5.15 Collection of data

The following pages compile the most important parameters of a selection of pickups. Some of the latter were bought new right before the measurements were taken while others already looked back on a long service life of 40+ years in musical action. None of the pickups necessarily is a typical representative of its kind but there was no indication of the contrary, either. It is safe to assume that for pickups produced by way of modern manufacture the production tolerances are small. This qualitative assumption is, however, not secured via an **analysis of variance**, and it therefore has a speculative character. For old pickups, there might have been a considerable spread over the years of production although again there is no proof for this. Some old pickups are traded for more that \$ 10000, - per piece; this supports the doctrine of correlation between price and demand. It did not seem justifiable, though, to enter this control loop and purchase e.g. 20 Gibson PAFs just to verify the parameter variances in these pickups. Even for the brand-new and therefore relatively "inexpensive" P90 (compared to vintage pickups), the required sum (290. - Deutschmark in 1998) was invested only once. In view of the rather plain construction, comments that come to mind regarding this stately price are exclusively non-printable.

During all measurements, we made certain that **errors** due to instrumentation contributed merely in a negligible manner, if at all, to the result. Likewise, we went to great lengths to ensure that interference effects were insignificant, or – if unavoidable – at least clearly recognizable. For level measurements, the tolerance was typically 0,1 dB which is more than adequate since changes become only audible if they exceed 1 dB. Position measurements close to magnetic poles proved to be more difficult. From a scientific point of view, tolerances of below 0,1 mm would have been desirable but could not always be achieved. For the user, this error is tolerable, since guitarists do not actually adjust the distance between string and magnet with a higher precision. The temperature of the measurement objects was not taken; in the vast majority of the cases it should have been room temperature between 20 and 24 °C.

Impedance measurements on pickups were done with imprinted current (3 mA_{eff}); the load by the meter connected in parallel was, at R > 10 MΩ, insignificant. In order to emulate the shift in resonance frequency due to cables, various styroflex capacitors were connected in parallel; in the framework of impedance measurements, the losses of these capacitors are negligible.

To pickup remained load-free for the measurement or the calculation of the transfer behavior, or it was loaded with a typical circuitry. **Fig. 5.15.1** shows the complex loading model, and a simplified equivalent circuit of this typical loading – the differences are insignificant in the relevant frequency range.

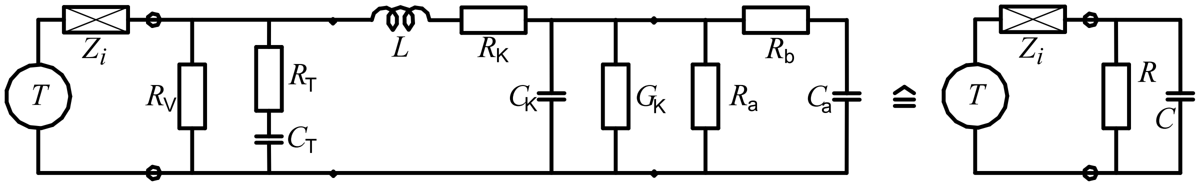
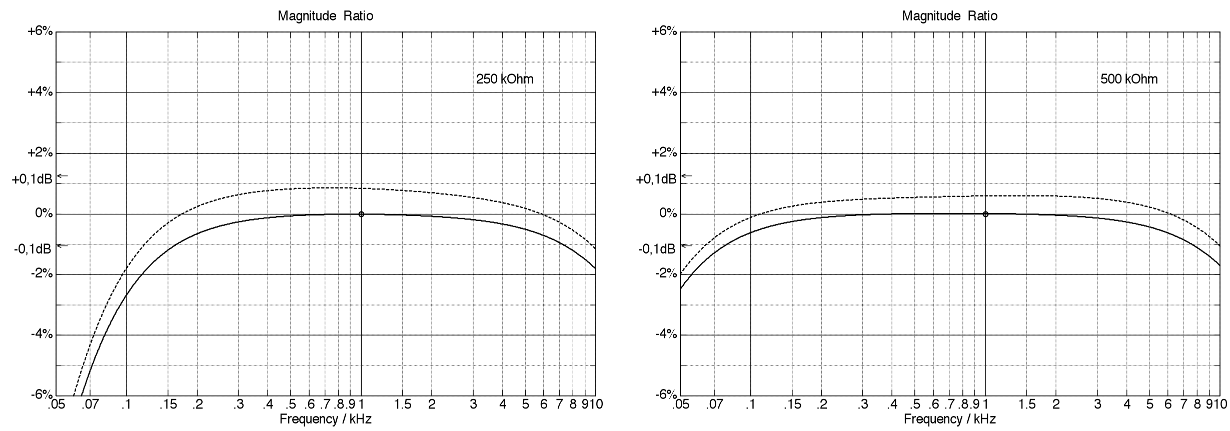


Fig. 5.15.1: Pickup-loading. T = pickup, Z_i = source impedance, R_V = Volume control, R_T = Tone control, C_T = Tone-Cap, L, R_K, C_K, G_K are elements of the guitar cable, R_a, R_b and C_a model the guitar amplifier. The $R||C$-circuit shown in the right represents a well-suited equivalent circuit.

In **Fig. 5.15.1**, the pickup *T* is modeled by its source-impedance Z_i , volume and tone controls are assumed to have their maximum resistance value i.e. both potentiometers are turned fully clockwise. For guitars with singlecoil pickups, these potentiometers frequently have a value of 250 kΩ, and for humbucker-equipped guitars usually the 500-kΩ-version is used. The tone control capacitor C_T often has 22 nF. The guitar cable is modeled via a series-inductance which – having a value of about 0,3 μH/m – may be ignored in the audio range with good approximation. Similarly, series resistance (R_K < 1 Ω/m) and parallel conductance (G_K < 5 nS/m) may be left without further consideration. The parallel capacitance C_K, however, needs to be taken into account; it shows about 100 pF/m (see also Chapter 9.3). For a typical tube amplifier, the parallel resistance R_a at the input usually amounts to 1 MΩ, and between the input jack and the first tube we frequently find two 68-kΩ-resistors connected in parallel (R_b). The tube input capacitance is enlarged by the Miller-effect; in combination with the wiring in the amplifier we obtain about 150 pF for C_a.

Although the load circuit shown in Fig. 5.15.1 looks complicated, it substantially has no other effect in the audio range than the R||C-circuit also given in the figure. **Fig. 5.15.1** exemplifies the differences between the two circuits. The R||C-circuit was optimized for 1 kHz; the small differences occurring at low and high frequencies are inconsequential in practice. As an orientation, each figure also shows the plots for two further R||C-circuits in which the resistor differs by 5 kΩ and the capacitance by 5 pF. Considering that typical tolerances found in potentiometers are much larger (> ± 25 kΩ), and that a capacity difference of 5 pF corresponds to a difference in length of 5 cm of the guitar cable, we clearly see that the equivalent circuit given here generates much less of a difference that the tolerances of regular component do. The equivalent circuit is therefore well suited to model the pickup load. With respect to the phase, differences are also negligible.



R_V = 250 kΩ, R_T = 250 kΩ.

R = 111,4 kΩ, C = 755 pF (-------)

R = 110,4 kΩ, C = 760 pF (———)

R_V = 500 kΩ, R_T = 500 kΩ.

R = 200 kΩ, C = 750 pF (-------)

R = 199 kΩ, C = 755 pF (———)

Fig. 5.15.2: Differences of the amount of the impedances (Z_{RC}/Z) of the load circuit of Fig. 5.15.1. C_K = 600pF was taken for the guitar cable, 1 MΩ, 34 kΩ, 150 pF for the amplifier input. The differences at low frequencies are caused by the tone capacitor (C_T = 22 nF), the ones at high frequencies by the tube-capacity. Since all component values have a tolerance of at least 5% (even 20% are not unheard of), the accuracy of the model is easily sufficient. In the low-frequency region, the source impedance of the pickup is less than 20 kΩ – any discrepancies in the transfer parameters are therefore reduced to much less than 1%.

Legend to the figures

For the measurements, all pickups were given an electrical "environment" as they would find it in their typical real-life situation: connected to a volume- and a tone-control (presenting a load consisting of two resistors in parallel), and to an amplifier input with an input impedance of 1 MΩ. This meant that all Fender-type single-coil pickups (typically connected to 250-kΩ-pots) faced a resistive load of 111 kΩ, and all Gibson-type humbuckers one of 200 kΩ (due to the typical 500-kΩ pots). The latter "Gibson-scenario" was also used for P-90-type pickups, the Gretsch pickups, the Rickenbacker humbucker, and the VOX pickup. Special cases were the Fender Jazzmaster, Jaguar, and original "Wide-Range" humbuckers (where 1-MΩ-pots were used): here the load was 333 kΩ. The Rickenbacker "Toaster" faced 91 kΩ (due to the additional series capacitor and volume control in the circuit), and the DeArmond Rhythm Chief 1100, FHC, and "Hershey-Bar" pickups with their integrated controls were connected to 167 kΩ, 167 kΩ, and 50 kΩ, respectively. For the connection to the amplifier, a cable is required, and the amplifier also has a capacitive input impedance – this was simulated for all pickups by a capacitive load of 450 pF and 750 pF (to take into account different cable lengths); an additional measurement was made with no capacitive load (but with the ohmic load)..

Impedance frequency response: the left-hand figure depicts the amount of the pickup impedance as a function of frequency – once without any load (*open*), and twice for purely capacitive load (450 pF and 750 pF, respectively). The impedance level is referenced to 1 kΩ: $L_Z = 20 \cdot \lg\left(|\underline{Z}| / 1\text{k}\Omega\right)\text{dB}$; 40 dB correspond to 100 kΩ. It is noted that looking at the impedance level is not a customary approach – it is however very advantageous since it can be interpreted easily. The angled orientation lines belong to purely inductive impedances. The cable connecting the pickup to the potentiometers is only considered if it is soldered internally to the pickup (as is the case e.g. for Gibson Humbuckers). The potentiometers are not considered (as load).

Transfer frequency response: the right-hand figure shows the transfer behavior (Chapter 5.9.3) of the pickup under load. The latter is the parallel connection of a resistor R and a capacitor C (Fig. 5.15.1). R models the usual guitar potentiometers and a high-impedance amplifier input (1 MΩ); C is the capacitive load with the same values as given in the left-hand figure (0 pF, 450 pF and 750 pF, respectively). The absolute sensitivity is indicated at the left margin with a dot; reference is a Stratocaster pickup (see Chapter 5.4.5). The ferromagnetic flux density B is indicated at the upper right (at 2 mm distance, Chapter 5.4.1).

Equivalent circuit diagram (ECD): the ECD shown was derived from impedance measurements; in terms of its complexity it represents a compromise between effort and accuracy. For most pickups, this ECD does serve well to model their transfer behavior; only for pickups with strong eddy-current losses it is of limited accuracy. The comb-filter frequency response found in humbuckers is not modeled with this ECD (for the impedance-equivalence see Chapter 5.9.2.3).

Pickup-data depend on the individual production processes; pickups of seemingly equal build can differ substantially in their electrical and transfer characteristics.

For the on-line publication only a limited number of pictures is released. The complete documentation is for the time being reserved for the print-version only. The text "Diese Abbildung bleibt der Druckversion vorbehalten" is the German explanation for a figure reserved for the printed version and thus excluded here.

Fender Stratocaster

The basic construction of this pickup was developed by Leo Fender as early as the late 1940's when he put together the Broadcaster (later Esquire, Telecaster): 6 alnico magnets are stuck into 2 flanges of vulcanized fiber, a lot of thin wire is wound between the flanges around this assembly … and done. This approach did prove itself, and the Stratocaster guitar issued 1954 received three identical pickups of the type. The 16 - 19 mm long alnico-5-magnets have a diameter of 4,8 mm (3/16"), and the enameled copper wire of 0,063 mm thickness was first insulated by formvar, then with plain enamel and later (after 1980) with polysol. The first Stratocaster pickups sported a number of turns between 8000 and 8700 – the belt-driven counters did not allow for a higher precision. In the 1960's, new automatic winding machines were introduced, and after some to-ing and fro-ing (or hither-and-thither, back in the day) a new standard was agreed upon: 7600 turns. Later came 7800, 8200, 8500, 9000, 9600 … it seems to be an endless story of variation and change. An abundance of speculations exists about the number of turns on the old pickups, but it is unlikely that this "secret" will be ever unlocked because nobody is going to unwind a 1954-Stratocaster just to check the winding and the number of turns (and even if somebody did that: what would we know about every other pickup given the variances in production back then?). A resistance measurement does not help, either: the wire diameter varies too much.

Fid. 5.15.3a: Fender Stratocaster [www.fender.com].

