Still Voicing, Still Dreaming, by Dana Bourgeois

American Lutherie # 61, Spring, 2000

Dana Bourgeois builds acoustic guitars in what could be considered Martin tradition. His association with Martin, Schoenberg, Paul Reed Smith, and Bourgeois guitar companies, not to mention his solo building career, has given him the opportunity to voice thousands of flattops, which in turn has given him as deep an understanding of the process as (perhaps) anyone alive.

Dana has also been writing and lecturing about lutherie for many years. In August of 1997 he presented a seminar on voicing the guitar at the American School of Lutherie. This article is an adaptation of that presentation. Comparing it with Dana's lecture printed in American Lutherie #24 shows many similarities, sometimes word-for-word. This is often the mark of a teacher who has been presented with no reason to change his thoughts. On the other hand, there are major changes in his voicing procedures demonstrating that none of us reach the end of our evolution as luthiers.

Imediately before this lecture Dana gave a demonstration of his brace carving technique using a standard braced top taken from his factory. A member of the audience was asked to time the demonstration, during which Dana conspicuously refrained from offering explanations. The demonstration took eight minutes. After the lecture Dana voiced a second top, giving a shaving by shaving explanation. The two voiced tops ended up sounding remarkably similar. One was later made into a Ricky Skaggs Signature Model guitar which Ricky Skaggs presented to Vince Gill as a personal gift. Dana is a complex man whose goal is still to make the best guitars possible, and we can all benefit from his experience.

--Editor

Still Voicing, Still Dreaming, by Dana Bourgeois

There has been a huge proliferation and blossoming of acoustic guitar building in the past twenty or thirty years. The field is so vast that I can't claim any expertise beyond what I have actually done. I have been building steel string guitars for twenty some odd years now. I built my first one in 1974. I built my first arch top in 1982. Now I have a small manufacturing facility in which we build about 500 guitars a year. From the point of view of voicing, from the point of view of how we bring out the tone of the instrument, every guitar I make today is built in essentially the way that I used to make guitars in my one-man shop.

The way a guitar sounds is primarily the result of two factors, design and wood selection. Once these essential choices are made, all you can do is either ruin or optimize. The act of voicing is the means by which you try to optimize the result. On a certain level wood selection is the first step in this process. When building 500 guitars a year, which is 40 per month, we buy the best wood we can get, this is the wood we have, and we learn to work with it. We prune out the material we don't want to use, and try to make the best guitars with what is left. Each one is different. In reality, we are like chefs working with the ingredients that we can find at the market.

Typically, we build guitars from batches of similar wood. We might have, say, 20 tops or 50 sets of bracing, all from the same source, the same age, handled and cured according to the same schedule, and often from the same tree. We try to figure out what the best approach to working with a given batch of wood. After two or three voicings a comfort level is usually reached for a given model and for a given batch of wood. On succeeding guitars you can usually get real close very quickly.

I don't pay much attention to the fineness of the grain on the top material. I glue up my tops with the fine grain in the center for the sake of appearance, and then I flex along the grain and across the grain. I pay attention to the weight and the feel of the top. I usually try to pick lighter weight tops for smaller bodied guitars. My friend Walter Lipton once said there is about a seventy-five percent correlation between the visual appearance of wood and it structural and tonal characteristics. I would have to agree. Sometimes you get narrow-grained wood that is very weak, across the grain in particular. Sometimes you get wide or uneven grain that is wonderfully stiff and resonant. Chances are if a top has got even color and even grain spacing and there is medulary ray all over the surface, then it's probably going to be a good one. But sometimes it will fool you. Sometimes you see terrible looking wood and it will have better qualities. The problem that we all face is that someone has told Joe Guitar Player that a top has got to have 16 grains per inch, straight grain, and perfectly even color. In our shop we refer to this as "wallpaper" grade, and sometimes it is a far more important consideration to the customer than tone, particularly in the case of some of our overseas distributors. Certainly there is an aesthetic appeal to wood. I think the aesthetic appeal of the wood is part of the quality of the instrument. It is part of what inspires the player. That can't be denied. But, in our lifetime we are going to have to deal with the fact that you can't put designer wood on every guitar.

