FACTORS ON WHICH A PICKUP SOUND DEPENDS:

There are many factors that influence the sound of a guitar or bass, but undoubtedly one of the most important are the pickups that the instrument has mounted. Thousands and thousands of articles have been written about how the design, selection of materials and construction of the pickup can affect the tonal result of the tablet.

From ToneWinder we want to contribute with our grain of sand, providing a quick guide of how the different elements of a pickup can affect the final tone, and **how ToneWinder can help you achieve your goal**.

The ten main factors that can modify the tone of a pickup are:

1. Coil dimensions.
2. Type of magnet used.
3. Charging the magnet used.
4. Gauge of thread
5. Thread class (INSULATION)
6. Number of laps.
7. Thread tension.
8. Winding strategy.
9. Post-winding treatment.
10. Inductance modification.

1. COIL DIMENSIONS:

In terms of dimensions and shape of the coil, there are innumerable designs aimed at reducing the effect of noise induced in the transducers by external electromagnetic radiation, such as the "hum" caused by the frequency of the alternating supply of 50Hz or 60 Hz (depending on the country), of the amplifiers and other nearby equipment, by fluorescent or LED lighting, by telephones, elevators, and a long etc. The shape and dimensions also affect, in addition to the noise generated in the coil, its sensitivity, output voltage and tone, since when changing the shape, other aspects such as the shape and position of the magnets and therefore the magnetic field and leakage currents are usually also varied (eddy currents in English, or Foucault currents), the number of wire turns and its total length, so that the inductance of the coil and therefore its resonance frequency and Q factor are also affected, also its resistance and impedance, its residual or distributed capacity, as well as the shape and intensity of the magnetic field.

There are many designs of pickups in which the dimensions of the coils are fixed, and we can not modify any dimension, but there are other types of pickups, such as simple stratocaster or telecaster pickups, that when assembling the coil we can vary the internal height of the coil (distance between plates). Suppose we have two equal pickups, but one of them is 2 mm higher than the other (in this way, the magnets will protrude less on the top plate). If both pickups are wound the same (with the same number of turns, wire gauge, tension, etc.), the first direct cause

will be that the highest tablet will have less output than the other, because it has more width in which to accommodate the thread turns, and therefore, the differential increase of thread per layer made will be lower. The less tall tablet, therefore, will have more meters of wire inside. This can lead to a more aggressive pickup, with more bass / medium and less clarity, mainly due to the extra wire.

However, if we calculated the number of equivalent turns of the pickups so that both had the same output (R), the higher one tended to sound with more brightness and presence. This is because the less tall and wide pickup will have greater capacitance and inductance, so it will reduce the high frequencies to a greater extent.

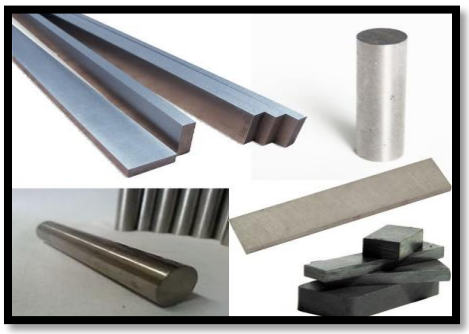
1. TYPE OF MAGNET:

The type of magnet (AlNiCo, Ceramic, Neodymium, etc.) and its shape, simplifying a lot, affect the sensitivity and the intensity or amplitude of the signal mainly, although they also modify the inductance and therefore the frequency. As a general rule, the greater the magnetic field generated by the magnet, the lower the total inductance of the pickup, and therefore it will have a greater presence of treble.

AlNiCo magnets have greater sensitivity, that is, the ability of the sensor to produce signal with minimal vibration, which can even be negative if the pickup is placed very close to the strings, or even enter into resonance with the strings, producing a very unpleasant noise that subsides when touching the strings with the hand, However, its sound is sweeter and warmer, with a tendency to distort softly. They differ by the compositions of the elements that compose it, which give them some properties or others.

For example, the Alnico 2 has a warm, round sound in virtually its entire frequency range. This is why it is usually used in vintage sound pickups or low output. The Alnico 3, which is probably one of the least used, tends to a clear and balanced tone. The Alnico 5 is more powerful (magnetically speaking) than the previous ones, which gives it a very good range of mids and treble. The much more powerful Alnico 8 has excellent highs and higher mids.

Ceramic magnets produce more signal and their sound is harder and less warm.



