Full-bodied without being boxy, Laskin's guitar has roots stretching back to both the classical instruments of Spanish luthier Antonio de Torres and the Central-European steel string tradition.

Building a Steel String Guitar

An overview of the fine points

by William "Grit" Laskin

There exists, especially among artisans, a general acknowledgement that musical instrument making is a singular endeavor, a category unto itself in the craft world. An instrument must please the eye, must be constructed so as to withstand perhaps many hundreds of pounds of pressure, must be playable with proper ease and, above all, must have the ability to produce tonally subtle, refined musical sounds that can reach the back of a hall unamplified.

A tall order? Perhaps.

If, however, it was an insurmountably difficult job to produce a good musical instrument, I wouldn't attempt to help you do just that. So, resist those thoughts of "too tough" or "I'm really just into furniture" and read on.

This is the first part of a three-article series in which I intend to guide you through the building of a superior steel string guitar. I can't provide you with every detail for each minute step in the process—for that, I'd need an entire book. What I *will* do as we move through each stage is focus on guitarmaking's trickier and most troublesome processes. Short of brief mentions, I'll leave the description of the more routine procedures to the authors of several fine, comprehensive texts that exist on the subject (see "Further reading and suppliers," p. 49).

Part one of this guitarmaking series of articles—the one you're reading now—will examine general theories of guitar design in conjunction with the needs that guide selection of materials. As you'll soon see, the two are greatly interconnected. By the close of part one, I'll have brought you to the very first assembly stages dealing with the soundboard, or top, and the back.

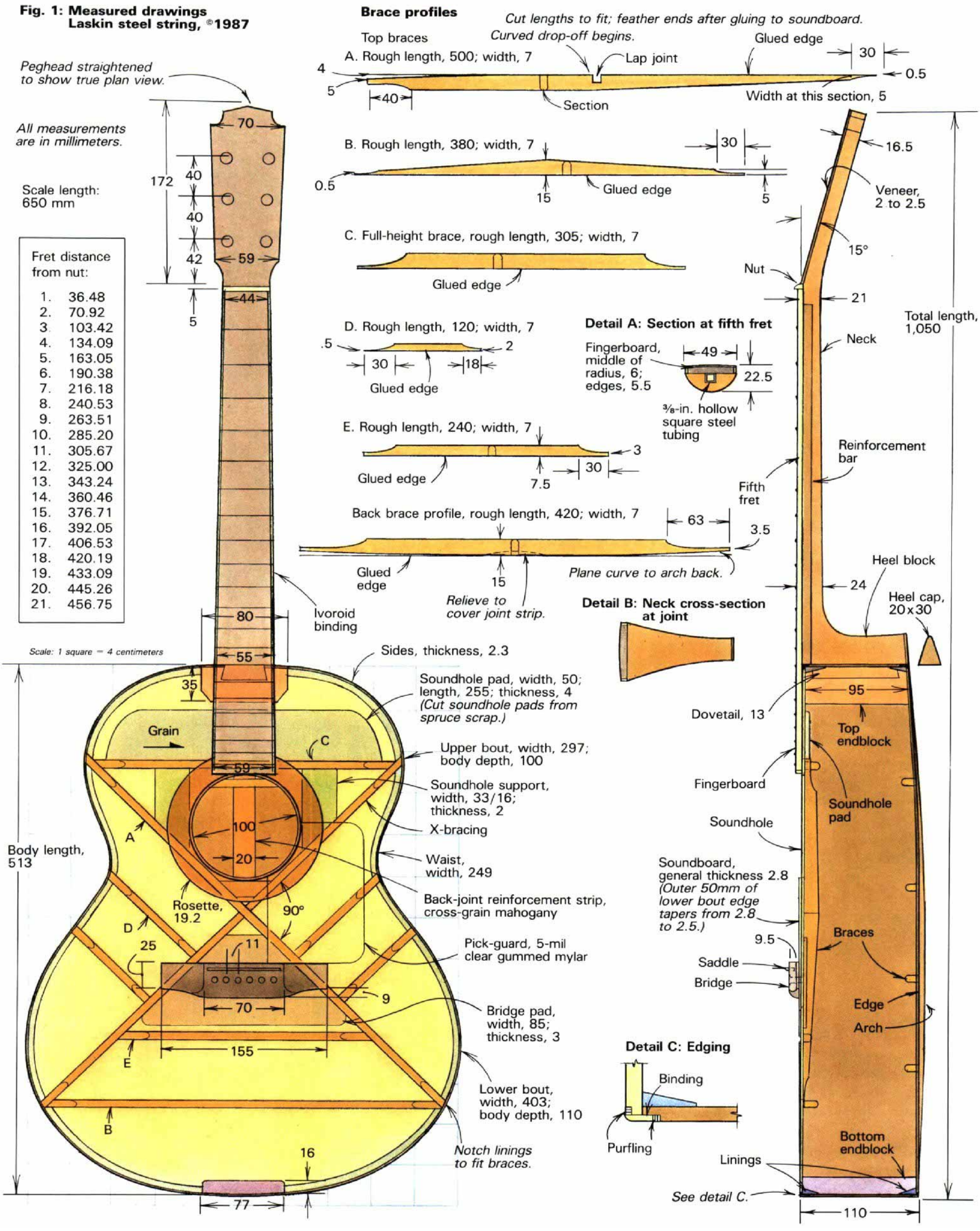
In part two, we'll bite into the meat of guitarmaking. This will include bending the sides, assembly and completion of the frame (the glued-up sides, interior blocks and linings), a brief look at the top, the how-to of achieving seamless purfling joints and the critical dovetail neck joint.

