8.7.3 Tactile vibration perception

There is scarcely any guitar test-report that does not praise the exorbitant vibration-happiness of the electric guitar under scrutiny: "The design shows considerable resonance properties, after each picking of a string it vibrates intensively and clearly noticeable." G&B 9/06. Or: " From a vibration-engineering point of view, the MTM1 ranks at the highest level because the whole structure resonates intensively into the last wood fiber after each picking of a string; this results in a slowly and continuously decaying sustain." G&B 8/06. Or: "Combined with the given open freedom of vibration (sic), we achieve a beaming sound color." G&B 8/06. Or: "Less mass can more easily be made to vibrate." Luthier Thomas Kortmann, Gitarrist.net. Or: "At Fender they even proceeded to build bodies from several wood-parts … Of course, the ability of the wood to resonate is restricted by such a number of differently sized pieces." And loc. cit.: "That Ash moreover has almost optimum resonance properties was thankfully acknowledged at the time. It does not bear contemplating that Leo Fender might have opted for mahogany back in the day." Day et al. Or: "Clearly noticeable right into the outermost wood fibers, both Strat and Tele show very good resonance properties." G&B 4/06.

Mind you: we are discussing electric solid-body guitars here, and not acoustic guitars. The clearly noticeable **vibrating of the guitar** is taken as a criterion for quality. Why don't we let one of the fathers of the solid guitar, Lester William Polfuss, speak: *"I figured out that when you've got the top vibrating and a string vibrating, you've got a conflict. One of them has got to stop and it can't be the string, because that's making the sound."* Mr. Polfuss sought to let only the string vibrate, and not the guitar top. O.k., one could object that the man was a musician, not an engineer. Still, he was a musician that replied to the question of who had designed the Gibson Les Paul with *"I designed it all by myself"*. The string is intended to vibrate, and the body should just shut up and be quiet. Only the very nit-picking ones will throw in at this point that only the relative movement counts, i.e. if the strings remain at rest, and instead the body would … no, enough with the theories of relativity, it does work better the other way 'round. However: what does that mean – better? What characterizes a better sounding guitar? In his dissertation [16], Ulrich May cites D. Brosnac with the insight that a guitar made of **rubber** would absorb the vibration energy of the string within a short time and therefore would not sound right. That is understandable but does not prove that ash (or maple, etc.) is better suited. Evidently, there are unsuitable body-materials that will withdraw an unbecomingly big amount of vibration energy from the strings. Rubber is among these materials – but who would want to build a guitar out of rubber? Presumably, damp towels[♣] also rank among the unsuitable materials. Or, fresh from the sleep-lab: since a bed of a length of 1,45 m (about 5 feet) is uncomfortable for most grown-ups, a 2,12-m-long bed has to be more comfortable than a bed of 2,05 m length. Or, more guitar-specifically: what the luthiers have learned for the acoustic guitar cannot be wrong for the electric guitar. A guitar has to resonate. Right into the outermost wood-fibers. Intensively and clearly noticeable.

So, what can we feel – as human being in general, and as a guitar-tester in particular? That depends, of course, on the stimulus and on the receptor. However, in terms of vibrations, the subcutaneous Pacini-corpuscles react most sensitively to stimulus frequencies of 200 – 300 Hz; they sense vibration amplitudes as low as 0,1 µm. That also implies that the sense of vibration becomes increasingly less sensitive above frequencies of about 250 Hz. Sound-shaping harmonics remain largely hidden from the tactile sense.

[♣] because of the high „damp"-ing ...

Fig. 8.47 shows the frequency dependence of the **vibration threshold**, i.e. the vibration amplitude that needs to be reached in order to generate any vibration perception in the first place. Besides the dependency on frequency and amplitude, the exact shape of the curve depends also on the area of the vibrating surface, and on the location that is stimulated. The given graph can be seen as typical for the thenar. Thus, if a guitarist feels a vibration in the neck or the body of the guitar upon striking the strings, it will be a case of low-frequency vibrations. To **check via a calculation**: if we take 10 N as force at the bridge, a mass of 4 kg, and 250 Hz as stimulation frequency, we get a displacement of 1 μm. It is therefore no wonder that vibrations result that are felt, even without any resonance-amplification.

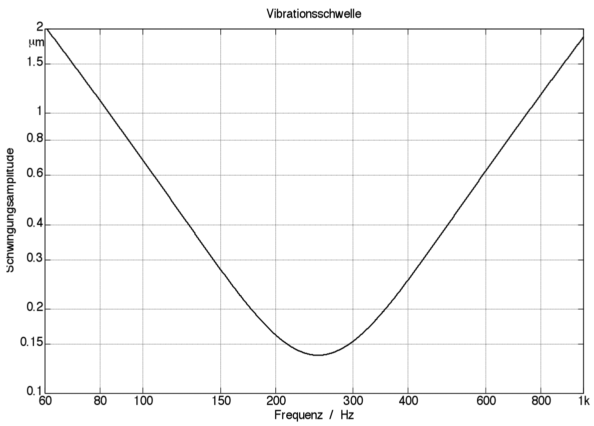

Fig. 8.47: Vibration threshold. Only values above the threshold lead to a perception of vibration. According to this graph, a vibration of an amplitude of 0,4 μm can be felt at 300 Hz; at 800 Hz it would not be felt anymore. "Schwingungsamplitude" = vibration amplitude; "Vibrationsschwelle" = vibration threshold

Therefore it is less a question of whether noticeable vibrations can emerge, but more how these should be assessed. If we take up again Les Paul's idea, any body-vibration to speak of would be counterproductive. With a lot of mass (ten-pounder Paula), this ideal can be approached at the cost of wearing comfort, and disregarding natural modes (eigenmodes) that amplify the vibration. The guitar neck in particular must not be too heavy; it will resonate to a noticeable degree in any guitar. What would in fact happen if guitar body and guitar neck could be manufactured to be vibration-free? On every guitar of this kind, comparable strings would vibrate in an identical manner given comparable picking! **Individuality is imperfection**, and it would fall by the wayside. In the acoustic guitar, the luthier seeks to form the transfer function frequency-dependently, and thus let some frequency ranges be radiated better, but conversely let other frequency ranges be radiated worse. An individual sound does result that way. The same principle could be applied for electric guitars, as well, and neck and body could be made to vibrate more at certain frequencies, i.e. the vibration energy would be more strongly dissipated. Whether this is indeed desired can only be judged in an overall consideration of all sound-shaping elements. Still, it would be a remarkable coincidence if exactly those frequency ranges for which the tactile sense is particularly sensitive would require the strongest damping. For one thing is certain beyond all doubt: the vibration energy that is felt, it is sourced from the string. The more intensive "the whole structure resonates", the less the string vibrates. One may agree or disagree with Les Paul's ideas – the law of conservation of energy should rather not be objected to.

Whether we would like to contradict Day et al., however, is again left up to us: "the vibrato-system itself was given a knife-edge-type shape at the six holes foreseen for the screws retaining it. The whole system was therefore mounted optimally in a very low-friction manner but still could transfer the vibrations of the strings optimally to the body." Indeed, this path is known: "**because the tawdry goes down to the corpus unsung**" … Schiller, Nänie. Or something like that.