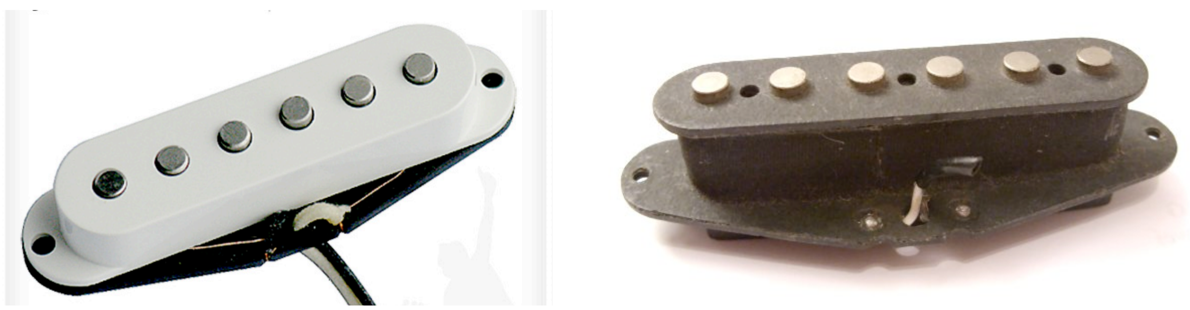
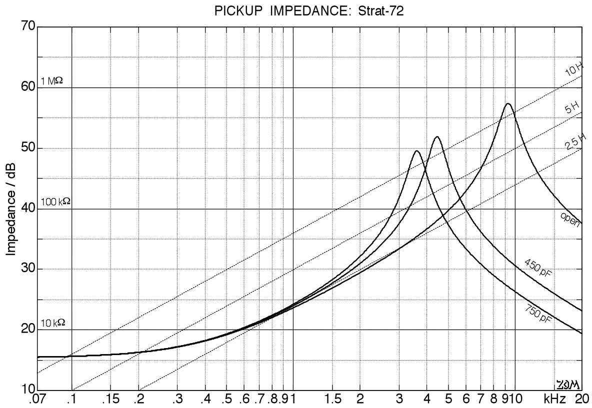
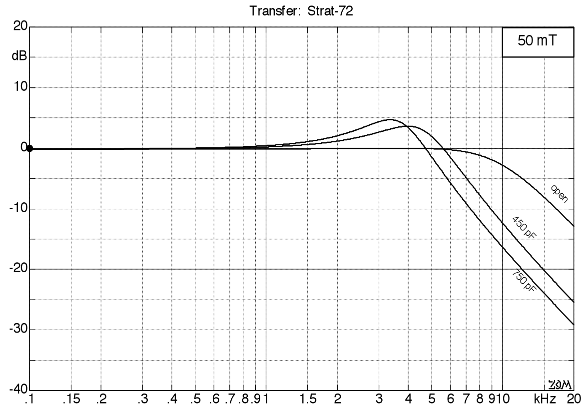


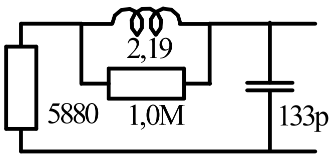
Fig. 5.15.3b: Strat-like pickup [www.phousemusic.com, www.guitar-letter.de].

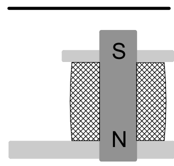
Fender Stratocaster '72

Singlecoil pickup, 6 cylindrical alnico magnets. #17492, probably from 1972.









Fender Noiseless Stratocaster (Neck)

Coaxial "Singlecoil"-pickup, 6 cylindrical alnico magnets.

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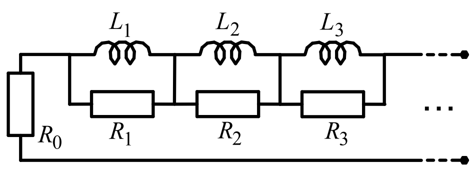

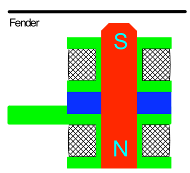

 Translated by Tilmann Zwicker

Fender USA-Standard Stratocaster (Neck)

Singlecoil pickup, 6 cylindrical alnico magnets.

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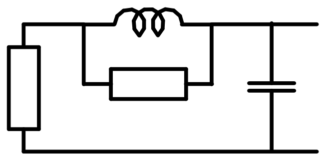

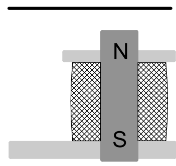

Fender USA-Standard Stratocaster (Bridge)

Singlecoil pickup, 6 cylindrical alnico magnets, 2 field-amplifying screws.

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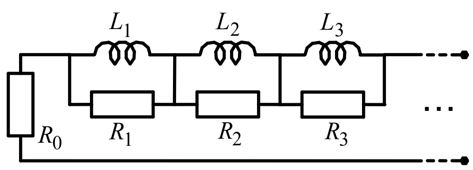

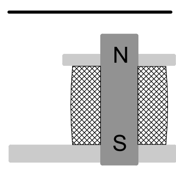

Fender Japan-Strat

Singlecoil pickup, ferrite bar-magnet.

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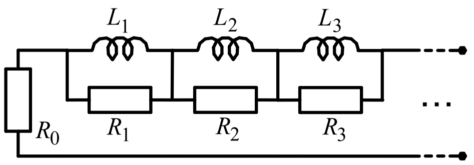

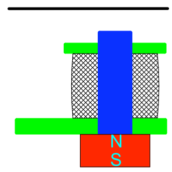

Rockinger (Strat Type)

Singlecoil pickup, ferrite bar-magnet.

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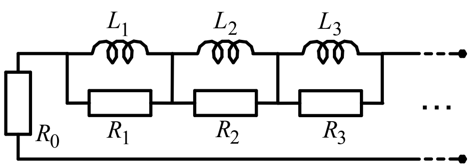

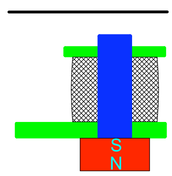

Ibanez Blazer (Strat Type)

Singlecoil pickup, ferrite bar-magnet.

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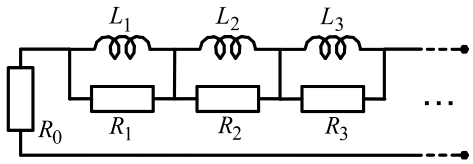

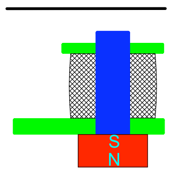

Seymour Duncan SSL-1 (Strat-Type)

Singlecoil pickup, 6 cylindrical alnico-magnets.

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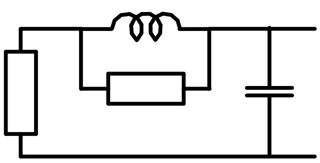

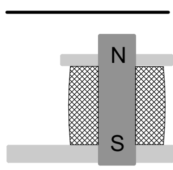

Lace gold

Singlecoil pickup, special guidance for the magnetic field

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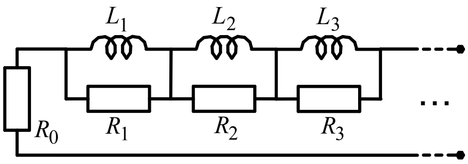

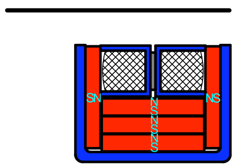

DiMarzio SDS1

Singlecoil pickup, 2 ferrite bar-magnets.

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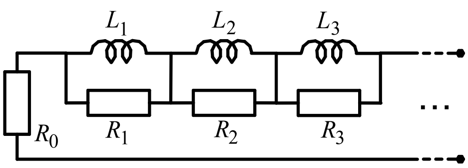
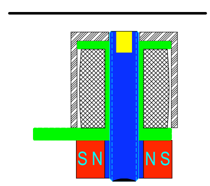




Fender Telecaster

Fender Telecaster Bridge-Pickup: the bridge pickup of the Esquire (the predecessor of the Broadcaster and the Telecaster) was developed in 1948 and 1949. It is based on the same construction as the Stratocaster pickup with 6 alnico-5 magnets and 2 flanges of vulcanized fiber. About 9000 turns of AWG-43 wire were wound onto the assembly. At the beginning of the 1950's a change to the thicker AWG-42 wire occurred, with the basic construction remaining the same. A special feature of the Telecaster bridge pickup is a metal base-plate – it was originally zinc-coated but later received copper coating. Dropped in 1983 to lower expenses, it was later re-introduced for special versions of the Tele. The "Texas-Special" has more turns than the normal version. The pickup is fastened in the cutout of a metal support plate that has the effect of an eddy-current-dampener and reduces the resonance emphasis.

Fender Telecaster Neck-Pickup: the Telecaster's neck pickup was developed in 1950 –it was first used in single specimen of the Esquire and then predominantly in the Broadcaster and Telecaster. It included 6 alnico-5 magnets, two flanges of vulcanized fiber and about 8000 turns of AWG-43 wire. Over the years there were many changes in some details but the basic construction remained the same. The Telecaster neck-pickup also has a special feature: a shielding cover made of nickel silver (German silver, Cu-Ni-Zn). For cheap copies nickel-plated copper is used, as well. The cover acts as an eddy-current-dampener.

Fender Telecaster Humbucker-Pickup: the same Seth Lover who developed the Gibson Humbucker also designed this pickup. Compared to the Gibson it features a slightly larger distance of the pole-pieces, and 12 adjustable CuNiFe individual magnets. Since CuNiFe has lost all significance as magnetic material and is difficult to obtain, new versions of this pickup are produced with a ceramic or alnico bar-magnets.

Fig. 5.15.4a: Fender Telecaster [www.fender.com].

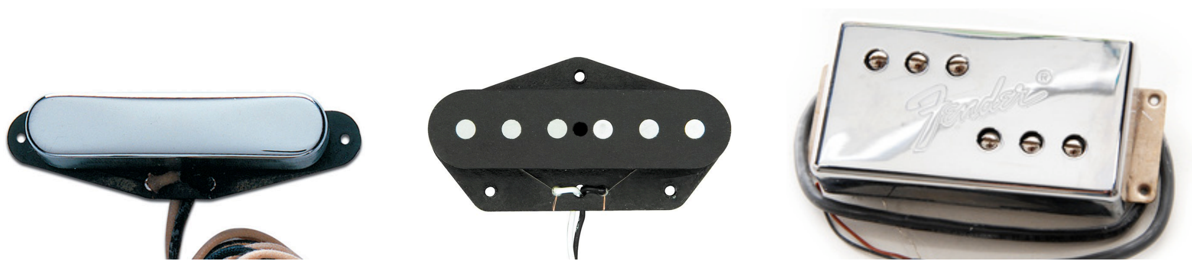
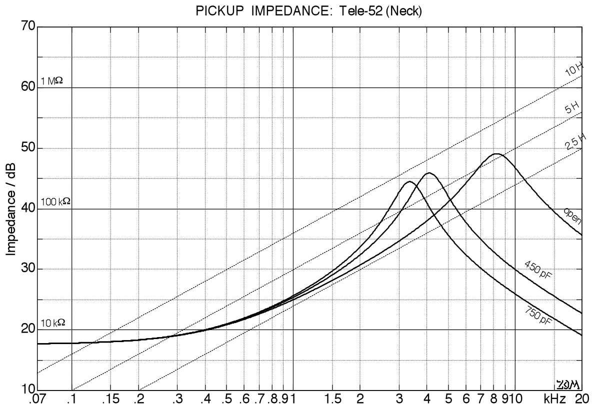
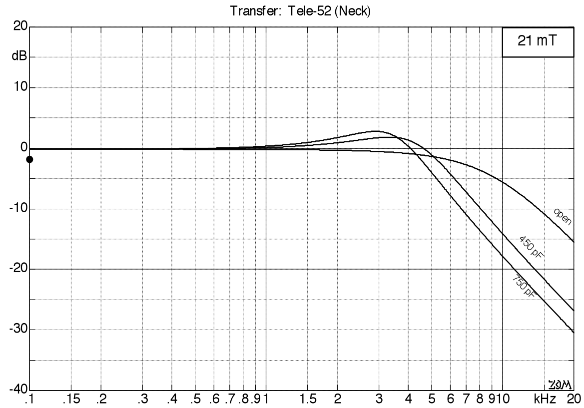


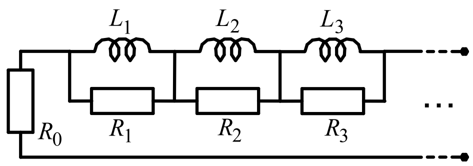
Fig. 5.15.4b: Fender Telecaster-pickups [www.fender.com, http://img3.musiciansfriend.com].

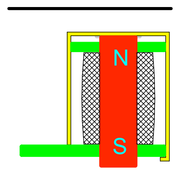
Fender Telecaster-52 (Neck)

Singlecoil pickup, 6 cylindrical alnico magnets.









Seymour Duncan APTR-1 (Tele-Type, Neck)

Singlecoil pickup, 6 cylindrical alnico magnets.

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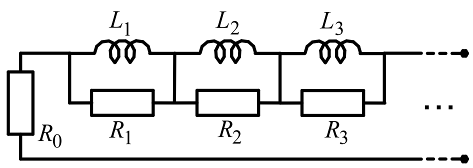

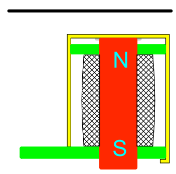

DiMarzio DP-172 (Tele-Type, Neck)

Singlecoil pickup, 6 cylindrical alnico magnets.

