### 5.4.6 Staggered and beveled polepieces

When picked with the same strength, the six strings of the electric guitar are supposed to generate an approximately equal voltage in the pickup. This requirement is met by a piezo pickup, but by a magnetic pickup not so much: if all 6 strings were constructed of solid material, the $E_2$-string would yield 4 times the output of the $E_4$-string (chapter 3.2). However, the winding around the lower strings is rather inefficient in terms of magnetism, and thus the bass strings produce roughly the same loudness as the treble strings. For reasons of clarity, we will in the following not look at loudness (which is dependent on numerous factors) but at the level of the fundamental of the string: **Fig. 5.4.32** shows the results for nickel-wound Fender strings. Basis for the measurement is an identical picking strength for all 6 strings. For solid strings the level is, for this case, only dependent on the fundamental frequency of the string♣ (dotted line). The $E_4$-, B-, and G-strings are assumed to be solid, while the remaining strings are taken to be wound, showing 4 – 10 dB less pickup output compared to the solid strings. (chapter 3.2). The dashed line gives the level for a *wound* G-string matching within the set.

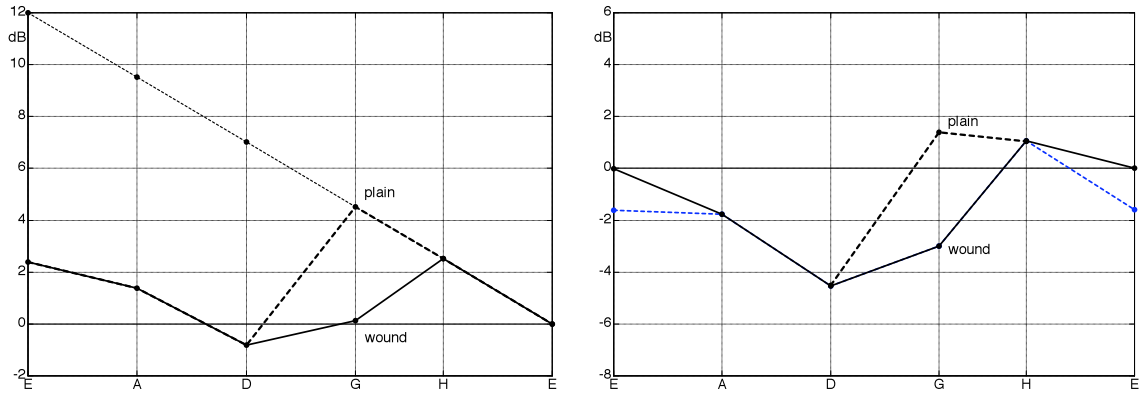


**Fig. 5.4.32:** level of the fundamental of the strings, Fender-150 (pure Ni-wrap): 42-32-24-16-11-09. Dashed line: with wound G-string. Left: equal string-to-magnet distance and equal pickup sensitivity for all strings. Right: convex string action across the neck as is typical for Fender; dotted line: boundary effects of the pickup.

When comparing the output level of the strings we need to weigh several effects: the magnetic efficiency of the strings (chapter 3.2), the distance between string and pickup, and the sensitivity associated with the individual pickup magnets. Due to the curvature of the fretboard (with a radius between 18 and 30 cm), the strings are not located in a plane but along an arch. In most scenarios the $E_2$-magnet shows a 1mm-larger distance to the string than the $E_4$-magnet, this leading – as an example - to the following **string curvature**: 1,0 – 1,5 – 1,7 – 1,5 – 0,9 – 0,0. For the string-specific pickup sensitivity we need to consider, on the one hand, the individual static magnetic field which can easily vary by 10%, and on the other hand the reduced sensitivity of the pickups for the **outer strings** ($E_2$ and $E_4$) typical for Fender pickups: this will be 1,5 – 2,5 dB less compared to the inner 4 strings, conceivably because the coil winding captures only part of the magnetic field of the string in the edge region. In summary, we arrive at individual level differences with small loudness deficits for the D- and G-strings, and a B-string that is a bit louder. The level differences between the strings are not dramatic but did lead to corrective measures: to compensate for level- and thus as well loudness-differences, Fender modified – as early as the 1950's – the magnet lengths such that the softer strings are subjected to a stronger magnetic field. These magnets protruding more or less far out of the pickup housing were called **staggered polepieces**, as opposed to **flush**