By part three, we'll be ready to look at those murky territories known as *action* and *set-up* (playability, string height, etc.—what is often called the "feel" of an instrument).

I realize that most woodworkers have no intention of becoming professional luthiers, but some of you might. So, similar to the way one must learn to add and subtract before attempting calculus, I strongly suggest doing as I did: begin by following your

Photos: Brian Pickell

Fig. 1: Measured drawings Laskin steel string, ©1987



Fret distance from nut:

1.	36.48
2.	70.92
3.	103.42
4.	134.09
5.	163.05
6.	190.38
7.	216.18
8.	240.53
9.	263.51
10.	285.20
11.	305.67
12.	325.00
13.	343.24
14.	360.46
15.	376.71
16.	392.05
17.	406.53
18.	420.19
19.	433.09
20.	445.26
21.	456.75

instructor's designs to the letter. Later, as your workmanship and skill at instrument making are honed, there will be time to indulge in all the wild and crazy ideas that you can't wait to turn into reality. The guitar in this series is the result of a 16-year synthesis of my teacher's ideas (which had evolved from those of *his* teacher), my own experimentation and the absorption of ideas from many sources. The experimenting, changing and redesigning processes—the rethinking and pushing of the limits-are the real challenge and attraction of a life in the trade.

With every step of construction, an instrumentmaker asks: how will this material/dimension/location/angle affect the sound? And how will it affect the instrument's ability to withstand its string tension in the long run? Maintaining the balance between these two properties—strength and sound production—is our ultimate goal.

The shape—If you glance at the scaled drawings, the first thing you're likely to notice is the shape of the body. Though mine is a large-bodied guitar, it doesn't have the squared-off look of a type known as a ***dreadnought***. The dreadnought was developed by C.F. Martin and Co. earlier in this century to produce a very popular deep-sounding, bass-heavy guitar.

In general, big, deep instrument bodies respond better to lower sound frequencies and smaller, shallower boxes (as the bodies are also called) do a better job on higher frequencies. I'm interested in a guitar with a balanced sound—equal volume and quality to both the treble and bass. Hence, my guitar differs from a dreadnought in that it has a tighter waist, rounder lower bout, curvier lines and marginally shallower depth. These features grew from classical guitar styling, but the shape is distinctly my own and like no other.