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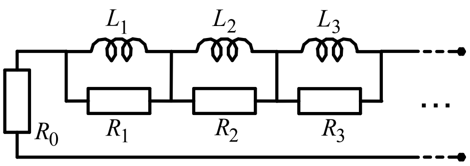
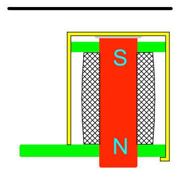
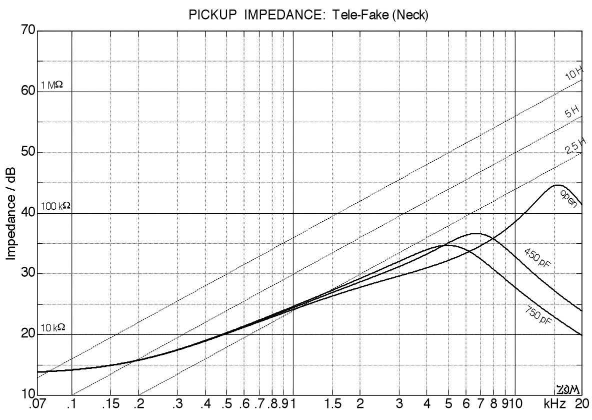
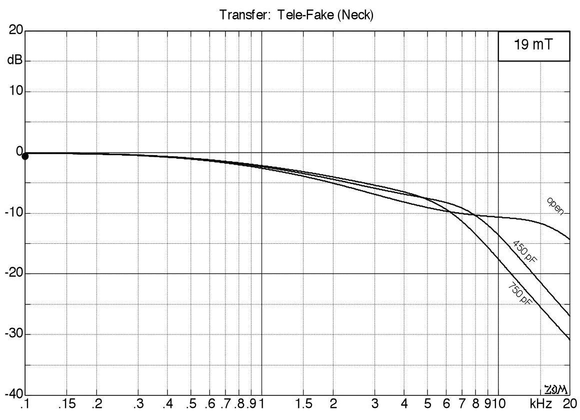


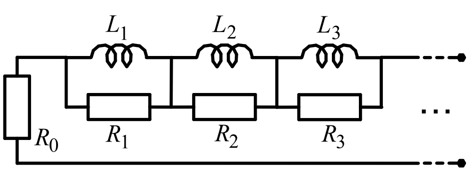


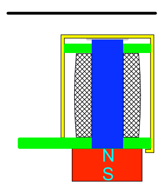
Telecaster-Fake (Neck)

Singlecoil pickup, ferrite bar-magnet.









Fender Telecaster-70 (Bridge)

Singlecoil pickup, 6 cylindrical alnico magnets.

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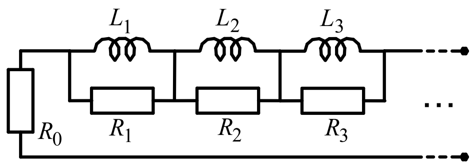

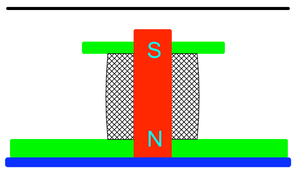

Fender Telecaster-73 (Bridge)

Singlecoil pickup, 6 cylindrical alnico magnets.

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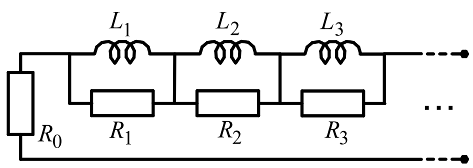

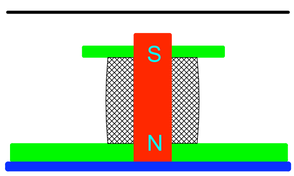

Fender Texas-Special Telecaster (Bridge)

Singlecoil pickup, 6 cylindrical alnico magnets.

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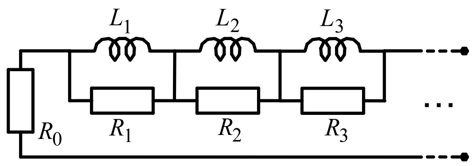

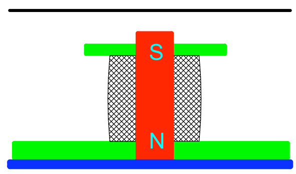

Fender Telecaster-52 (Bridge)

Singlecoil pickup, 6 cylindrical alnico magnets.

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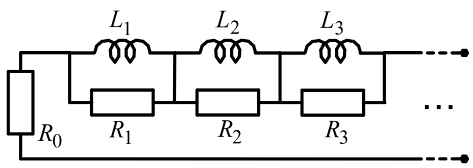

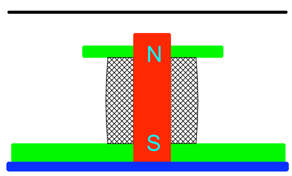

Seymour Duncan APTL-1 (Telecaster-Type, Bridge)

Singlecoil pickup, 6 cylindrical alnico magnets.

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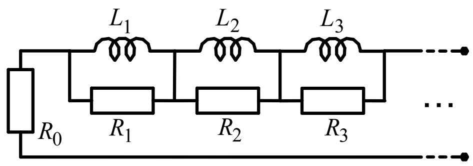
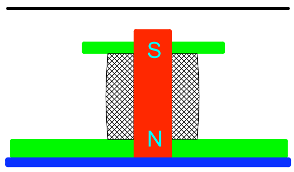
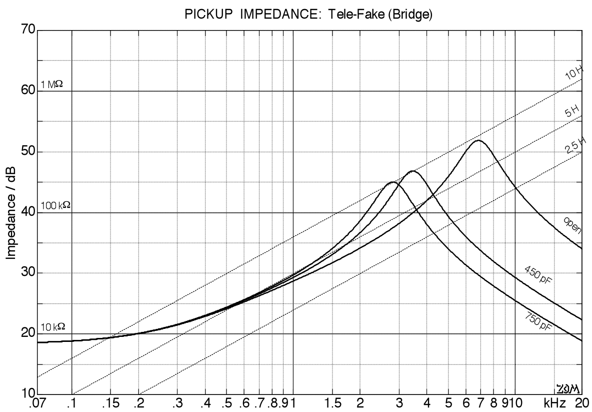
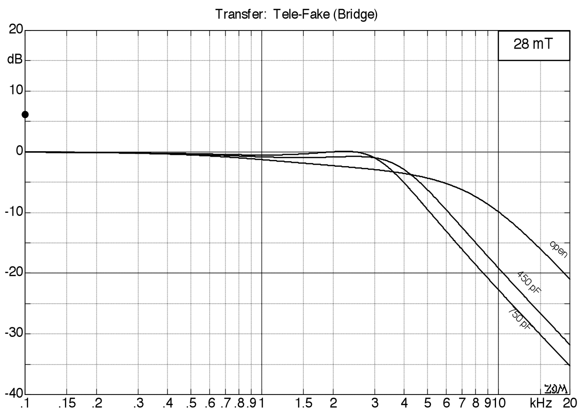


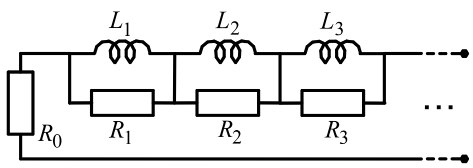


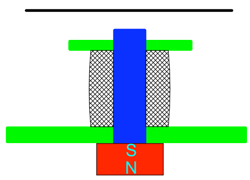
Telecaster-Fake (Bridge)

Singlecoil pickup, ferrite bar-magnet.





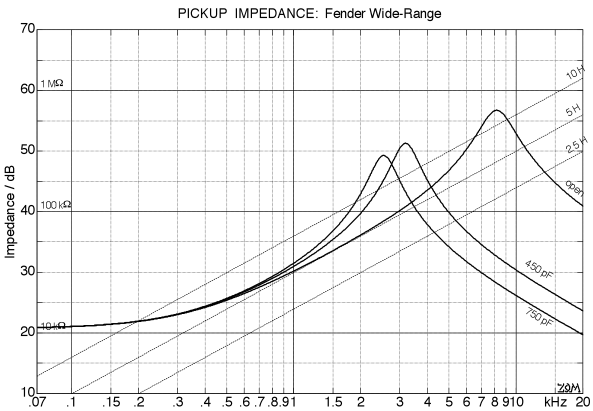


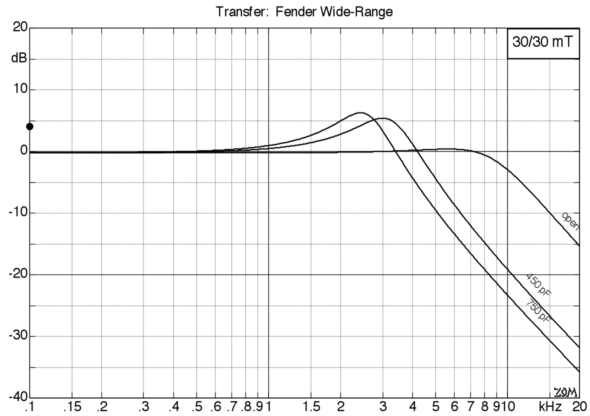


Translated by Tilmann Zwicker

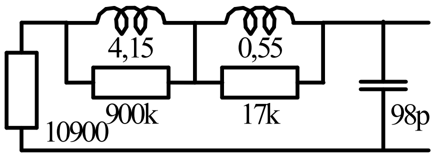
Fender Wide-Range Humbucker

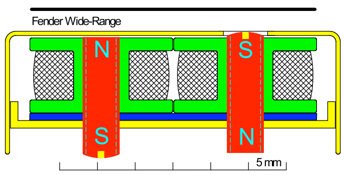
Humbucking pickup, 12 CuNiFe magnets.





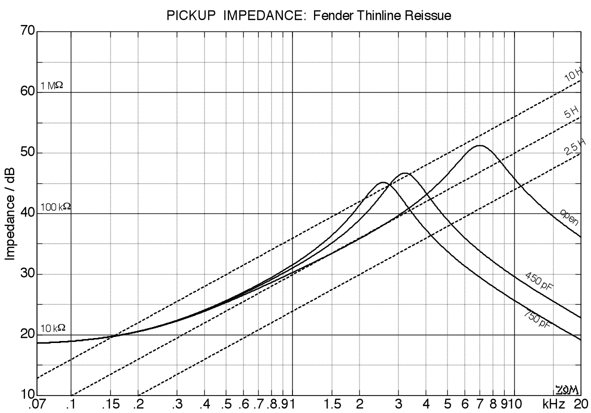
Two potentiometers 1 MΩ each i.e. load impedance = 333 kΩ

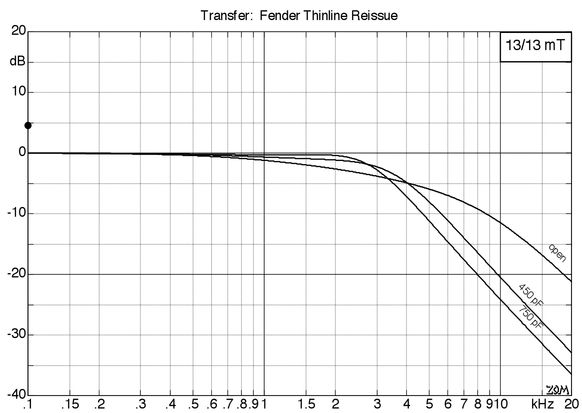




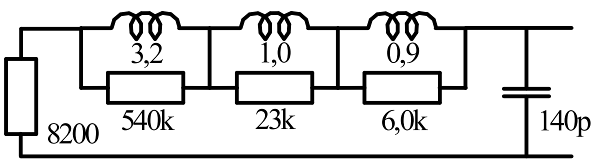
Fender Thinline-Reissue Humbucker

Humbucking pickup, alnico bar-magnet.





Two potentiometers 250 kΩ each i.e. load impedance = 111 kΩ



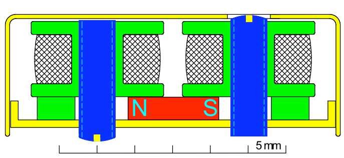


Fig**. 5.15.4c:** Fender Telecaster Thinline [www.fender.com].

Three variants of the Telecaster received the "Wide-Range"-humbucker (as it was called): Thinline (second generation), the Custom (second generation) and the Deluxe. Originally fitted with CuNiFe-magnets, later copies are of a completely different build and fitted with bar magnets (both of the alnico- and ceramics-variants). On top of this, there are different circuits with potentiometers of 250 kΩ or 1 MΩ, and capacitors of 10, 22 or 50 nF.

Two different Fender humbuckers could be examined: one original Wide-Range from the 1970's and a reissue pickup from a 2012-Thinline. The original has surprisingly special magnets. The reversible permeability of the CuNiFe-magnets is very small (compare to Fig. 4.42), and their static magnetization is decidedly peculiar. That may be a special characteristic of this individual pickup – we could not establish an assembly-line-production standard with just one representative. In any case: two of the **magnets** feature south poles on both facing surfaces! Yes, this is indeed physically permissible if a north pole is located in between the two south-poles. Also, the pickup does not become totally unusable, either, because the large differences occur on the lower side of the pickup. This still is rather peculiar …vintage, in any case and after all….

