

THE BASICS OF GUITAR DESIGN

MOST CLASSICAL and flamenco guitars are remarkably alike in size and shape, having been more or less standardized in body outline, bridge design, etc., from the middle 1800s on. But steel string guitars come in many shapes and sizes. There are dreadnoughts, jumbos, weird little travel guitars, concert models, parlor models, orchestra models, twelve and fourteen fret models, narrow-waisted and wide-waisted guitars, cutaways, bowlbacks and flatbacks, flat- and arch-tops, two-necked instruments, electrics and acoustics, fanned-fret and double-soundhole guitars, etc. – not to mention shapes or designs which are associated with specific factory makers like Martin, Lowden and Breedlove or individual makers like Steve Klein, Stefan Sobell, Jeff Traugott, myself, and others. This list, furthermore, is bound to expand. This plenitude is shaped by two important musical/cultural factors.

First, are the origins of the guitar itself. The Spanish guitar's design crystallized within a craft tradition, around (1) a romantic design aesthetic – i.e. a naturalistic/organic/poetic sense of line, as opposed to a mechanical or merely functional one – and (2) the very real accomplishment of having solved a specific musical problem which other fretted instruments of its time and geography had not. This was: that it could successfully hold its own on the level of the human voice. It could accompany singing successfully; it had carrying power and presence within the register of the human voice; it could be clearly heard without either its drowning out the singer or being drowned out by him; and it was capable of polyphony and harmony. All this with only gut stringing and no amplification! This was a real breakthrough – and the traditional design still works after all these years; hence its stability. Later, when the classic guitar became a separate subset of the Spanish guitar, the size and shape of the instrument was kept the same for reasons of both tradition and the aesthetic preferences of that market.

Second, in contrast, the steel string guitar is a quintessentially American creation. Its design coalesced in part around (1) the simple musical use of providing loud sound *within a rapidly growing culture of popular and folk music*; (2) a more pragmatic design aesthetic, (3) the availability of cheaper strings^{12,1},

and (4) the development of a mechanical structure sturdy enough to hold up to the pull of metal strings. This latter was “invented” (more successfully than by anyone else) by the Larson brothers in the late 1800s.

These factors are variously intertwined, or they can also stand separately. But the upshot is that the steel string guitar, as we have known it, is the creature of commercial production rather than of craft tradition. In the absence of a Guild system such as had existed in Europe and that regulated who could enter the market, production of guitars in the New World fell open to any entrepreneur who cared to or was able to do so – or hire the labor to do so. The steel string guitar has consequently, from the beginning, been a commercial product marketed to a hierarchy of budgets on the basis of features, shapes, options, sizes, materials, appointments, etc. – much more so than it has been identified with a particular craftsman or skilled tradition. As part of this this package, different types and sizes of guitars were developed for and marketed to different social and musical uses. Parlor guitars, for instance, wouldn't have been the first choice for orchestral or band performances. Rather, orchestral entertainments created a need for guitars that could command the bass, tenor, baritone and soprano voices – and such instruments were therefore made. Today, the models that most steel string guitar makers emulate are the older factory ones, and the Martin guitars seem the chief point of reference: such guitars have already been produced and accepted, and no guesswork needs to be done about salability in the marketplace when it comes time to market a “new” model. This is not necessarily a bad thing to do but it is not, typically, how the makers of the most sought-after Spanish guitars have done business.

^[5] Be all that as it may, the aim of this book is to explain the true functions of the guitar's various dynamic elements, and not the promotion of any specific but still more or less mechanical method for assembly operations, or for making copies of this or that feature along the paths of least resistance. I believe such an understanding is best gotten through the craftsman's approach to the work in which there is no division of labor and the maker can pay attention to all the important things one at a time.

Then, when one has a feel for the procedures and the materials and subsequently wants to make something traditionally designed that functions better, or move on to an original design that works successfully, one will have some useful conceptual grounding for how to create it. Some aspects of these matters were already touched on in Chapters 2 and 6.