So the first part of voicing is actually selecting the wood. The second part of voicing is thicknessing the top plate, which we do after the rosette has been put in and the sound hole has been cut. Four different people are actually involved in the voicing process at four different stages. I don't participate in either of these first two steps, other than at the approval level.

We usually thickness our tops in batches, and we basically thickness to flexibility. We run a bunch of tops through the wide belt sander and as they come out we flex them, and when they feel about right we set them aside. If they feel stiff we send them through again and take off another five thousandths of an inch. Removing top mass has an exponential effect on stiffness. If you remove 5% of the top you'll change the stiffness by more than 5%. It's a process of doing that until all of the tops feel about right.

We have to remember that different species of wood, as well as individual pieces of wood, are unique in different ways. It's important to consider the relationship of stiffness across the grain to stiffness along the grain, which means that you can't base your judgment on a single variable. For example, Englemann spruce can be very stiff across the grain, especially the stuff which is being harvested in British Columbia, a fairly northern climate. But it can be relatively weak along the grain. So you might be tempted to make the top too thin. You can always thin the edges of a completed top to get the cross-grain stiffness down, but once you've thinned out the entire sheet, you may be stuck with an inherent weakness along the grain. The same with cedar. With cedar we pay most attention to the stiffness along the grain. Most spruce tops start out anywhere from about .110"-.125", depending on the model and the wood. Cedar tops are in the range of .135"-.150". My approach has always been to make cedar tops as stiff as those of spruce, and the only way to do that is to make them fat. Select stiff cedar if you can to begin with, but also leave it thick. We also give consideration to the different models. If we are going to build OM guitars, we might build to a different thickness than if we are going to build dreadnought guitars.

The third stage of voicing is brace carving. Our braces are pre-machined. We have a standard X, a standard tone bar, and a standard upper transverse bar. And we have standard stock from which we make the finger braces. For the past year I have been doing all of the brace carving myself. When I get the tops the pre-shaped braces are already glued in place. The ends of the X are sanded to a given height. Not much else is done.

I hold the top at a couple of known nodal points and tap over the braces. I draw little circles on the top at the nodal points, so I can visualize where they are. I tend to hold from two different points, one on the bass side and one on the treble side.

Since the top is asymmetrically braced, the nodal points are going to be in different places from side to side. I will also hold the guitar above the sound hole, but I don't consider this as important. As I work I continually flex the top to help gauge my progress.

I listen to the tap tones, then alter the bracing with chisel and finger plane, and then listen to the tap tones again. I don't care about the specific pitch at any point. Some people tune to certain pitches, particularly in the violin world. Whatever they are doing seems to work for them and produces wonderful instruments, but that is not my approach.

I listen for musical qualities that are very difficult to describe. I care what it sounds like when I tap over the bridge area but I also want to hear what the other braces sound like. How clear is the tone? How musical does it sound? As I remove wood from the braces I'm always asking myself, "Is this as good as it can be? Or, can it be a little bit better?" If I decide that it can be better the question becomes, where should I remove wood? That's where experience takes over. I don't really have a rigid method. The answer is that I remove wood where it seems like there's too much of it. There are certain things I'll do if I am in a groove. And there are others I'll try if I feel that a standard approach isn't working. Constant flexing helps with the decision process. Remember that I am working on a batch at a time. Once I find a groove I can hopefully maintain it throughout the batch.

I tend not to focus on one brace at a time, but rather to move all around while I am listening and take a little bit here and a little bit there, working the whole top, until I can tap over every brace and get clear notes everywhere. I like to work quickly so I can remember where I started out. And I try to fall within a flexibility range that I know is correct for the style of guitar that I am making. Ideally I want to be able to hold a top and tap it anywhere and get clean notes. In reality that's not going to happen, but if I can hold and tap in a variety of places and mostly get clean notes, that's what I'll actually settle for. The whole process of brace carving only takes about eight minutes. These eight minutes probably add more value to the guitar than any other eight minutes in the construction process. Lastly, I'll try to sand these braces without undoing what I just did. I try to work as cleanly as I can so I don't have to sand the top braces very much. I use little sanding sticks and pieces of 80 grit paper, then I'll take everything down to 120. I am more concerned about what I can see through the sound hole, and I'll sand that to 180.