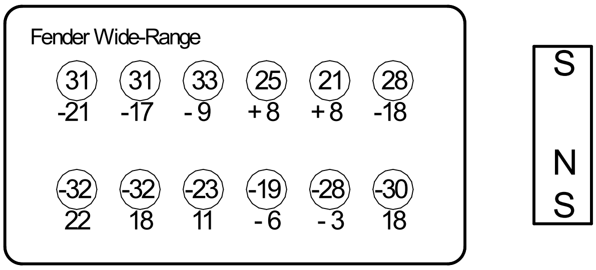


Fig. 5.15.4d: Fender Wide-Range humbucker [www.fender.com]. In the right-hand diagram the magnetic flux density measured at a distance of 2 mm is given; within the circle = top, numbers below: bottom of pickup

Fender Jazzmaster

Leo Fender developed this pickup for the Jazzmaster guitar introduced of in 1958. The pickup included 6 alnico-5 magnets, 2 flanges of vulcanized fiber and about 9000 turns of AWG-42-wire. Production was shut down in 1982, and later re-opened for replicas. Due to the larger coil the Jazzmaster-pickup is relatively prone to interference fields. At the same time, the larger size does not make its sensitivity profit in the same way because the magnetic field of the strings is locally limited, and thus hum-rejection is only moderate (Chapter 5.7).

The larger-size coil was chosen because Leo Fender sought to sample a section of the vibrating string as long as possible in order to obtain a wider spectrum. This approach holds two conceptual errors: first, the width of the aperture does not depend on the coil but on the magnet, and second, the width of the aperture and the frequency bandwidth are reciprocal to each other i.e. there is an inverse dependency.

The Jazzmaster pickup has relatively short alnico magnets creating next to no eddy-current dampening. In combination with the high-resistance 1-MΩ-potentiometers, the result is a very treble-laden, almost shrill sound. That the Jazzmaster would have a soft sound "due to its wide coils" is pure fantasy (Chapter 5.4.4). Despite the similar look, the Jazzmaster pickups must not be confused with the Gibson P-90, either.

Fig. 5.15.5a: Fender Jazzmaster [www.fender.com]

Fig. 5.15.5b: Jazzmaster pickup [www.petesrareguitars.com]

Fender Jazzmaster-62 (Neck)

Large singlecoil pickup, 6 cylindrical alnico magnets.

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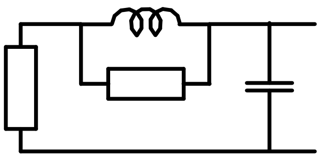

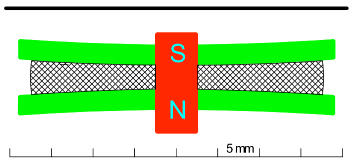

Fender Jazzmaster-62 (Bridge)

Large singlecoil pickup, 6 cylindrical alnico magnets.

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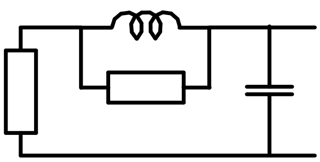

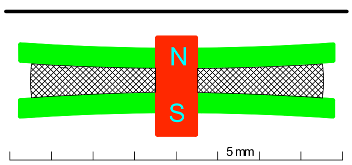

Fender Jaguar

Designed to be the ultimate flagship, the most expensive of all Fenders, *with all of the top features*. Meaning: *Floating Bridge and Tremolo* (from the Jazzmaster), *Lead/Rhythm-Selector* (also from the Jazzmaster), two *wide-range high-fidelity pickups* (its only very special feature), a *String-Mute* (jeez-no …💣). Plus, often forgotten: a 61-cm-scale! In the meantime, one could do very well without the string-mute, the Stratocaster already had a much better working vibrato-system, the rhythm-circuit – involving merely the neck pickup – was rather limited … so why invest all that money, thank you very much? Because of the pickups? O.k., these were indeed different from all the other Fenders, featuring a u-shaped metal shield. Allegedly, that had the effect of "focusing the magnetic field", of "increasing sustain" (!), of "reducing sensitivity to hum", of "improving the sound" – the patent application (issued as US 3,236,930) wallows in superlatives: the Jaguar would be *highly superior* compared to all the junk produced up to (that) date.

It would not be fair to suggest that icons such as Leo Fender might have not been playing with a full deck – no, in case of doubt it was the patent attorney who formulated that kind of nonsense, with a lot of tolerance on the side of the patent examiner. Pay attention, guitarists near and far: the guitars built until 1962 (i.e. pre-Jaguar, such as the Stratocaster) had, according to the Jag-patent, *undesirably characteristics*, *poor response to string vibrations*, much shorter sustain, were profoundly insensitive in the bass-range, their sound was *with small harmonic content*. Why on earth then did they have to so soon reduce and finally shut down the production of the *highly superior* Jaguar? By the way: we also find in the patent description that the Jaguar pickup would be *highly simple and economical* ... that again does sound like Leo.

An effect of the u-shaped magnetic-field guide (which Leo Fender hat patented once again in US 4,220,069) cannot be disputed, though: the treble loss created by it as well as the magnetic shielding is examined closely in Chapter 5.4.7.

Fig. 5.15.6a: Fender Jaguar [www.fender.com]

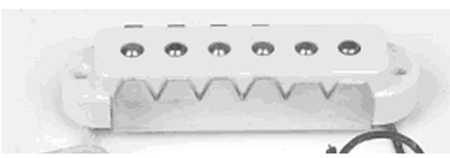

Fig. 5.15.6b: Fender Jaguar pickup [www.guitar-parts.com]

Fender Jaguar

Singlecoil pickup, 6 cylindrical alnico-magnets, u-shaped, serrated metal shield.

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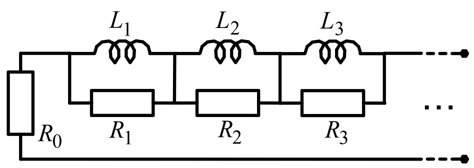
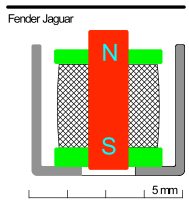




Gibson P-90

A large singlecoil pickup, the P-90 was developed by Gibson technician Walter Fuller and produced from 1946. It features 2 alnico-5 bar-magnets, 6 pole-screws, a bobbin and about 10.000 turns of AWG-42 wire. From 1957 onward it was installed only in the lower grade Gibson models – but again from 1968 also in Les Pauls. It has a black or cream-colored housing and also came (as the "dog-ear" version) in a metallic housing with two flanges.

P-100-L (L = Lead, bridge position, about 10 kOhm), **P-100-R** (Rhythm, about 6,5 kOhm). Coaxial pickup with two coils on top of each other and connected in parallel. Not a big success, it is not produced anymore.

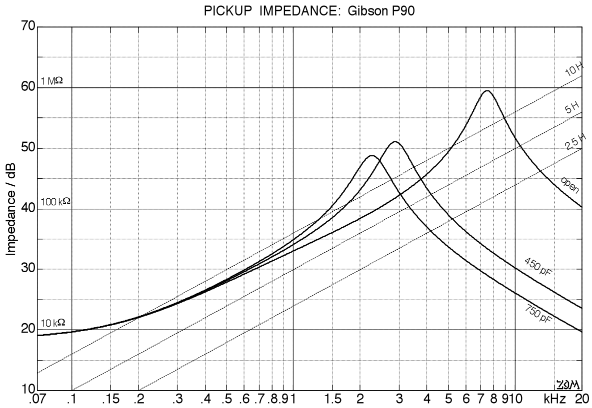
P-94 = P90 in the format of a Gibson Humbucker. The bobbin is shorter and slightly higher than that of the p-90.

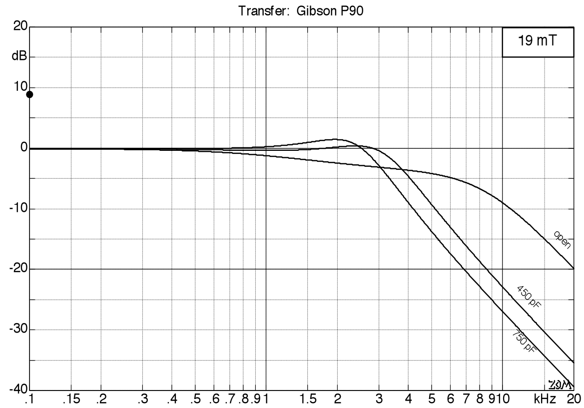
Fig. 5.15.7a: Two "Soap-Bar" P-90 in a Gibson Les Paul [www2.gibson.com]

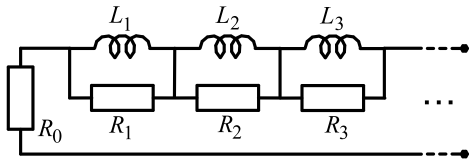
Fig. 5.15.7b: Two "Dog-Ear" P-90 in an Epiphone Casino [www2.gibson.com]

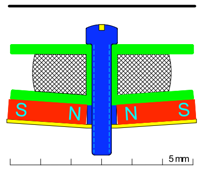
Gibson P-90 (Soapbar)

Large singlecoil pickup, 2 bar magnets, adjustable pole-screws.









Rockinger P-90 (Soapbar)

Large singlecoil pickup, 2 bar magnets, adjustable pole-screws.

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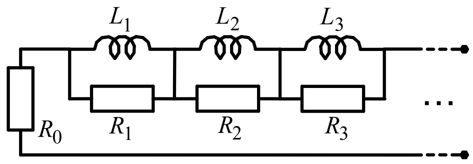

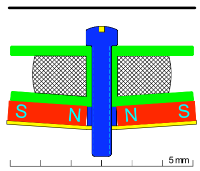

Rickenbacker

From about 1931, Adolph Rickenbacker installed electromagnetic pickups on Hawaiian guitars in California. The instruments were made of metal and later also of Bakelite. From 1936, various stringed instruments were fitted with a horse-shoe-magnet-pickup, and from the mid-1950's solid-body and hollow-body electrical guitars were available. When at the beginning of the 1960's the Beatles were sighted with Rickenbacker guitars, the brand became popular in Europe and the UK, as well.

Fig. 5.15.8a: Rickenbacker 325, three "Toaster"-pickups [www.fatendfirst.com].

The pickup examined in the following was installed in a 1966 Capri. In the US, the corresponding model range was designated Model-335 while the export-version was named Model-1996. The US-version had a wedge-shaped sound-hole ("cat's eye") while the export-version sported an f-hole.

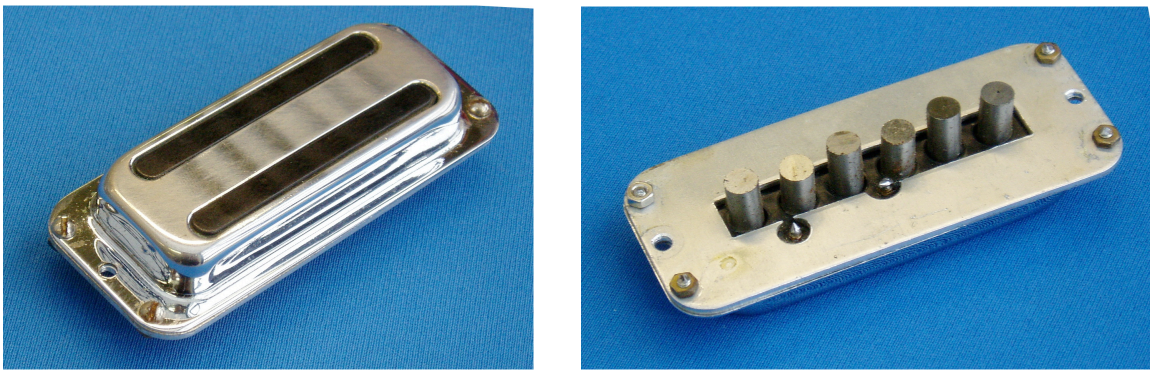

Fig. 5.15.8b: Rickenbacker "Toaster"-pickup.

The humbucker internally has 2 narrow blades at a distance of 12 mm.

Fig. 5.15.8c: Rickenbacker Humbucker.

Rickenbacker "Toaster"

Large singlecoil pickup, 6 cylindrical magnets (∅ 6,3 mm).

