7.11 Solid Body vs. Hollow Body

In order to be able to radiate sound as well as possible, the archetypical guitar featured a hollow body sporting a thin top. Early protagonists of electrification tried to sense the vibration of the top using pickups of record players, but Adolph Rickenbacker, Paul Bigsby, Les Paul, and Leo Fender (to name but a few) soon realized that the sound-amplifying effect of a hollow body can be dispensed with as soon as the loudspeaker takes over. Enter the solid body guitar. Its body consisted of a solid board (or several boards glued together) of an overall thickness of about 5 cm, and it was not hollow anymore but solid (hence the name). However, not all electric guitars operate according to this principle, there have been (and still are) several variants:

- The "electrified" acoustic guitar, that received pickups merely as an add-on,
- The hollow semi-acoustic guitar,
- The semi-acoustic guitar fitted with a sustain block (semi-solid guitar),
- The solid guitar (solid body).

The electrified acoustic guitar (having a "full resonance") has a hollow body of about 12 cm thickness and includes 1 to 3 magnetic pickups. N.B.: alternatively, it may feature a piezo pickup stuck to the top; after Charlie Kaman took care of associated groundwork, this pickup has been banished into the (Ovation-) bridge. Besides these big matrons that are often lovingly cradled in the arms of Jazz guitarists, we find (heavy) solid-bodies (e.g. Les Paul or Stratocaster), and in between the more or less hollow ones: semi-solid (e.g. ES-335) and semi-acoustic (e.g. ES-330).

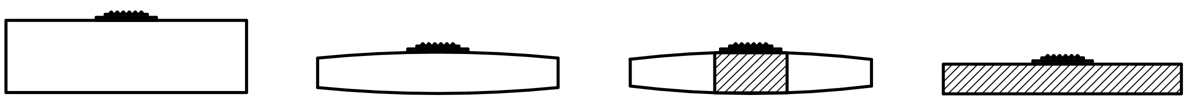

Fig. 7.123: The four basic types; acoustic, semi-acoustic, semi-solid, and solid-body guitar.

On top of the basic models shown in **Fig. 7.123**, there are some more intermediate variants such as the solid body into which more or less extensive cavities have been milled, or the more or less braced semi-acoustic; and all these with or without sound- (or F-) holes (real or just painted-on). The bridge finds very solid (sic!) footing with little damping on the body of a solid-body guitar such that the vibration of the string is determined for the largest part by attenuation due to air, internal damping, and damping due to the neck♣. Give a freely vibrating top, things are very different: the bridge placed there is not as immobile as it is on the solid-body, it yields somewhat to the string excitation and in turn dampens the decaying oscillation of the string. The determining magnitude here is not just the **bridge mass** because any stiffness acting on the bridge will reduce the reactive share of the mass. As a formula:

$$\underline{Z} = W + s/j\omega + j\omega m = W + (s - \omega^2 m)/j\omega$$ Spring/mass/damper-system

Combining this equation with the condition for resonance $\omega^2 = s/m$, the imaginary (reactive) parts compensate each other, and only the damping resistance W remains. The active share of the bridge-admittance $\underline{Y} = 1/\underline{Z}$, i.e, the **conductance** introduced in Chapter 7.7.4.4, reaches values of such magnitude in acoustic and semi-acoustic guitars that it becomes significant relative to other damping mechanisms. Only in guitars of such build has the wood of the body a more-than-marginal influence on the "electric sound" – only for such guitars is it worth to investigate the construction of the body more closely.

♣ Other mechanisms of damping are summarized in Chapter 7.7.

 Translated by Tilmann Zwicker

Fig. 7.124 juxtaposes the conductance and the decay times of the partials in several guitars, including the Fender Stratocaster as archetypical solid-body, the Gibson ES-335 as sustain-block-reinforced semi-solid, the Rickenbacker Nr. 335 as semi-acoustic with a strong top, the Gretsch Tennessian with a thin top, and the Martin D-45V as purely acoustic guitar. The measurements were taken with some time lag; smallish differences between the decay curves and the conductance curves may therefore be possible.

