

Introduction

It is not that hard to build an acoustic guitar. Thousands of people every year complete their first guitars, generally yielding them great satisfaction. However, to design and build a really good guitar requires a union of artistic and technical disciplines rarely found together. The sciences of acoustics, physics and mechanical engineering blended with the craft of fine wood working and the arts of visual design and music must be successfully combined to yield the finest instruments. Gathering these skills together typically requires a budget that only large companies can afford, yet mostly the large guitar companies are necessarily about making money rather than making the best guitars. Much of the innovation consequently stems from the smaller shops and independent luthiers who push out the boundaries of the known and understood along the lines of their own particular skill sets. This, to a large extent, explains the rather sporadic development of the instrument over the last century.

In this text we bring together the science, craft and art of guitar building as we understand it, having learnt from many sources and from our own experience over more years than we care to remember. We would like to think that most of what we have written is fact. The vast majority certainly is, but our understanding still has its limitations and so some of what we have written can only be called opinion. But we understand why we hold those opinions! There are many areas where we find we disagree with previous writings in the field, particularly in the more theoretical area of the Design section. This is because we have found many earlier texts to be simply wrong. Either the logic of an argument doesn't stand scrutiny, or opinion has been expressed as fact, or mathematical analysis based on some "going in" assumption has been found to be mathematically incorrect or the assumption to be unjustified. Consequently, it is not surprising that guitars, their designing and their building are surrounded by myth and legend. Certain bodies of people, particularly those who trade in vintage instruments, have a vested interest in perpetuating these notions. "They don't build them like they used to..." Well, no, "they" don't. The guitars built now, including factory instruments, are vastly superior in practically every department. Our view is that the value of an instrument should be judged primarily on its playability and musicality, not its age or pedigree and that is not just because we build instruments, it is because it is logical and sensible. After all, guitars, like the rest of us, have a useful life and then they die!

We have not dwelt on the history of the instrument as we believe this to be reasonably documented by others. Rather, our focus has been on the future of the instrument, providing methods and techniques for building better guitars in what is already recognised as a golden age of guitar building.

We have organised the text into two major sections, Design and Build. In Design we start with the basics of sound, hearing and the nature of vibrating bodies. Our many conversations with other luthiers, student builders and musicians have demonstrated that there is a diverse range of understanding of these essential topics. But to communicate effectively we require a shared lexicon and a common understanding of these subjects. We then dive into the physics of vibrations and the mechanics of structures so that we can understand the implications of varying the guitar's structural and acoustical parameters in order to yield a more satisfying instrument for its intended purpose. We introduce the concept of "the efficient guitar", an instrument that is significantly louder and more responsive than the instruments you will typically find in a main street guitar store. Furthermore, we are able to quantitatively define "efficient" with reference to guitars so that the parameters to be manipulated in their creation can be readily understood. We dedicate a section to mathematical modelling in order to demonstrate some of the relationships between the sound of the guitar as we hear it, the acoustics of how that sound is generated and the relationship between the acoustics and the woodwork of the instrument. We dissect the frequency response of a guitar and relate features in the guitar's response spectrum to our perceptions of the sound produced and the structure of the instrument. This allows us to relate sound to structure in a way that facilitates the tailoring of a guitar's sound to more closely match our intentions. We then consider the practical techniques required to bring a guitar from its build state to its design specification.

This puts us in a position to be able to articulate a design objective – the Perfect Guitar. Clearly, this can be a very different beast from musician to musician, but unless we can

articulate such an objective in predominately quantitative terms we cannot know what we are trying to build. We take a look at why guitars sound different and what governs that.

We develop design parameters for a number of different styles of guitar, two different bracing designs for steel strung instruments (X-braced and falcate braced) with their attendant usages (to our tastes!) and two bracing designs for classical instruments (fan braced and lattice braced) with descriptions of their differing flavours. We have selected these styles because we believe them to be seminal designs that have stood (or will stand) the test of time.

We examine the detailed design of each aspect and component of the instrument following the philosophy governing that instrument style. We consider the material choices available and how these choices may complement or compromise a particular design. We explore how composite structures, primarily wood and carbon fibre, can be exploited and how to make efficient use of modern materials. We examine how an instrument is laid out, an exercise in drafting and design, to be functional, musical and buildable. We do not consider sandwich constructed soundboards or non-wood soundboards.

Our overriding consideration is that function defines form. The constraint this places on the aesthetics of a design is absolutely minimal, and one could argue that this philosophy actually enhances the aesthetics of a design. If the aesthetics are allowed to dominate in the absence of serious consideration of function, the performance of the instrument as an efficient generator of musical sounds will surely be compromised. Throughout, we bear in mind the concept of "the efficient guitar", an instrument of extraordinary responsiveness that brings with it associated complexity; the complexity involved in balancing high volume, graded tonality, evenness across all the notes on the fretboard and in-tuneness, the features that distinguish truly inspirational instruments.

Having created a workable design, we move on to the Build section. We offer two views of many of the building processes; those techniques suitable for the small professional shop and those suitable for the non-professional builder, where productivity is not such a serious consideration. Some processes are very similar or identical, as we have assumed that the non-professional builder already has a reasonably comprehensive tool set and is prepared to invest further either to make a particular tool or add further tools. We do not expect the non-professional builder to have access to stationary machinery such as jointers, thicknessers, wide belt sanders etc., but we do expect a drill press, a band saw, a light router that can be used free or mounted into a table and a selection of edge tools (chisels, planes, scrapers). We anticipate that the builder will already possess some woodworking skill to go with the tool set, otherwise a guitar project will indeed be challenging. We also recognise that even the best make mistakes and some of the secret to success lies in recovering effectively from those mistakes and learning to eliminate them. So we offer advice to "get you out of jail" in areas where we foresee potential difficulties.

If we have encouraged people to expect instruments well beyond the capability of those usually found in main street shops and if we have encouraged people to experiment with guitar design and construction, we will feel that we have succeeded with this text. Whilst we expect to provide answers to many questions which have previously been unanswered or unasked, we also anticipate the generation of more questions, discussion and probably some controversy. If this is the case we will be happy in the knowledge that the future of the acoustic guitar is in good hands and we hope you enjoy what we have to offer.

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