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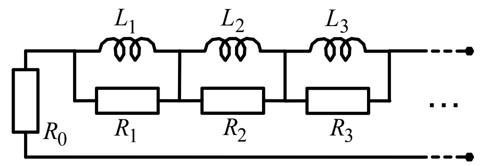
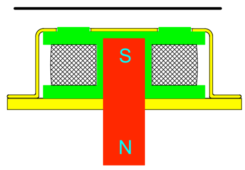
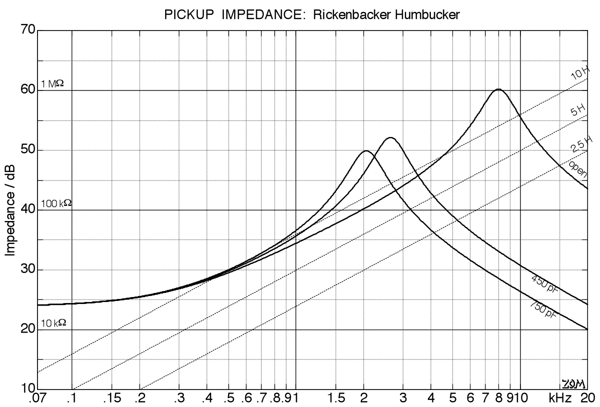


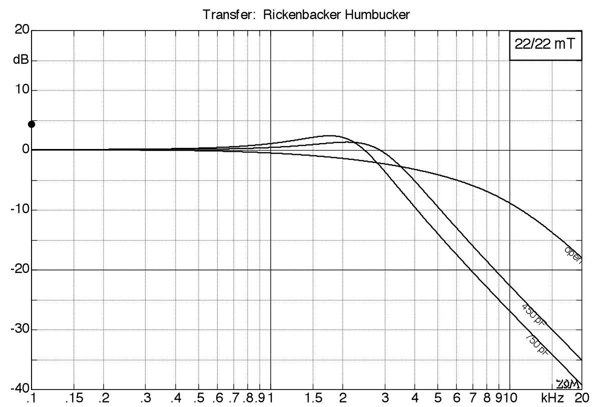


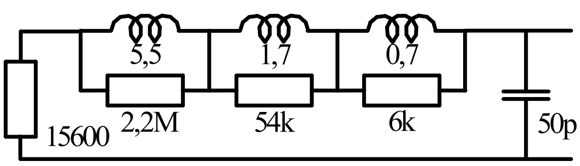
Load impedance 81 kΩ

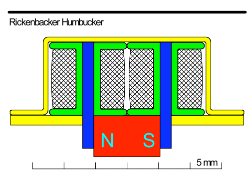
Rickenbacker Humbucker

Humbucking pickup, bar magnet with 2 blades.









Gretsch

The first Gretsch guitars (from 1949) were fitted with DeArmond pickups; in 1957 the FilterTron was introduced, and from 1961 the HiLoTron pickup was available. Its eccentrical pole-arrangement is similar to that of a humbucker, but in fact this is a singlecoil with a very special guide for the magnetic field (Chapter 5.10.5). The FilterTron, however, is a true humbucker (Chapter 5.7). The replicas built today have at least the cosmetics in common with the originals. Approximately, anyway ….

Fig. 5.15.9a: Gretsch guitar with 2 FilterTron pickups [www.gretschguitars.com].

Fig. 5.15.9b: Gretsch-guitar with 2 HiLoTron pickups [www.gretschguitars.com].

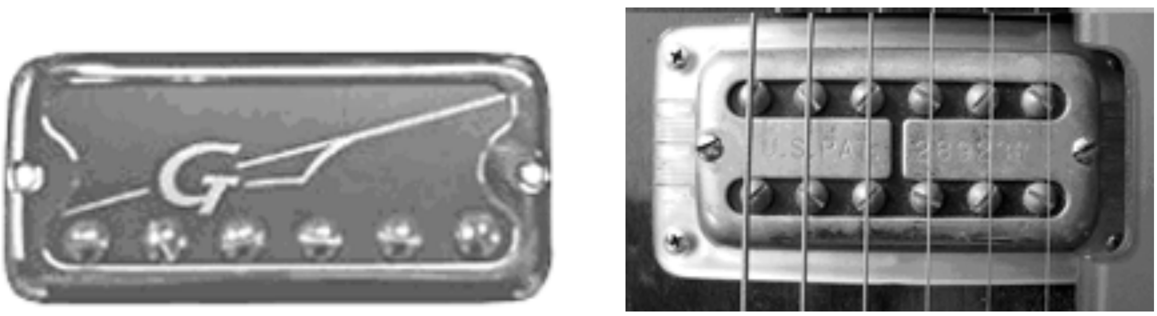


Fig. 5.15.9c: Gretsch-pickup [www.gretschpages.com].

Gretsch HiLoTron

Large singlecoil pickup, alnico bar-magnet.

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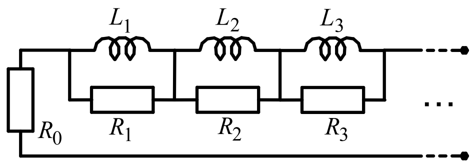

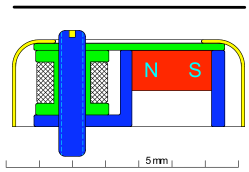

Gretsch FilterTron

Humbucking pickup, alnico bar magnet.

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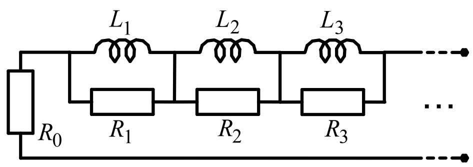
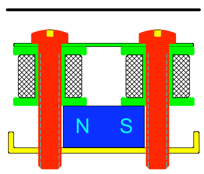




Gibson Humbucker

Developed around 1955 by Gibson technician Seth Lover as an alternative to the P-90, it targeted the reduction of the sensitivity to magnetic interference. It includes two side-by-side, serially-connected coils, an alnico bar-magnet, 6 polepieces (slugs) and 6 pole-screws (Chapter 5.9.2.6). The Gibson Humbucker is produced in a number of variants: with or without cover, with different magnet materials, with more or less winding on the coils, and equal or different numbers of turn between the two coils. Anyone seeing 5% difference between the coils as substantial will happily fork over the extra $.

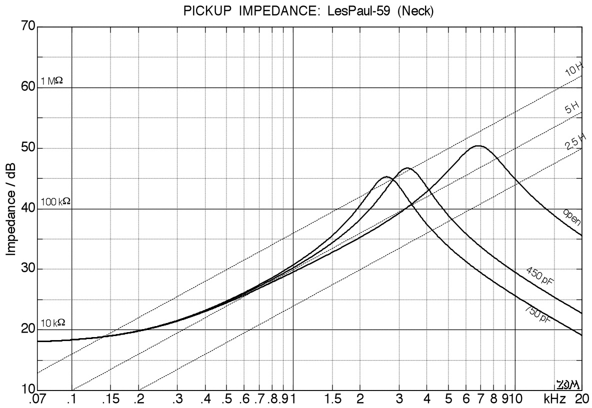
The Gibson Humbucker samples the string in *two* locations – this leading in particular to considerable treble-loss in the sound of the low strings (Chapter 5.4.4). However, this effect is not necessarily undesirable: with strong distortion a special sound does result.

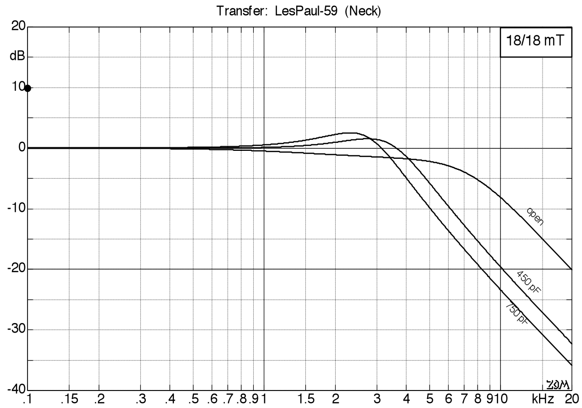
Fig. 5.15.10a: Two Gibson Humbuckers in a Gibson Les Paul [www2.gibson.com]

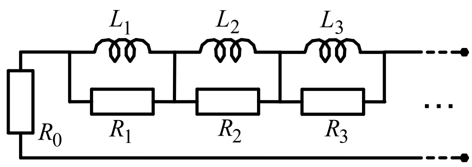
Fig. 5.15.10b: Gibson Humbucker [www.boutiquemusicinc.com, rainbowguitars.com].

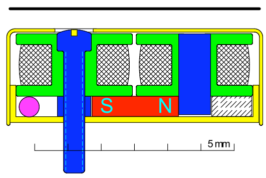
Gibson Burstbucker (Neck)

Humbucking pickup, alnico bar-magnet.









Gibson Burstbucker (Bridge)

Humbucking pickup, alnico bar-magnet.

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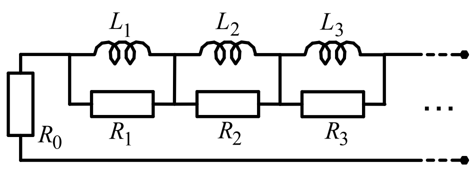

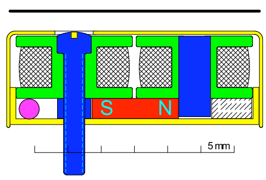

Gibson '57 classic

Humbucking pickup, alnico bar-magnet.

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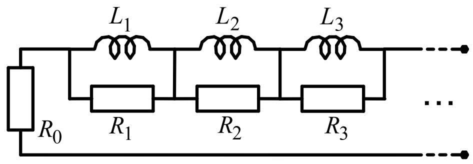

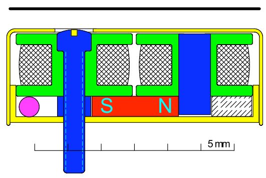

Gibson Tony Iommi

Humbucking pickup, bar-magnets.

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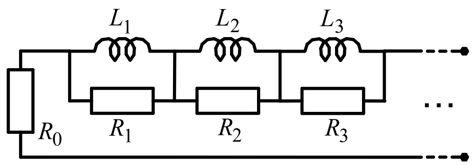

Fender Squier (Neck)

Humbucking pickup by Squier (Fender), similar to the Gibson Humbucker but with smaller inductance.

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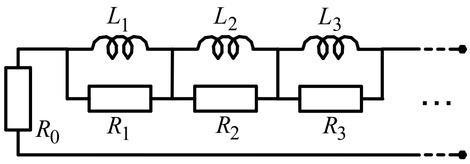

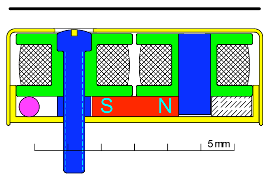

Fender Squier (Bridge)

Humbucking pickup by Squier (Fender), similar to the Gibson Humbucker but with smaller inductance.

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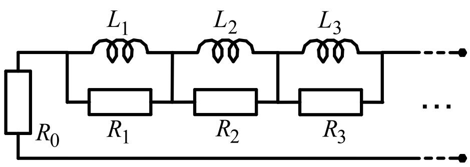
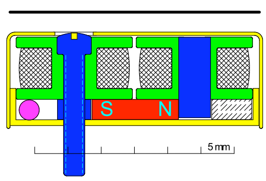




Gibson Firebird

Built in the 1960's, the Firebird featured humbuckers with two side-by-side coils; in the 1970's there was also a Lawrence-variant with coils rotated by 90°. The originals had an alnico bar-magnet inserted fully within the coil and operating as a sort of magnetic blade. The build is not visible since there are no openings in the top of the metal cover. The distance of the poles is 12,5 mm and therefore smaller than that seen in the standard Humbucker (19 mm), and consequently the interference gaps are found at different places. The resonance frequency is higher than that of the standard Humbucker; some specimens with somewhat fewer turns can almost reach values found in Stratocasters.

Fig. 5.15.10c: Gibson Firebird with 2 Firebird pickups [www2.gibson.com]

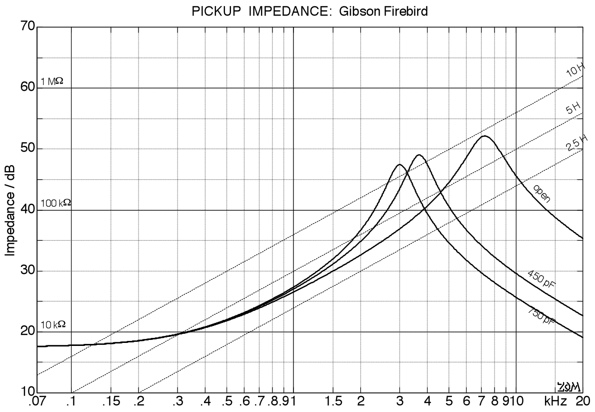
Gibson Mini-Humbucker

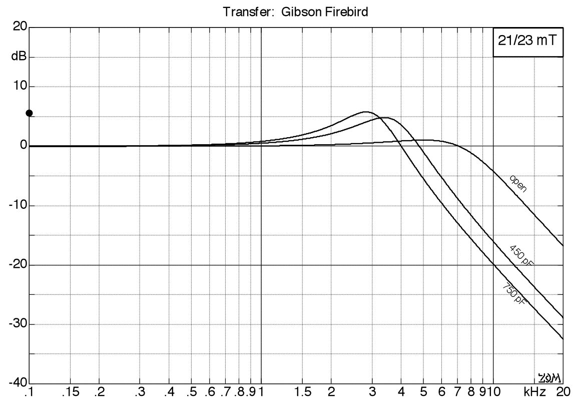
Gibson-Mini-Humbuckers were installed in the Les Paul Deluxe from 1969 to 1984. It is tempting to surmise that this is simply a reduce-in-size version of the standard Humbucker, but in fact it is an alternative (probably inspired by Epiphone). One coils carries the usual pole-screws, but the other does not have slugs but a thick steel-blade running the full length. Like in the Firebird pickup, the pole-distance at 12,5 mm is smaller than that seen in a standard Humbucker (19 mm). As a consequence, and also aided by the inductance bearing towards lower values, the Mini-Humbucker sounds more brilliant than a standard Humbucker

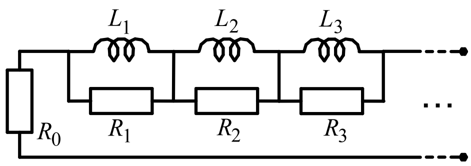
Fig. 5.15.10d: Gibson Les Paul Deluxe with 2 Mini-Humbuckers [www2.gibson.com]

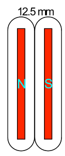
Gibson Firebird

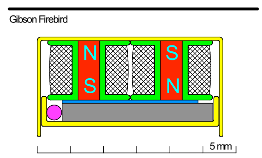
Humbucking pickup: 2 alnico-5 bar-magnets located <u>within</u> the coils, pole-distance merely 12.5 mm.





