to making something "better" . . . although it certainly is the modern accepted right answer.

Five luthiers -- ten opinions. Remember?

Q9.

Some traditionalists ridicule measuring for stiffness, weight , and thickness. They feel that it makes the process too scientific resulting in less soulful instruments. I feel it is critical to make these measurements to better understand the materials. With this data you can better assess what parts will work for a specific design criteria. Like J. Gilbert says, "Guitarmaking is 95% science and 5% art, the art is in using the data." I think the old masters used stiffness, weight, and thickness as a criteria, but instead of using calipers, micrometers, and gram scales they used their sense of touch and feel. How important for you is measuring for stiffness, weight, and thickness of critical design materials? David Schramm

A9.

Your best question yet, I think. I don't think the answer to it will be found on the field of attempted rational discourse so much as in the almost-universally neglected consideration of exactly what relationship one has to the guitar. This is a profound question. It is one whose roots are put down in early childhood as a result both of how one has developed as an individual and how one has learned to respond to life.

Anyway, as I was saying, how you approach the guitar is profound, and goes to potentially profound things, and statements made about this or that aspect of lutherie, which sound diametrically opposite, can often be found to be merely differently worded, or differently perspected (sic) takes on the same thing.

Obviously, measuring things is useful. Now, if guitarmaking represents a musical problem, you may find measuring useful. Or you may opt for the hands-on path. Measuring certainly will be useful if guitarmaking is, for you, a technical or woodworking problem. It may be useful to you if it is a historical problem; at least, in part. If making a guitar is an artistic or creative problem for you, though, then measuring may not be all that useful a part of your approach. If it's a problem of the ideology of the workplace then only some measuring will likely be useful; the rest won't.

Further reply to David Schramm:

Hi, David:

I remembered your quote by John Gilbert about guitarmaking being 95% science and 5% art, and realized I hadn't fully answered your question of a few days ago on this topic.

For me, measuring scientifically has become less and less important as time goes on. My instruments are consistent without extensive use of these particular tools, and I am persuaded that, over time, I have developed enough "clinical sense", to use medical parlance, to function adequately using my own five or six body senses.

John's quote seems to me one of those question-beggin' aphorisms that sound as though they capture and encapsulate a valuable truth, while perhaps losing some of this authoritativeness if one examines them a bit critically. My second thought, in this vein, was to say: 95% science? No, not at all.

Making a guitar is mostly craft- and WOODWORK, for starters. I mean, the guitar is a project of glued-together wood joinery just as you'd find in a piece of furniture, is it not? There is science to it as well, and if you examine what kind of science there is in it you'll become aware that there is a genuine measuring and recordkeeping dimension [I think this is what John meant] -- which has a necessary component of ACCOUNTING to it as well as science.

The SCIENCE part is the interpretation of the data: how much is just right? How much is too much or not enough? What's the limit of what we know, and where are we guessing? Then, there's ENGINEERING: the guitar is made best which is made just strong enough to not collapse, yet loose enough to make a lot of sound; and you have to know how to create a wooden structure which is strong-enough-yet-weak-enough to do this. I tell you this with authority, because my first guitar failed its engineering final spectacularly. Then, there's ARCHITECTURE, a separate field of science: this is the use of space and mass and structure to create an object that is pleasing to hold and is reasonably well balanced, not too big nor too small, and uses architectural principles like cantilevering, placement of openings, and functional stressed reinforcing elements. And, not least, is functional in and by itself.

There's also ART in a more-than-merely-interpreting-data way: the aesthetics of the thing. Is it pleasing to look at? Does it flow well insofar as line, color, balance, proportion and overall visual harmony are concerned? Is the rosette static or dynamic, in addition to being merely colorful, and does it complement the other elements of the construct? Let's not neglect CRAFTSMANSHIP while we're at it: are the surfaces smooth and seamless? Are there clean transitions from one part to another, or are there awkward places? Is the finish well executed and pleasing to the eye? Is it perhaps shiny enough, but really too thick, to keep from damping the top movements a bit? Along with this is the invisible but decidedly important craftsmanship consideration of "is it well built?" -- which includes the question of " was it intelligently and efficiently made within the rules of craftsmanship"?

This last goes to yet another dimension of guitar-making work: THE BUSINESS DIMENSION. Was this object made in a reasonable amount of time, and does the price reflect a practical return on effort expended? You have to admit one could build a Taj Mahal of a guitar which sounded like sh-t and be extremely expensive nonetheless.

While we're at it, let's not forget HISTORY: most guitars are built in reference to principles and techniques, not to mention aesthetics and traditions, which others have used in the past. There's an undeniable cachet to having a guitar made just like a Fleta, or a Santos Hernandez, or a Hauser, or a Panormo, or a Simplicio, etc. and people will pay for this. As a matter of fact, if you make a guitar too far removed from these concerns you do so at your own economic and possibly tonal peril.

