7.8 Specialist Journalism

"Only write about subject matter that you are familiar with!" Any reference book on journalism will teach that – or at least it should teach it. So, why would a renowned neurobiologist write: "*Presumably*, due to the homogeneous and generally similar structures in the neo-cortex ..."? If he comprehends how neuro-plasticity works, he wouldn't have to *assume* anything, would he? And if he does not have sufficient comprehension, he shouldn't write a book about it, now, should he!? Well, if only the matter were *really exactly* known! In the fringe areas of research, at the borderline to terra incognita, conjecture is indeed quite permissible. And thus, a scientist may publish a new idea in the hope that soon proof will appear, and that – given that he has more of these ideas – he will eventually be regarded as the genius forward thinker. Even though one day it transpired that more than the six planets hypothesized by Kopernikus are revolving around the earth, the book published by him still remains *one of the biggest steps ever taken in the recognition of natural processes*[♣].

Is the above sufficient to legitimize the conjecture found in many a specialist magazine for guitar and bass: that the vibration of the string should be conducted as comprehensively as possible into the instrument body? In corresponding elaborations, the restriction "presumably" does not even appear anymore … apparently there is a *common consensus* about the "fact". Or maybe it is *common nonsense* – the corresponding circles are, after all, known for a notoriously carefree handling of loanwords and technical terms. Popular mix-ups are between inductance and induction[⊗], Oersted and Gauß, stiffness and compressive strength, bifilar winding and criss-cross winding. An alleged "expert" in circuit design introduced himself with the kind words: *myself, I often can't distinguish between when currents "flow" and when a voltage "is on"*. Doesn't matter, the guy is allowed – in spite of such profound moxie – to write up a monthly column about circuitry details in tube amps, praise the brash vibrations of the guitar "that you feel in your gut" as a quality attribute, and discuss relaxation effects in guitar cables as soon as he doesn't confuse the spelling of the term anymore. Are all these areas in fact fringe areas of research? Has nobody discovered the law of conservation of energy, the permeability, the Young's modulus, or the susceptibility? Of course they have – and quite some time ago, too! If you still surmise that tone wood will only by deformed permanently if the weight of 9 Leopard tanks presses down on the area of a 1-Euro-coin, you expose yourself to ridicule; you're not a specialist journalist but a universal dilettante then.

A journalist should impart knowledge, not stupidity. How can somebody be allowed to roam free while seriously claiming that the pickup-voltage of a Les Paul would change 'significantly' if its paper-thin layer of varnish has cracked in a few places? Or that the coloring (!) of the wire-insulation has effects on the sound? You may have such thoughts … but only in private. The reader does not have to know what inductance means in a pickup, and what induction brings to the table. Not knowing indeed often is motivation to read up. The author, however, really does need to know – otherwise he should dispense with publishing.
One myth rattling around in guitar literature is the topic of the next two chapters: allegedly, the body of an electric solid body guitar has a "**primary tone**" that shapes the sound to the extent that the pickup can only add a few nuances. It's ok to speculate about that, but it may not be corroborated with ludicrous assertions as it happened in the article "Stratone" (see Chapter 7.8.3). Sorry, dear author, but you have crossed the Rubicon. If you're looking for trouble, you've come to the right place. There's no more mere rolling of the dice from hereon.

♣ Der große Herder, Volume 7

⊗ That's about as small a difference as between astronomy and gastronomy.

 Translation by Tilmann Zwicker

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.