It's an interesting phenomenon that in an X brace system there are a lot of triangles. The most rigid 2 dimensional geometric shape is the triangle. The triangles are made by the rim of the guitar and the braces. In an x braced top you will find one triangle on the bass side and another on the treble side, and these are going to be your rigid planes. On the bass side, I am concerned with trying to overcome the triangle's inherent rigidity. That is why I work a lot on the lowest part of the X brace, which is the stiffest member of that triangle. You are not going to loosen up the leg of the triangle that is determined by the rim, so you must work on the brace. A fourteen-fret dreadnought, for example, usually produces its deadest tap tones when held by the treble side and tapped on the bass side, so I work to bring life to the bass side. This is accomplished by selectively cutting down the lower part of the X brace. This may seem counterintuitive, since dreadnoughts are supposed to have good bass response. But in reality, traditionally braced guitars are lacking in a fundamental response low enough to properly support the note at the open E string, let alone a dropped D. For that reason most open A strings sound better than the open E. I find that a little tweaking in this area helps dial in the note on the open string, without muddying the overall tonality. This is analogous to using a parametric equalizer as opposed to using a graphic equalizer. By the way, on many of my models only the bass side of my X braces is scalloped, and this is true of the dreadnought. My OMs are scalloped on both sides, which has the effect of using a graphic equalizer on the entire lower range. You also have to deal with the open string effect here, so here's where you haul out the "parametric equalizer" again.

Back to the shop sequence. After I've adjusted the braces, I glue the top and the back to the rims at the same time. Then I pass the box on to someone who trims the overhangs. The plates are initially sanded with a random orbital air sander to remove lumps and ridges. At that point, the top is flexed and bounced to see where it's at. We lightly drag the finger after tapping, and we want to feel a spring in the top that pushes back on the finger. If the person who thicknessed the top has done his job right, and if I have correctly shaped the braces, then by the time the top, back and sides get an initial leveling the top and back plates should be starting to bounce. We continue to use the air sander to adjust the thickness of the top until the desired bounce is achieved. This work usually concentrates on the perimeter, somewhat avoiding the area over the end block. Thinning around the bouts increases flexibility across the grain, and sanding over the endblock increases flexibility along the grain. If a guitar is really in trouble the whole lower bout might get a sanding. We can tell by flexing around the edges if a top is too stiff, and we also monitor the flexibility as we sand the perimeter. We do the same thing to the back. It's a good idea to leave everything ever so slightly on the heavy side. After binding the guitar it will be scraped and sanded one more time, and allowance must be left for that. When the resonance of the box and the resonance of the air chamber are properly coupled, there is a life that is greater than the sum of its parts, and you can really notice the top starting to "push" back at you. There are a couple of points during the thinning of the perimeter where this will happen. We've noticed that you can actually thin a top right through a springy point and then it will lose its liveliness. If you continue to work the top you will come to another springy point with a totally different tonality, though probably not the one you're looking for. What's happening here is that the wood resonance and the air resonance are coupling at different frequencies. Given the sound in my head, I'm after an ideal coupling point. Adjustment of the braces determines the wood resonance, the element that controls the guitar's color and balance. When you properly couple that to the air resonance you get power.

When I voice a guitar there is a physical model in my head that allows me to do what I do. The guitar is a coupled oscillating system. It starts with a vibrating string. The string is attached to the bridge, through which it transmits vibrational movement to the top. The top moves in and out like a speaker diaphragm, moving the air inside the body of the instrument. And that moving air sets up pressure waves outside the instrument that subsequently vibrate your eardrums. At every step along the way the original vibrations of the plucked string get mimicked and amplified. At the same time there is a filtering process going on. The primary vibration of the string subdivides into various harmonics. If every guitar purely mimicked the vibrating string without any filtering then all guitars would sound alike, and they would definitely not sound like guitars. What we expect to hear from a steel string, or an archtop, or a classical guitar depends on the way that the body of the guitar filters the original vibration of the string.