SCALE LENGTH: THE BASIS FOR LAYOUT

In guitar design everything starts with the scale, which is the vibrating length of the strings, and the twelfth fret position of which is always the midpoint. From the scale one can extrapolate the fingerboard and neck. The scale also determines the distance from the nut to the bridge; and how many frets you want on the fingerboard brings you to the upper perimeter of the soundhole. Traditional builders have long known of the benefit of putting the bridge in the middle of the lower bout (see Chapters 4 and 17). Understanding this, and knowing the location of the bridge as determined by a chosen scale, enables the guitar maker to arrive at the outlines, sizes and shapes of their guitars *in such a way as to create a lower bout that wraps around the bridge so as to make it central* (Fig. 12.1).

The scale is variable, of course, but only by so much. The fret spacing has to fit the abilities of the average human hand and it has to support the load of real strings. Make the scale and fingerboard too short and the fingers will crunch together. Make the scale too long and the left hand is strained to make reaches. Also, the scale length determines the tightness of the strings when tuned to pitch: a short scale may make the strings too loose and floppy and render them incapable of driving the face adequately; a long scale may make the strings so tight that they are hard to play and break easily, or even overpower the ability of the guitar and its neck to hold together over the long term. For steel string guitars the standard scale was set long ago by the Martin Company at 25.4 inches. Fingerpickers, in my experience, are comfortable with a slightly shorter scale of 25" to 25¼", although there are players who are comfortable with scales as long as 25⅝" to 26", or as short as 24¾". Spanish guitar makers in all countries traditionally use metric measurements, and their scale length is typically 63½ to 66 centimeters (25 to 26 inches).

SUCCESSFUL BODY CONTOURS

Getting good contours of body, once the guitar's gross size has been determined, takes a good eye and a bit of care. It's worth taking pains over if one wants to make the body beautiful and its lines flowing, not

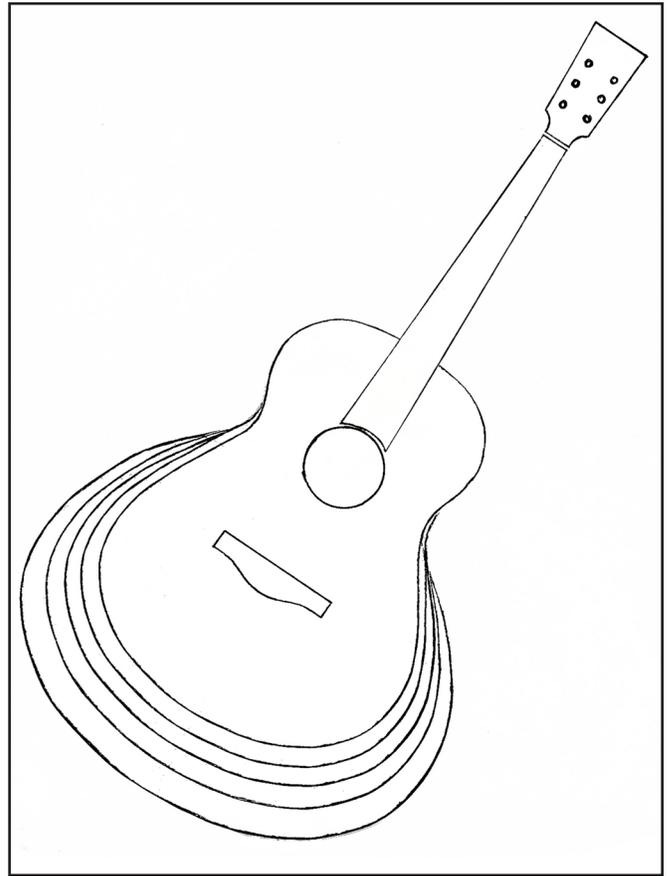


Fig. 12.1 *The scale length determines the location of the bridge in the lower bout and the guitar body will wrap itself around that fixed point according to how large, small, wide or narrow that body is.*

clunky. As an example of this principle of design, consider the object shown in Fig. 12.2. It is a bronze tripod leg that, with two others just like it, once helped to support an object. It is beautiful far above its utilitarian function in that every part and curve of it is aesthetically pleasing and right; even by itself, isolated from the rest of the original armature, there is no vantage point from which to look at this object that makes it look awkward or clumsy. This aesthetic is arrived at by the sum of all its elements, each of which is in balance with the others; if one changed a single curve more than just minimally, or a length, or a thickness, or a taper, or even flattened the almost imperceptible crowning of the smooth inner surface ... the entire design would lose something decisive and look cheapened. The best guitars are made with such care^{12.2}.