Then, there's FANTASY AND IMAGINATION. In the area of artistic imagination you should really check out the work of Fred Carlson. He's brilliant in my opinion. If it rings any bells, he studied with Ken Riportella, who was no slouch in this department either. In an entirely different area of FANTASY there are the Kasha guitars, which I've rendered opinions about separately.

So: let's add this up. Let's say we have 90% science [measuring] and 5% accounting, 5% arts of interpretation, 14% history, 28.5% engineering, 21.9% architecture, 18% aesthetic art, 22.3% craftsmanship and good workmanship, 10% fantasy and imagination, 15% business, and . . . eeeek! We've left out acoustics and dynamics!!!

Cheers. Ervin Somogyi

Q10.
You have an excellent balance of intuitive, scientific, and artisitic methodology towards lutherie. How important is science in lutherie?

Thanks for your contribution and willingness to share. I've enjoyed your workshops on tonewood selection, A.L. articles, and the NCAL meetings at your shop. Regards, David Schramm

A10.
All knowlege is not subject to measured, scientific validation. Many of you reading this, as craftsmen, know not in your brains but in your arms, hands and fingers, what "the right amount" is. Or you should, if you've been doing something long enough -- even though you might not know now. Cooks know with their eyes, their taste buds, their bodies, and their noses, what's right and what isn't: they either have native ability, or they learn, or both. Athletes know things somatically and not by considering them intellectually. Artists know things . . . uh . . . nonrationally. People KNOW things with every part of their bodies, if their awareness hasn't been put to sleep, and I'm happy to spread the word that the bodies are just as useful -- and cheaper -- than a lot of equipment.

Just so with lutherie. You can learn to use your fingers and eyes to achieve readings, sensitivities, and levels of effectiveness that are unbelievable to the merely academically educated. For John Gilbert, etc. to use balances and calipers toward achieving his results is merely his way: more power to him.

John once showed me a spiffy device he'd made that he clamped onto guitar fingerboards that had a buzz that he'd been asked to fix. This device [made from a precision metal straightedge] carried a slight electrical charge which, when the string was played and hit the high fret it closed the electrical circuit, and made a light go on. John was really proud of this: he could find a high fret by simply playing the guitar and whenever the light went on he knew he'd found the high fret! I was deeply impressed. And envious. I didn't have this kind of impressive equipment. John, having spent a lifetime working with such devices, found it easy to make one. I don't believe it would have occurred to him to not make one.

Later, in my attempts to replicate this device, I found that by looking at the fingerboard under a worklight I COULD ACTUALLY SEE WHICH FRET WAS HIGH WITH MY NAKED EYE. I've used this technique since, and teach it to my students and apprentices. Total cost: learning at what angle to set the light so you can see the fingerboard and frets accurately: the correct light highlights the offending fret without possibility of mistake.

I know a luthier who works with a crystal pendulum for knowing how to treat his guitar woods -- and he makes great guitars! I cannot attack nor endorse any of these approaches, but believe, as I said before, that they are rooted in deep parts of us. For my personal statement on my relationship to these matters, go to my website [www.esomogyi.com] and read my statement on "Why Lutherie?"

Cheers! Ervin Somogyi

Q11

I thought I'd keep you busy: Have you ever used carbon fibre for either struts or as a sandwich with wood for fans? Ive heard of a luthier who used a system to displace some of the tension of the bridge to the end block so he could use a lighter top. It sounds feasible though I would have though it would interfere with the monopole much like a soundpost would. Breedlove steelstrings had a system which I imagine would work in the same fashion.

Are your own guitars traditional or do use more modern methods? I once read an article you wrote where you mentioned bouncing a rubber ball on the top of a guitar to test the absorption of energy. Have you ever put the theory to the test? Cheers, Colin

A11.
Hi, Colin:

I don't know what you mean by asking whether my own guitars use traditional or modern methods. Do you mean traditional or modern features, or techniques of construction? They're pretty traditional.

"Traditional" is a very elastic word, however. I'm exploring the uses of doming in guitar faces these days, and am aware that the early Spanish makers all domed their guitar faces. Yet, when the guitar "caught on" and Southern luthiers migrated to Madrid and other big cities where they could make a living, and started the famous houses which have produced zillions of guitars in this century, many of them found that they could build guitars more quickly, efficiently and easily by eliminating or reducing the face doming. So many Spanish guitars built over the last umpteen decades have been flat topped, or nearly so. Many people would call guitars made in this period "traditional" too.

I have not started to use epoxy graphite in my guitars, other than as neck reinforcements in my steel string guitars.

The Breedlove guitars come with a patented anti-torque bar which connects the bridge with the tail block. It prevents the bridge from torqueing into the face, and also helps prevent the bridge from teeter-tottering around the center line of the face. In anchoring the bridge in this manner the device inhibits both cross-dipole and long-dipole activity, while allowing the up-and-down bellowing of the face which is the monopole. Breedloves have monopole with a vengeance: their bridges are kept from activity in the other modes. You may or may not like what these guitars sound like, but you'll have to admit that they are bassy in a loud way. I think this is a good idea for steel string guitars and a bad one for classic guitars. It'll turn them into folk guitars.