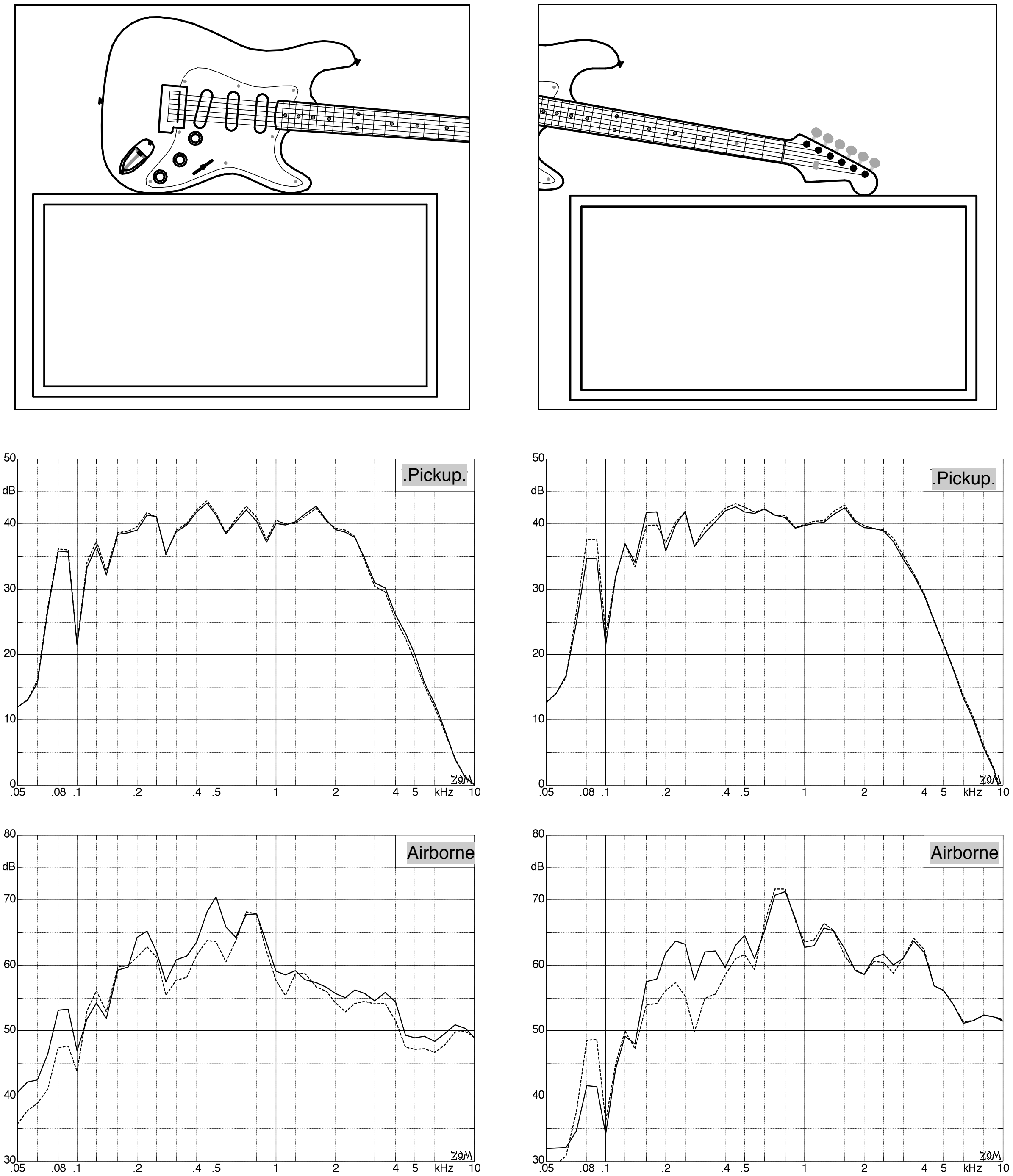

Fig. 7.86: Stratocaster. Left column: body with (——) and without (----) contact to the wooden box.
Right column: with/without contact to the neck. Middle row: pickup output, bottom row: airborne sound

In its right-hand column, **Fig. 7.86** shows $1/3^{rd}$-octave spectra of the pickup voltage and of the airborne sound. The standard deviations of the $1/3^{rd}$-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.

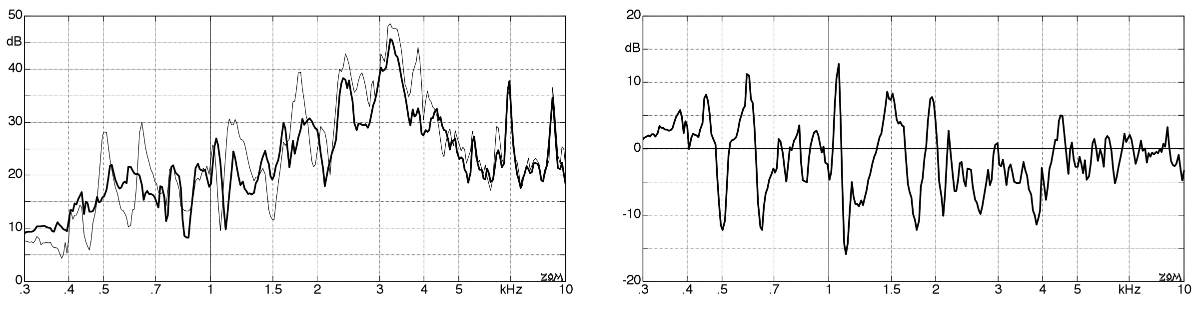

Fig. 7.87: Transmission from excitation force to SPL (bold line: w/pickguard, thin line: w/out pickguard). Right level differences; positive values = pickguard amplifies, negative values = pickguard attenuates.

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).

7.8.2 "Stratone"

A citation from the German magazine “Gitarre & Bass”, issue 05/2007: *For the sound, density, elasticity and hardness are decisive. Compared to ash, alder features a 10 – 20 % smaller density, i.e. a smaller weight relative to the volume – resulting in a faster response. The oscillation excited by the guitar string needs to push less mass. Furthermore, the smaller mass of alder results in a higher Eigen-resonance of the body. Resonances in particular absorb much oscillation energy, and so these frequencies disappear first. Ash, however, sounds brighter, and richer in harmonics.*

The faster response of alder mentioned above is further supported by the material’s higher elasticity. While the density describes the amount of mass per cm^3, the modulus of elasticity describes the maximum pressure that wood can mount against an external force without any permanent deformation.

Alder’s higher elasticity (relative to ash) has the effect of a cushioning of the vibration and thus of extraction of energy from the string, resulting in a shorter response time (i.e. harder attack), but also in a shorter sustain.

From the point-of-view of sound, the hardness of wood is considered in conjunction with the density. Harder woods, especially those with a high density, react substantially more sluggishly to vibrations than softer woods, and extract less energy from the string. The string shows a slower transient response but holds the vibration for a longer time. In the present case, ash is categorized as medium-hard to hard (i.e. with longer sustain), and alder as soft.

Compared to a Stratocaster made of alder, ash sounds harmonically richer and has longer sustain. On the flip-side, the response of alder is more direct, the guitar reacts more dynamically.

So much for the first part of the article, titled *Body*. Stating: *Alder has a smaller density relative to ash* – is that already incorrect? No, that’s o.k. as such, especially in a magazine article with the required reasonable length. Of course, there is not “the” alder nor “the” ash – we find black, white, green and red alder, and black, white and green ash (the latter also termed red or swamp ash), and of course the climatic conditions under which the trees grow will vary resulting in different physical parameters. So, only a radical simplification is the way out, if you do not want to “go down for the third time” already in the first paragraph, with special literature describing not just three but “65 different types of ash”. Given this simplification, alder has a 10 – 20% smaller density: 0.55 g/cm^3 versus 0.69 g/cm^3. We most humbly add that according to datasheets there is also heavy alder at 0.86 g/cm^3, and light ash at 0.41 g/cm^3. In dried condition, that is, because humidity will also influence the density.

However, whether a smaller density will result in a faster **response** is unfounded speculation. *The oscillation excited by the guitar string needs to push less mass.* O.k., so what? A mass alone will not define any attack-time. And most of all: it is the vibration of the string that the pickup of the Stratocaster investigated here samples, and not the vibration of the body. *Furthermore, the smaller mass of alder results in a higher Eigen-resonance of the body.* Huh? How does that work? A resonance frequency depends on both mass and stiffness, and nothing has been said about the latter so far. Body resonances exist – no contest there. But they exist already from a few hundred Hertz, and their impact on the string vibration remains purely speculative in the article to begin with.