Historically, Spanish makers have from the beginning been intuitively aware of the organicity of the guitar's line values and proportions. Steel string guitar makers have not; they are generally blind to this aesthetic and seem informed by a more

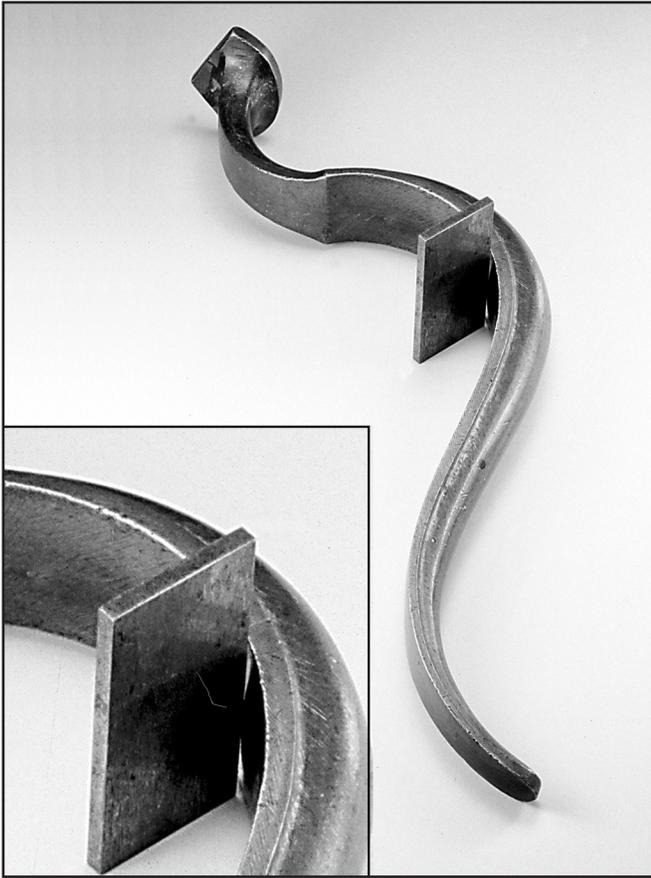


Fig. 12.2 Change *anything* about this object (including the gentle rounding of the inner surface as shown off by the straightedge), and the visual flow of its lines and proportions would be harmed. The best guitars try for such an overall effect.

pragmatic and geometric one (**Fig. 12.3**)^{12.3}. For example, when making a slightly larger guitar, early steel string guitar makers have been known to take an existing outline, cut it down the middle, spread the two halves apart by an inch or two, connect the dots, and presto! new guitar size – without having to mess with proportions or blending old contours into new ones^{12.4}. Another example is the body contour of the Martin dreadnought guitar: its universally recognized shallow waist was decided on in part because it was less problematic to bend (i.e., there were fewer fracture problems) than the traditionally sharper guitar waist, in a factory/production setting. For further elaboration on the Aesthetics of Design see Chapter 22, and also paragraphs 31-33 in Chapter 34.

^[10] Once the guitar's physical footprint has been decided on, a life-size outline is useful for planning one's bracing layout, distribution, and even shaping. You want to be able to place things in the right locations without crowding or starving any part of the face insofar as bracing/stiffening goes. A second use



Fig. 12.3 Some guitar's lines flow nicely and organically. This is most often true of guitars based in Spanish guitar aesthetic, whose lines are adapted to serve the eye. Contemporary American steel string guitar's outlines are a mix of curves and flat areas and often seem ungraceful.

of a life-size plan is to determine consistent indexing-points to help with the guitar's various shaping, slotting, curving and assembly operations. Indexing pins are used to hold the jigs and parts steadily as they are being worked.

Finally, the size and proportions of the bouts, the waist, and their relative location with respect to the centerline, the soundhole, and the bridge are well worth taking some time over. I repeat: design with good proportions will be lovely; a design with indifferent curves, flat spots and countercurves will look uninteresting or even unattractive.

