7.8.1 The legend of the primary tone

A citation from Gitarre&Bass 11/05: *Let us first distinguish between two categories of parameters that decisively influence the sound (primary tone) of a guitar. On the one hand, there is the basic construction that is determined by the selection of wood, the geometry, and the craftsmanship of the builder. The second category describes the (flexible) tuning of the hardware and the process of playing-in the guitar.* Type of wood, geometry, and processing – without doubt these are important elements of the electrical guitar. The expensive but not very solid balsa-wood is as unsuitable for a guitar neck as a 5mm-thick plank from spruce would be as the sole constituent for the guitar body. Glue joints of a width of a millimeter are not evidence of great craftsmanship – even if found in expensive instruments [G&B 1/09]. However, what significance do differences have that occur within the well-trodden paths of decades-old tradition? Ash vs. alder, polyester vs. nitro lacquer, 3.1 vs. 4 kg, brass vs. aluminum? Corresponding opinions range from *completely irrelevant* to *fundamental*, and the rationales are as inconsistent as the proclaimed dogmas. The following statements are given by one and the same author: *the so-called old-wood tone of 50's Les Pauls is of such excellence that these icons cost a fortune today [G&B 10/08]. Personally though, I do think that there is not much to the legend of the old wood [G&B 2/07]. A real 59 is, after all, the holy grail that bewitches our ears. Apparently, there is something to that. [G&B 3/08]. The so-called vintage market is a first-grade web of prejudices [G&B 4/06]. The sound depends on the selection of the wood first [G&B 3/06].*

Of course: the **wood**: *The electrified solid-body guitar predominantly is an acoustic instrument. The woods determine the character of the sound; the pickups contribute only very little [G&B 02/00]*. It should follow that if we change the wood, the sound would also change. That is the primary tone, i.e. the sound in the air as radiated by the guitar itself, and as a consequence allegedly also the "electric sound" generated by the loudspeaker. It is taken to such an extent as self-evident that the electric sound is coupled inextricably to the sound coming from the body, that test reports often not even clarify anymore what is designated "smack", "throaty", or "funky" in this area. But is it really true that the guitar played "dry" already reveals "it all"? Scientific theory vehemently objects – but the true old-wood guy will not be ruffled in his opinion by something as academic as vibration theory … especially if he has just spent a small car's worth of dough on selected premium wood. Well then – let's experiment. Since it is practically (!) impossible to play an electric guitar with sufficient reproducibility the same exact way again after exchanging the body, we choose a different approach. A Stratocaster (American Standard) was played in the anechoic room in turn with and without solid contact to an (open) wood cabinet. **With contact** indicates that the lower bout of the guitar was placed on the cabinet; **without contact** means that the guitar was at a distance of a few centimeters from the enclosure. Using this method it was possible to enlarge the guitar body by a resonator of a volume of 75x39x25 cm^3 and to more than double its weight. The airborne sound was recorded using a measurement microphone (B&K 4190) positioned at 10 cm in front of the neck pickup; in parallel the voltages generated by the neck pickup was also captured. Just like in the "Stratone"-report [G&B 5/07], an experienced guitarist continued to play an E chord in the lowest position. As was to be expected, the change from "without contact" to "with contact" was clearly perceived when listening to the airborne sound: the guitar sound stronger and fuller with contact – the drastically enlarged body converted the Strat into a kind of semi-acoustic guitar. So, with the purely acoustic sound telling us the whole story about the primary tone of this modified Strat, the electric sound would have to show a similar difference. Getting a bit uneasy now, dear wood-freaks? A small difference maybe? A slight trend, at least? Mind you, the body of the Strat has increased by half a square meter. Let's listen, and let's take some measurements.