The faster response of alder mentioned above is further supported by the material's higher elasticity. While the density describes the amount of mass per cm^3, the modulus of elasticity describes the maximum pressure that wood can mount against an external force without any permanent deformation. We are now leaving the area of journalistic freedom and encounter the first grave error that unfortunately exposes the author as rather ignorant and apparently missing crucial knowledge. To confuse elasticity and mechanical strength – that must not happen. The E-modulus – abbreviated from "modulus of elasticity" (or Young's modulus) – is a characteristic variable in the area of elasto-mechanics. Elasticity is the characteristic of a solid body to resist a deformation caused by external forces given linear, reversible behavior. Now, the modulus of elasticity is NOT the limit of the linear behavior but specifies the behavior far below the limit of linearity (i.e. at small loads). Indeed, while this modulus of elasticity does have, with N/mm^2, the same unit as the pressure, it does in no way specify a maximum allowable pressure. Dear young friend who writes about limit values in such an easygoing way, have you at all considered that this would-be limit-pressure for ash would be approximately reached if the mass of a car (1300 kg) pushes down on 1 mm^2!? Or if 9 combat tanks weigh in on the surface of one Euro (translator's remark: that's about as many tanks loaded onto the surface of one quarter US-$)!? No way, not even high-grade steel could withstand that. The E-modulus is a kind of specific stiffness: for alder about 9000 N/mm^2, for ash about 13000 N/mm^2. *Alder's higher elasticity (relative to ash) has the effect of a cushioning of the vibration and thus extraction of energy from the string, resulting in a shorter response time (i.e. harder attack), but also in a shorter sustain.* Indeed, alder features a smaller E-modulus, i.e. a smaller stiffness and thus a higher flexibility (which we could call elasticity) – but besides that, things already go awry again: extraction of energy, i.e. **dissipation**, will happen only in resistive elements (friction resistances) and not in springs. With the E-modulus, a parameter for spring stiffness was chosen, and not one for losses. How fast the vibration energy of the string is converted into heat depends on several parameters (see Chapter 7.7), the E-modulus alone does not help us here.

Since we have at our disposal now a specific stiffness (= E-modulus) on top of the volume-specific mass (= density), let's have another look at the resonance frequency. Assuming a piece each of ash and alder with the same dimensions, the mass of the piece of ash will be larger than that of the piece of alder – at least given the simplifications discussed above. However, not only is the mass of the ash larger but the stiffness of the material is also higher, and since the resonance frequency is dependent on the quotient of stiffness over mass, the resonance remains the same in a first-order approximation. No further speculations are allowable because both density and E-modulus vary – the piece of alder will therefore not universally have the higher resonance frequency.

From the point-of-view of sound, the hardness of wood is considered in conjunction with the density. Harder woods, especially those with a high density, react substantially more sluggishly to vibrations than softer woods, and extract less energy from the string. The string shows a slower transient response but holds the vibration for a longer time. In the present case, ash is categorized as medium-hard to hard (i.e. with longer sustain), and alder as soft. Ash is harder that alder, that much is correct. Any connection to transient processes (that is the term systems-theory has for "attack" and "decay") is totally speculative und unfounded. A transient process cannot be explained by a single material parameter. Which system should be in transient, anyway: the string or the body? If the body reacts sluggishly, the string should be able to respond quickly, shouldn't it?

Compared to a Stratocaster made of alder, ash sounds harmonically richer and has longer sustain. On the flip-side, the response of alder is more direct, the guitar reacts more dynamically. At last, here we have a statement that does not ride on any pseudo-scientific reasoning, and, as a subjective opinion, it does not make itself very vulnerable. It the author perceives it that way, he certainly may write it down. It is, however, clear from what follows that the unamplified sound radiated from the solid body is meant – but that sound is so unimportant that it does not take long to deliberate whether the descriptions are correct.

So what remains as a first **appraisal** before we turn to the neck of the guitar? There are some reasonably correct statements regarding density, stiffness, and hardness, we read some unfounded or even incorrectly reasoned assumptions regarding resonances and transient processes, and we find speculations about the holiest of all cows – the sustain – without a single word about material-specific damping parameters. But let's see how things progress:

*From 1959, a rosewood **fretboard** was used because of its higher durability. Taken by itself, the higher density and hardness of the rosewood would point to a more pronounced content of harmonics. However, the overall construction with the glued-on fretboard results in an additional disruption of the sound propagation within the wood – this makes for a softer and slower string attack in the rosewood-fitted neck compared to a solid maple neck.* Are you sure about that? Is it the string that is excited by the guitar body? It is almost as if the guitar player hits the guitar, the body of which needs to start vibrating in order to then make the strings vibrate. Just to be clear: the guitarist deflects the string with the pick, or fingernail, etc., and as soon as he lets the string go, it commences to vibrate. The latter happens very, very quickly, and completely independently of the guitar body during the first few milliseconds. That a string will start to vibrate more slowly and mellow – that is nonsense. *From 1959 – 1962, the interface between the maple neck and the rosewood fretboard was flat (slab-board). The sound becomes particularly meaty and fat, and gives an enormous depth to the characteristic mids.* In the book by Day/Rebellius, that reads rather differently: *the "slab-board" is one of the secrets of the renowned, old, crystal-clear vintage sound.* And then we find other verdicts, as well: *the direct A/B-comparison between a poplar-Strat with one-piece maple neck and an ash-Strat with maple/rosewood neck indeed reveals only minute differences (Gitarre & Bass, Fender special edition).* Even more radical is the statement by Lemme: *a one-piece maple neck and a neck with (extra) fretboard sound identical [Lemme, 2003].*

And on we go to the "**playing-in**": *scientifically, playing a stringed instrument for a long time implies, first of all, that the instrument is subject to vibrations for a longer time.* Hard to believe: that is actually totally correct! But then: *the effects are almost impossible to capture analytically because a piece of wood excited by the corresponding vibrations would have to be compared to an identical piece of wood that has been merely stored and not played.* Or as alternative: we would have to construct a setup that allows for a reproducible picking of the string both before and after the "playing-in". That would not be impossible – but it is not entirely trivial, either. Let us remember, though, that the energy transferred from the player to the string is very small (typically a few mWs per struck string). If we would take the above conjectures about non-reversible deformations seriously (granted – that sounds a bit polemic here), then *permanent deformations* would occur only at more than 13000 N/mm^2. So: no worries, mate, in reality only about 0.1 N/mm^2 weigh down on the wood, and that is even less than the compressive strength specified in datasheets (around 50 N/mm^2). We do not want to dispute generally that a guitarist <u>may</u> perceive outrageous improvements in the sound after a period of "playing-in", but the reasons for that can be highly diverse.