BRIDGE HEIGHT

Bridge height – and the torque it creates – is a factor in sound quality; and consistency of bridge height is important in successful guitar making. If your strings' driving torque varies from guitar to guitar a lot of your design thinking and otherwise careful work in bracing, etc., will be bypassed. *Therefore you'll want your bridge/string height to be a non-negotiable target measurement around which to construct your instruments.* Serious guitar makers take the trouble to do exactly this; amateur guitar makers too often build the soundbox, join the neck on, and then make a bridge and saddle to fit the resulting construct – rather as an afterthought. This is like setting up a business, hiring employees, and then drawing a name out of a hat to see who will be the office manager.

SCALE AND PROPORTION

One important dimension of guitar design is that of scaling/proportionality of elements. It is one of the areas in which a luthier can customize his instruments intelligently. This is particularly applicable to guitar parts such as the soundhole diameter, the bridge, and the braces. These sometimes have to perform similar or parallel (that is, mechanically and tonally balanced) tasks while being of different sizes. The importance of this can be appreciated by noticing that manufactured guitars of different sizes often have the same diameter soundholes, the same height braces, identical bridges, etc. Yet, placing any one of these on a small guitar is the equivalent of having a larger one on a normal sized guitar, just as when you put “normal” sized elements on a “large” guitar body you might be underbuilding part of it.

Another example how good proportions apply to guitar making has to do with the design, construction and bracing of the back. Most steel string guitar backs have four braces. Why? Early European, Spanish and American guitars were small and had three back braces. But once guitar bodies were made larger it made sense to increase the back bracing proportionally: after all, they were supporting a larger surface. Today, as smaller bodied steel string guitars are becoming popular again, it is appropriate to reduce their back bracing in quantity and/or size. I use four braces on my larger guitars’ backs but I only put three on my smaller ones: to do differently would be to overbuild or underbuild and thereby miss the target^{12.5}.

^[15] A better example of the principle of proportionality can be observed when someone makes a pencil line at, say, $\frac{1}{2}$ " around the inside of a mold or $\frac{1}{2}$ " around the outside of a template of an already established design, in an attempt to create a variation that’s a little smaller or a little bigger than the original. This formula approach never works. Adding or subtracting a *constant increment* to/from all points of a design’s perimeter will destroy its proportional integrity (**Fig. 12.4**).

THE SHAPE OF THE BODY: THE WAIST AND THE BOUTS

In previous chapters we’ve looked at brace wood selection and treatment, materials properties, bracing systems, and guitar dynamics. In the next chapters we’ll be looking at top and back plate construction, bridge placement in 12- and 14-fret guitars, voicing, etc. All of these are pertinent to the shaping of sound.

But from a design standpoint, aside from the specifics of what bracing, shaping, bridging and voicing we choose to do, one must also ask just

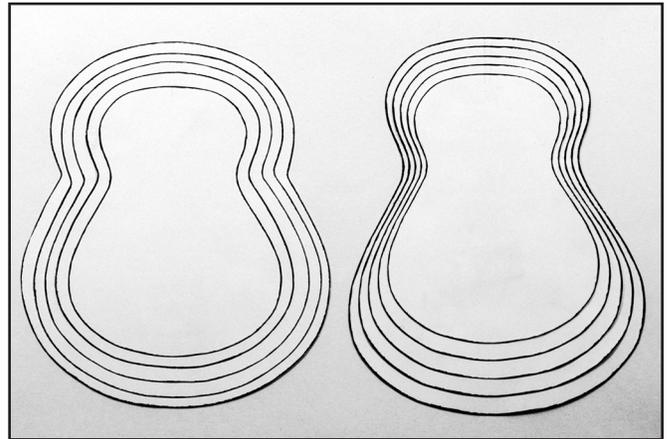


Fig. 12.4 Adding or deleting a constant increment to parts of a design will change it fundamentally. Enlarging or reducing a design proportionally keeps it intact.

what, exactly, is The Thing Itself that we are bracing, thinning and shaping? That is, what part does the size and shape of the top itself have to play in all of this – outside of the popular wisdom that the larger the guitar body, the boomier and bassier its response, and vice-versa? That’s why, for example, a jumbo with a 17½" lower bout has a bigger sound than an OM with a 15" lower bout or a dreadnought with a 16" lower bout, right?