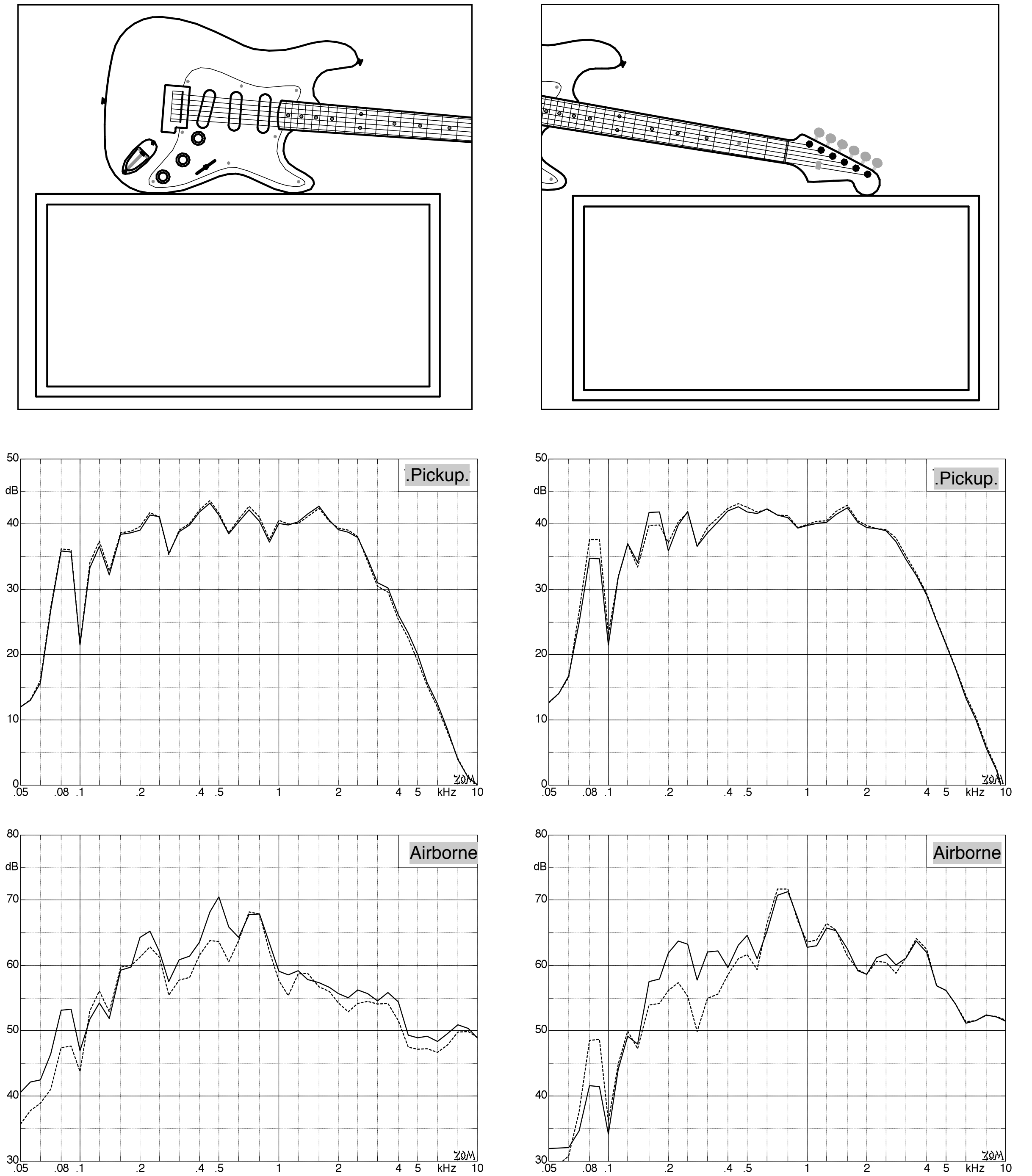

Fig. 7.86: Stratocaster. Left column: body with (——) and without (----) contact to the wooden box.
Right column: with/without contact to the neck. Middle row: pickup output, bottom row: airborne sound