So much for the first part of this "specialist article" about the Strat. Given what we have established so far, it ends with an outright threat: *in the following issues I will report on the development of the mechanical components and the electronics of the Stratocaster.* This then reads as follows: *until the beginning of the 1970's, bent steel was used for the* ***bridge saddles****. The elaborate manufacturing process resulted in particularly dense material. Afterwards, the bridge saddles were first made of brass, then of coated, cast zinc. Relevant to the sound is the density of the materials – it dropped with each successive version of the bridge saddles. The densest material then is the steel. Zinc is even lighter than brass. According to generally valid material science, a less dense material absorbs less energy than a denser one.* Excuse me?! The density of brass is, according to generally valid books on material science, 8.1 – 8.6, while that of steel is 7.7 – 8.0, and that of cast zinc is about 6.7, each with the unit kg/dm^3. How much energy a material absorbs (i.e. converts into heat) depends not primarily on its density but on its internal damping parameters. The latter are, however, nowhere specified in the text – rather there is speculation about frequency dependencies: *less density and mass result in fewer harmonics*. In other words: higher density supposedly will give more harmonics. A few lines on, however, we read: *a Strat with bridge saddles made from steel that sounds too twangy and sharp can sound milder and more balanced with bridge saddles made of brass.* How can that be? Brass is, in this group of materials, the one with the highest density! It is hard to avoid the impression that the term "density" has been misunderstood. What happens if you compress a material? It becomes denser! And what were the bridge saddles of old Strats made from (according to Duchossoir)? From "**pressed steel**"! Well then … pressed steel, that's compressed i.e. mightily dense, isn't it? No Sir, it ain't – you failed to understand what the term actually means. *Pressed steel* means: the part is made of punched-out steel bent into shape. That is what the bridge saddles of old Strats were made of, and how they were made – in sharp contrast to the block-shaped pieces introduced later that – simply due to larger volume – featured more mass. The latter aspect is, however, totally ignored, just like the unavoidable friction occurring in the gaps between the parts of the bridge assembly.

It does get still worse, though: *Compared to a block of cast steel as it has been used since the 1970's, the earlier, cut-out block contains less oxygen and therefore has more mass.* **Oxygen** within a block of steel: now that's not something the metallurgist likes – at all. From way back, our memory switches on a red warning lamp when oxygen and iron show up in combination: RUST! The generally valid material science comments: the oxygen bonded to the iron atoms is present as FeO-slag after solidification of the molten mass, and can partially be released to other metals (e.g. Al) as desoxidisation happens. In any case, the share of oxygen remaining in steel is so small that it cannot have any substantial effects on the density. That's what material science says. The Stratone-author, however, says: *predominantly, the cut steel-block makes itself felt via additional harmonics and stronger attack*. Rather on the side, we are informed that the cast-iron block is thinner by 2 mm compared to the cut block. That could also have an effect on the mass, couldn't it? Nobody denies that the tremolo block can influence the sound, but ludicrous conjecture (*the behavior is similar for metal and wood*) does not help to get to the bottom of that. Quite amusing: another G&B-expert states in G&B 7/2005 that **titanium** would be the best material for the trem-block. Titanium, however, has – at 4.5 kg/dm^3 – an even smaller density than cast zinc, and therefore there should cause a treble loss, according to the first author. Far from it, though: *due to the titanium block, the sound is richer in harmonics.* Despite the fact that the titanium block – precisely weighed – *is roughly 120 g lighter than the original.* Isn't that strange? What does hold here: *less mass = additional harmonics* (G&B 7/2005), or *less mass = less harmonics* (G&B 6/2007)? In any case, we get: less mass = more money, because titanium was never cheap – 330 Euro, to be precise. That's just for the trem-block, not for the guitar, and including stainless-steel screws … for titanium screws would have cost another 40 Euro extra.

Before we call in frequency spectra to corroborate this G&B-mess of loosely collected conjecture, let's digress a little into vibration engineering. We read: *the **nut** is supposed to transfer the vibration energy as completely as possible into the neck.* Sure: the neck should vibrate tremendously, and the string should transfer its vibration energy as completely as possible to the neck, and consequently stop vibrating … This would follow from the well-know physics-law of conservation of energy. Because when the string has transferred all its vibration energy to the neck, it has no vibration energy anymore itself. Too bad, we would have gladly granted it that extra sustain, the holiest of cows. But more about that later.

Now, the Stratone-author does not limit himself to conjecture about the scientific reasons for differences in sound, but he procures 7 different Strats, and analyses their sound: *for the recording of the unamplified sound of the guitars, a Rhøde NT2 condenser microphone was positioned at 10 cm distance pointing to a spot between neck pickup and heel of the neck.* Then analysis was done using short-term DFT. The spectra depicted in the magazine are without scaling on the ordinate and can therefore not purposefully be evaluated. However, the sound files were also available at www.gitarrebass.de, and with these a scaled analysis could be carried out. We will not right now go into whether it is meaningful at all to analyze the purely acoustic sound of these solid body guitars; let's just look how the measurements and the G&B-statements line up.