Two main things happen in the guitar. One set of resonant frequencies is associated with the movement of the wood, and another set of resonant frequencies is associated with the movement of the air. The air frequencies are defined by the volume and shape of the air cavity and where and how big the sound hole is. These are features that cannot be manipulated except through design modification. You can, however, manipulate the wood.

You may have seen pictures of glitter patterns on guitar or violin tops. These pictures show distinct vibrational patterns that are produced as the wood vibrates. The top tries to mimic the way the string vibrates. In the first mode the whole top vibrates, and in the second mode the top vibrates in halves, and so on. The air cavity does the same sort of thing. And all of these ways of vibrating are actually happening at the same time. But even in a good guitar, there are only a few discernible resonant frequencies. The people who do these glitter tests on the guitars say that if you can get four or five recognizable patterns then this is going to be a pretty good guitar. And there are only a couple of distinct measurable resonant frequencies in the air cavity. That’s not an awful lot of variables.

From guitar to guitar these patterns occur at different frequencies, and show different levels of strength. Most steel string guitars have something like 44 notes. Each of these notes is theoretically made up of a fundamental tone and a series of harmonics, plus some element of white noise content. So how do we get 44 notes and all of their harmonics out of a handful of resonant wood and air frequencies? The answer is that we probably don’t. This is what I mean by filtering. There are bound to be some holes in the range of frequencies that the guitar is theoretically capable of amplifying. In some cases they are astonishingly large; for example, most guitars are unable to amplify the fundamental note on the open bottom string. So how do we get around this? We work with the top and back to get as many different tap tones as possible, and concentrate on clarity and musicality. When you tap the top you hear the brace that you’re tapping but you also hear a bunch of other notes, presumably vibrating in sympathy. If the intervals between the various notes are sweet, then the guitar will be sweet. This is the musicality part. If there is another sympathetic note that happens to be out of phase with the one that you are trying to tap, then there will be cancellation. This is the clarity part. That’s why you have to keep moving and tapping, moving and tapping. At some point you end up with a compromise in which you’ve minimized cancellation and maximized musicality. You haven’t eliminated any "holes", you’ve just moved them around to where they can do the least amount of damage.

My old way of thinking was that as you remove wood from a brace you are necessarily lowering its frequency. However, I have since learned that some other rules also come into play. I once saw a demonstration on marimba keys. The smallest marimba key is the highest one, the largest one is the low one. The pitch of any marimba key can be raised by shortening it, or lowered by scooping out its underside. There are also ways of bringing out certain harmonics and thereby making a more pleasing and fuller sounding note. I think that braces are marimba keys. By scalloping the end of a brace your can effectively shortening it, thereby raising its pitch. And you can also lower the pitch by removal of material from along its length. And by manipulation of certain proportions you can achieve pleasing harmonics, or fail to do so. These are the extra notes that you hear, or some of them, when you tap the brace. These are the ones that you want to sound musical. Just like the shaping of marimba keys, all of this manipulation can be accomplished entirely through a subtractive process.

I used to voice guitars by first gluing the top to the rim. In a lecture at the 1990 GAL convention I said that I didn’t voice the free plate because I couldn’t hear what was going on. It's true that when you glue the top to the rim and you hold it up to your ear, it’s amplified like a big drum. While I was working out some of my methods for building, that seemed like a more useful method of doing it. Then, later on, as I got more comfortable with what I was doing, I decided it was easier to just do the plates. Another thing I used to do was to measure the stiffness of all of my braces. And that was also useful at that point. Because the stiffness was all over the place. Now I just use red spruce for braces and they are stiffer in general but still all over the place. We try to minimize runout on the brace stock. Runout causes short grain and can minimize stiffness, especially on Sitka spruce. On red spruce this is less of a concern.

I use bridge plates made from the waste of rosewood back plates. They seem to work fine and give me the tones that I like. I have also used maple and Brazilian rosewood in addition to the Indian. The bridge plate adds mass to the top and that is not necessarily a good thing. So I don't want too much bridge plate. The main function of the bridge plate is to keep the ball ends of the string from tearing into the spruce. If the bridge plate extends out beyond the bridge, however, it also acts sort of like a lever to help drive that area of the top. Too much bridge plate though, and the mass tends to overcome the advantage of the lever. When the bridge plate is too large it dampens the tone. My bridge plate extends about 1/4" behind the bridge and about 1/8" in front of it. I nip the corners a little bit just to keep some flexibility and to keep the weight down. My bridge plates are about .090" thick.