In its right-hand column, **Fig. 7.86** shows 1/3rd-octave spectra of the pickup voltage and of the airborne sound. The standard deviations of the 1/3rd-octave levels across 20 E-chords with and without contact amounts to about 1 dB; therefore the differences visible in the graph for the pickup-spectrum are definitely insignificant while the differences in the airborne sound certainly are. However, we wanted to avoid getting too theoretical – so let's move on to the listening test: the microphone recordings reveal every single contact change, while from the pickup signal not a single change can be identified. That's 100% against 0% - it does not get any clearer than that. Increasing the Strat body changes the airborne sound (the primary tone) so *dramatically* that even the layperson will recognized the difference. **For the pickup signal, even the expert cannot hear any difference.**

Just to be safe, the experiment was repeated the next day, this time using 2x32 E-chords. The result was the same; changes in contact were very clearly audible in the airborne sound while there was no way to hear from the pickup signal whether the guitar had any contact to the wooden box or not. There is a simple explanation: the retroactive effect of the guitar body on the string is so minute that the pickup voltage changes only insignificantly. From a very theoretical point of view, the voltage must change a tiny little bit, after all – but we were not going into much theory here: that was considered extensively in Chapter 1.6. Or by Fleischer [8], who puts the differences between acoustic and electric guitar very nicely in a nutshell: *while in an electric guitar the strings are to be kept as immobile as possible at the bridge, they have to rest on a moveable bearing in the acoustic guitar. There is no other way to convert the string signal into sound in a purely mechanical manner without electro-acoustic means.* In the **acoustic guitar** with its efficient coupling between string vibration and airborne sound, the material of the top merits highest attention because the top needs to vibrate and radiate the main share of the airborne sound. Compared to this situation, vibrations in the body of a solid electric guitar are of subordinate significance. This does not mean that just any material would be suitable for the electric guitar, and that its body has no impact at all: rubber would indeed be not conducive. However, if contact to half a square-meter of blockboard has no audible effects onto the electric sound, the issue of whether the body is made of ash or of alder moves rather far into the background.

Besides the body, there is another resonator that is the object of any evaluation of a guitar: the **guitar neck**. Due to its elongated, relatively thin shape, it is predestined to exhibit Eigen-oscillations (natural oscillations), and its material is subject to extensive speculations, as well. Therefore, in a second experiment, the headstock of the Stratocaster was brought into contact with the wooden box, or not – so again it's with and without contact. The results can be seen in the right-hand column of **Fig. 7.86**, and this time we can isolate a small effect: at two places in the pickup-spectrum, small differences show up – they may just be noticeable. In theory, that is – practically, again no difference was audible in the listening tests. In contrast, the microphone signal did sound different. It seems that the two small changes in the pickup signal do not weigh in sufficiently compared to the many 1/3rd-octave levels that remain (on average) the same. The acoustician is not surprised about any slightly more pronounced differences in the pickup spectrum that appear as the neck is brought into direct contact with the wooden box: the neck could operate as transformer (lever) and improve the matching to the wooden box. To verify this hypothesis, supplementary vibration measurements would be required; but these were dispensed with because the effects are too small.

And so we arrive at our first **conclusion**: those who enthusiastically record the airborne sound of a solid-body guitar, those who may even consider such activity as the main purpose of such guitars – they certainly will be wise to pay attention to the material and build of the guitar body. We other guitarists who plug the guitar into an amp that we then turn up, we should only think about the wood when it comes to ergonomics or cosmetics; the luthier will not have used insulation board for the instrument i.e. the material will be ok. Back in the day, Leo Fender cut up wood that was affordable and in reach to him – neither ash nor alder are classical tone woods, and they don't have to be, either. For the acoustic guitar, things are very different: who would ever bolt *a steel-sheet casing of the dimensions of an external 2.5" hard drive to his or her pre-war Martin*? Fender does that for their VG-Stratocaster, and nobody is bothered; *the guitar fully meets all expectations [G&B 7/07]*. A hole for the battery compartment is also milled into the body – great guitar, still! And why not, the thing will work as long as neck and bridge can be solidly fixed to the body. With the Martin (to stay with the example), that situation would be very different, but that guitar is something else entirely, compared to Fender's VG.