Well, not necessarily: the fact is that, everything else being equal, a Jumbo guitar top has a tap tone higher in frequency than a dreadnought’s top – especially when “X” bracing is involved – and hence does not have a bigger sound in spite of the fact that the former has a larger lower bout than the latter. The explanation is twofold.

First, the width of the lower bout is, in itself, a misleading indicator of tonal potential. Remember: the guitar top functions like a drumhead – and it is a drumhead with a specific shape: namely, it has a waist. Besides being an ergonomic feature, the waist represents a constriction of the vibrating diaphragm and is an impediment to its motion: the waist makes the top behave as though it were smaller and tighter than it actually is (**Fig. 12.5**).

^[20] Obviously, the narrowing of the waist into the vibrational footprint of the face has significant tonal implications. The sharper and deeper the waist the more the top is stiffened and inhibited, and the more it overrides whatever tonal potential toward openness a wide lower bout would otherwise have. On the other hand, everything else being equal, the softer the waist the more the soundboard’s tonal

response is opened up – certainly as far as monopole activity is concerned (**Fig. 12.6 A/B**).

Second, typical Jumbo and OM guitars, with their tight waists, are particularly subject to this,

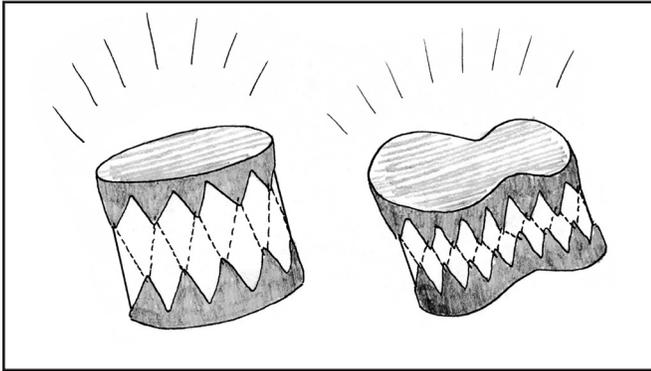


Fig. 12.5 Circular drumhead vs. guitar-shaped drumhead: the freedom of movement of a vibrating plate is influenced by its shape.

and to “X” brace them only serves to further stiffen already constricted body contours in the upper bout. Such bodies close in on the top half of the “X”, almost hugging it, and the upper legs of the “X” are essentially more firmly coupled to the guitar’s perimeters. It’s very much as though those upper legs were more massive (**Fig. 12.7 A**). Unless these braces are appropriately reduced in size and stiffness such a narrow-waisted arrangement will choke off a certain portion of the ability of the “X” to move freely under the pull of the strings – especially as compared to a less constricted arrangement such as the one found in the dreadnought (**Fig 12.7 B**).

DESIGNING FOR HUMAN USE: THE POSITIVE USES OF THE WAIST

Appreciating the effect of the span and position of the waist in relation to the bracing and other parts of the guitar is one of the important but normally unrecognized subtleties of any kind of guitar design and is a help to an understanding of the success or failure of certain models^{12.6}. It is also the design feature that separates flatpicked guitars from fingerpicked models – so it merits some attention if one wants to make guitars for players of different music. I don’t mean that the waist defines how the guitar will be played; but it facilitates how it is held as it is played.

The flatpicked guitar, regardless of its actual shape, is very typically played in standing up position, with the help of a shoulder strap. The guitar’s waist and physical balance point become unimportant. While any guitar can be played by a standing player if