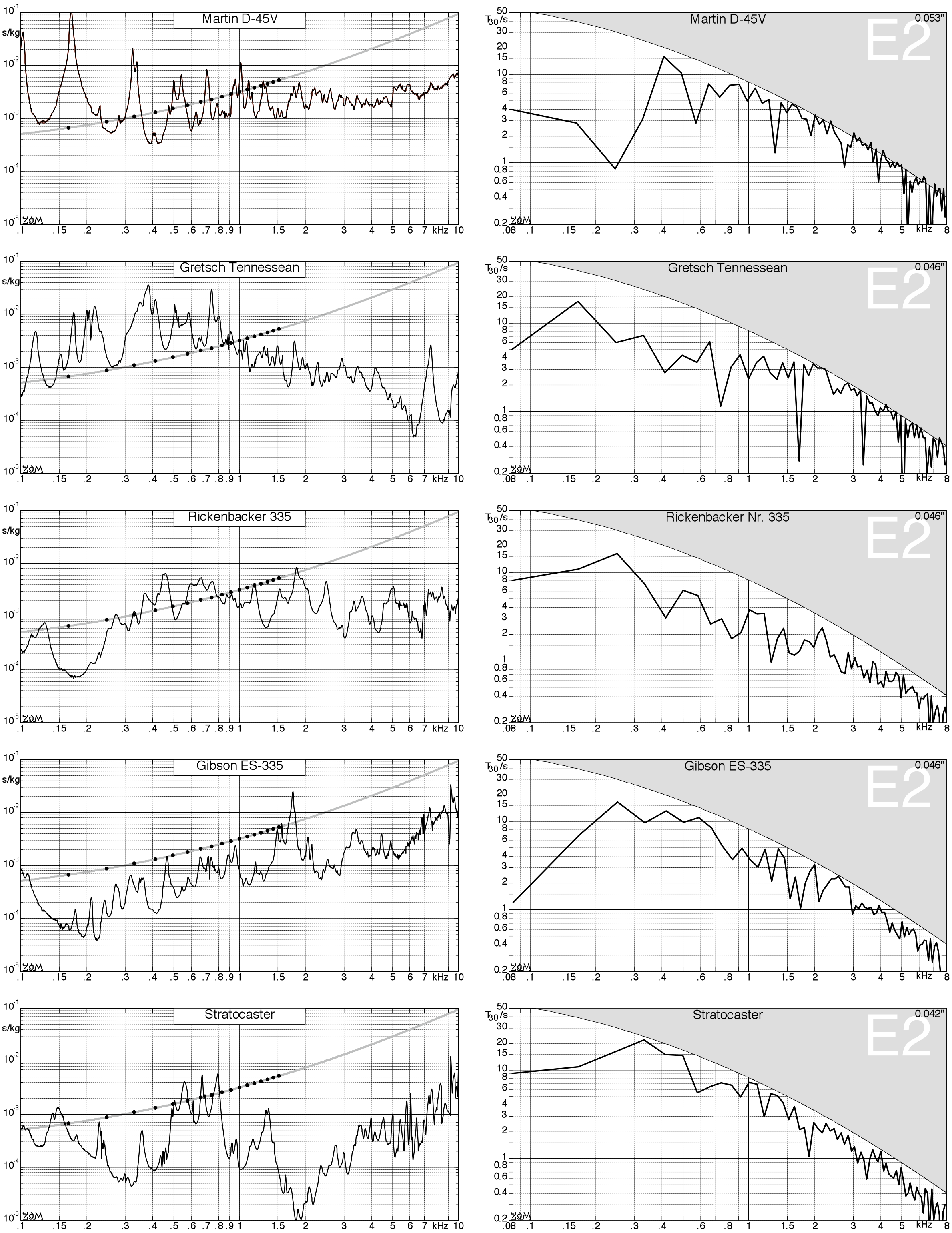

Fig. 7.124: Bridge conductance and decay times of partials (open E2-string).
The grey area indicates the theoretical maximum T_{30}-decay due to internal & radiation damping (Chapter 7.7.2).