Oh, I forgot about the rubber ball. I don't test my guitars like that, but you can use things like super balls as teaching devices with which to make a point. The idea is to demonstrate, or at least get a reading on, how solid and stiff your guitar tops are; their main function, remember, is to respond to string energies -- so you don't want them impregnably stiff. A superball will bounce high off a stiff, solid face; it will bounce noticeably less on a more yielding face, because the face absorbs some of the impetus of the superball. This can be useful in the long run as a luthier learns to correlate "bounce" with sound . . . but you have to make a bunch of guitars for this technique to be fully useful. Having said that, I'd like to add that I don't know any faster techniques requiring the making of fewer guitars, for learning how guitar tops behave.

Cheers, Ervin Somogyi

Comment

First, thanks to Ervin for taking on a tough task: I chickened out. I hope nobody will mind if i add in a couple of observations.

Colin asked:

<<I prefer to make the saddle no more than 5.5 but I am tempted to make this less as the impedance of the wood is closer to that of the strings so should be more efficient.>>

The question of impedance matching and efficiency is a trick, in some ways. Maybe you could make a 'perfectly impedance matched bridge', but what would it sound like?

As Ervin pointed out in his answer:

<<The principal function of the saddle is to be a clear and unambiguous "starting point" for the string as it jumps off into space.>>

If there were no impedance mismatch at the bridge the string would not 'know' where it ended, and it's frequency would be undefined. The hard point of the saddle is the place where the wave that travels down the string reflects back. The weight of the bridge also enters into the mix.

There is an example we are all familiar with of a stringed instrument that has a bridge that is a very good (but not 'perfect') impedance match with both the strings and the top: the banjo. If you want a sound like a banjo, play a banjo.. :o)

There is another way to do almost the same thing, of course; the violin bridge, which acts as a smooth 'matcher' between the low impedance/high amplitude of the strings and the higher impedance/low amplitude of the top. If the fiddle is looked at as an electrical circuit, the bridge is a transformer. This is one reason that fiddles don't have as much sustain when plucked as guitars do. The trumpet bell works in much the same way, enabling the instrument to 'dump' a lot of energy into the air, and only reserving enough to keep the oscillation going.

As usual, there seems to be a 'proper' impedance match to get the combination of the 'open' and 'free' tone we love, reasonable volume, and enough sustain. Finding that balance point can be tricky, but it's helped by starting from a good design. If you copy the masters, you won't be too far off.

Alan Carruth / Luthier

Response
Al Carruth wrote:

>>> The question of impedance matching and efficiency is a trick, in some ways. Maybe you could make a 'perfectly impedance matched bridge', but what would it sound like? <<<

Actually, a _perfect_ impedance match would mean that _all_ the energy traveling down the plucked string would be transfered to the bridge and the string would not vibrate at all except perhaps as part of a larger system of string, bridge, and perhaps top depending on where the first impedance missmatch occurred causing energy to be reflected. Since the string would be behaving like a transmission line rather than a resonant circuit, the sound would probably be more like a percussion instrument than a guitar.

Bob
--
Robert L. Spooner
Registered Professional Engineer
Associate Research Engineer
Intelligent Control Systems Department

RESPONSE Robert Spooner wrote:

<<Actually, a _perfect_ impedance match would mean that _all_ the energy traveling down the plucked string would be transfered to the bridge and

the string would not vibrate at all except perhaps as part of a larger system of string, bridge, and perhaps top depending on where the first impedance missmatch occurred causing energy to be reflected.>>

That's sort of what I meant when I said the frequency would be undefined. In the real world, of course, the likelihood of making a bridge that was a 'perfect' impedance match to the string at every frequency would be nil.

There is a problem that can arise though when a resonance of the top-bridge system exists that is very close in frequency to some mode of a string and is also very active: the string will actually vibrate with two frequencies at the same time. When we pluck a string it is usually displaced in some direction at an angle to the top; there is some crosswise motion and some up-and-down motion. The bridge can only really move easily up and down. If there is a resonance that causes that up-and-down motion to be very large, the string will 'think' it is shorter or longer than it really is in that direction of motion. Thus the up-and-down part of the string's motion will have a different frequency than the side-to-side part.

This is not just a theoretical possibility, either: I've seen several guitars with particularly nasty buzzes due to this. It can take quite a while to find this sort of thing, and then it's sometimes a trial to figure out how to get rid of it, particularly on a guitar that otherwise has a really nice tone.

Dont'cha love these 'simple' instruments?

Alan Carruth / Luthier

Q12

Hello Ervin, Great Showcase Presentation!