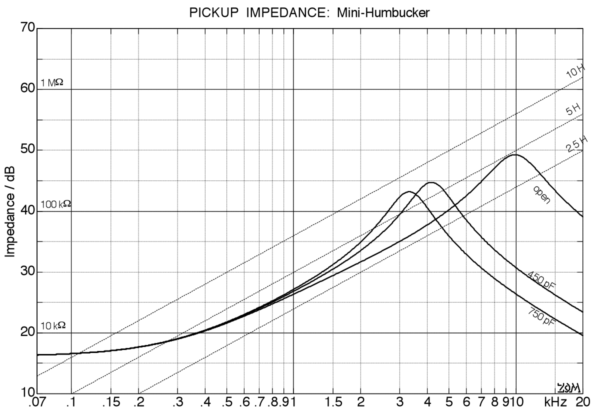


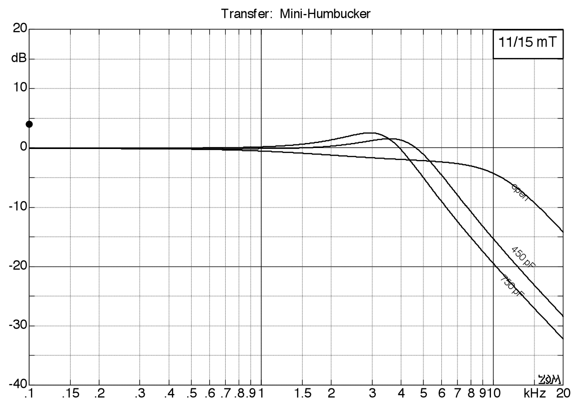


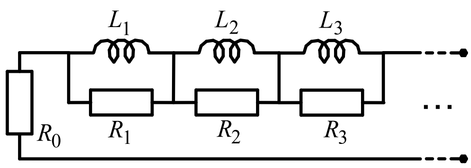


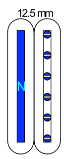
Gibson Mini-Humbucker

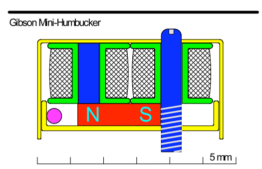
Humbucking pickup: bar magnet underneath the coils; pole-distance merely 12.5 mm.











VOX pickup

VOX became famous in the 1960’s with their tube amplifiers but also distributed electrical guitars. The HDC-77 shown below is not from the old days but a new development. The pickup is new, as well – allegedly. In an interview, VOX chief designer Eric Kirkland stated that “Planetz” were the "inventor of the CoAxe Pickup", and continues to explain: *While there are many good-sounding humbucking and stacked "single coil" pickups available, they are generally limited to one good noise-canceling sound. The unique magnetic structure and tapped coils of the VOX CoAxe offer both the power of a traditional humbucker and the high frequency detail of a true single coil – and the most effective noise canceling available in a passive pickup*. This is not entirely incorrect: indeed the hum-cancellation is impressive and so is the loudness of the pickup. What about the sound? Supposedly, the pickup should sound like a Fender singlecoil, or a P-90, or a humbucker. That’s what it should do, but apparently the pickup is oblivious of this job it was given.

The string-sampling at two positions is the characteristic of a humbucker. The P-90 and the Fender singlecoil sample at one position but the CoAxe does so at three. How is the CoAxe supposed to emulate a humbucker if its magnetic filed cannot not be switched? Only its coils are switchable (they are tapped) – which gives merely a meager effect: 2,5 dB change in level and 20% shift in resonance frequency. In the humbucker mode a series-circuit of a resistor (100 kΩ) and a capacitor (1,5 nF) is connected to the pickup – that’s all (although achieved via a monster switch with no less than 28 terminals). How could this turn a P-90 into a humbucker? Sorry: close but no cigar. The CoAxe pickup is nice, but it remains different compared to the targeted role models. Also: it ain’t something new, either – see the patent by Aaroe, applied for in 1981.

Fig. 5.15.11a: VOX guitar with 2 CoAxe pickups [www.korg.co.uk].

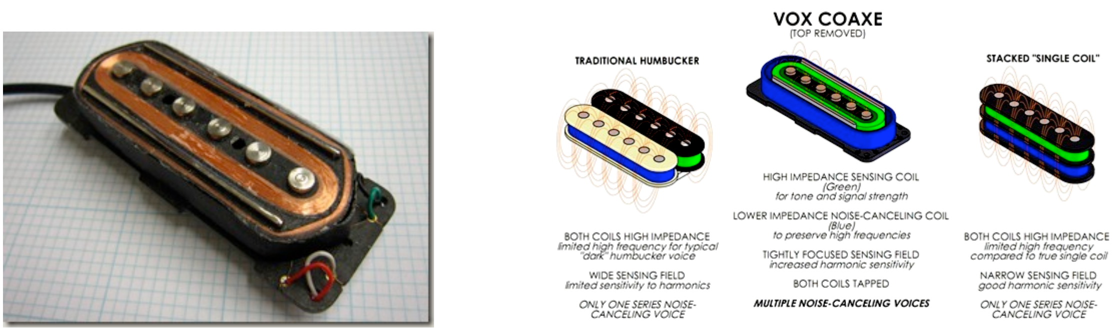


Fig. 5.15.11b: CoAxe pickup [www.planetz.com].

VOX CoAxe-Pickup

Humbucking pickup: 2 co-axial coils, 6 slugs, 2 blades, 2 ceramic magnets.

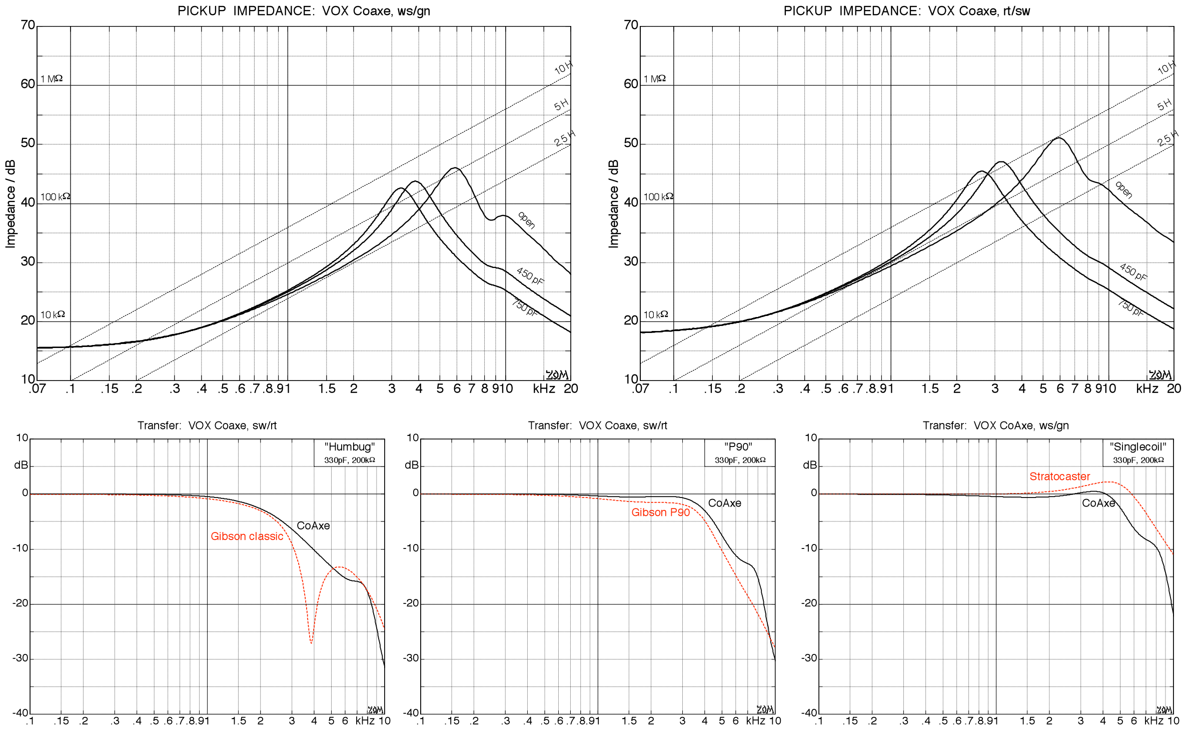


Fig. 5.15.11c: top: impedance; bottom: normalized transfer (laser measurement, string-specific!)

Fig. 5.15.11d: circuitry (left: innere Spule = inner coil, äußere Spule = outer coil), cross-section of the CoAxe pickup (right)

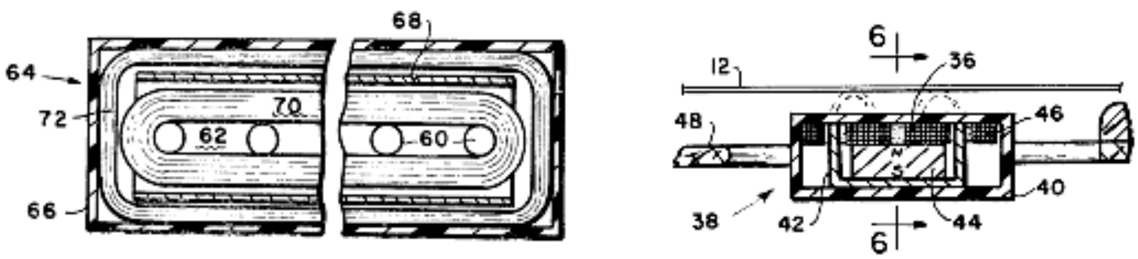


Fig. 5.15.11e: pictures taken from US-patent 4,372,186 (Aaroe, 1981).

Conrad pickup

The globally operating sales chain Conrad Electronic sells two pickups at an unbelievably low price (date: 2012): there is a so-called “P-90 Soapbar” for as little as € 12,75, and on top of that a so-called “PAF-Custom” for a staggeringly small amount of € 10,95. This is a blatantly obvious demonstration that neither the cost for the materials nor the cost for the production of a pickup needs to be very high. At the same time (2012), Gibson (USA) charges $ 141,59 for a P-90 and no less that $176,99 to $212,39 for a Humbucker. Of course everybody expects Gibson pickups to be much better that the low-cost Conrads – but are they? O.k. – at least in Germany the Gibsons are not as expensive as the official US price list suggests, but a P-90 will still set you back in the order of € 70, and a Gibson Humbucker will drain € 85 – 100 from your pocket. The Conrad humbucker is € 10,95 - …. isn’t that asking for trouble?

Well, at least it’s not a complete disaster. The **PAF-Custom** does not carry any pole-screws but 12 slugs – a fate it shares with many a colleague. The associated adjustability is however, not that important. We could establish the fact that different eddy-current losses are present as a deviation, and even as a deficiency, but the PAF-Custom does not seek to replicate your regular Gibson PAF. Rather, it shows autonomy: its transfer factor is about $2/3^{rds}$ higher than that of a Gibson Humbucker (e.g. a Burstbucker) and its resonance frequency is about 20% lower. It is thus darker and louder in sound than the original.

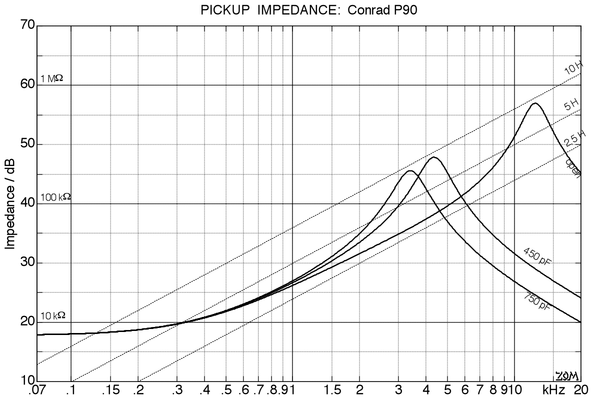
The **P-90** is by about 40% less sensitive than the Gibson P-90 and its resonance frequency is about 50% higher than that of the original – in comparison it is therefore softer and brighter. One might like that sound but it is not that of the original. The Conrad P-90 sounds like a strong Strat pickup even though it does not look like it. We can take the description “*a singlecoil just like the original*” to be misleading, or we accept it grudgingly, because the original is indeed a singlecoil.

