7.3 Geometry of Strings and Neck of the Guitar

At its bearings (nut and bridge), the string receives a directional bend of 4° – 30°. This bend angle ensures of the required bearing forces but also contributes undesirable frictional forces. Moreover, fretting the string results in a further bend angle at a point where tension forces and playing forces interact. The following two chapters will describe the geometry of these bends – Chapter 7.4 will then look into the corresponding forces acting on the string.

7.3.1 Angle of headstock and neck

For most electric guitars, the upper surface of the fretboard does not run in parallel with the upper surface of the guitar body. Rather, the neck is very slightly angled towards the rear. This way, the point where the string runs across the bridge moves somewhat away from the guitar, helping to increase the bend angle of the strings across the bridge, and thus to increase the bearing forces at the bridge. Typically, the neck angle is 0° - 7°. With a set neck, the angle is fixed; for a bolt-on neck, the angle can be adjusted using screws and/or shims, or by removing wood from the neck-joint section.

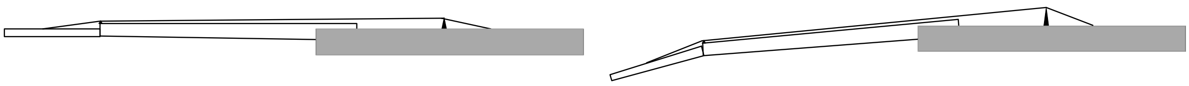

Fig. 7.8: Bend angles of headstock, neck and strings. On the left, the angles between headstock and guitar neck, and between neck and guitar body are 0°; on the right, the angles are 10° and 5°, respectively. (Customarily, the sharp angle, e.g. 10° is given, rather than 170°). On the right, the bend angle of the strings is greater, resulting in a higher bearing force at the nut and bridge, respectively.

The adjustability of neck angle, neck curvature (truss rod) and bridge height (**Fig. 7.8**) provides for the possibility to accommodate the playing action as desired by the guitarist. More extensive adjustments involve the height of the frets but taking these steps remains with the specialist. With regard to the playing action: whether changing the neck angle or the bridge height makes no difference – but pickup-to-string distances, and the bend angle at the bridge are affected. If, when playing the strings on the upper frets (around the 12th fret and higher) strong string-rattle occurs, either the bridge needs to be raised, or the neck needs to be angled towards the front. In case the action is now too high at the lower frets, the truss-rod may be (carefully!) tightened. The manufacturers recommend a slightly concave curvature of the fretboard (between nut and bridge). Every guitarist needs to find his or her own optimum setup. Those who prefer a low action for solos may adjust the neck to be completely straight … convex curvature, however, is to be avoided. More of a concave curvature will be preferable to those mainly playing chords on the lower frets. Still, the necessary adjustments will be a matter of a few tenths of a millimeter.

Again, a **warning**: the truss-rod may break if tightened too much – to replace it, the glued-on fretboard will probably have to be removed, or the neck will have to be replaced (if bolt-on). Therefore, beware of overly enthusiastic “home-improvers”, and too zealous “sales experts”!

The effect of the neck angle on the **sound** is and remains a mystery: in the book “The Gibson” [13], the neck angle of the 1952 **Les Paul** is specified with 1°. Over the following years there are several changes; the reissue towards the end of the 1960s sports a 7°-angle. The 1952 original is attested *"very good sustain"*, the 1953 Les Paul (with 3° neck angle) still receives a *"good sustain"* verdict.

When in 1960 the neck angle increases to 5°, *"less sustain"* is noticed. The book continues: *"in the 1970s it was increased to 7°. A lot of players at that time complained that the guitar sound became harsh and had less sustain compared to the older models. The reason was of course the much steeper angle of the neck".* Of course? The book gives conjectures without any reasoning. In the 5-page Les-Paul-historiography, so many changes in the details are listed that we could surmise that only the number of strings and the name of the guitar were left alone. Subject to change were: frets, materials of body and neck, neck cross-section, number of parts the body and the neck is – respectively – made from, the bridge design (at least seven variants!), the pickups … the neck angle was merely one of many details. In the absence of exact data, pure assumptions as those given above are eagerly seized and spread like wildfire in the guitar-world. "Mystery of the old Les Pauls (by now selling for 6-figure numbers) unraveled: it's all in the neck angle!"

Let us give two experts a change to speak: *"The first Gibson Gold-Tops had a very shallow neck angle… This design made the sustain suffer. Around 1953, the angle was increased ... it made for improved sustain."* So much for Bacon and Day's comments in the Les-Paul-Book. Jun Takano writes quite differently in The Gibson: *"The angle of the neck joint was 1° when the Les Paul Model was introduced. The sustain of the guitar was very good because of the shallow angle of the neck. In 1953, when the bridge was changed to a stud type, the angle of the neck joint was altered to 3°. However, sustain was still good, because the neck angle remained shallow."* While Bacon/Day assume that the sustain improves with increasing neck angle, Takano surmises the exact opposite: *"As the angle of the neck gets shallower, the string tension♣ gets lower and sustain gets longer."* The authors of both books do however also report about a change of the bridge in 1953 – therefore there are, at least, two potential reasons for a change in sustain *(translator's note: if indeed there really is such a change).*

Changes in the neck-angle can have two effects: they can change the instrument geometry and thus the instrument's Eigen-vibrations ("natural" vibrations at natural frequencies – or Eigen-frequencies – of the instrument), and they can change the bend-angle of the strings at the bridge. That angle depends on *two* sections of the string, though! When in 1954, due to the introduction of the Tune-O-Matic bridge, another change in the bridge happened, the bend angle at the bridge became variable, and now was not at the neck angle's mercy anymore.