In my guitar, all of the various physical elements are intended to exist in tandem with each other to produce the loud, very clear, balanced sound I desire. Another maker experiments similarly until all of the design elements click together in the way he or she desires—and so it goes throughout the trade. And, it's important to note, there's no single physical aspect of the instrument that doesn't affect its sound.

When you have a chance, strum a chord on a guitar and, while it's still sounding, lightly touch the tip of the peghead. You'll feel that it, too, is vibrating. In fact, every part of the instrument responds to vibration. As a consequence, each part receives—and, to varying degrees, returns—those vibrations, thereby affecting the total collective sound wave that moves the air, ultimately hitting your eardrum. That description may be somewhat simplified, but I feel it is an important concept to grasp on the road to gaining what one might label a holistic sense of the guitar. By "holistic" I mean never losing sight of the instrument as a whole, either as a single physical thing or as an object inseparable from its function.

If you do this, it won't come as a surprise when you read about someone clamping weights to a guitar's peghead and dramatically increasing sustain (the duration of the musical tone once the string is plucked). Or when you learn that a finish that's too heavy or of the wrong substance can negate many of the valuable sound qualities that would otherwise have been present. Or when you hear the difference even a one-centimeter change in the string length can make to the projection, brilliance and volume of the sound. All of these things, incidentally, will happen regardless of how the body was constructed.

I should say a word here about the metric system, which will be used for the guitar plans throughout. Out of deference to readers in the United States, I seriously considered converting my measurements to inches. This proved extremely clumsy—the distance of this guitar's vibrating string length, 65cm, is 25.59 in., or a hair less than 25$\frac{19}{32}$ in.; what figure should I give? Furthermore, it soon became obvious that, with all the rounding up and rounding down required, working in inches was not the way to build this particular guitar. The reason is that its design springs from a European tradition, embraced from Spain through Germany—it was conceived in and evolved in the metric system. I realize that many excellent guitars are built in inches, but to try it with this one would be to buck a strong head wind all the way.

Materials—In addition to this guitar's dimensions, the materials it's made of influence its sound. Each part of the guitar has a distinct role to play—some more important than others—in terms of sound or strength. The properties intrinsic to each part's particular species of wood should match its required function.

As near in time to us as the middle of the last century, a Spaniard by the name of Antonio de Torres was single-handedly responsible for standardizing the elements of guitar design, much as Stradivari did for the violin. The steel string guitar, though today a very different instrument than a nylon-strung classical, is the result of adapting Torres' pioneering designs to strings of much higher tension and dissimilar sound qualities. To function well under the differing demands of steel strings, guitars were given steel neck reinforcement rods, a larger body and an X-shaped inner top bracing of triple the mass that Torres' guitar used. Yet the overall design concept is still Torres'. So, too, are the choices of materials for the various parts of a guitar.

For the soundboard, Torres did not face a difficult choice. The spruce and pine family had already proven their worth in numerous other stringed instruments—harpsichords, viols and early guitars, to name just a few. Other woods, such as Western red cedar, redwood and softer mahoganies, are among the variables that modern makers sometimes use in place of spruce. Cedar, in fact, has become as common as spruce for classical guitar tops.

As to precisely why the structure of a certain softwood is its ticket to superior performance as a soundboard, there has yet to emerge a conclusive theory. Physicists, acousticians and luthiers the world over have been grappling with that puzzle just long enough to begin forming better questions.

Our next order of business is with the other major segments of the sound box—the back and sides.

Many varieties of hardwoods and softwoods—rosewood, maple and cypress among them—were the side and back choices of guitarmakers even before Torres. It was from his work, however, that we saw rosewood predominate. (This excludes traditional flamenco guitars which, to this day, are built of Spanish cypress.)

The material selected for the back and sides of the guitar must play two major roles. One is to provide reflective surfaces with a minimum of dissipating absorption of vibrations. This quality is crucial in providing projection and volume. Second is the planned shaping of tone color. Rosewood, with its particular combination of brittle hardness, density and weight, gets high marks in both of these categories. Musical properties of guitars that you might hear described as "mellow clarity," "brilliant trebles" or "deep yet clear bass notes" will more often than not be emanating from a rosewood body.