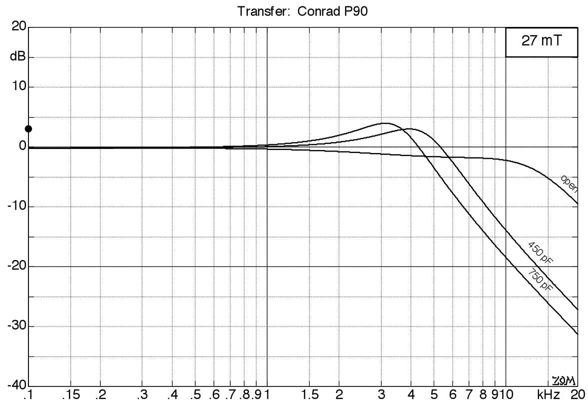
Bottom line: neither Conrad pickup replicates the sound we would expect them to have on the basis of the designation. If, however, we see them as “their own pickups”, they are a fully fit alternative at an unbeatably low price. Of course, we know nothing about their longevity – they may evaporate without residue after 5 years …

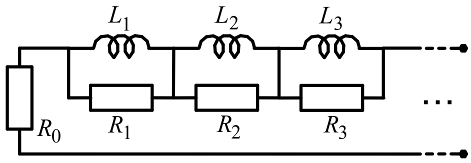
Fig. 5.15.12: Conrad pickups [www.conrad.de]

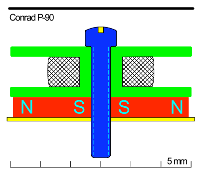
Conrad P-90 Soapbar

Large singlecoil pickup, 2 ceramic bar-magnets, 6 adjustable pole-screws.



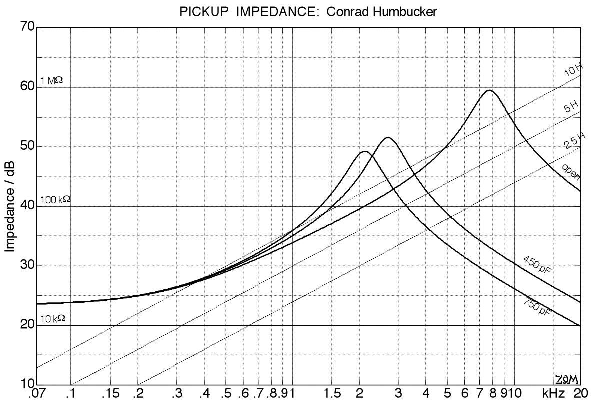


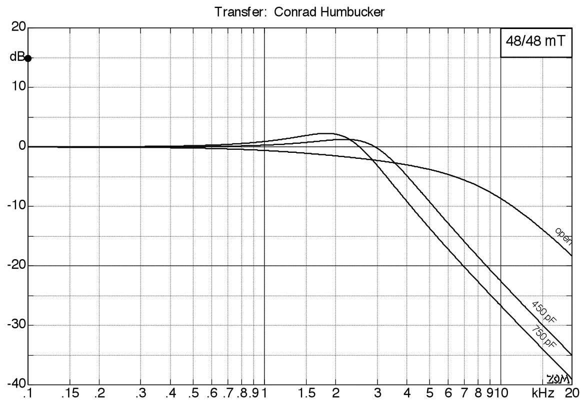


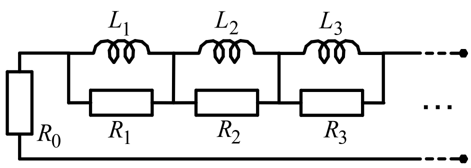


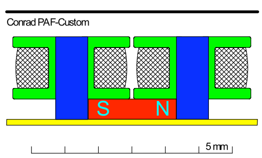
Conrad PAF-Custom

Humbucking pickup, ceramic bar-magnet, 12 slugs; very high sensitivity.









DeArmond

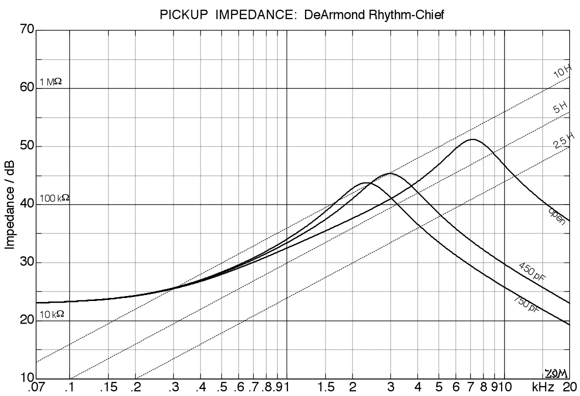
In cooperation with Rowe, the DeArmond company has produced and distributed a large variety of pickups since the 1930's. They were installed e.g. in guitars made by Gretsch, Guild, Epiphone, Eko and Höfner, and of course into big-bodied acoustic guitars … that's how it all started, anyway. A pickup sought after even today is the Rhythm-Chief (see Chapter 5.4.8). It was available in different variants – just as several realizations existed under one and the same name for other DeArmond pickups. All the DeArmonds examined here are fully encased in sheet metal provoking substantial eddy-current losses. **Thus, the transfer-function derived from the two-terminal equivalent circuit is not adequate; additional laser measurements are shown in Chapter 5.4.8.**

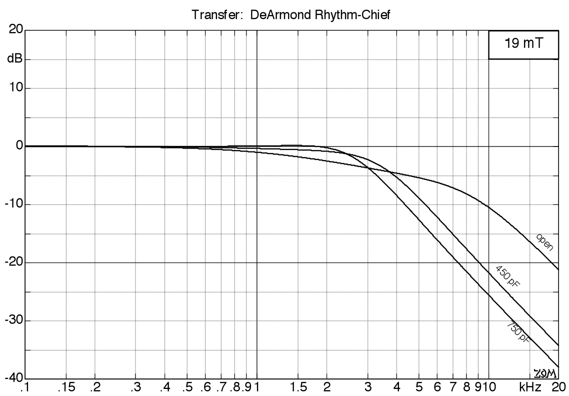
http://theunofficialmartinguitarforum.yuku.com

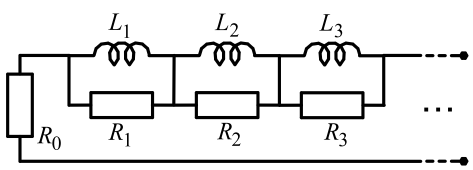
http://www.harmonycentral.com

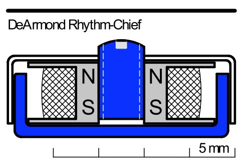
DeArmond Rhythm-Chief 1100

Singlecoil pickup, probably with plastic magnet within the coil.





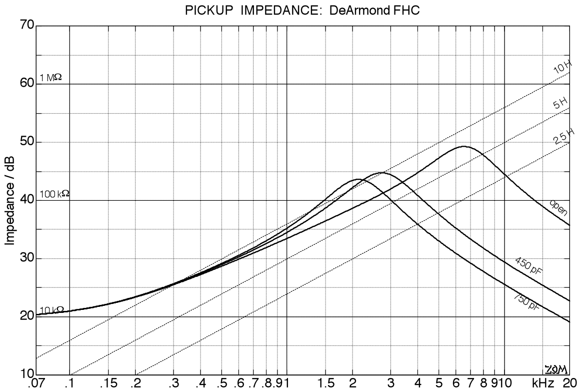


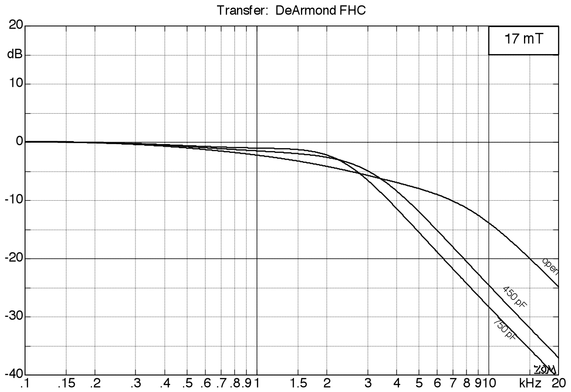


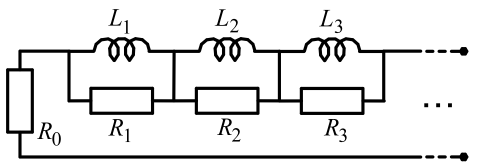
Load impedance 167 kΩ (integrated controls)

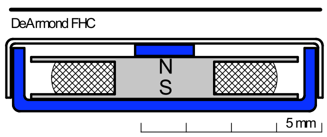
DeArmond FHC

Singlecoil pickup, probably with plastic magnet within the coil.





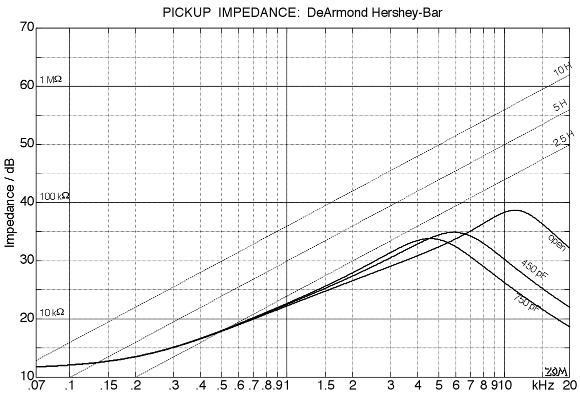


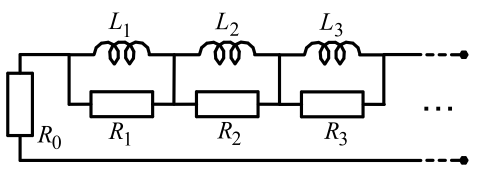


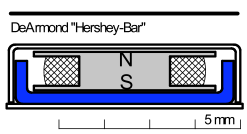
Load impedance 167 kΩ (integrated controls)

DeArmond "Hershey-Bar"

Singlecoil pickup, probably with plastic magnet within the coil.







Load impdedance 50 kΩ (integrated controls)