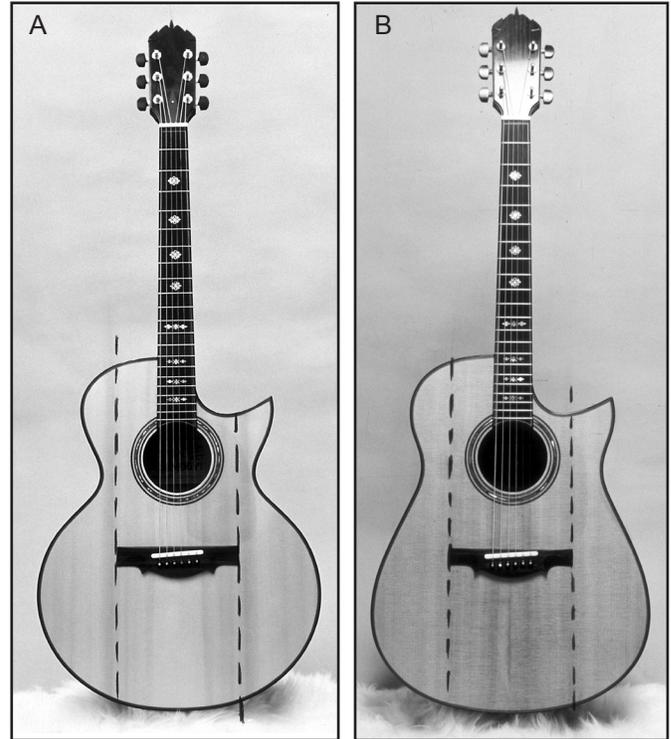


Fig. 12.6 (A) Tight-waisted guitar top with respect to the load/excursion path of the bridge; **(B)** Softer waisted guitar, with respect to the load/excursion path of the same-sized bridge.

a strap is used, the most common model of flatpicked guitar in the world is the dreadnought, which has the shallowest waist of any contemporary steel string guitar in existence. The fingerpicked guitar and the jazz guitar are very typically played while sitting down: they have to balance and stay on the player’s lap. Orchestra, band, and fingerpicked guitars – such as the OM, OOO and Jumbo models as well as the L-5 jazz guitar, the Maccaferri guitars, and archtop

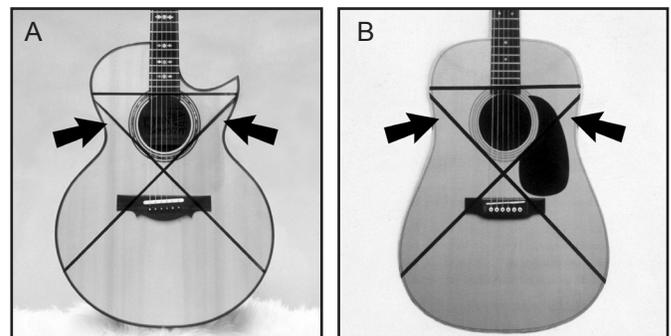


Fig. 12.7 (A) The sharper the waist, the more it “crowds” the upper legs of the “X” brace and hampers their movement; **(B)** The shallower waist of the dreadnought guitar leaves the upper legs of the “X” brace relatively unconstricted: note the altered angle that the legs make as they approach the rims.

guitars in general all have pronounced waists for this ergonomic reason. The dreadnought, with its shallow waist, is unique in that it cannot stay on the lap: it slips and slides around much too much during vigorous playing. Also, because of the position and flatness of the waist, the dreadnought's center of balance is off: it is top-heavy. The center of balance also has the secondary function of making the guitar seem weightless. Players will immediately notice if a guitar is heavier or lighter than another one, but a truly well-balanced one makes the weight seem to disappear as soon as one sits down with it and starts to play.

FINE TOUCHES

In addition to the above elements and features, the fine touches that give any guitar its extra "something" are limitless. One of the traditional fine touches is what might be called harmony or felicity of the parts. **Fig. 12.8** shows an example of this. Otherwise, fine touches are traditionally found in elements of body contour, on the fingerboard, the peghead, the bridge, on edges and in corners, the heel, around the soundhole, and in specific ornamentation. These things are the subject of Chapter 22.

THE WAIST AND THE BRIDGE IN THE NON-X-BRACED GUITAR

^[25] Considerations of how the waist pinches into the "X" bracing of the steel string guitar, as described previously, applies differently to Spanish guitars for two reasons. First, these typically have fan bracing instead of "X", and fan braces don't usually enter the upper bout: they stop at the transverse brace below the soundhole. Second, the waist is above this transverse brace and separated by it from the area of the guitar's greatest vibrational activity. And thus being in an acoustically neutral part of the guitar top, the waist can be pretty much any size.



Fig. 12.8 The peghead of this guitar is "offset" to match the angling of the fanned frets; it makes a more pleasing and continuous line than if the peghead were of its usual squared-off orientation.