Of the more than 200 different rosewoods around the world, only two or three species have been found suitable for guitars—so far, that is. The first and longest-reigning king was Brazilian rosewood. Its distinctive black and brown grain patterns shone from beneath the finish of the vast majority of high-quality instruments up until the early 1960s. At that point, Brazil surprised the guitarmaking community by placing an embargo (still in effect) on its large rosewood lumber. Having over-harvested its rosewood forests for decades, Brazil simply decided that it was time for the millwork and veneer-making profits flowing into other countries to be diverted back home. As a result, only thin furniture veneer and small, low-grade lumber pieces now find their way to export.

Guitarmakers and players cried and tore their hair and thought the sky had fallen. But, when the dust settled, the guitar world had shifted to another qualitatively similar and eminently available rosewood: East Indian.

The rosewood from East India may not be as pretty as Brazilian, but, aside from being slightly less brittle (and, therefore, less prone to cracking), its properties of weight, strength and density are almost identical. Hence, East Indian rosewood easily produces a guitar equal to one of Brazilian rosewood. Don't let anyone tell you different.

The third rosewood, used occasionally as an alternative, is the orange-brown African bubinga. It's the only other major rosewood with a hardness and density suitable for making guitars. When East Indian rosewood is embargoed or no longer available because of over-harvesting—and that day will come—I predict that guitars will be made with bubinga.

For necks, the ideal wood is not too heavy and not too dense, is strong for its weight and is generally stable. A good mahogany from tropical America fits the bill. Maple is also a good choice, as would be any of the softer hardwoods that meet the criteria.

In this part of the instrument, stability is of utmost importance. If the neck wood responds too easily to fluctuating climatic conditions, as will a dense rosewood or ebony, the neck will be like a tree in the breeze, bending backward and forward at the beck and call of the changing seasons. The fingerboard/neck angles are so critical to the instrument's playability that they must be set onto reliable, stable materials you can count on (as much as is possible) to stay put. One other important property of the neck is the effect it has on sustain. Think back to the idea of attaching a weight to the peghead, mentioned earlier. A neck of increased weight or density has the same effect.

A typical steel string guitar has a metal truss rod inside it and heavy, geared machine heads, both of which add greatly to the weight of the neck. This fact, plus the inherent nature of steel string wire, serves to equip the normal steel string guitar with good sustain from the start. For this reason, enhancing sustain is unnecessary. Were we building a more sensitive classical guitar, where simply substituting curly maple for mahogany would produce noticeable sustain gain, I would have altered our materials list accordingly.

Glued mostly to the neck and partly to the guitar top is what's known as either the fretboard or the fingerboard. Because this is the part of the guitar that gets the most wear—the digging and scraping action of your fingers and nails as they reach for and press the strings, plus the holding of the fret wire—the fingerboard must be made of a hard material. The two universal wood choices for this job are ebony and rosewood, both of which can be found on Torres' guitars. Obviously, the better choice is the denser and harder of the two: ebony. It's also, to my mind, the more sleekly attractive of the two.

The earliest ebony of commerce came from Ceylon in East India. When production there dropped, various African species, the best being gaboon, took up a little of the slack. Today, the scales have tilted slightly back, and Ceylon ebony is once again the easiest ebony to obtain in good quality.

Ebony has, in addition, become the traditional wood for steel string guitar bridges. A hardwood of some type is a necessity here, as much as for the fingerboard, because the bridge has to cradle the saddle—the thin, notched strip that the strings run over—and offer a securing point for the strings. Above that, a correctly sized dense wood acts as the ideal driver of the soundboard by the way it naturally transfers the vibrations it receives from the strings and saddle.

Finally, we're left with the nut and saddle—the points at which the strings are in physical contact with the instrument at both ends of the established string length.