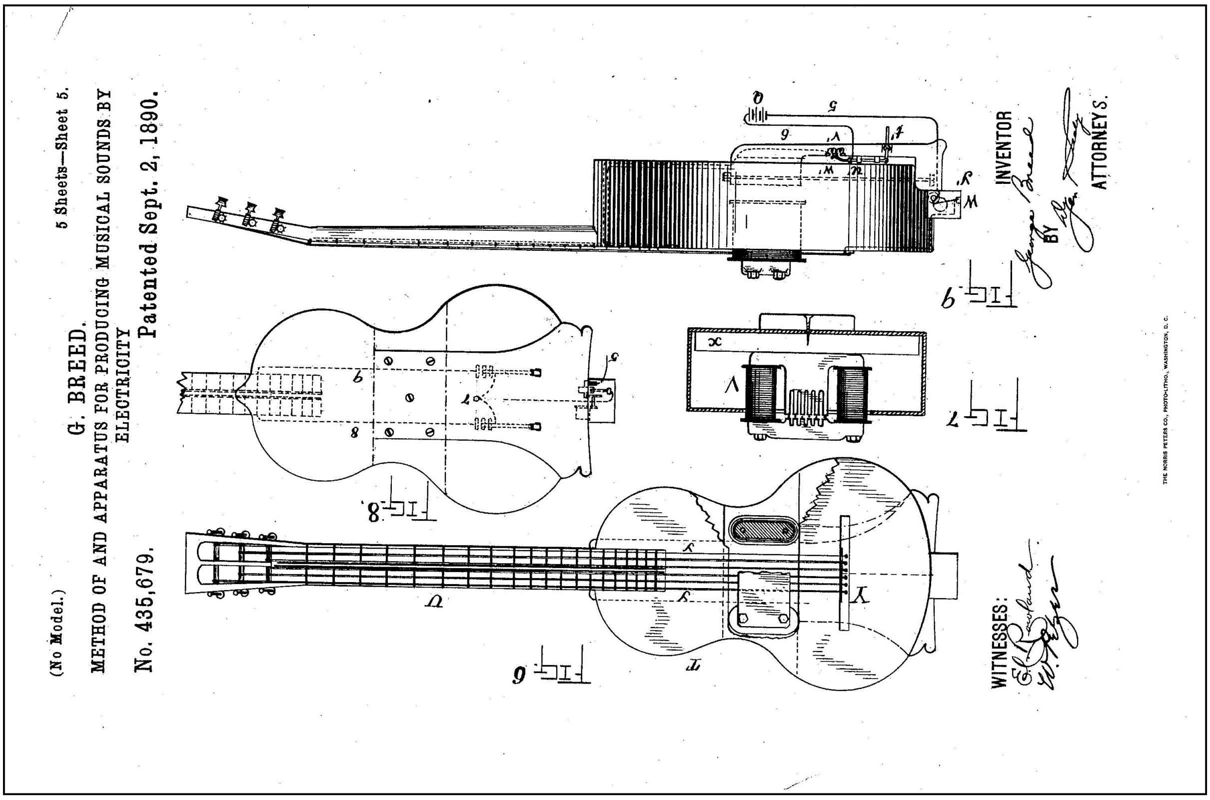
 Translated by Tilmann Zwicker

5.16 Patents und inventions

5.16.1 American Patents (selection)

1890	435679	Breed: the first guitar pickup? 1890!!
1927	1933299	Vierling: piano-pickup (PU)
1929	1839395	Kauffman: tremolo (vibrato-unit)
1929	1838886	Tuininga: violin-HB
1930	2027073	Vierling: piano-PU (see also 1933299)
1931	1906607	Jacobs: piano-PU
1931	1915858	Miessner: piano-PU
1931	1978583	Kentner: piano-PU
1934	1941870	Severy: synthesizer
1934	2020557	Loar: guitar with structure-borne-sound-PU
1934	2025875	Loar: guitar with structure-borne-sound-PU
1934	2089171	Beauchamp: Rickenbacker Frying Pan, Horseshoe-PU
1935	2026841	Lesti: PU w/out permanent magnet
1935	2119584	Knoblaugh: stacked HB w/out permanent magnet
1936	2087106	Hart/Fuller (Gibson): Charlie-Christian-PU
1936	2170294	Dopyera: National Hawaiian guitar, Blade-PU
1936	2152783	Beauchamp: Rickenbacker Electro Spanish Guitar, Horseshoe-PU
1937	2175325	Sunshine/Epiphone: "Oblong Pickup"
1938	2145490	Miller (Gibson): further development of 2087106
1938	2241911	Kauffman: motorized tremolo for steel-guitar
1939	2262335	Russell: HB w/horseshoe-magnet
1940	2261358	Fuller (Gibson): retrofit-PU
1940	2294861	Fuller (Gibson): retrofit-PU
1944	2455575	Fender/Kauffman: Solidbody guitar w/PU
1946	2455046	DeArmond: PU "Type-1000"
1948	2542271	Alvarez: Piano-HB
1948	2567570	McCarty (Gibson): PU within the pickguard
1948	2686270	Ayres: piano-HB
1949	2557754	Morrison: Solidbody guitar w/PU potted in wax, 6 cylindrical magnets
1950	2573254	Fender: Telecaster-precursor
1950	2612072	DeArmond: PU w/6 adjustable cylindrical magnets
1950	2612541	DeArmond: PU w/6 adjustable cylindrical magnets PU and u-shaped yoke
1952	2683388	Keller: HiLoTron PU
1952	2740313	McCarty: McCarty-bridge
1952	2737842	Les Paul: bridge & tailpiece
1953	2784631	Fender: tone control
1954	2741146	Fender: Stratocaster
1954	2911871	Schultz: similar to P-90
1955	2896491	Lover: Gibson-HB
1956	2817261	Fender: first Fender-HB (for steel guitar)
1956	2909092	DeArmond: cylindrical magnets w/threaded sleeves
1956	2964985	Webster: slideable stereo-PU
1957	2892371	Butts: Gretsch-HB
1957	2968204	Fender: 7 magnets for 6 strings
1959	2976755	Fender: split-PU (for Precision-Bass)
1960	3035472	Freeman: bar magnets, out-of-phase-circuit
1961	3147332	Fender: split-PU
1962	3236930	Fender: Jaguar-PU (with u-shaped yoke)
1962	3249677	Burns: low-impedance-PU, sampling of individual strings
1964	3290424	Fender: Marauder
1968	3541219	Abair/Rowe: cylindrical magnets w/threaded sleeves
1969	3588311	Zoller: bi-directional PU
1970	3657461	Freeman: stacked HB
1971	3571483	Davidson: omni-directional Pickup
1971	3715446	Kosinski: right you are if you think you are
1974	3902394	Stich/Norlin: HB w/standing coils

1974	3916751	Stich/Norlin: HB w/standing coils
1974	3983778	Bartolini: wide magnetic field
1975	4026178	Fuller: PU with u-shaped yoke
1975	4051761	Nylen: magnetize strings by hand
1977	4133243	DiMarzio: SDS-1
1978	4145944	Helpinstill: ´magnetic field & structure-borne sound
1979	4220069	Fender: PU w/ceramic bar magnet and yoke
1979	4283982	Armstrong: HB, ceramic magnet in between the coils
1980	4320681	Altilio (DiMarzio): PU with top-position plastic magnet
1981	4364295	Stich (Lawrence): 2-blade-HB
1981	4378722	Isakson: string-penetrating coil
1982	4442749	DiMarzio: stacked HB
1983	4463648	Fender: angled HB
1983	4524667	Duncan: stacked HB
1985	4624172	McDougall: tube-like polepieces
1985	4686881	Fender: serrated polepieces
1986	4581974	Fender: dummy-coil
1987	4809578	D.A. Lace: Lace-"sensor"
1991	5168117	Anderson: stacked HB w/neodyne-magnet
1995	6372976	Damm (Gibson): P-94
1996	5668520	Kinman: stacked HB
1997	5792973	Riboloff (Gibson): HB w/3 magnets
1998	6291758	Fender: stacked HB
1999	6846981	Devers: stacked HB



Breed: Is this the first guitar pickup? In a way, yes, even though the idea was to obtain an actuator – but reversible transducers work on both directions. Pity that the first amplifier tube was still 16 years away …

US-Patents, numerical list

1215973 1557476 1838886 1839395 1906607 1915858 1929027 1933299
1978583

2001392 2015363 2020557 2020842 2025875 2026841 2027073 2027074
2048515 2087106 2089171 2119584 2145490 2152783 2170294 2175325
2179237 2209016 2222959 2225299 2228881 2235983 2236946 2239985
2241911 2261358 2262335 2263973 2293372 2294861 2310606 2323969
2327277 2340001 2413062 2455046 2455575 2503467 2542271 2557754
2567570 2573254 2581653 2612072 2612541 2628524 2683388 2686270
2725778 2737842 2740313 2741146 2764052 2784631 2793293 2817261
2892371 2896491 2897709 2909092 2911871 2958249 2961912 2964985
2968204 2976755 2989884

3003382 3035472 3066567 3079535 3084583 3147332 3177283 3183296
3207976 3236930 3249677 3288906 3290424 3417268 3435610 3472943
3483303 3530228 3535968 3541219 3544694 3571483 3588311 3602627
3657461 3657481 3668295 3711619 3715446 3725561 3902394 3911777
3915048 3916751 3962946 3963975 3969771 3983777 3983778 3992972

4010334 4026178 4050341 4051761 4056255 4096780 4133243 4138178
4143575 4145944 4151776 4164163 4171659 4175462 4188849 4201108
4220069 4222301 4254683 4261204 4268771 4269103 4283982 4319510
4320681 4364295 4372186 4378722 4379421 4408513 4412454 4442749
4463648 4472994 4480520 4499809 4501185

5031501 5111728 5136918 5136919 5153363 5155285 5168117 5204487
5221805 5252777 5290968 5311806 5336845 5354949 5376754 5389731
5391831 5391832 5399802 5408043 5418327 5422432 5430246 5438157
5438158 5455381 5463185 5464948 5530199 5569872 5602353 5610357
5641932 5668520 5670733 5684263 5789691 5792973 5811710 5834999
5894101 5898121 5908998 5949014

6103966 6111185 6162984 6271457 6291758 6291759 6372976 6414233
6476309 6525258 6846981 7227076

5.16.2 Discoveries, inventions, and other milestones of technology

1694 Voltaire: France's precursory experiment. Even the name failed.
1800 Volta: the Italian original. Electrochemical series, electrical battery
1820 Ampere: current-force-law
1820 Oersted: electric current deflects a magnetic needle
1823 Sturgeon: electromagnet
1826 Ohm: Ohm's law: $U = R \cdot I$
1830 Henry: law of induction
1831 Faraday: law of induction; dynamo, magnetic field
1833 Gauß/Weber: electromagnetic telegraph
1855 Maxwell: electromagnetic field theory
1860 Philipp Reis: contact microphone
1861 Philipp Reis: telephone (w/out commercial success)
1863 Thomson: theory for the condenser microphone
1863 v. Helmholtz: teachings of sensations of sound
1876 Bell: improved telephone (see also Gray)
1877 Berliner: carbon microphone
1877 Lord Rayleigh (John W. Strutt): Theory of Sound
1878 v. Siemens: patent for the electro-dynamic loudspeaker
1878 Hughes: improved microphone (USA)
1878 Lüdtge: improved microphone (Germany)
1878 Edison: Phonograph (precursor of the turntable)
1881 Gaulard/Gibbs: transformer
1883 Edison: Edison-effect (electron emission from hot cathode)
1886 Hertz: generation of artificial electromagnetic waves
1887 Berliner: grammophone, sound disc (record)
1890 Breed: US-Patent (Nr. 435679) Horseshoe-Actuator for guitar
1890 White: carbon-gain microphone (series production standard)
1906 – 10 von Lieben, deForest: amplifier tube (Triode)
1913 Langmuir, Schottky: double grid tube (Tetrode)
1915 Jensen/Pridham: Magnavox-loudspeaker
1923 E. Reiß: carbon-powder microphone
1925 Rice, Kellog: moving-coil cone-loudspeaker
1925 Lilienfeld: field-effect-transistor
1926 Tellegen: thee-grid-tube (Pentode)
1927 Vierling: electromagnetic piano-pickup (w/permanent magnet)
1928 Pfleumer: tape recorder
1929 Tuininga: electrical violin w/structure-borne-sound-sensor)(humbucker)
1931 deArmond (Rowe): retrofit guitar pickup
1932 Beauchamp (Rickenbacker): solidbody gitarre "Frying Pan", horseshoe-pickup
1932 Celestion: permanent moving coil loudspeaker
1933 First artifical head recording (no, not yet the "Aching Head")
1934 Loar (Vivi-Tone): guitar w/magnetic structure-borne-sound-PU
1935 Lesti: solidbody guitar w/string-humbucker (no permanent magnet)
1935 Knoblaugh: stacked humbucker (no permanent magnet)
1935 Telefunken: magnetophone
1935 Gibson: Electric Hawaiian Guitar and Amp EH-150
1936 Beauchamp (Rickenbacker): Electro Spanish Guitar (Bakelite), Horseshoe-Pickup
1936 Hart/Fuller (Gibson): Charlie-Christian-Pickup
1936 Dopyera (National): aluminum-Hawaiian- guitar wit "Blade-Pickup"
1936 Alnico-Magnets, Rola G12-Speaker
1937 Sunshine (Epiphone): steel-guitar with "oblong-shape-pickup" (patent application)
1938 Fender: Radio Repair Shop
1939 Russell: guitar-humbucker
1940 Gibson: ES-125, ES-300 w/singlecoil pickup
1941 Zuse: first digital computation machine Z3 (elektromechanical)
1941 Hewlett&Packard: Wave-Analyzer HP-300A
1941 Les Paul: guitar prototype "The Log"
1944 Fender: Leo's first electric guitar "Electro Spanish"

1946 Fender: Leo’s first guitar amplifiers: Princeton, Deluxe, Professional
1946 Fuller (Gibson): singlecoil pickup P-90
1946 DeArmond: "Type 1000" guitar pickup
1947 Shockley, Bardeen, Brattain, Pearson: bipolar transistor
1947 Paul Bigsby: Merle-Travis-guitar, plus further custom guitars
1948 CBS: vinyl-LP
1948 Alvarez: piano humbucker
1948 McCarty (Gibson): pickguard with pickup and potentiometers
1949 Morrison: solidbody guitar, potted pickup with individual magnets
1949 Brüel&Kjaer: first level meter
1950 Fender: Telecaster precursor (US Patent 2573254)
1950 DeArmond: pickup with 6 adjustment screws for the magnet
1951 Fender: Precision-Bass
1952 Keller: pickup as seen later with Gretsch (HiLoTron-Pickup)
1952 McCarty (Gibson): McCarty-bridge
1952 Les Paul (Gibson): bridge & tailpiece
1952 Gibson: Les Paul guitar
1952 world’s first hydrogen bomb misses Los Alamos by almost 10000 km
1954 Fender: Stratocaster (US Patent 2741146)
1955 Seth Lover: Gibson Humbucker (US Patent 2896491)
1956 Fender: humbucker for steel guitar
1957 Butts: Gretsch Humbucker
1957 Fender: Precision-Bass with split humbucker
1958 Jennings: VOX AC-15
1959 Hank Marvin (The Shadows) starts grinning – and never stops again …
1959 Berry B. Goode
1960 v. Bekesy: Experiments in Hearing (Nobel-price 1961)
1960 WEM Copicat 'D.T.S. Model'. D.T.S stands for "Death to Selmer" [Elyea]
1962 Fender: Jaguar-Pickup w/u-shaped yoke
1962 Bran: first Marshall-Verstärker
1962 Beatles: first VOX AC-30
1964 Early prepatory work for “Physics of the Electric Guitar”
1965 Cooley, Tukey: FFT-Algorithm
1970 Hendrix pulls the plug
1970 Freeman: stacked humbucker
1970 Lover (Fender): CuNiFe-humbucker (Telecaster-Thinline und -Custom)
1974 Stich (Gibson): humbucker with upright coils
1976 Apple I, personal computer
1977 Brüel&Kjaer: first digital third octave analyzer
1978 Brüel&Kjaer: single channel FFT-analyzer
1979 Armstrong: humbucker
1981 IBM-PC, personal computer
1981 Stich: 2-blade-humbucker
1982 Commodore C-64, home computer
1982 DiMarzio: stacked humbucker
1983 Duncan: stacked humbucker
1987 D.A. Lace: Lace-"sensor"
1990 Gibson: stacked humbucker P-100
1991 Anderson: stacked humbucker
1996 Kinman: stacked humbucker
1998 Turner (Fender): stacked humbucker ("Noiseless")
1999 Devers: stacked humbucker
1999 Zollner: Physics of the Electric Guitar ☺