♣ Given these conditions, a set of higher-gauge strings is not louder, because the higher required tension reduces the string displacement and thus also the string speed

**polepieces** which are also called **level polepieces**. Not all guitars received staggered polepieces: the Jaguar and the Jazzmaster (then considered the flagships of the line) sported flush polepieces while the Stratocaster had staggered polepieces. Opinions about the principle according to which the magnet protrusions should be arranged seem to have differed over the years: the D-magnet was longest at some point, then the D- and G-magnets were of the same length but longer than the others, then again all 6 magnets were of the same length, then again they were staggered. **Fig. 5.4.33** shows some of the designs, without any claim to completeness.

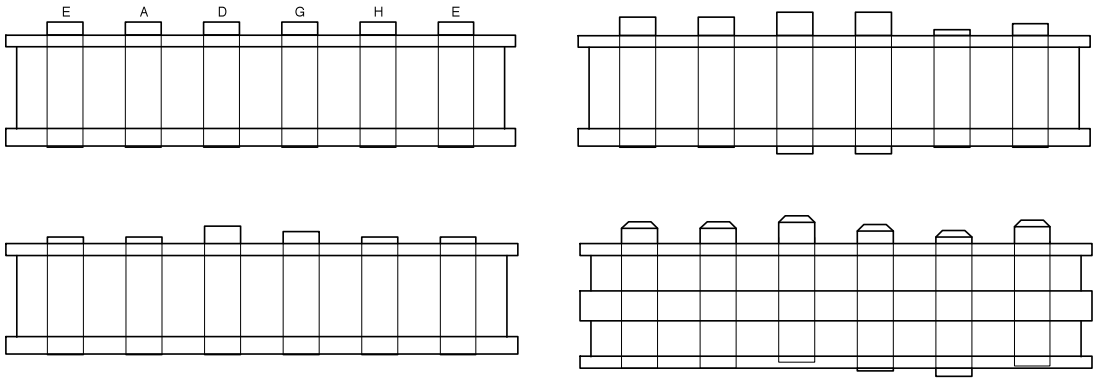


**Fig. 5.4.33:** different-length magnet protrusions in Fender pickups. Upper left: flush polepieces, upper right: 1972 Stratocaster, lower left: 1973 Telecaster, lower right: 2004 Stratocaster („noiseless“).
N.B.: „H“ (German) = „B“ (international)

The 1972-Stratocaster-pickup investigated for the example had extended D- and G-magnets, a shorter B-magnet and a slightly shortened $E_4$-magnet♣. This configuration leads to the level dependencies shown in **Fig. 5.4.34** – indeed a visible improvement over Fig. 5.4.32 – especially with a **wound G-string**, as it was the standard in the 1950's when the first Fender guitars were built! As late as 1968, the Fender brochure indicates for the 1500 string set: 12–16–26w–34–44–52 *this set supplied on all new instruments except* ¾. Alternatively the "light gauge rock 'n roll" string set was already available (gauged 10-13-15-26-32-38 and with solid „unwound“ or „plain“ G-string) – the wound G-string was still standard, however. When thinner strings with a solid G-string became the new standard, the old magnet-protrusion-profile did not fit anymore. The solution was typical for musicians: newer pickups have the