Since ancient times, hard substances such as ebony, shell, bone, ivory, metal or stone have been employed as the underpinners and guiders of strings on musical instruments. The need was for a material with the hardness to maintain its edges under tension

Further reading and suppliers

Many of the books listed below can be ordered from: Bold Strummer Ltd., 1 Webb Rd., Westport, CT 06880, or Books About Wood, R.R.#3, Owen Sound, Ontario, Canada N4K 5N5. Check a local library for the availability of out-of-print books.

Steel string guitars

The Steel String Guitar: Construction And Repair by David Russell Young. Chilton Book Co., Library Services, Chilton Way, Radnor, PA 19089; 1975.

Steel String Guitar Construction by Irving Sloane, E.P. Dutton, New York, NY 10016 (out of print).

The Steel String Guitar by Donald Brosnac, Panjandrum, Los Angeles, CA 90025 (out of print).

Classical guitars

Classic Guitar Construction by Irving Sloane. Sterling Publishing Co., Inc., 2 Park Ave., New York, NY 10016; 1966.

Make Your Own Classical Guitar by Stanley Doubtfire. Victor Gollancz, London, 1981; reprinted by Schocken Books, 200 Madison Ave., New York, NY 10016; 1983.

Classic Guitar Making by Arthur E. Overholtzer, Brock Publishing Co., Chico, CA 95927 (out of print).

General

Guitar Making: Tradition and Technology by William Cumpiano and Jon Natelson. Rosewood Press, 85 North Whitney St., Amherst, MA 01002; 1987.

Guitars: Music, History, Construction and Players—From The Renaissance to Rock by Tom Evans and Mary Anne Evans. Paddington, London, Eng., 1977.

Guild of American Luthiers, 8222 South Park Ave., Tacoma, WA 98408. Quarterly publication and data sheets on guitarmaking.

Journal of Guitar Acoustics, back issues available from Rosewood Press, 85 North Whitney St., Amherst, MA 01002.

Suppliers

A & M Wood Specialty, 358 Eagle St. North, Box 3204, Cambridge, Ontario, Can. N3H 4S6.

Eastern Mercantile, Box 153, Frederickton, N.B., Canada E3B 4Y9.

Euphonon Co., Box 100, Orford, NH 03777.

Exotic Woods Co., Box 32, Haddon Heights, NJ 08035.

International Violin Co., 4026 W. Belvedere Ave., Baltimore, MD 21215.

International Luthier's Supply, Box 580397, Tulsa, OK 74158.

