### 5.4.7 Fender: Jaguar and Lace

Both the Lace pickup distributed by Fender and the Jaguar pickup generate – with the aid of a u-shaped yoke – a special magnetic field which shall be further investigated in the following. That Lace advertising tireless tries to convince us that the Fender Lace Sensor is not a pickup but an "*acoustic emission sensor*" is merely typical sales mumbo-jumbo: every pickup is a sensor, anyway. However, at the same time the ads claim that the Lace has *the ability to accurately reproduce the sound characteristics of any existing conventional pickup*. Now that is going a few steps too far and would seem to be quite a put-on. Just looking at the Lace patent (US 4,809,578), i.e. using Lace's own reasoning, casts some serious doubts: the patent notes that all other pickups dampen the string vibrations – it's just the Lace that doesn't. If so, it does NOT reproduce the characteristics of all other pickups – in fact it lacks at least that one.

Over the years, the Fender company tried several times to bend the magnetic field of single-coil pickups, starting with the base-plate of the Telecaster bridge pickup up to the pickup with a ceramic magnet patented in 1980. Leo Fender was of the erroneous opinion that the more string-length is sampled, the better the sound would be, and for this reason the Jazzmaster receives a pickup with a particularly coil and the Jaguar pickup a special yoke. In agreement with this kind of thinking, the patent for the Jaguar discloses that in regular pickups, the magnetic field lines *pass through only very small portions [of the string], with small harmonic content*. In contrast, the teethed yoke of the Jaguar pickup is supposed to magnetize a approx. 2 cm long area (**Fig. 5.4.35**), and for the Lace pickup the magnet strips allegedly push the magnetic field outward, i.e. they make it broader (**Fig. 5.4.36**). But aren't the aperture width and the frequency bandwidth in a reciprocal relationship? Of course they are: the shorter the sampled piece of string, the better the treble reproduction – that's also exactly why the old tape recorders had the smallest possible magnetic gaps in the tape heads.

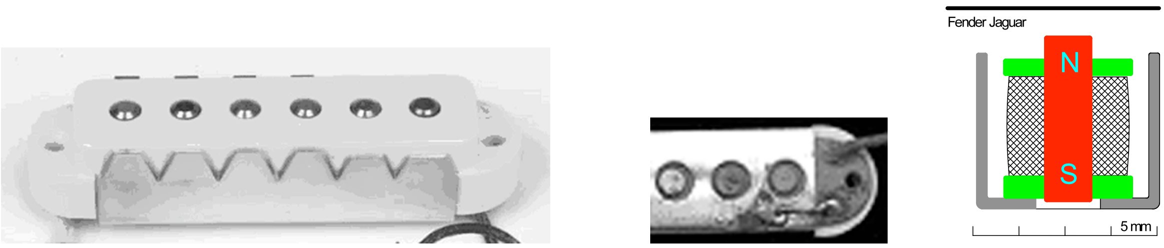


**Fig. 5.4.35:** Fender Jaguar pickup [www.guitar-parts.com, www.jimshine.com]; the teethed u-shaped "claw" leads a part of the magnetic flow returning from the string back to the south-pole

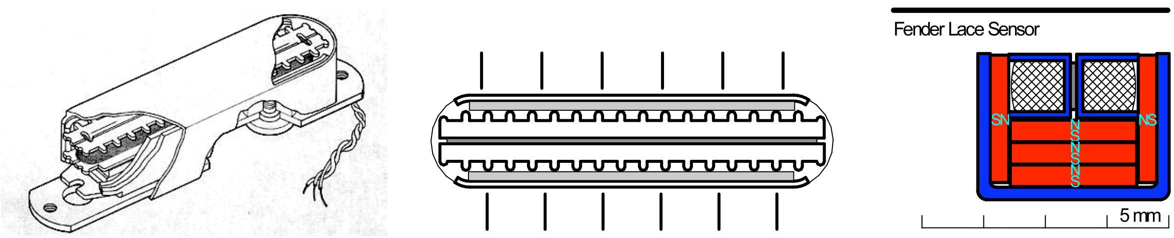


**Fig. 5.4.36:** Lace-Pickup [Fender-Actodyne]. The ferromagnetic coil bobbin has a teeth-shaped upper side to generate a magnetic field "as inhomogeneous as possible". The distance of the teeth has no regular relation to the distance of the strings (in the middle section above two typical cases are hinted: top: 51 mm, bottom: 49 mm) .

Luckily, the magnetic field lines ignore the patent publication for the most part and instead follow the laws of physics when seeking their path. **Fig. 5.4.37** shows, in its left section, the magnetic window of the **Lace pickup** measured with rotating string, while the right-hand section depicts the aperture-frequency response derived from the window. Yes indeed, there is a difference to the Stratocaster pickup, but the treble-loss is still limited, as also verified via the transfer measurement using the laser-vibrometer (**Fig. 4.5.38**, measurement setup as given in chapter 5.10.5).