I finish the bottom of my bridges with a slight radius to accommodate the dome of the face. A matter that you brought to my attention is that on a winged bridge, the bottom radius results in a thinning of the bridge at the area where the tie block ends and the wing portion begins. This thinning could affect the cross dipole because the bridge flexes at that point. I believe that Gilbert and Byers solve this problem with the channel cut bridge. Is this correct? What has been your experience this type of bridge? I have tried to stay within the traditional approaches, but I am willing to move in other directions. Regards, Ben Tortorici

A12

Hello, Ben:

You're correct in that Gilbert-influenced bridges are purposely made stiffer along their long axis than traditional bridges. Mainly, though, they are more stable because they are more impervious to deformation over time. Repairmen will have noticed that older guitars -- particularly those with the bridges coming off -- have distorted bridges. The backs of these, in the tie block area, are permanently bent in the direction of the lift of the face behind the bridge. The fronts, under the saddle mound, are usually still flat, or at least noticeably less arched.

The changing of the shape of the bridge over time as it accommodates to the "settling in" of the face means that these bridges now have a different ability to drive the face than they did originally. In fact, the entire face-as-a-system now has a different dynamic because it's changed its shape. Bridge shape is part of its energy- delivery capacity; change one, and it argues changes in the other.

Whether this settling in/accommodating is a good thing or not [after all, most people like a developed, mature, played in or settled in sound, or at least claim to] it introduces a potentially uncontrolled variable into the guitar, from the point of view of the luthier.

John Gilbert recognized that traditional bridge design was [to use the engineering language appropriate to weight-supporting elements] weakest along the stress line [that part of a beam that's being "pushed together": the front of the bridge] and strain line [that part of a beam that's being "pulled apart": the back of the bridge], and strongest along the neutral axis [that part of a beam that's in the middle, where the pushing and pulling forces cancel each other out: the middle of the bridge]. So he redesigned the bridge in line with these principles. These bridges are more stable in the long run, and also are stiffer per gram of weight than standard bridges.

Ben: As usual, I forgot to answer part of your question. Sorry. The reason I forgot is that I have no experience with these bridges. I understand the thinking behind them and they work; but their aesthetic does not appeal to me, and I've come up with a different way of profiling my bridges to increase their longitudinal stiffness and stability. They taper from one end toward the middle block, and back down again to the other end, without the traditional notch/dip between the wings and the middle mounds. I think they look beautiful, too, in that they don't sacrifice the crispness of visual element that a traditional bridge has. Jeff Elliot's bridges, which are traditional, are marvels of clean line. Gilbert's bridges have, to me, a somewhat industrial look.

I do yet other things to affect these factors on my steel string guitar bridges, a design element to which no one has paid much attention in a hundred years. But that's outside the scope of this discussion.

cheers! Ervin Somogyi

RESPONSE
I used Gilbert's bridge design as a model for my own design in my early guitars. In about the last 10 years I have reverted back to a traditional design. Both work, and with my guitars, the difference in sound appeared to be rather subtle. I went to a more traditional design because it is easier to service, particularly at a distance (I often send snug-fitting saddles through the mail), players don't have a chance to lose, exchange, or reverse the posts, and there didn't seem to be any benefit in sound. With another design this might not be true.

I also used to dome my tops more than I do now, though the doming is still quite noticeable. Along with the stiffer bridge, I believe (notice I used the spiritual term, not the rational "I know") this tended to enhance the upper partials. In new guitars this can be a problem, though after years of use a characteristic brilliance remains that is usually regarded favorably.

Like Gilbert, I used individual metal posts for each string. He used titanium, I believe (there it is again, though this time it can be verified one way or the other), and I used (heavier) nickel. It is possible to get a very clear, clean sound this way, with lots of separation, but most players prefer the sound of bone. They tend to think metal posts give a metallic sound. When bone is shaped carefully, it is virtually as loud ad nickel. I have subsequently made bone posts for the treble strings of many of these early guitars.

I would never use graphite, if only because it is so nasty to work with, but in addition to bone, I have used Mammoth ivory, which is soft and gives a "soft" sound, and fossilized Walrus ivory, which is very hard and vitreous and is really quite wonderful if you can find it in good quality, which you can't.

Regards, Gregory

Gregory Byers, Luthier

RESPONSE
Greg Byers Wrote:

>>> Like Gilbert, I used individual metal posts for each string. He used titanium, I believe (there it is again, though this time it can be verified one way or the other), and I used (heavier) nickel. <<<

In the early development of the saddle pins, John used coat hanger wire. Later he experimented with other metals such as titanium. Finally he decided on stainless steel, .093"or 3/32" diameter which is found on the majority of Gilbert guitars.

Since I spent 20 years in the cycling industry building road bikes and mountain bikes and wheels from scratch for professional racing teams I had access to stainless steel bicycle spokes. I have a huge supply of 13 gauge(.093") DT stainless steel spokes that I use for my saddle pins. They work great for this application.

Regards,
Dave Schramm

Q13
Hi! Question to all:

In the past 25 or so years science has been used as a means to try and make the guitar better. As Ervin pointed out in one of his texts very few pro players have used Kasha- type guitars. My own view on this is that the human ear, not being linnear in response, actually prefers the sound of a guitar where the middle frequency is more dominant. If I'm right this would be the cross dipole. Much like boosting the 1khz or middle frequency on a hi fi. Thanks for all your time and hel,p Ervin. Living in Scotland I don't get the chance to chew the fat with other luthiers all that often.