Doming is a great way to gain stiffness without mass. There is probably a point beyond which you don't want to go with doming unless you are aiming for a particular kind of sound. I use a 400" radius on the top and a 200" radius on the back. LMI sells sanding bowls with 15' and 25'radii. We plotted these on a CAD system and found about .015"of a difference from what I use, which I can say doesn't really matter. I arch my X braces to induce an arch in the top. The other braces are flexible enough to follow suit. With a domed top there is less distortion when you load the guitar with string tension. I don't think that distortion is a bad thing in itself. I have seen guitars with large distortions that sound great, but they are hard to sell. You could probably deal with distortion through design, but some distortion is an OK thing in my view.

The cross section of the braces I use is triangular, which makes them stiffer than braces that are lower and wider. Now, you may want the tone that comes from braces that are lower and wider. I have seen some fine guitars that have that kind of brace profile.

What I have done with back braces is interesting. When I tap the guitar over the four different braces, I get four distinctly different notes that all sound equally present. I have gone to very small braces on the upper half of the back and I have experimented with placement and size in order to accomplish this with a minimum of voicing. In my view the back is a secondary soundboard and is treated in a similar manner to the top. I want to hear a variety of clear and musical tap tones, but I don't expect anywhere near as many as I can get from the top. Though there are fewer, however, they are usually clearer, and more musical. This is undoubtedly why they are important.

These are some of the variables you can play with as you strive for the tone you want to hear. Don't do anything too radical. Try it a little bit at a time. I have the luxury of building ten guitars in a week and hearing them a couple of weeks later. On the basis of any one guitar you can't tell anything. You have to do a whole bunch to really know. None of these details are engraved in stone. Michael Cone was my mentor when I first began building. He makes renaissance guitars, small but very loud. Michael recently told me that he now buys spruce that is off-quarter and very flexible. He makes the top very thin and extremely light but his bracing is heavy at the edges. The heavy bracing will adequately support the top, but the center around the bridge is left quite flexible. His back braces are two parallel bars that tie into the neck block. He achieves a continuum of tonality along these braces, meaning that everywhere he taps he gets a different note. This way of building is totally foreign to my understanding but it illustrates that there is no one way of achieving results that you're looking for.

My belief is that if a guitar produces its tone easily and projects well; if it has relatively even note-to-note and string-to-string balance; if it has reasonable sustain, then ultimately I don't care about tone coloration. This is because there's no way to maintain strict uniformity of tone from guitar to guitar as long as one insists on making guitars out of wood. The point of voicing is to optimize the interaction between wood and design. What I try to do is get as many clear and distinct wood resonant frequencies as I can get out of a given guitar. That is why I tap over all of the braces and hold the top at different points and make sure that it sounds pretty good in as many directions as possible. I'm not going for particular pitches. I want to end up with a guitar that's within a certain weight range, and within a certain flexibility range, and I want to end up with a guitar that has a healthy variety of clear and distinct resonant frequencies. When that happens the guitar will have an even response and string-to-string balance. After I put the box together, if I can get that springy action to happen, then it's also going to have power. If it has those two factors, it's going to sound like the combination of design and wood selection. Putting these two elements together is like plotting two equations and getting a parabolic curve that illustrates how good your guitar can be. The idea is that you want to be at the top of that curve.

Voicing does not really control the tonality of the guitar. That is controlled by other factors. I am just allowing it to come forward. Voicing will not make a dreadnought sound like an OM. You don't have that range of possibility in your voicing. The range that you have is that it can either sound well balanced and have power, or not. If you try to radically manipulate tone through voicing you usually end up sacrificing balance and power, which are precisely the things that you really can control. To manipulate the tone of the guitar, I would work with design elements. Change the woods. Change the bracing. Change the body size. Those are the big factors.