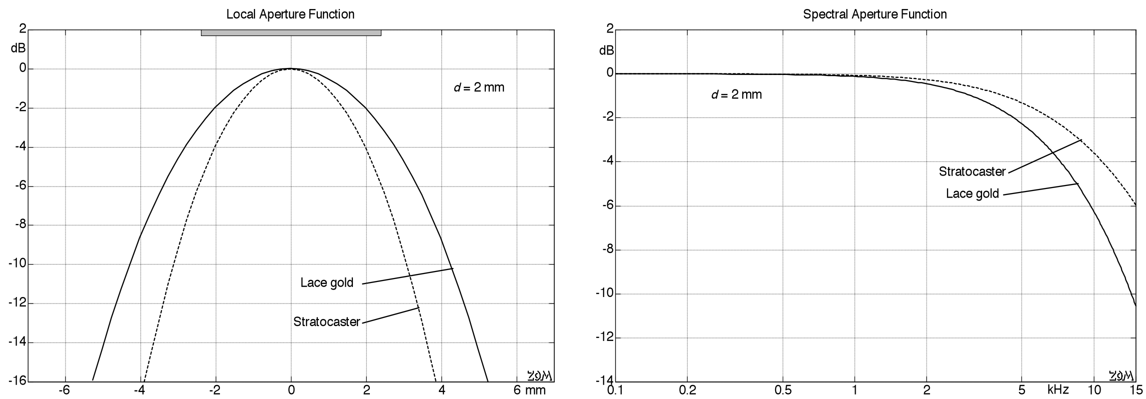


**Fig. 5.4.37:** left: aperture of the magnetic field; right: aperture-frequ.- response ($E_2$, with dispersion, $b$ = 1/8000).

The impedance-frequency-response (**Fig. 4.5.38**) reveals further differences: the yokes lead to stronger eddy current losses and consequently the emphasis of the resonance in the Lace pickup is a bit less than that of the regular Stratocaster pickup. Similar differences can easily be achieved as well via changes on the resistance of the connected potentiometers, and thus Lace and Stratocaster pickups are very similar regarding their transmission. There are, however, big differences in the **sensitivity to hum** (chapter 5.7) and in the strength of the **magnetic field** – the latter is about 60% less than that of the customary Stratocaster pickup. That's not really "Leo-compliant" since he thought it to be patentable to generate – in the Jaguar pickup – a magnetic field stronger than that of conventional pickups. Conversely, the allegedly patentable subject matter in the Lace is a magnetic field weaker than that of conventional pickups. Who would have thought .....

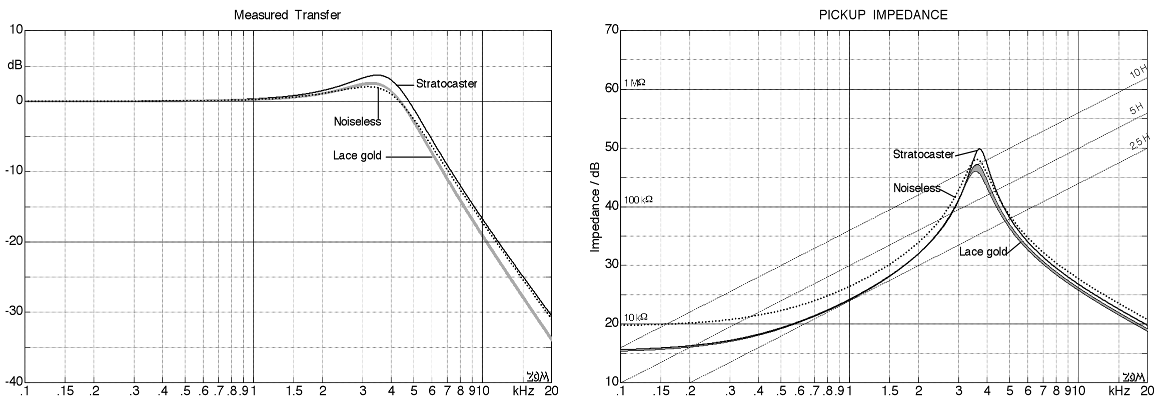


**Fig. 5.4.38:** left: frequency response measured with the laser-vibrometer. right: impedance-frequency-response. Two specimen of the Lace were analyzed. Noiseless. (Noiseless = Fender Noiseless-Strat-Pickup).

Now then: is the Lace good or bad? In a nutshell: the advertising may be dubious but the pickup is quite o.k. It features a good hum rejection♣ with only a slight treble loss.

♣ However, the Fender Noiseless-Strat-pickup shows an improvement of another 13 dB in its hum rejection.