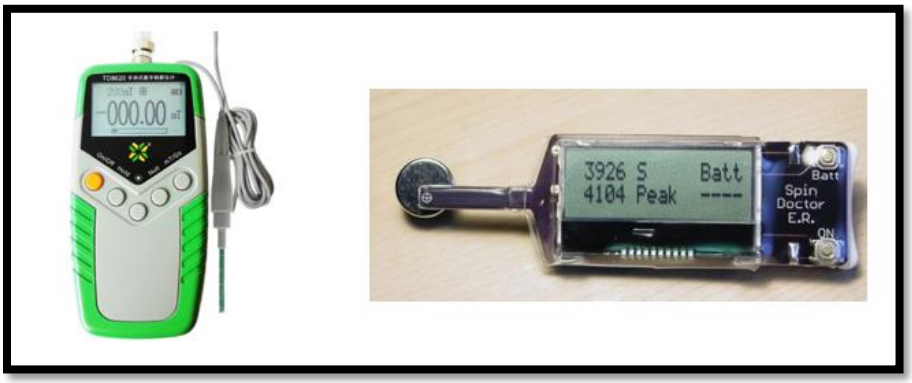
Good quality tablets usually incorporate Aluminum, Nickel and Cobalt alloy magnets or also some ceramic magnets, others of low price incorporate even plastic binder magnets with magnetic powder. As for the shape, independent cylinders, screws or bars attached at one end to a magnetic base, magnetic bars, each of them with its advantages and disadvantages in terms of construction and adjustment.

In summary, the type of magnet used will define the final sound of the pickup, mainly due to its composition, which directly affects the inductance of the coil, and the magnetic field produced by it.

2. MAGNET LOADING :

The load of the magnet used affects, as already mentioned, the sensitivity and amplitude of the signal. Higher load produces greater sensitivity and amplitude. Heavily loaded magnets, such as AlNiCo 8, must be placed with great care to avoid, or at least reduce, the possibility of the transducer coming into resonance with the guitar strings.

Many of the magnets that are sold may arrive demagnetized, either because the manufacturer sells them like this or because they have been unloaded due to some special situation during storage or transport. In fact, nowadays the strength of the magnetic field can be pinned down relatively easily, using specific magnetic field meters, based on the hall effect (they can also be easily constructed by oneself, since there is a lot of information about this on the internet)



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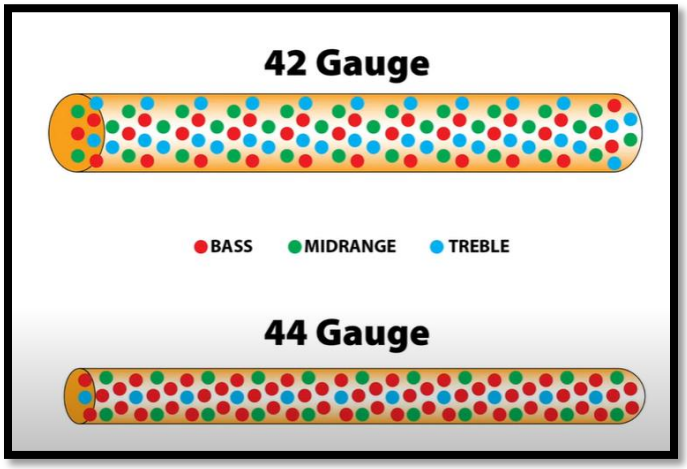
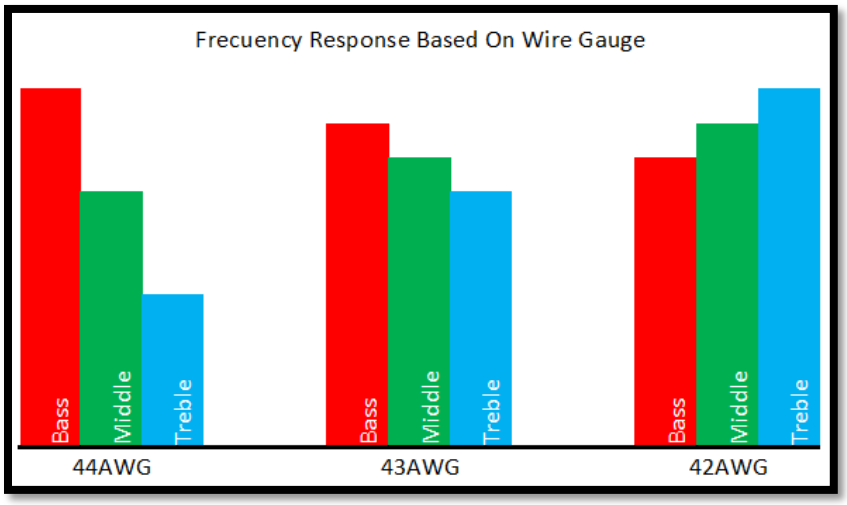
We can also reduce the maximum magnetic field of a magnet, to modify to some extent the final sound of the pickup. If we reduce this field, we will obtain a slightly darker and less bright sound. This is easy to do in simple cells type strato or tele, bringing two much more powerful magnets (for example, some of Neodymium N52), to the poles of the tablet, with the same polarity that has pole on that side (if it is N, you have to the N of the Magnet. On the other side we will have the S, so we will have to approach the S of the Neodymium magnet). This operation must be performed in a controlled manner, not bringing the neodymium magnets too close, since there is a risk of demagnetizing the magnets too much, or even changing the polarity of the tablet, with the tonal consequences that this can entail.