Subject to analysis are alder-Strats built in 1959, 1962, 1972, and 1974, as well as ash-Strats built in 1972 and 2005. The 1995 alder-Strat was not evaluated – its file differed too much from the others. In the following analyses, **ash-Strats** are designated with an S and **alder-Strats** with an L. Under scrutiny is the G&B-statement: *compared to the alder-Stratocaster, the ash-Stratocaster sounds richer in its harmonics and has a longer sustain.* In **Fig. 7.88**, the analyses of the first 4.5 s of sound are shown. And here we already run into the first problems: the sounds result from an E-major chord played across all 6 strings – but the author was not aware that he should strike all 6 strings as similarly as possible for all test sounds. And so the plectrum gets caught a bit in this string or that string, or it audibly strikes the pickguard. Well, we have to live with these inadequacies – no other recordings have been published. Let us regard the first statement: *compared to the alder-Strat, the ash-Strat sounds richer in its harmonics.* The $1/3^{rd}$-octave spectra averages over the first 4.5 s do not confirm this assumption: it's the 1972-alder-Strat that featured the strongest treble. In the summation level, the assumption regarding the sustain cannot be confirmed, either: an alder-Start is ahead only between 0.5 and 1.2 s, from then on there is no difference remaining between 2 ash- and 2 alder-Strats. Since for all guitars the higher-frequency partials decay more quickly than the lower-frequency partials, a faster decay of the overall level is to be expected for more trebly sounds (slightly simplifying things): the more the higher partials define the overall sound, the faster the latter decays.

Of course, one may object to these analyses that neither the summation level nor the averaging over 4.5 s is very meaningful. Narrow-band level measurements, encounter other problems, however: the levels of individual partials decay only in exceptional cases according to a simple exponential function, and beats often occur due to circular wave polarization and due to bearing impedances dependent on the direction of the oscillation (Chapter 1.6). Moreover, there are interactions between the partials of individual strings that can lead to pronounced beating. **Fig. 7.89** shows the $1/3^{rd}$-octave levels for the individual guitars. The $1/3^{rd}$-octave level at 80 Hz approximately captures the E_2-fundamental that may decay both for the alder- and the ash-Strats with or without strong beating – no confirmation is found in these measurements that ash-Strats would have a longer sustain.

The comparison at 125 Hz is different in that with one single exception, all 1/3rd-octave levels decay with practically the same speed, but again there is no longer sustain apparent for ash. Yet different again is the situation for the 160-Hz-level: all 6 measurement-curves differ significantly – as it is the case at 500 Hz, as well. Given such strong level-fluctuations, a general statement in the sense of *ash-Strats have a longer sustain* has no foundation.

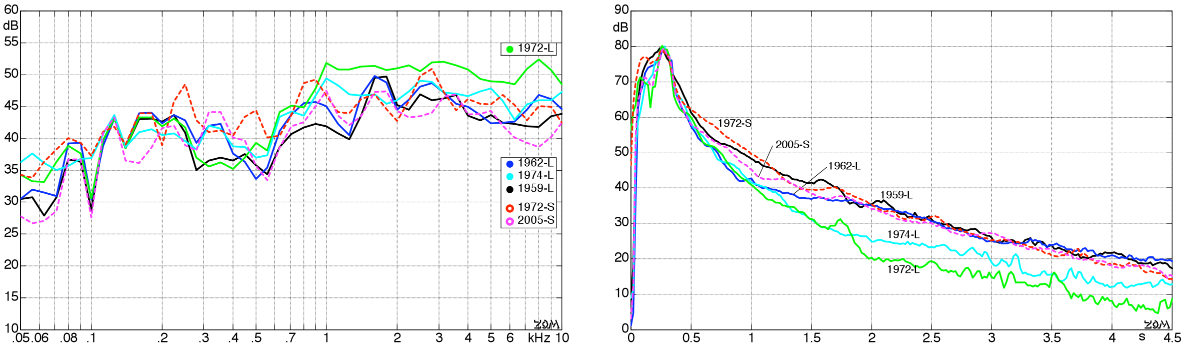

Fig. 7.88: 1/3rd-octave spectra (left) und overall level (right); sound-files acc. to G&B 5/2007 p.212, normalized.

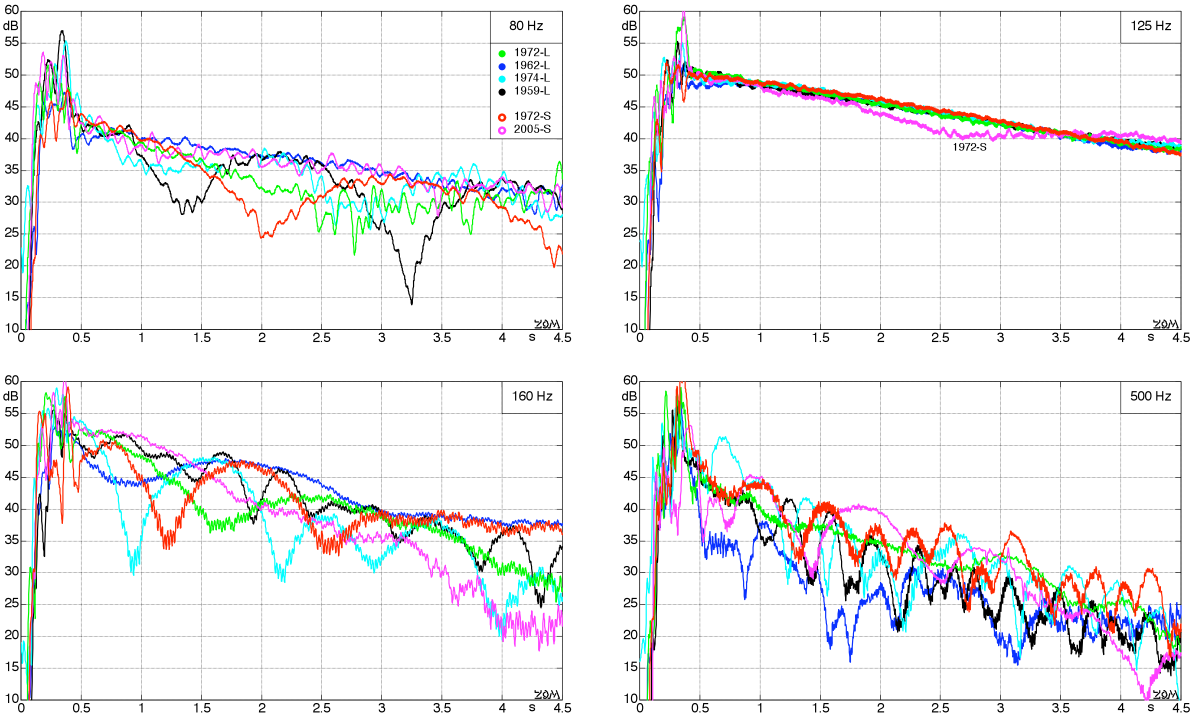

Fig. 7.89: Decay of individual 1/3rd-octave levels. Since in these curves only the decay (or the slope) is of interest, they were vertically shifted for best possible evaluation and comparison.