Cheers
Colin

A13
Reply to Colin from Scotland:

I am not convinced that the reason the Kasha guitars have not found general acceptance among members of the classical guitar playing community is that they are deficient in midrange as defined by cross dipole activity or lack of it.

Have you ever played a Kasha-influenced guitar? I've played a few over the years, and I have simply not liked most of them. I've found them insensitive to left- hand technique: they just don't respond to it. They have had a very long rise and very long decay gradient, which means that the sound is very slow to arrive and slow to leave. This makes it difficult to play most music because the guitar's own sound keeps on getting in the way; playing them is much like piloting a fully loaded oil tanker. They just can't respond to the help quickly.

John Gilbert once commented that when you play one of these instruments on stage you finish the piece, then you put the guitar down, and then the last two chords come out of it. However, as I said yesterday (?), Boaz El-Kayam has found a way to use these same principles of guitar design in what is clearly a more successful way than I've seen done previously.

Another factor in this drama is that Dr. Michael Kasha, the originator of this system, only rather lately has admitted that one of his much-defended initial ideas, the split impedence-negating bridge -- which was a prominent feature of many initial Kasha design guitars -- was not such a hot idea after all. He no longer espouses this particular design feature. So, " the Kasha design" changes and evolves.

Cheers.
Ervin Somogyi

Q14
First, Ervin, this stuff really rocks!

Second, can you give the phonetic pronunciation of your last name, so if I ever meet you I won't come across as a moron?

When I think about how to word this, it is going to come across more as a dilemma than a question. One of us has built a guitar with neck angle, fingerboard thickness, action, and string height at bridge in mind. Let's not forget breakover angle. We have spent our waking and sleeping hours thinking about these numbers and how they will affect the sound. We string up our guitar, after everything thing has settled in, we celebrate each in our individual way, make careful record of the numbers involved, turn off Art Bell, and go to bed.

Sometime later, upon showing said guitar to a prospective customer, the customer proclaims, " I LOVE this guitar! Let me pay you for it now (pulls out huge wad of Benjamins and a 6" ruler), but you have your action set at (insert acceptable range which varies slightly from maker to maker and player to player). I'd like you to drop it 1mm at the 12th. When can I pick it up?"

The common, easy solution is to loosen the strings, remove the saddle, and lop off 2mm at the belt sander. Which will lower the string height, and change the sound.

The obsessive compulsive way would be to remove the fingerboard and replace it with one that is 1mm higher at the 12th. Not so uncommon with older guitars that have had their necks bow forward and/or tops pull up over time. I guess a good argument has just been made for a neck joint that is in one way or another resetable.

So a question did pop up out of all of this. When a customer comes to you with a request to change the action, how far are you willing to go to preserve original string height at the bridge?

Ken

A14
Hi, Ken:

Thanks for the good questions.

First, no one really knows how my last name is pronounced. It's baffled experts for years. I say SO-MAH-GEE with the accented MAH as in SMART. Others say SO-MOE-GEE; that's o.k. too. In Hungarian it would be SHO-MO-DJI, rhyming with SHOW-MO-GEE, but said fast, and accented on the first syllable.

Ah, yes, the ol' “please chop a millimeter off the action” problem: I know it well. You know, there really is no one correct answer to this. One answer, and often my answer of choice, is that the customer should have what he wants. I usually go this route unless the customer wants something two standard deviations from what I've already done, and will likely affect a significant change in tone, playability, etc. But these things are always a judgment call.

One of my apprentices made a sale to a prominent local musician last year; a real feather in his cap! Unfortunately, the musician insisted on the saddle being drastically recompensated to accommodate her playing style and ear. It was such a drastic re-compensation that I got pulled into this project: the new owner wanted a setup that was so radically overcompensated that the guitar would now be, in fact, out of tune. We pointed this out. But she insisted that it had to be done that way for the guitar to work for her. The work was done as requested, and it seems to have had its desired effect: the guitar's owner was pleased and has not come back for any tweaking or further adjustments, and we have not heard from any lawyers.

Will a 1/16" [2 mm] change in saddle height make a difference to sound?

Yes.

Will a 1/16" change in saddle height make enough of a difference for it to be audible?

This is debatable.

The human ear is surprisingly insensitive to differences in volume. Studies have shown that for the average human ear to distinguish whether one sound is louder than another, the first has to be some 25% louder! This is pretty amazing. It's sort of like not being able to tell the difference between a six-foot tall basketball player and a seven-foot tall basketball player, because the height difference is less than 25%.

So you can futz with incremental changes all over the guitar without anyone effectively being able to notice it. Frankly, any customer who wants to argue that a 2mm difference in bridge height will, by itself, make or break a guitar's sound is someone to quickly refer to your nearest Guitar Center.

I said somewhere in my ramblings of the last two days that no individual element in a well made guitar is likely to have any importance: it's rather the sum of many little improvements which will push the overall response of such a guitar past the 25% threshold, so that the average person can at last tell that something is really better than something else. But as with stereo systems, a small improvement is expensive in time, labor, attention and effort. That's why you're expected to pay significantly more for something that's a bit [at least] better.

