0.3 How the vibrations of the strings arrived in the Orkus

There's scarcely any test-report on guitars that does not praise the exorbitant vibration-propensity of the investigated electric guitar: "the design shows considerable resonance properties; after each string attack it vibrates intensely and clearly noticeably " [G&B 9/06]. Or: "From a vibration point-of-view, the MTM1 ranks at the highest level, since the whole structure resonates intensely into the last wood fiber after each string attack, resulting in a slow and continuously decaying sustain" [G&B 8/06]. Or: "Combined with the given open freedom of vibration, we arrive at a brilliant sonic image" [G&B 8/06]. Or: "Less mass can be more easily be made to vibrate" [Luthier Thomas Kortmann, Gitarrist.net]. Or: "At Fender they even proceeded to build the bodies from several pieces of wood. … Of course, the ability of the wood to resonate will be reduced by such a number of pieces varying in size, as well". Und o.a.: "At the time, the fact that ash also has almost optimal resonance characteristics was noted with appreciation. It doesn't even bear contemplating what had happened if, back in the day, Leo Fender had opted for mahogany" [Day et al]. Or: "Clearly noticeable, both Strat and Tele show very good resonance properties right to the outermost wood fibers" [G&B 4/06].

Take note: this is about solid body electric guitars, and not about acoustic guitars. The clearly noticeable **vibration of the guitar** is taken as a criterion for quality. Let's have the father of the solid body, Lester William Polfuss, have a word here: *"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 wanted only the string to vibrate, and not the top of the guitar. Well, one could object that the man was a musician and not an engineer. Still, he was a musician who, answering the question about who in fact had designed the Gibson Les Paul, said: *"I designed it all by myself"*. The string is supposed to vibrate, and the body is supposed to keep quiet. Only the overly pedantic will interject here that in fact it is the relative movement that counts, i.e. if the string remains in rest, the body could instead … no, enough about the theories of relativity; it works better the other way 'round. But then, what does "better" mean? What characterizes the better sounding guitar? In his dissertation [16], Ulrich May cites D. Brosnac who realizes that a guitar made of **rubber** would absorb all string energy within a short amount of time, i.e. it would not sound right. This is easily understood but does not prove whether ash, or maple, etc. are better suited. Obviously there are unsuitable body materials that withdraw quite a lot of vibration energy from the string. Rubber would be one of them. But who would want to build a guitar from rubber? Presumably, dough for steamed bread would be unsuitable, as well♣. For another approach, fresh from the sleep clinic: a bed of a length of 1.45 m (4.75 ft) is uncomfortable for most grown-ups, therefore a bed with 2.12 m (6.95 ft) must be more comfortable than a bed of 2.05 m (6.72 ft). To be more specific to our field: what the luthier has learned with respect to the acoustic guitar cannot be wrong for the electric guitar. A guitar needs to vibrate. Right into the outermost wood fiber. Intensely and clearly noticeable.

So, what in fact is noticeable, or perceivable, for the human in general and for the guitar tester in particular? That of course will depend on the stimulus and the receptor – but regarding vibration, the subcutaneous Pacini-corpuscles are most sensitive at stimulus frequencies of 200 – 300 Hz, and can sense vibration amplitudes of as little as 0.1 μm. However, that also implies that for frequencies above 250 Hz, the sensitivity increasingly drops rapidly. Sound-shaping harmonics therefore remain mostly outside of the reach of the sense of touch, the feeling of vibration..

♣ due to the strong „damp-ing".

Fig. 0.1 shows the frequency dependency of the **vibration threshold**, i.e. the vibration amplitude that needs to be reached such that any vibration sensation can emerge in the first place. The exact shape of the curve depends not only on the frequency and the amplitude but also in the area of the vibrating surface, and on the stimulated location. The shown dependency can be seen as typical for the thenar (area below the thumb). If a guitarist, upon plucking the strings, feels a vibration in the body or the neck of the guitar, these will be predominantly in the low-frequency domain. If, as a **calculation to check the assumptions**, we take a force at the bridge of 10 N, a mass of 4 kg, and 250 Hz as excitation frequency, we get a displacement of 1 µm. Hence it is no wonder that noticeable vibrations may be generated, even without any resonance-amplification.

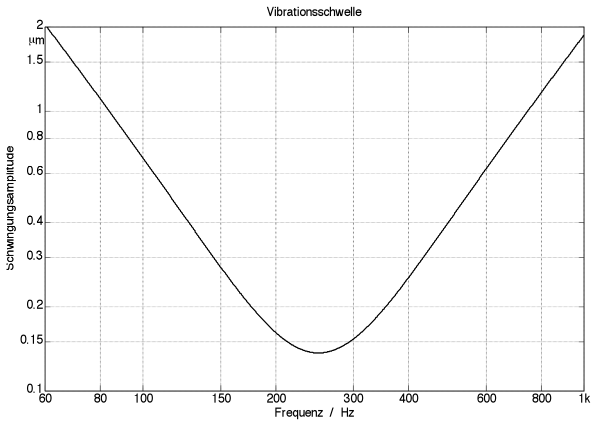

Fig. 0.1: Vibration threshold ("Vibrationsschwelle").
Only values that lie above the threshold lead to a vibration perception. According to this curve, a vibration with an amplitude of 0.4 µm is noticeable at 300 Hz, but not anymore at 800 Hz.

"Schwingungsamplitude" = vibration-amplitude
"Frequenz" = frequency

Therefore, the question is not so much whether perceivable vibrations can occur but how these should be interpreted. Taking up Les Paul's idea again, any noteworthy vibration of the guitar body would be counterproductive. With a lot of mass (a ten-pounder Paula), we would approach his ideal at the cost of comfortably carrying the instrument – and we would still disregard vibration-amplifying natural oscillations (Eigenmodes). The neck of the guitar in particular cannot be arbitrarily made heavier; it will vibrate noticeably in every guitar. However, what would happen if we could manufacture a guitar to be vibration-free? For comparable plucking, comparable strings would vibrate identically on every guitar of that kind! **Individuality is imperfection**, and it would fall by the wayside in this scenario. For the acoustic guitar, the luthier seeks to form the transmission factor in a frequency-dependent fashion, and therefore makes some frequency ranges radiate better, but others weaker instead. This way an individual sound results. The same principle could be applied for the electric guitar, and neck and body could be made to vibrate more strongly at certain frequencies i.e. to dissipate the vibration energy more quickly. Whether this is indeed desirable – that can only be assessed in an overall consideration of all sound-forming elements. It would however be a particular coincidence if it were exactly those frequency ranges that would require the strongest damping, in which the vibration perception is especially sensitive. One thing is clear beyond doubt: the source for the sensed vibration energy is the string. The more intense "the whole structure resonates", the less the string vibrates because it looses its energy to "the whole structure" very quickly. One may disagree or agree with Les Paul's ideas – going against the law of energy conservation is not advisable.

Disagreeing with Day et al., however, is at everybody's liberty: "The vibrato system itself received a knife-edge arrangement at the six corresponding holes, such that the whole system had a very low-friction bearing but could still conduct the string vibrations optimally <u>into the body</u>. Yep, that's a well-known path: **For the ignoble goes down to the (c)orc/pus in silence**. Schiller, Nänie (Nania). Or something like that.