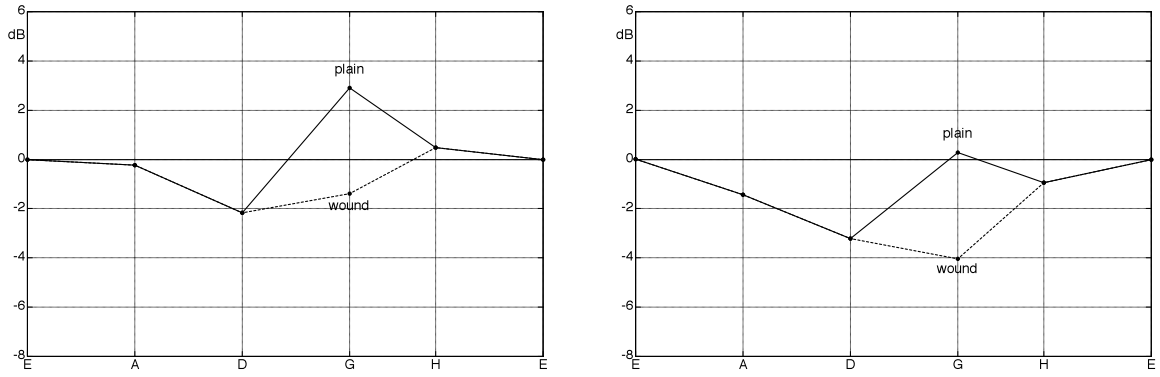


**Fig. 5.4.34:** level of string fundamental, Fender-150 (pure Ni-wrap): 42-32-24-16-11-09. Dashed line: with wound G-string.. Left: '72-Stratocaster, right: Noiseless Stratocaster (2004). Convex string action.

♣ In old Stratocaster-pickups the magnets were mostly flush on the lower pickup-side. Here is an example in which presumably 2 of the magnets were moved . NOT RECOMMENDED: **RISK OF DAMAGE**!

G-magnet protrude only little, but "vintage pickups“ using the old profile are available new, as well. Not only a few guitar players request the vintage profile ... but still mount the light gauge strings with the "plain“ G ....

How significant is a level difference of 3 dB? From a pure signal-theory point-of-view an increase of 3 dB ties in with a doubled power i.e. 200 W instead of 100 W. That would be quite substantial. On the other hand: Johannes Webers writes in his book on studio electronics ("Tonstudiotechnik“, Francis, Munich) that the attenuation-per-step in stepped level controls typically amounts to 1,5 dB – this would be correspond roughly to the smallest discernible loudness difference. 3 dB would thus be twice such a minimum step: perceivable in direct comparison but not really a very big deal. **Seth Lover**, developer of the Gibson Humbucker, remembers: "My PAF prototype ... worked well. When the salesmen saw this, without any adjustment screws, it was like breaking their arms. They just didn't have anything to talk about. So, next came the punched-out holes and the adjustment screws." [Vintage Guitars, Feb. 1996]. Business as usual, then: sales has to straighten out mistakes made in R&D ... or was it the other way round?? A later development in the Gibson product line, the Tony Iommi pickup, lacks the adjustment screws again. The times they are a-changing. Or Greek-orthodox: panta rhei.

Of course, the adjustment screws give power to the guitar player, and individuality to his or her instrument: "only after I had turned the second screw a quarter-turn counter-clockwise I suddenly got this awesome sound“. Immediately, however, the maestro runs into the next problem: if he doesn't tell anyone, his genius remains unrecognized. If he does tell, they all can copy his awesome sound. An improved statement, then: "of course I first need to fine-tune every guitar I receive from the manufacturer: those guy deliver such shitty stuff – even from the custom shop, it's unbelievable. However, with my extremely sensitive hearing I got every Custom to sound great. It's just that there are so many years of hands-on experience involved that can't really relate it all". O.k. then ... keep them screws turning. Incidentally, Jimi Hendrix did not modify the pickups in his Stratocaster whether or not he had access to a lefty and had to restring a righty. "We don't need another hero ..."

Next to staggered magnets the other specialty are **beveled magnets**. These are tapered like a truncated cone on the side pointing towards the string (45°-bevel, Fig. 5.4.33, Noiseless Stratocaster). One might speculate whether the pickup assembly (the press-in operation) could be done more easily, or whether Leo Fender was hoping for a stronger magnetic field. Measurements with turned magnets in a Noiseless-Stratocaster yielded practically no difference: on average the "improvement" of the response of 0,2 dB is within typical measurement tolerances and insignificant. For the harmonic distortion, as well, no difference could be found relative to Stratocaster-pickups with strictly cylindrical magnets. The theory, too, fails to point to any big differences: in the range of the facing edge (i.e. the intersection between cylinder barrel and the end surface of the cylinder), the flux-density of the cylindrical magnet is very high; the magnetic material is in **saturation** and consequently rather inefficient

It is not recommended to "sharpen" the cylindrical magnets. The sole possible working-method would be to grind them – however this would involve extreme heating of the magnetic material which can lead to a lasting change in the magnetic properties (watch den Curie-temperature!).