Thanks for the compliments. When people ask what accounts for my being such an effective teacher I tell them that there are three principles I try to follow. First, to respect my audiences. Second, to never reveal everything I know.

Cheers!
Ervin Somogyi

COMMENT
From: Ken Whisler
>>>>>Or is the design a means of prevention, meaning distance of the strings from the top? I've been getting 12mm, which I feel is neither excessive or too close. <<<<

Ken,
The distance of the strings from the top will change the sound. It is not for playability. It is part of the design that will affect sound. That distance is influenced by the materials used and the sound you desire. Don't let finger nail scratches influence your saddle height.

Dave Schramm

Q14
Question to all luthiers:

I’ve seen many guitars with different amounts of negative angle on the neck to raise the the angle above the plane of the body. I’m not sure how this affects modal vibration but would like to know. I usually use 1.5 mm back angle measured from the solara at the nut. I also taper the fret board so I have an even saddle height of 11 mm .
What’s other luthiers up to?

Colin.

A14
Reply to Colin Morison:

As far as I know neck angle has no relationship to nodal vibration whatsoever. Neck angle is a device to enable the strings to arrive at the bridge position at a specific height. It's the strings' specific height [as well as their pull, which involves what kind and brand you're using, but again bears no relationship with neck angle] which has to do with nodal vibration. Re-read my writings of the last few days.

Neck angle will vary as a function of whether you have a flat top or an arched (domed) one. This is because a dome will change the bridge's position with respect to the plane of the guitar's rim assembly. Some luthiers, like Hauser II and -III -- and even me -- have made guitars with sunken in [anti-domed] faces. All this affects neck angle. But that's all it affects. It's only once the strings arrive at the bridge that the guitar's real work begins.

Cheers. Ervin Somogyi

COMMENT
Colin,

There is no need to angle the neck portion of the solera. In the Spanish style of building I glue the back on last. This allows me to set the neck angle. This is how I do it. I use a dummy fingerboard which is a block of wood about 2" wide x 8" long x .335" thick. The thickness of this board equals my fingerboard thickness plus the fret height, .285" +.050"=.335. I clamp this on the neck. Now to set the neck angle you need to know what action you want off the 1st string and the saddle height. For me it is .110" for the first string action and .400" saddle height.

Now you need to subtract 2x the action from the saddle height, 2 x .110=.220.So, .400-.220=.180. This number is critical. I actually add .010" to this for a total of .190" Now I use a drill bit of this diameter and lay it on it's side at the position of the saddle and tape it down so it does not roll around. This becomes a reference point. Now I lay a straight edge on the dummy fingerboard and bend the neck until it touches the dowel. When it does I attach the back which locks the neck into the proper set.

I should mention that the glue is already on the linings and foot. The back is attached and spool clamps are clamping the back up to the upper bout. When the neck is set I then clamp the upper bout and foot thus locking the neck into the proper set. It only take a couple minutes to set the neck and glue the back on.

This method gives you more flexibility in choosing saddle height and neck set.

Hope this helps,
Dave Schramm.

COMMENT
Ervin Somogyi wrote:

<<Regarding the modes of vibration of the face: it is my position that the monopole, cross dipole and long dipole are the most important modes of movement of the face. I think I'm right; but authorities such as Graham Caldersmith think that a fourth, the cross tripole, is also very important.>>

The consensus of the literature I've seen, and my own experience, suggests that the most important mode, by far, is the main top mode, or monopole. After that the cross tripole is the most efficient radiator of sound on classical guitars (it often is not seen on steel strings). The dipole modes are, to some extent, self-canceling, and, if they radiate sound at all, tend to send it out to the sides.

In addition, the long dipole mode generally is out of phase with the monopole mode on classical guitars, and this cancels out some of the radiation of the monopole at the dipole frequency.

Of all the top modes, the bridge has the most influence on the cross tripole. The bridge bends a lot in this mode, and the stiffness of the wings of the bridge in particular is very influential. I know makers who carve the wings to follow the arch of the top initially, so that they are uniform in thickness. Then, when the guitar is together they will thin the bridge wings at the tieblock end to drop the frequency of the cross tripole mode to a desired range.

We could discuss this stuff all day, and I suppose we should not tie up the list with too much of it. Still, I think there is some benefit to a player in knowing a little of this.

Alan Carruth / Luthier

Q15
What is the function of the bridge plate, if any? In Courtnall's book, page 128, Romanillos said:

"I have decided to do away with it now." "the plate is in conflict with the rest of the soundboard."

Marty

A15
Reply to Marty, about bridge plates:

There's as much romance, guesswork and myth about bridge plates as there is about anything else, including seven-of-nine's real bra size. [pardon the humor: it's been a long day for me.]