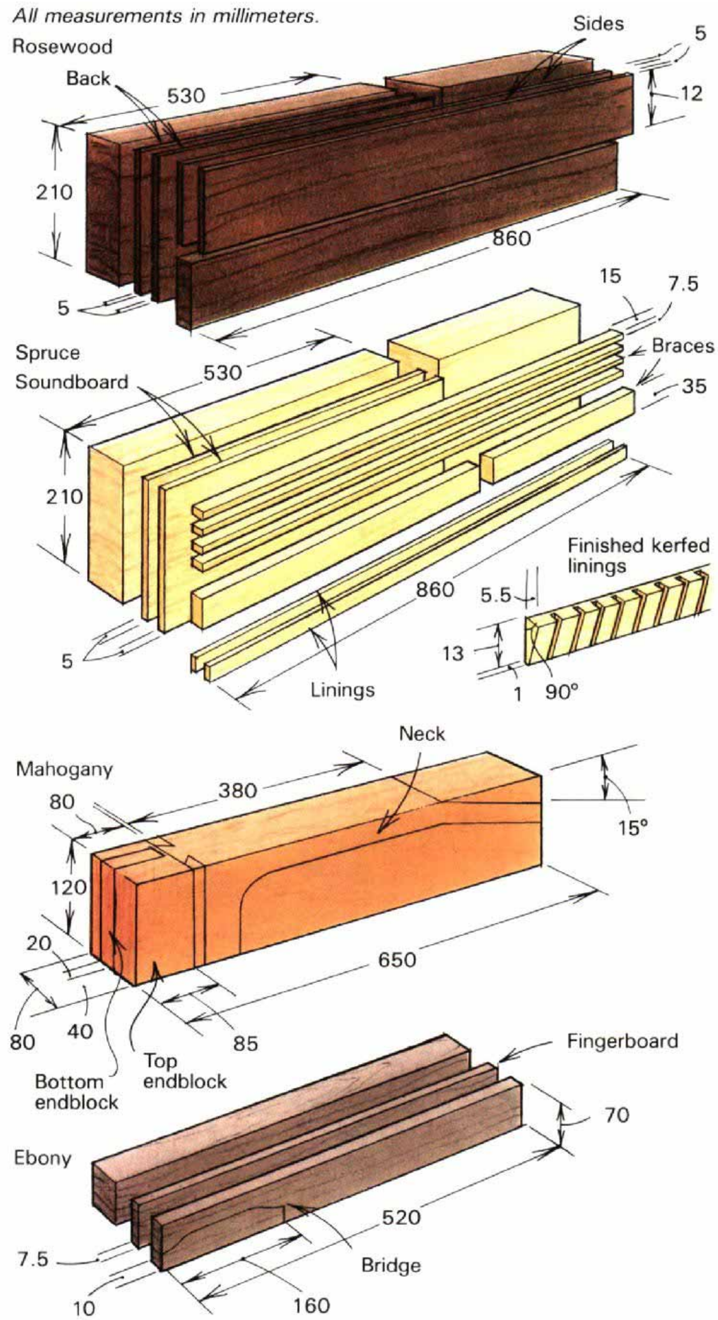
Luthier's Mercantile, Box 774, 412 Moore Lane, Healdsburg, CA 95448-0774.

Martin Guitar Co., Box 329, Nazareth, PA 18064.

Stewart-Macdonald, 21 North Shafer, Box 900, Athens, OH 45701.

Unicorn Universal Woods, 4190 Steeles Ave. W, Unit 4, Woodbridge, Ontario, Can. L4L 3S8.

Fig. 3: Grain orientations



and through thousands of string changes. Ideally, that material should also be easily workable for accurate shaping. Those needs were best met, historically, by bone and ivory. Ivory is nicer to work with—if you have no qualms about using a material that's "harvested" from an endangered species—but bone will do, as will some man-made materials, such as Corian and Micarta.

A direct result of the nut's and saddle's locations at the start and end of the scale length (the musically active span of the strings) is that they affect the initial vibration on its way to the rest of the instrument. When the nut and saddle are of softwood, they tend to dull the sound. Conversely, when they're made of a metal such as brass or steel, the sound takes on a harshly bright edge. Bone and ivory are in the middle ground, delivering a tone clear and ringing, yet round and warm. Try for yourself the various substances I've described. Experiment with any guitar at hand and you'll easily hear the differences, practiced ear or not.

Cutting strategy—The next consideration is bandsawing the wood to rough size. The accompanying illustrations are generally self-explanatory. Slice from your lumber as shown in figure 3, to the dimensions marked, which provide allowance for further shaping. Note that the idea in most cases is to begin with quartersawn wood (with the annual rings running reasonably close to 90° to the wide faces of the board) to produce quartersawn pieces. I'll discuss the reason for this shortly.

A mid-size bandsaw (14 in. or smaller) will have a difficult time cutting 8½-in.-deep rosewood stock. The easy way out is to obtain matched, rough-sawn pairs of backs and sides from a luthier-supply company, and I'd recommend this approach to anyone without bandsaw experience. If you want to try sawing your own parts, however, I suggest searching out a large saw to tackle the work. Perhaps a high-school woodshop or a local commercial shop will allow you time on one of their machines. The 8½-in. spruce stock is another matter. My own saw is a 15-year-old 14-in. Rockwell/Delta with a height extension that enables me to cut stock almost 12 in. deep. I've also installed a 1-HP motor and, via pulleys, slowed the blade to about one-third its standard speed. With these amendments and a ¾-in., three-tooth-per-inch blade, a small saw cuts spruce guitar tops easily enough.