Incidentally, Mr. R. Blackmore responded to the question whether he was happy with the Lace: "well ... sure – would I use it otherwise?" (in a German music magazine in May, 2005). Seems the interviewer was actually in luck that he didn't get smacked. By the way, it appears that both have fallen out of fashion a bit: Fender almost never installs the Lace anymore, and that Blackmore guy ... who was that again ... anyway, there's probably enough lace of the other kind in Blackmore's Night.

The **Jaguar pickup** is not in a front-row position anymore, either, despite it being better than its reputation. If indeed the u-shaped yoke would generate a 2-cm-wide aperture window, it would face a significant treble loss. As it is, nothing really changes much. That is connected to the fact that, contrary to the patent, Fender does not mount the yoke directly and without any gap to the magnet but leaves a 1-mm-wide annular air-gap (**Fig. 5.4.35**). Off to the patent office right away, and only afterwards do some testing ... ain't that so, Leo? Without the air-gap, microphonics could take over too much, and that's not what we want, do we? And then: the magnetic field doesn't have to be that strong, anyway, and we can make the yoke a bit thinner than in the patent, and shorten it by tow teeth, and change (1964) to staggered magnets ... it's a fit!!

Measuring the impedance (**Fig. 5.4.39**) shows 3,8 H with the yoke and 3,15 H without it; that is more than for the "normal" Strat pickup which had approx. 2.2 H. The DC-resistance is higher than that of the Strat (6,8 kΩ versus 5,7 kΩ) which indicates a larger number of turns. The ferromagnetic yoke increases the inductivity but also reduces the emphasis of the resonance due to the resulting eddy currents. The main differences to the Strat-pickup are: the resonance frequency is lower, the resonance emphasis (Q-factor) decreased, but on the other hand the Jaguar pickup is louder and receives significantly less hum (chapter 5.5, 5.7)

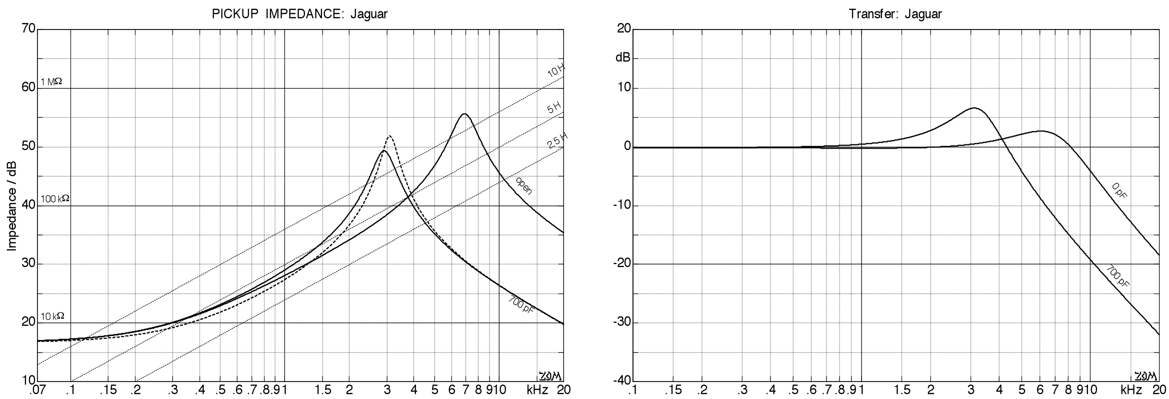


**Fig. 5.4.39:** Impedance-frequ.-response (--- = w/out yoke). The transfer is for a 333 kΩ load (amp = 1 MΩ).

Comparing both *guitars* divulges a further peculiarity: for the Strat the pots have 250 kΩ each, for the Jaguar 1 MΩ each! That's why the resonance emphasis for the Jaguar in fact even *bigger*. However, the 1-MΩ-pots are not really purposeful: turning down the volume just a bit all the treble is lost (chapter 9). But that's not all, folks: the Jag holds a **secret** which has occupied the fan community for decades: why are two teeth shorter and which way 'round should the pickup be installed? It appears that even in the Fender company there was controversy about this, and the shorter teeth were installed underneath the E2- und A-string ... but also underneath the H- und E4-Saite. Had the issue been solely the loudness of the individual strings, it would have been solved by the staggered magnets. Probably there was the wish to give the two bass strings more brilliance. Not a bad thought in principle – however the improvement is only a few tenth of a dB, and we can check off the issue. Myth busted ....

The comparison between the calculated transfer function ($H_{Uv}$ chapter 5.9.3) and measurement with a laser (chapter 5.10.5) show a slight treble loss (**Fig. 5.4.40**), the cause of which quite surely is the special magnet aperture. The left hand part of the figure shows the local weighting function belonging to the transfer function – it is obtained via the inverse Fourier transform. The saddle-shaped drop around 5 kHz is a consequence of the secondary maxima of the aperture function: without the secondary maxima the transfer function has the shape of the dotted line.