Here's what's going on, as I see it. The guitar, like all objects made of wood, breathes. That is, it takes on and gives off moisture, depending on the weather. This results in the guitar's swelling up and shrinking down. The typical guitar's face is something like a hundred and fifty times as wide as it is thick, so whatever expansion and contraction there will be will most noticeably be sideways, rather than the face becoming thicker and thinner.

Once this moving plate is braced -- that is, when its fibers are locked into a certain position by virtue of having pieces of wood glued across the grain -- such lateral movement becomes impossible. It may become problematic in that the tendency of the wood to want to move may overcome its tensile strength at a certain point: that's when soundboards and backs crack open.

Nonetheless, most guitars don't crack; yet, they WANT TO MOVE. Since the bracing prevents sideways movement, the motion is displaced in either an up or down direction. That is, the face bulges out, or sinks down. You can appreciate that it would do this because it has to do something with its inner tensions, and motion will follow the path of least resistance.

In this, the guitar is helped by the fact that while it is always protected externally by its finish, the inside surfaces are normally raw, naked, vulnerable exposed wood. It is of course through these surfaces that the guitar will most easily gain or lose moisture.

Some unsung genius figured out that you could stabilize the face by sandwiching it between the bridge on one side [the bridge is the one element that locks all the fibers in across the board] and a stabilizing strap on the other: this will have exactly the same effect on face movement as the bridge [and the finish] does; namely, it will prevent movement from happening.

This is not so much a factor of importance for people who stay put and take reasonable care of their guitars season in and season out. But for people who travel across different climates, humidities, temperatures, altitudes, etc. -- professional musicians on tour, for instance -- it's a real pain in the butt to have their actions really high one night during their concert in Seattle but really low the next night as they play in Denver. The bridge strap solves this problem.

As far as I know, the bridge strap is a skinny little ribbon of wood with minimal mass and virtually nonexistent stiffness. I don't see how it could possibly either help or hinder the guitar's soundmaking ability. It simply stabilizes the system.

Cheers. Ervin Somogyi

Comment
Marty,

There may be other analogies about this, but I think that the bridge strap came into existence because of the top being very thin and the struts inside being very thin as well.

The Ramirez Factory in Spain used this strap on their guitars for extra support since their struts inside contained a very thin width across them. The flamenco guitars were strutted with 5 thin fans with the strap under the bridge for support.

As far as Romanillos understood it for his own guitar design, his tops were thicker and had more struts to brace the inside of the top. The strap "does" pull against the top grain causing stress, and that may be the reason he didn't want to use it.

In the case of the "Miguel Rodriguez" guitar design, they used a very thin strap about 1/2 inch wide as opposed to an inch wide for the Ramirez bridge straps. The "Rodriguez" family also went a step further and put their "sound hole" reinforcement braces on a slant all the way to the heel inside the top to avoid the problem of having the braces pulling against the top grain at an adverse angle like being completely perpendicular. This eases the swelling and shrinking problem of the glued joints. They don't put as much stress on the top this way. Case in point is if you glue a brace across the top, then take it all the way to the edge of something to avoid it pinching the grain when it shrinks and swells. That's the reason for tapering the "bridge strap" at the ends, either with a point or a round taper. A square end would definitely cause the grain to be pinched. Many guitar makers still use a square edged perpendicular strut above the sound-hole underneath the fingerboard for support, but Rodriguez has changed it to an oblique (slant) angle to avoid the stress as much as possible by extending the sound-hole braces all the way through to the heel.

You can check the sound-hole braces out on my web site, on the update page. http://tguitars.home.texas.net/index.htm

Regards,

Tom Blackshear

Comment
As with everything on the guitar, it has several functions. The answer to the

question 'which of those functions is the most important' will depend on whom you ask, and when.

One obvious function is to reinforce the top in an area that is highly stressed.

Classical guitar tops are often quite thin, and the bridge amounts to a great discontinuity: it is much less flexible than the top it is glued to. This means that there is a lot of stress concentrated around the edges of the bridge. Since the ends of most bridges run along grain lines this could lead to cracking there, and it also means that there is a lot of bending going on along the front and back edges of the bridge, such that I have seen guitars with the tops creased along those lines.

A bridge plate that extends a little way past the outline of the bridge will spread that stress out. Many times the bridge plate is tapered down to a fine edge, and the ends are not cut off square, but shaped into a rounded point. Both of these things help to spread the stress.

The bridge patch adds a certain amount of crossgrain stiffness to the top. This can raise the frequencies of normal modes that bend in that direction, such as the cross tripole, which is an important sound producing mode. In this aspect a bridge patch is particularly useful on tops that tend to be a little less stiff in the crossgrain direction relative to the traditional European spruce, such as Sitka spruce and Western Red cedar.

A bridge patch adds a certain amount of mass. This could have the effect of lowering the frequencies of modes that involve a lot of motion at the ends of the bridge, but not much bending, such as the cross dipole mode. The effect would tend to be small, though, as the patch is usually light. A patch that extends well past the bridge end, where the cross dipole is bending a lot, could raise the frequency, of course.