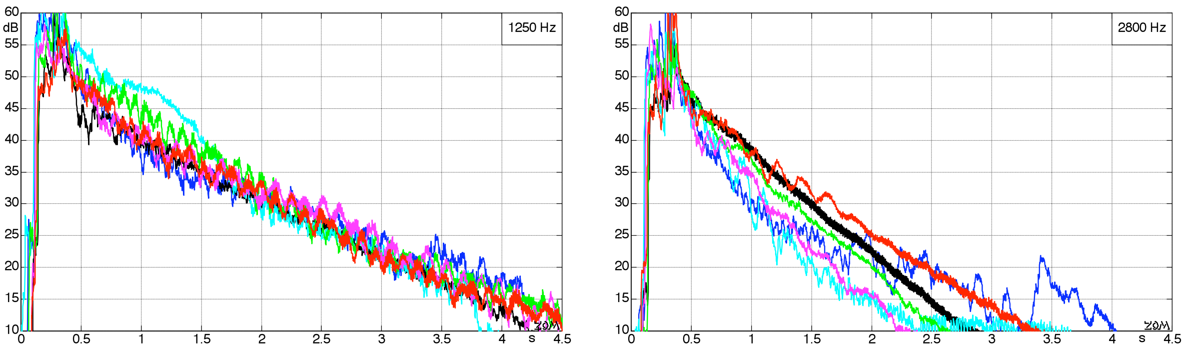

Fig. 7.90: Decay of individual 1/3rd-octave levels, compare to Fig. 7.89.

It does not make any sense to measure the beating-parameters, because with a minimal detuning of one or more strings, the beating will change. Such beats also show up in the waterfall-spectra published in the G&B-article albeit there is no scaling. As we move towards higher frequencies (**Fig. 7.90**), the beating decreases in strength (many partials per 1/3rd-octave), but again the statement regarding the difference in sustain cannot be confirmed. At 1.25 kHz, the ash-Strats correspond to two alder-Strats, and at 2.8 kHz already the two ash-Strats (red/magenta) differ significantly from each other. **Conclusion**: the level measurements cannot support any significant difference in sustain between ash and alder. Even before we advance to the core question of whether parameters in the airborne sound have any relevance for the pickup signal, we have to recognize that already the statements about the parameters of the airborne sound fail to bear objective scrutiny. Therefore, dear Strat-analysts: don't forget to always put a scale to the ordinate – then you will see this result yourselves, too.

While it is highly commendable that statements regarding the wood are deduced from results of experiments, the framework for these experiments still needs to fit, and the investigated guitars must exclusively differ in the wood. In the present experiments, they do not – as the G&B-author attests. Most important for the decay process of the string vibration is the distance of the string to the frets, and the initial displacement of the string. No information at all is given about the condition of the frets, and we can only surmise that the guitars were not refretted before the experiments. Not even regarding the action (distance from string to frets or to fretboard) there is any information, and the author is silent about the age of the strings, as well. So what's the point here? If we carry out such experiments, it is mandatory to restring all guitars with the same kind of strings, and the action needs to be adjusted to be as similar as possible. The strings must be reproducibly picked with a suitable device, and even the support for the guitar is significant: already lightly gripping the guitar neck with thumb and 1st finger (without even touching the strings) changes the decay behavior quite substantially (compare to Chapter 7.7). However: even with perfect conditions, what actually is the connection of the airborne sound recorded at a distance of 10 cm from the guitar to the voltage generated at the output jack? That is the central question here … but the answer shall be put on the backburner because there is a lot of text regarding the guitar electrics still to be looked at. *The signal runs through a capacitor that presently has a value of 0.022 µF. In combination with the coil it forms a band-pass.* Close, but topologically this is a low-pass (series-L and parallel-C). *Our comparisons show that the more massive build (of the capacitor) promotes a more musical effect due to fewer frequency cancellations in the pass-band. The sonic image of the larger capacitor seems fuller and denser.* What rubbish – here a blind man judges colors. The pass-band is in fact characterized by passing signals, not cancelling them. Also, what is actually the pass-band of this *band*-pass? What does *a more massive build* indicate? Smaller, i.e. less (geometric) volume? Ceramics rather than foil? Or more weight? Very puzzling, this …

Regarding the **pickup**: *sonically relevant is not only the main resonance that can be calculated mathematically, but also the countless ancillary resonances and cancellations. The winding is mainly responsible for this … back in the day it was customary to guide the wire in such a way that overlaps would result i.e. that not all turns were exactly in parallel. This method is called biphilar winding.* Okay … phew … after we've all managed to compose ourselves again, and have not incurred any permanent damage by this blow, let's get this straight: a bifilar winding is set up if induction is not desired – in short. The term is bifilar (not biphilar) because two threads (Latin: filum = thread) are wound. Using today's terminology we would say: two parallel wires with connected beginning are wound. The two ends then make for the connection poles. A coil with two opposed windings will result i.e. one without inductance (idealized).

Had the pickup a bifilar winding, no voltage could be induced. What the author means to address is “wild winding” or “cross-winding”, in contrast to “winding in layers”. Differences exist between how old and new pickups were wound – no contest there – but there was never ever a bifilar-ly wound pickup. *Still, a clear sonic tendency of the biphilar winding can be recognized: our investigations show that the magnetic field takes on more homogenous characteristics compared to a machine-wound coil. Certain level-values of the resonances are simply not exceeded.* Level-values of resonances? Does the man mean the Q-factor of the resonance? Why doesn’t he then just use that term? And what are those resonances that allegedly occur in *countless* numbers? They may not be countable as we progress towards infinity – with a pickup, though, 10 kHz is the utmost limit. Even if we think 20 kHz is required: there are not countless resonances. It is indeed not possible to model every pickup as a 2^{nd}-order-system (i.e. with one single resonance), but with a 4^{th}-order-model we get extremely close. However, apparently, something else is meant: *the result of the machine-winding is a frequency graph with very narrow and very loud level peaks ... Moreover the coil is more loosely wound by hand, resulting in more resonance frequencies in the treble range*. Here we can’t help but suspect that when regarding spectra he has not really understood, the author interprets maxima generated by the string-partials as pickup resonances. Or does he imply that the hand-wound coil has a lower winding-capacitance resulting in a main resonance of higher frequency? The term “winding capacitance” doesn’t appear anyhere, though – but we do find: *from a higher inductance, an upward-shift of the main resonance results.* Wrong again: the resonance frequency drops with rising inductance. Why is it actually absolutely necessary for a person to write a “specialist article” in a so-called “specialist magazine” if that person is not at all, in any way, a specialist in the given specialist area?