3. WIRE TICKNESS:

The selected wire gauge is another important factor to take into account when designing a pickup, not only because of the tonal considerations it may entail, but sometimes it is necessary to use smaller calibers for reasons of space. With a smaller gauge you can achieve a much higher output using the same winding space. This is why many of the Hi-Gain pickups sold are made with 43 or 44 AWG thread. Calibers normally used range from 41 to 44 AWGs, but sometimes different calibers are used (for example, the use of the 38AWG for a Charlie Christian replica).



The gauge of the wire affects little to the inductance of the coil, but much to its resistance and capacitance, while a larger gauge (at equal turns) leads to a greater weight and size of the transducer. The larger the wire diameter, the lower the output signal amplitude. Also higher caliber causes (keeping the other factors the same) a greater capacitance and therefore a lower cut-off frequency, that is, less harmonic, less treble.



In addition, taking into account that the tension of the wire during winding is one of the most important factors in which we can influence, when winding a pickup the gauge of the wire that is being used must be taken into account, due to its breaking tension (it is not the same to be winding with a 42 AWG or with a 44 AWG). In this sense, Tonewinder allows you to monitor in real time the tension of the thread with which the pickup is being wound, in order to wind the pickup without fear of breaking the thread, being able to set minimum and maximum limits to avoid breakages and defects. Here are some average values of elastic limit stress and break limit stress for some gauges:

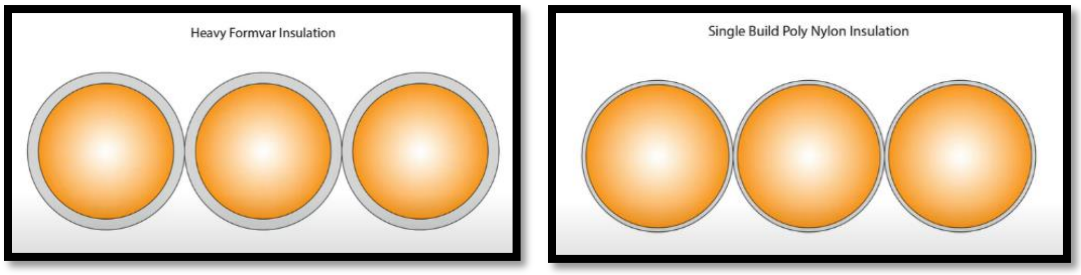
AWG	41	AWG	42	AWG	43	AWG	44	AWG	45	AWG	46	AWG
Diameter (µm)	71	µm	63	µm	56	µm	50	µm	45	µm	40	µm
Diameter (mm)	0,071	mm	0,063	mm	0,056	mm	0,05	mm	0,045	mm	0,04	mm
Diameter (m)	0,000071	m	0,000063	m	0,000056	m	0,00005	m	0,000045	m	0,00004	m
Area (m2)	3,96E-09	m2	3,12E-09	m2	2,46E-09	m2	1,96E-09	m2	1,59E-09	m2	1,26E-09	m2
Young Modulus (N/mm2)	1,2E+11	N/m2	1,2E+11	N/m2	1,2E+11	N/m2	1,2E+11	N/m2	1,2E+11	N/m2	1,2E+11	N/m2
Elastic Limit (N)	475,1	N	374,1	N	295,6	N	235,6	N	190,9	N	150,8	N
Elastic Limit (gr)	47,5	gr	37,4	gr	29,6	gr	23,6	gr	19,1	gr	15,1	gr
Break Limit (+15%) (gr)	54,6	gr	43,0	gr	34,0	gr	27,1	gr	21,9	gr	17,3	gr
Equivalent SWG	45	SWG	46	SWG	46	SWG	47	SWG	-	SWG	48	SWG
Inches	0,0028	inches	0,0025	inches	0,0022	inches	0,002	inches	0,0018	inches	0,0016	inches

It should be noted that the voltage reading during winding is an average of the voltage measured by the sensor, since, during a simple turn, there are areas where the wire will be subjected to greater tension (when it approaches the ends of the coil), and areas where the wire has a lower tension (in the straight sections of the coil), due to axial asymmetry of the coil. Therefore, we recommend not winding with tensions higher than the elastic limit of the wire used. Otherwise, maximum tension points will be generated at the ends of the coil and can cause short circuits between turns (eddy currents, which create energy losses through the Joule effect). This factor is almost impossible to control by performing windings with manual guidance.