Together, the added stiffness and mass raise the impedance of the bridge somewhat. This would tend (all else being equal) to increase the sustain of the instrument, and lower the volume. I have observed that a heavy patch or low bar (such as is sometimes called a 'Bouchet brace', (although I understand the actual system used by Bouchet is a little different) can add stiffness and mass approximately in proportion, so that the resonance frequencies are not affected to speak of, but the impedance rises rather a lot. These guitars often respond well to heavy strings and a strong technique; the entire dynamic range is translated up one or two levels. I've heard the resulting tone called 'piano-like'. They can be hard to play, but rewarding for the person who spends time onstage.

Also, due to the higher impedance, the node line for the long dipole mode tends to be more exactly along the bridge line when there is a heavy patch or a cross brace under the bridge. Some people claim various acoustic benefits from this:

I'm not convinced: it would be difficult, at any rate, to separate out causes and effects in so complex a beast.

We must not overlook the purely mechanical need for some sort of hard patch on guitars with pin bridges, like Panormos and the gut-strung Martins. The string knot would quickly eat through the soft top wood without some sort of patch.

That's about all the functions I can think of at the moment. The only other reason for putting one in that comes to mind is the one my Dad used to give when I asked more questions than he wanted to answer: "To make little boys ask questions!".

Alan Carruth / Luthier

Response
Hi, Al and all:

Al Carruth said that the guitar string moves both up and down and sideways. I thought I'd get punctilious and mention that it doesn't do these at the same time. A cross sectional representation of string movement would reveal it to actually be rosette-shaped; that is, the string moves back and forth along its initial line of displacement, and then starts to rotate clockwise or counterclockwise, like a pendulum. So if it's moving up and down (with respect to the guitar face) it will pretty soon be moving sideways, and returning to up and down, and so on.

Early on in my career I spent lots of afternoons at the U.C.Berkeley music library poring over (and xeroxing) articles from the Lute Society of America, the Journal of Acoustical Engineering, etc. My library burned up in the Oakland Hills fire, so I can't give you a reference of the above information. But I still remember that the author got a grant to study string motion! Can you imagine getting paid to discover that strings move in rosette-patterns, as viewed cross-sectionally? Jeez.

Cheers. Ervin Somogyi

Comment
Greetings,

In comments this week (the Milburn discussion) and last week (the Somogyi discussion) there are a few broad statements used to characterize a number of Spanish guitarmakers. Last week there was the statement from Ervin that the domed top was eliminated or reduced by "famous houses" in their quest to make zillions of guitars. I believe that Eugene Clark made a statement (I cannot find it in the mass of messages I receive) that the Spanish lost the sound when they stopped doming their tops (Am I correct that he said this?) Then this week there is discussion by Tom B. within the context of the Milburn discussion that some Spanish makers (I assume he means well-known luthiers) thinned the area below the bridge.

In the workshops I have visited around Spain over many years (Miguel Rodriguez, Felix Manzanero, Aguado y Hernandez, Archangel Fernandez and Marcelo Barbero (hijo), Juan Alvarez, Jose Ramirez factory, Manuel de la Chica, Jose Bellido, Manuel Reyes, etcetera, I seem to remember always seeing a carefully made solera (i.e., a concave workboard for doming the soundboard). Similarly, in the current Valencia to Alicante production houses there are expensive jigs/machines which hold the soundboard in a domed shaped while the braces are glued on.

It seems to me that the Spanish hold the concept of the domed top in high regard. Isn't it one of the features of the Torres guitars which they all use as a model? For the sake of clarity I ask who did Ervin and Eugene have in mind when referring to domeless Spanish makers.

With regard to Tom, I ask who are the Spanish makers which thinned the bridge area? How many such makers are there compared to those Spanish makers who kept the bridge area thicker and thinned the edges?

I think these things should be cleared up for the non-luthier readers on this list who have probably come off with the idea that the "Spanish" makers typically make flat top guitars with thin bridge areas.

Respectfully yours,

Ron Fernández

Comment
Charles Fox guitar fact correction

Hi, Tom and everybody:

I've received a communication from Charles Fox pointing out an error that I made in attribution to his instruments in one of my previous comments. I said that as far as I knew Taylor and CFox, and perhaps other production makers, were putting flat bottomed bridges on their domed-face guitars. I made this inference because I believed I'd seen deformations at the bridge ends consistent with this method, under the glare of stage lights.

Charles was emphatic in asserting that he does not put flat bottomed bridges on his domed-face guitars: that he instead radiuses his bridge bottoms to the curves of the face doming before gluing; and also, that I was probably wrong in attributing this design feature to the Taylor instruments.

I apologize to Charles for my error. And to Taylor, if error was made. As I get older the number of things I know little about seems to increase most disconcertingly. Charles reminded me that in spite of the fact that I have my nose to the workbench most of the time I should remember that my opinion carries weight and authority, if only because of the fact that I've been making guitars for [what feels like] about 300 years. But, seriously, I meant no harm nor disrespect in my oversight of the facts.

Yours, Ervin Somogyi