And we get to the **wire**: *given a diameter of 0,0030", the wire was, 46 years ago (i.e. 1961, thicker by 0,0004" compared to today. Combined with the fact that today 400 more turns are included, a smaller inductance results, i.e. a lower output voltage of the old pickup.* Whether a diameter with or without insulation is meant remains unclear. Duchossoir opines that from the 1950’s to the 1990’s, 42-AWG was used always, i.e. 63,5 µm Cu … may the better man win. The number of turns varies so strongly over the years (according to Duchossoir: from 7600 to 9000) that “400” should be interpreted rather generously. And at last the **insulation**: *not only the thickness of the coating has an effect on the sound, but the material, as well, because the material surrounding the copper within the coil has, acting as a dielectric, a direct influence on the magnetic field.* Nope – again close but no cigar: dielectrics act in a polarizing fashion in the electric field, while in the magnetic field, the permeability is the quantity with direct influence. *The Formvar coating consisting of a resin composite makes for a more open and lively sound than the chemical Polysol layer.* Of course: the chemical stuff doesn’t sound right! What does the chemical scientist comment regarding Formvar, though? Formvar lacquers contain polyvinyl-acetal to which phenolic resin is added. And phenolic resin is counted as a … chemical synthetic.

A person testing a guitar is certainly at liberty to write as a conclusion of his labors: *I like the 1962 Strat the best.* However, as soon as this subjective evaluation is being substantiated with misunderstood scientific principles, the dulling of the reader’s mind begins. Mistakes happen, of course. The admitance, the cahtodyne, the E-modul – even biphilar would not be worth a single line if it were just a spelling mistake. Specialist magazines with a good reputation have an editorial office and proof reading where most of the smaller errors are caught and ironed out. They also have a reviewer who will point out subject-specific deficiencies.

7.8.3 "Flachjournalismus" – Where's the bottom in that barrel of specialist journalists?

Translator's note: I choose not to translate this very satirical sub-chapter since much of its effect relies on idiosyncrasies of the German language and on specifics of the music scene in Germany (especially the Munich scene into which the author has some serious personal insights) and Austria. To those with some knowledge of German and looking for a laugh, reading of the chapter is highly recommended – although they should not expect much scientific gain from it. I might still try to do a translation in the future, but it will be a real labor of love to match this pun on rock concerts, music magazines and specialist journalism to American and/or British culture.

Thorbi hatte Ungeheuerliches entdeckt. Eigentlich war er zwar völlig privat unterwegs, aber was heißt schon privat – ein Starfotograf ist praktisch immer im Dienst. Eigentlich ... eigentlich sollte um 21:00 der Liedermacher Wolf Amboss im Zirkus Krone eines seiner zahlreichen Comebacks performen, doch nun war's schon 21:30, und das Volk wurde langsam unruhig. Also schlenderte Thorbi, der diesen Act der Nachwelt ganz privat in Bild (legal) und Ton (nun ja) erhalten wollte, schlenderte also Richtung Bühne, Backstage. So ganz dicht kam er zwar nicht ran, konnte sich aber (man kennt sich ...) einen relativ guten Platz direkt bei der Inneren Security erobern, von dem aus er Amboss fast sehen konnte. Weil's aber eben nur fast war (wozu man auch sagen hätte können, es war überhaupt nichts zu sehen), scannte sein Gehör die unmittelbare Umgebung, und da wurde er Zeuge eines journalistischen Komplotts, das er seiner GuitarLicks&Tricks-Redaktion unbedingt mitteilen musste.

Direkt neben ihm überlegten nämlich zwei arbeitslose Chemie-Abbrecher, wie sie zu Geld kommen könnten. Das wäre zwar im Grunde so alltäglich, dass kein Mensch hingehört hätte, doch im Gedränge hatte sich Thorbis Recorder eingeschaltet, ein Segen, wie sich alsbald herausstellen sollte. "... *geben wir eine neue Zeitschrift heraus ... Zange&Tupfer .... so mit Medizinberichten und Tablettentests und so* ..." Thorbi rückte näher, um besser hören zu können. "*Nee, der Titel ist Scheiße, besser was mit Anspruch, Health&Care vielleicht*?" "*Das können wir ja noch später, wenn wir die ersten Entwürfe fertig haben. Aufs Cover kommt immer ein Foto der getesteten Tabletten, dazu ein Interview mit einem Chefarzt, eine Kolumne 'Das haut rein', weil der Piepenbrink ja auch noch keine Stelle hat, dazu viel Pharma-Reklame, und zweimal im Jahr einen Bericht von der EITA. Geil, oder*?" Ehe eine Bewertung erfolgen konnte, öffnete sich eine Backstagetüre, und eine dickliche, schwarz kostümierte Blonde lief heraus, etwas angewidert einen Lappen von sich weghaltend. Ganz automatisch brachte Thorbi die Minikamera in Position, und vergaß für einen Augenblick das Tabletten-Komplott, doch – wie erwähnt – der Recorder recordete sowieso schon. Durch die geöffnete Türe konnte man sehen, dass Amboss nicht etwa, wie der Hallensprecher mehrfach durchgesagt hatte, im Berufsverkehr festsaß, nein, er war schon da. Teilweise, zumindest, das Physische jedenfalls lag in voller Größe am Boden. Ein Unfall? Thorbi musste mehr wissen, und stupfte Moski, den nahe im stehenden Security-Boliden, mit einem fragenden Blick an. "*Hat was Falsch's gessn*" war die wenig ergiebige Antwort, doch die begleitende Handbewegung lies keine Zweifel offen. Später erfuhr Thorbi, dass WA eine zufällig rumstehende Flasche mit einem Mikrofon verwechselt hatte, probehalber reinsingen wollte, von der dabei rauslaufenden Flüssigkeit so überrascht wurde, dass ihm ein kleines ... äh ... Missgeschick passierte, auf dem er dummerweise ausrutschte und der Länge nach hinfiel. Als Profimusiker sollte man wirklich mehr drauf achten, was man vor dem Gig isst ...