Fig. 7.124 shows the **Stratocaster**-bridge to be relatively immobile; only between 500 Hz and 800 Hz we find any significant maxima in the conductance – these are due to the special design (spring bearing). The **ES-335**-bridge, too, is rather on the immobile side, with the exception of the bending vibration between 1.5 kHz and 2 kHz. The **Rickenbacker**-bridge fails to find a truly solid base on the freely vibrating top (only reinforced by a simple X-bracing), and the quite significant conductance results in a reduction of the decay times up to about 2 kHz. The **Tennessean** exhibits an even larger conductance with the thin top vibrating strongly (and absorbing correspondingly). The **Martin D-45V** is a pure-bred acoustic guitar (without pickup), and its top has pronounced low-frequency resonances.

The **conductance** at the bridge is not the only source of string-damping, but it may become its main component. However, if the conductance drops to insignificant values (such is the case for the Stratocaster above 800 Hz), the bridge and the body below it do not contribute much to the sound (in this range) anymore at all. It has already been elaborated in Chapter 7.7 that the string moves in circular and longitudinal vibrations, that inner damping and neck-damping also contribute to the overall damping, and that pick and the attack performed by the player have a big influence on the sound. Generally evaluating the decay time of the Stratocaster, we identify three ranges: below 300 Hz there's neck-absorption, between 500 Hz and 800 Hz, there's bridge/spring-absorption, and above 800 Hz, the treble dissipation due to inner damping occurs. Addressing all those who seek to give extra value to the many individual peaks: be cautious, since these small peaks change permanently if we merely press the little finger against the bridge. It has also repeatedly been noted that the decay time shown in Fig. 7.124 can **only** be measured if **brand-new strings** are being used. After only 30 min of stage work, the decay times for the E_2 at middle and high frequencies may have dropped off to $1/3^{rd}$ or $1/4^{th}$!

Compared to the Stratocaster, the other guitars analyzed in Fig. 7.124 reveal shorter decay times in some ranges – this is i.a. due to the respective bridge- or top-construction. How much (or how little) the bridge conductance depends on the given bridge of one and the same guitar, is shown in **Fig. 7.125**: the Gretsch Tennessean (made in the 1960's) was fitted with an **aluminum bridge** (Rocker bridge), but the **cylindrical bridge** (straight bar bridge) could be found in the case, as well. Up to about 1 kHz, the bridge conductances differ only slightly – for this guitar, the influence of the top dominates in this frequency range. At higher frequencies, the differences in conductance between the two bridges are more pronounced, because the cylindrical bridge is a bit less happy to vibrate and therefore dampens slightly less. However, these conductances have little influence on the string movement because in this (middle and high) frequency range, the internal damping of the string already dominates.

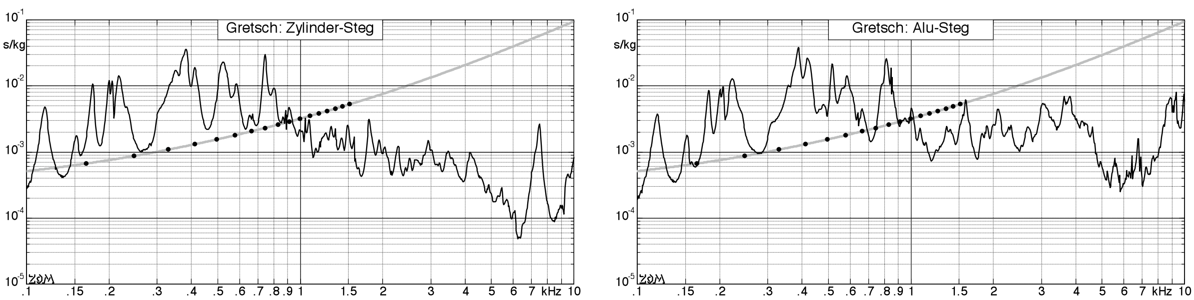

Fig. 7.125: Gretsch Tennessean, bridge conductance for two different bridges (E2-string); "Zylinder-Steg" = cylindrical straight-bar bridge; "Alu-Steg" = aluminum Rocker-bridge.