It's valuable though not absolutely necessary that the backs, sides, fingerboard and bridge be quartersawn. But for the neck, and especially for the top, quartersawn wood is a must for its stability and strength. It's equally important that the top wood has a minimum of grain runout (grain that angles away from the surface of the soundboard). A top with more than a little grain runout will be physically weaker than one with none and, it's generally accepted, will result in poorer sound.

The easy method of avoiding runout is to wedge-split your spruce before bandsawing. Split off a large chunk, joint or plane two adjacent surfaces flat and square for stability against table and fence, then saw. This is as close as you can come to following the wood's own grain movement. The surface may be naturally wavy when split, but flattening those waves—a necessity for cutting—is doing little or no harm.

For the top, back and sides, you'll need to end up with what are called "book-matched pairs"—two consecutively cut pieces that, with bottom edges touching, are allowed to fall open like a book, one to the left, one to the right.

The neck blank, as shown, is cut from one piece. It's very practical, however, to make a jointed neck, with the glue joint at the heel block. This is a good compromise between economy and convenience. You'll find necks assembled out of as many as six pieces, and as few as one. The determinants are usually lumber dimensions and cost. Obviously, cutting a one-piece neck blank—peghead slant, heel and all—wastes the most wood. At the other end of the scale are necks built up out of 1-in.-thick lumber. The heel becomes a sandwich of four or five pieces, while the peghead slant is achieved by a 15° angled joint. The style of neck assembly you choose is of little consequence. All have been time-tested and found to be more than strong enough for the job. A separated neck joint is rare. If you do follow the two-piece method, endeavor to cut the heel block from the same board as the neck piece, and the same section of the board if possible. You'll have a better match of grain and color this way.

The remaining elements—the fingerboard, bridge, peghead veneer, endblocks, lining and bracing material—are straight, slightly oversize blanks of wood at this stage. Cut them out as shown and place them aside in a dry, well-ventilated spot.

Now, I think, is the best time to discuss a subject that can make or break your guitar, regardless of the care you take in every other respect. I refer to moisture content and humidity.

Wood shrinks and swells as it absorbs and loses moisture. If a guitar is built from wood that's too wet, it will shrink and crack when the weather becomes dry. A guitar built from wood that's too dry will swell when the humidity goes up and may buckle, though this is less of a danger. The trick is to dry the wood just enough, so that it'll be stable in the conditions the guitar will exist in. With rare exceptions, the desirable dryness will be that of a normal home as heated in winter—6% to 8% equilibrium moisture content (EMC).

Stack the wood somewhere in the living area of your home for a month or more. Place stickers between the pieces so that air can circulate. Blow a fan across the stack if you wish, to speed the drying process, although this is not absolutely necessary. It's a good idea to weigh a piece of the various species of wood periodically; when the wood ceases to lose weight, it has arrived at the correct moisture level, and you can proceed with construction.

Without further digression, then, here are our first steps in the assembly process.

To begin, I suggest you make a simple exterior mold for the guitar body. This will be your reference template when bending the sides, as well as the clamping jig for numerous stages of constructing the box. Using the dimensions taken from figure 1, I recommend following the mold-building method described in David Russell Young's book, *The Steel String Guitar: Construction And Repair* (Chilton Book Co., 1975).

I have one amendment to Young's mold design. Rather than using screwed-on end plates to hold the two halves of the mold together, I suggest adding a small extension in the lower bout (see photo, right). When your mold halves are complete, glue them together at the upper bout only. Long clamps, stretching across the mold and applied with minimum pressure, should secure this joint. Then, drill a hole through the added extension that's large enough to loosely take a long bolt. Install the bolt with a washer and wing nut on one end. You now have a mold that can be partly opened. By loosening the wing nut and slipping a small wedge into the opened gap between the mold halves, you'll gain a ¼-in. opening—enough to allow a guitar body to easily slip out.