Because we do not want to rip the neck from a 1954 Les Paul only to glue it back at a different angle, we only have this – rather poor – **lesson**: there are many speculations about the effect of the neck angle on the sound; we should refrain from adding yet another one. Rather, we can again recall specialist literature:

"The sound is particularly wonderful if the neck angle is 3.5°. One could say that at 3.5°, the tone sings; at 4° there is a fatter bass – but it won't sing as well." That's luthier Thomas Kortmann speaking, at Gitarrist.net. Wouldn't it have been wonderful to know what the sound at 3.6° is? *"The sound of an electric guitar is predominantly determined by the bend angle of the strings." E-Gitarren, page 89.* That will make all those happy who own substandard pickups. *"We often find reports about Gibson having increased the neck-angle when the new McCarty-bridge was introduced. That is a myth and not true. A Les Paul sporting a stud features the same neck angle as an earlier version with trapeze. Only in 1955 the neck-angle was substantially increased… and even better sustain resulted." Gitarre&Bass, Gibson special edition, 2002, page 15.* Whether that result was due to the neck angle, or due to other factors introduced at the time is not specified.

♣ This speculation about the string tension certainly will not find any scientific basis: given the same string, the pitch depends solely on the string tension - the latter therefore remains unchanged with constant pitch.

7.3.2 String tree

The strings of a guitar rest on two small ridges: the nut and the bridge. In order to obtain a force-fit without slack, the string needs to experience a change in direction. The corresponding bend angle is specific to the guitar and varies between 5° and 15°. For achieving the bend at the upper string end, the classical method has the headstock angled back relatively strongly towards the rear. In a Martin D-45, for example, the resulting bend angle is 15°. Gibson's electrics reach this value, too – or even exceed it. With Fender, the situation is different. Always frugal with the available materials, Leo Fender does not waste any wood and refrains from angling the headstock backwards. The result is a very small bend angle of the strings (**Fig. 7.9**), and string buzz occurs when playing open strings. Remedy is found in the form of hook-like string guides that deflect in particular the B-and E_4-strings, pulling them towards the headstock

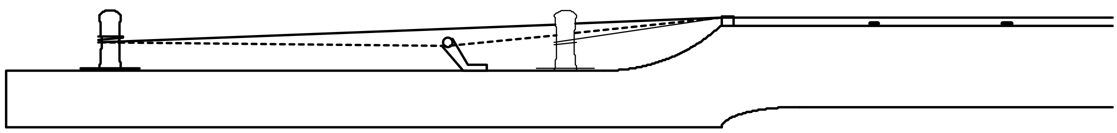

Fig.7.9: Side view of the headstock of a Stratocaster. Without string tree, the bend angle of the E_4-string amounts to only 2°; with string tree, it increases to 6° (dashed). For the E_2-string (thin line), the bend angle is sufficient without string tree.

String trees are offered in different shapes: as "butterfly" vintage original (a stamped strip of sheet metal), as roller bearing (roller string tree), as washer, or a thin oblique pin. They do increase the bend angle at the nut – but also generate an additional frictional force in terms of any longitudinal movement of the strings. This friction is considered undesirable. The wrap-around angle at the string tree of a Fender guitar can amount to as much as 7° – generating a frictional force that is even higher than that occurring at the nut. On the other hand, a Gibson-typical bend angle of the strings is, at e.g. 15°, more than twice that on the Fender-ish competition – and yet in guitaristic circles, Gibsons are not actually known to be unplayable. That does not mean that friction would generally be no problem at all: there are sharp-edged string trees of the butterfly-type that wound strings more or less clamp themselves to. Let's not enter an expert discussion here why, in the first place, a wound string would have any business interacting with a string tree on one of Leo's guitars … anyway: corrective action is easily possible via a delicate file or a practically invisible strip of Teflon. That aids the mechanics and does not hurt the look. Oil, Vaseline or machine grease would be suitable to reduce friction, as well.

Does a string tree change the sound? No, here we do not mean the targeted improvement via the increase of the bearing force of the string at the nut – but would there be any additional, possibly undesirable effects? Very theoretically, the Eigen-frequencies of the headstock could retune themselves due to the additional mass of the string tree, but that has no practical relevance. The same holds for the Eigen-frequencies of the strings running across the headstock: plucking an open string and damping these remaining string sections with the other hand will not cause any changes in the "electrical sound"… N.B.: the *acoustical* sound of an electrical guitar is insignificant, anyway (Chapter 8).