Im Raum, dessen Türe immer noch offen stand, liefen mehrere wichtige Leute hin und her, und ein Oberwichtl rief mehrmals "*so könn ma den net rauslassn, der Siggl soll sofort kommen*". Der kam postwendend, sein Gesicht hinter einem Bass versteckend, (Fender, Shortscale), und verschwand flugs in der Türe, doch Thorbis Nachbarin hatte ihn schon erspäht. Ihr "*mei is der kloa*" war etwas deplaziert, und ihr "*is die Nikoll aa do*?" attestierte ihr eine gewisse Ignoranz, die dem Münchner Opernpublikum aber auch nachgesagt wird und stadttypisch ist. Denn der Eine hatte mit dem Anderen rein gar nichts zu tun, hier erhielt gerade eine im Stadtwesten bekannte Boygroup die Chance, groß rauszukommen, doch das ist eine andere Story. Von Backstage war nur mehr "*zwoa extra starke Kaffee für'n Barny*" zu hören, dann wurde die Tür zugeworfen, und Thorbi hatte wieder Ohren für seine Nachbarn.

"*... hab ich schon Vorarbeiten für einen MAO-Hemmer-Test durchgeführt, etwa in der Art: Auf dem Zettel steht zwar, mit etwas Flüssigkeit nehmen, aber ich mache zuerst immer einen Trockentes t. Schon dabei fühlt man eine Art Vibrieren, das den ganzen Körper durchdringt und selbst im Bauch spürbar ist. Nimmt man beide Tabletten zusammen, entsteht so eine Art glockiges, glasiges Gefühl, man durchlebt alle Höhen auf einmal, während die Einzeldosis, (und zwar die Tablette, die am Rand der Cartridge sitzt), mehr ein erdiges, die Gefühle verzerrendes Erlebnis bringt. Unsere Messung ergab, dass diese Tablette etwas schwerer war als ihre Kollegin: 3 gegen 2 Gramm. Dass die Anzeige der Küchenwaage in beiden Fällen zwischen 2 und 3 hin- und hersprang, müssen wir ja nicht dazuschreiben, oder?*" "*Und das geht so einfach, ich meine, so ganz ohne großes Drumrum?*" "*Natürlich, und am Ende schreiben wir noch eine plus/minus-Bewertung drunter ... und das einmal pro Monat.*" "*Aber wenn sich nun jemand auf unsere Bewertung verlässt, und das Zeugs kauft, ich meine – wir sind doch noch keine Profi-Pharmakologen, wenn da ein Fehler drin ist, kann's da keine Schadensersatz-forderungen geben?*" "*Tja, Kohle will ich keine rausrücken, dann nehmen wir halt ein anderes Sujet ...*" er sah sich prüfend um, bis sein Blick an einem Musiker hängen blieb, der, leicht schwankend, '*wo's mei Ka...ffee*' lallte, und dabei Halt an einer Gitarre suchte (Fender, Strat, weiß, relic). "*Eine alte Stratocaster, das ist eine noch bessere Idee, wir könnten doch auch ein Fachmagazin für Gitarren herausgeben, oder?*" "*Aber so richtig Ahnung davon...*" "*Das macht nix, die anderen haben doch auch keine Ahnung. Ich schreib meinen Tabletten-Test über die MAO-Hemmer leicht um, Tonabnehmer statt Tablette, Henry statt Gramm, und du ...*" er unterbrach einen Moment, weil die Türe aufging, und eine Gestalt heraushuschte, hinter einem Fender-Shortscale Schutz suchend, "*du machst die Bass-Testberichte. Vielleicht kriegen wir ja noch ein Interview mit'm Amboss. Wenn der schon wieder einen Auftritt verkackt, kann er froh sein, wenn sich noch irgendjemand für ihn interessiert.*" "*Ja, aber besser erst morgen, wenn sich sein Zustand wieder normalisiert hat.*" "*Lieber keine Vermutungen, was bei dem normal ist. Wie heißt eigentlich die Ersatzband, die jetzt gerade einläuft?*" "*Irgendeine regionale Boygroup, irgendein Murphy, der Sänger wahrscheinlich.*" Und weil aus dem Hintergrund ein 'Basedow' zu hören war, kam's zu der viel beachteten Headline: AMBOSS WIEDER INDISPONIERT, MURPHY BASEDOW RETTET DEN ABEND MIT BAYERISCHEM POP. Das mit dem gründlichen Recherchieren werden sie schon noch lernen, den Umgang mit den Anwälten auch. Letztlich waren sie dann froh, dass (dank Thorbis dezenter Vermittlung) bei GuitarLicks&Tricks zwei neue Stellen geschaffen wurden, und so begannen zwei neue journalistische Karrieren ...

Amboss kam übrigens doch noch auf die Bühne, gerade als "Murphy Basedow" seine erste Zugabe spielte, war aber leider nur zu sehen, und nicht zu hören, weil er in eine zufällig rumliegende Flasche sang, die er für ein Mikrofon hielt. Umstehende sagten später, derartige Verwechslungen hätten auch ihr Gutes, aber das waren vermutlich fanatische Murphinisten. Die verstehen ja auch nicht, warum zwei Tage später in ebay ein Putzlumpen (*"nicht neu, mit Gebrauchsspuren, backstage im Beisein des Künstlers versiegelt"*) für 18 Euro versteigert wurde. Ja gut, man hatte sich mehr erhofft, aber dank prophetischer Weissagungen war man vor-gewarnt gewesen: ... es is scho oos und du hast glaabt es fangt erst oon ...