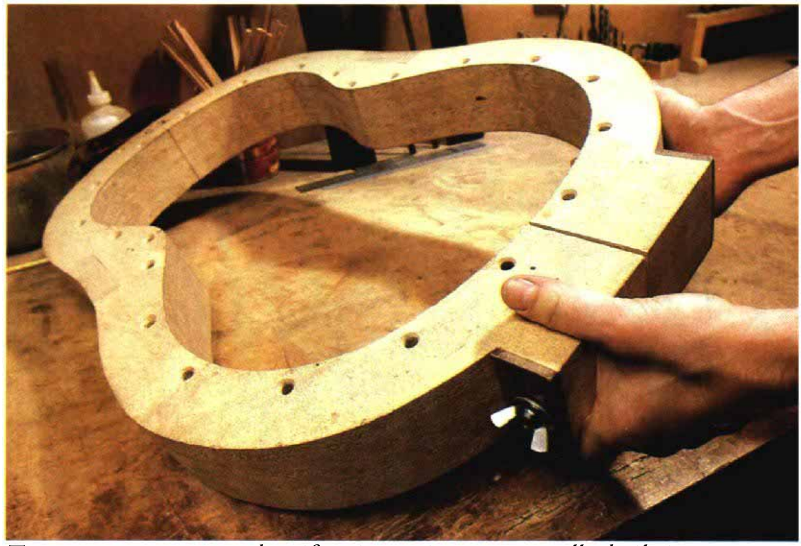
I'll now leave you with one actual assembly step. Don't forget, however, that before you do this step or any of those that will follow, your woods must be given proper stabilizing time.

Joining the back and top—Before joining, the pieces of the back and the top should be brought to nearly their final thickness—around 4mm is good. If you have access to a thickness sander, that's the best method. A planer is liable to chip, especially on the rosewood. If you have the stamina, handplaning is your other option. The spruce will be easy enough, and can be planed with the grain. Rosewood will demand some elbow grease, but planing *across* the grain will make the job immeasurably easier.

You want these joints to be both perfect and, particularly on the spruce top, invisible. The easiest way I've found to make an accurate joint is with a well-set-up jointer. Accurately handplaning these edges is tricky, even for the experienced craftsperson. When using a jointer, move across the blades slowly and evenly. Don't settle for a joint that's less than perfect.

There are a number of common methods for clamping backs and tops. Pictured at top right is what I consider the most straightforward, since it requires no jigs. Trim the two halves of the top and back into slight wedges by removing some material from the outside edges. Place them tightly together on your bench and nail or clamp sturdy wooden strips along the outer edges. Run glue along your joint, place wax paper beneath and a weight on top, then push the top/back into the strips to wedge the glue joint tight. Leave the work clamped for one hour. When unclamping, remove the weight last. If you intend to put some sort of decorative strip in the center of the back, the joining procedure is still the same.

Guitar tops, as well as backs, are usually made of two pieces book-matched along a centerline joint. The joint can be glued by tapering the pieces, then gently tapping them into a matching pair of cleats that are fixed to the bench to form a wedge-shaped recess. A weight prevents the wood from buckling upward.



To ensure symmetry and uniformity, guitars are usually built in a mold. Laskin's mold can be loosened at the bottom so the sides can be slipped out without damage.

For this and all other gluing on the guitar, use an aliphatic resin glue such as Titebond or Elmer's Carpenter's Glue. For discussions of the relative merits of hide glues—an alternative for certain guitar joints—I suggest checking the texts I've recommended under "Further reading and suppliers."

Until part two, I'll leave you with one last bit of advice. Carry this in your mind throughout the building of this guitar: Be patient. That was the most valuable lesson of my apprenticeship. I learned that certain jobs for which one normally might have set aside an hour to accomplish in truth took half a day or more to do well. Think of the musician practicing year after year to master an instrument. A few more hours of your time at each stage of construction is a painless counterbalance to that effort. You'll never regret it. □

Grit Laskin's shop is in Toronto, Canada. Part two of this series is slated to appear in the March/April issue of Fine Woodworking.