Would all the energy fed to the guitar via the plectrum be (acoustically) converted into sound, an SPL of more than 90 dB at the ear of the guitarist would result. In reality, we find only 60 dB, corresponding to an **efficiency** of a mere 0,1%! In fact, the energy in the airborne sound is a part of the original oscillation energy of the strings, and thus any changes in the airborne sound do indicate changes in the string damping – but this effect is most insignificant. If we assume the hearing threshold to be at an SPL of 10 dB (as a simplification), and a decay time of the tone of 6 s, the guitar sound having 40 dB SPL initially would become inaudible after 6 s. A cavity (resonator) coupled to the guitar improves the sound radiation to 50 dB SPL, and we hear the guitar sound for 8 s – *the decay time is the same*. If we amplify the pickup voltage, and have a loudspeaker generate an SPL of 70 dB, we hear the string ringing for 12 s. There are several simplifications in this scenario, but the basic principle remains clear: the time we hear the strings of the unamplified guitar ring says nothing about the mechanical damping of the strings, nor does it indicate anything about the sustain of the guitar played through an amp.

Drilling holes into the guitar body that later are again covered up by a panel (the **pickguard**) will have a significant impact on the vibration behavior of the body. In a Stratocaster (Fig. 7.86), the pickguard covers almost half of the upper side of the guitar body and will necessarily influence the sound radiation. Of course, apart from the size, also the local distribution of the vibration velocity is important for the sound generation of such a panel, and here we run into difficulties. There is no doubt *that* the pickguard vibrates, but *how* does it vibrate? Over the years, the thickness and the material have changed; for some periods there was an aluminum sheet between wood and pickguard; then again the sheet was replaced by a mere foil, and even the number and placement of screws fastening the pickguard varied. In later years, the cutout in the wood was enlarged so that humbuckers could be accommodated, up to the point where a huge section of wood between neck and bridge was removed. All this will supposedly have no impact on the sound, as long as ash (or alder) is used for the wood of the body? Only the wood determines the sound? An allegation that is highly questionable.

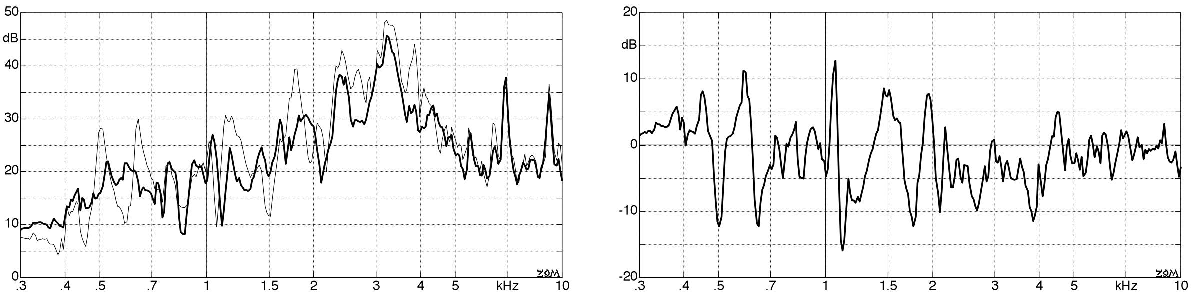

Fig. 7.87: Transmission from excitation force to SPL (bold line: w/pickguard, thin line: w/out pickguard). Right level differences; positive values = pickguard amplifies, negative values = pickguard attenuates.

A simple experiment demonstrates the effect of the pickguard: via a shaker (B&K 4810) located close to the bridge, a Stratocaster was subjected to vibration in the anechoic chamber, and a measuring microphone (B&K 4890) recorded the radiated airborne sound in front of the guitar body. **Fig. 7.87** shows the transmission from excitation force to airborne sound: with pickguard, and without. Clearly, the pickguard changes the radiation by more than ±10 dB – in fact that's just the behavior that may be expected given a bolted-on cover. As we change the torque used to fasten the mounting screws, the radiation changes, as well; the same happens if we sand down the surface the cover rests on. The voltage of the pickups is not at all affected by any of this in any way. It may be relevant for the "dry test" (i.e. the purely acoustic sound of the solid-body electric guitar). It's just that the "dry test" itself is entirely irrelevant (for the electric sound of the solid-body electric guitar).