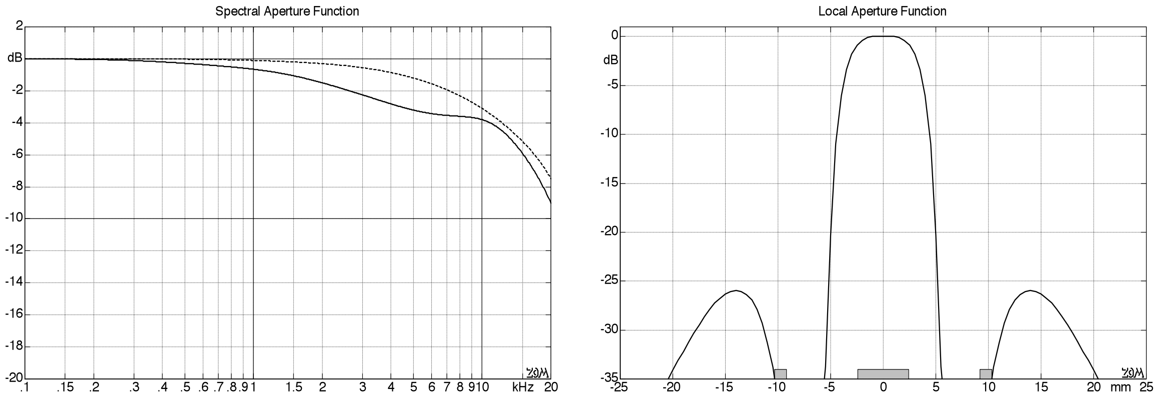


**Fig. 5.4.40:** Jaguar pickup, left: aperture frequency response (— with & --- w/out second. maxima); right: local weighting. Wound string, outer diameter = 1,1 mm; string-to-magnet distance = 4 mm, $f$ = 82 Hz for the 65-cm-scale. The dimensions of magnet and heads of the "teeth" are indicated in grey at the bottom of the diagram.

For the analyzed Jaguar pickup, the magnetic field enters the string over the pole (N) and exits it again from approx. 7 mm (compare to Fig. 5.4.8). The flow back to the south-pole generate the **secondary maxima** of the aperture function which are located a small distance outside of the "teeth". The u-shaped yoke including the teeth is able to focus these flows somewhat; this causes the saddle-shaped treble loss – in addition to the reduced sensitivity to hum. Of course, without the yoke with its teeth, the flow back to the south pole is also present – but it is more distributed in space and thus with less attenuation of the treble. The secondary maxima show up in measurements at -40 dB but can be determined only as an approximation since the measurement accuracy is dropping considerably from 5 kHz up.

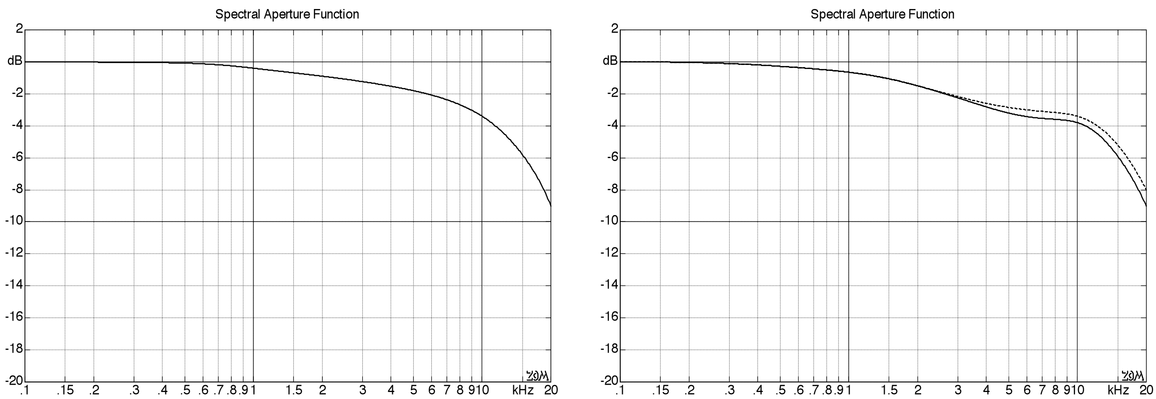


**Fig. 5.4.41:** left: Jaguar pickup without the teethed yoke, otherwise as Fig. 5.4.40; right: measurements with teethed yoke, above the D-magnet (——) and the A-magnet (----, shortened "tooth"), respectively.

In **Fig. 5.4.41** we see the transfer function without the teethed yoke on the left; on the right the treble gain caused by the shortened tooth shows but it's in fact, not worth mentioning. The shielding, however, is quite a success and reaches second place of the investigated (true) single coils.