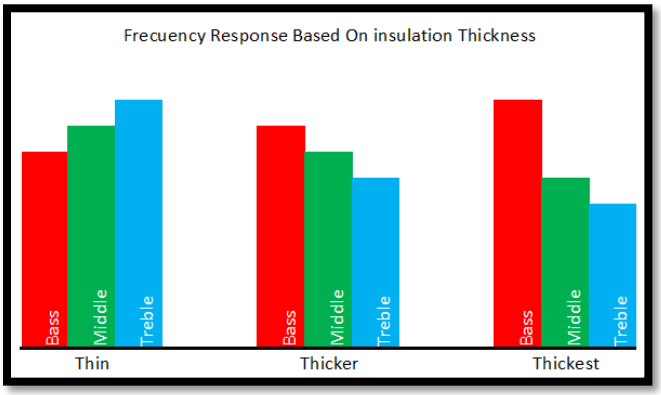
Another factor that can subtly influence the tone is the composition of the copper (for example, purity or flexibility), but this already depends on the manufacturer of the wire used.

4. WIRE TYPE (INSULATION):

The insulation of the wire mainly affects in terms of its thickness, since, at the same winding tension of the wire, the thickness of the insulation affects the distance between wires and therefore the capacitance and also in terms of its insulating capacity (dielectric constant). However, the sum of the type of insulating material, its thickness (usually 10%-15% the diameter of the wire), its elasticity, its magnetic permittivity, its homogeneity in terms of thickness, can also affect some parameters of the coil and provide some color to the sound.



There are many types of insulation for copper wire, but the most commonly used are Plain Enamel (PE), Formvar (F) or Polyurethane (P). The PE tends to sound softer, transparent and melodious, and is usually resorted to when you want to obtain a more vintage sound, because the threads are closer together and on the one hand there will be greater capacitance between them, but we will also reduce the diameter of the coil, its inductance and its impedance. On the other hand, the Formvar, which usually has twice the coating thickness of the PE, for the same total number of turns, will generate a coil of different dimensions, with less capacitance between wires, but greater diameter, inductance and impedance. As a consequence, a greater cut of high frequencies and greater presence of bass.



5. NUMBER OF TURNS:

The number of wire turns conditions the resistance, inductance, capacitance and also, the final dimensions of the coil (density and shape of the magnetic field). It is for all this that it is one of the aspects with the greatest influence on the characteristics of the signal.

The greater the number of turns, the greater the resistance, inductance and total capacitance, that is, the higher the output signal and the lower the high frequencies, the thicker the sound. With fewer turns we have just the opposite, less output signal, less "punch" but a richer and more complete sound, greater number of harmonics and high frequencies.

6. WIRE WINDING TENSION:

The tension of the wire during winding affects the density of the magnetic field, the capacitance of the coil, its final shape and also and mainly the susceptibility of the coil to the phenomenon called "microphonism". Very little winding tension increases the possibility of vibration of the wire and therefore the effect of microphonism, in addition to causing an irregular finish of the coil, however "it is said" that less tension of the thread produces a sweeter tone. And there are always those who like microphonism.

With a winding tension around 50% of the breaking stress, a correct and homogeneous arrangement of the wire is achieved. From this point (50%), small variations in winding voltage have a smaller effect on sound compared to other transducer variables.

As mentioned in point 4, the upper limit of the tension, we would have it in the elastic limit of the wire, since, from here other side effects can be introduced into the winding.

It is difficult to reproduce exactly the wire tension with manual winding, however, exquisite control can be achieved during winding with Tonewinder.

7. WINDING STRATEGY:

As for winding strategy, first of all, we must mention two types, manual guidance winding and automatic guided winding.

Although there is a myth that anything manual or artisan should be better, the truth is that it mainly depends on how it is done. A handmade coil can be very bad or a wonder, depending on how it is made, and in any case, you may like it or not. Winding by hand you can vary the tension and the way of placing the wire in the coil, which as we have already mentioned affects the density of the magnetic field, capacitance and to a lesser extent inductance. All this conditions the timbre of the sound produced by this coil. By winding by machine, we can do the same as winding by hand, but in a totally reproducible and controlled way. Apart from the tension of the wire, the way in which the wire is arranged in the coil, with more or less distance between wires, and with greater or lesser variation in the angle of the wire loops in relation to the coil (creating space between wires and "putting" air in between the wire) which definitely affects the timbre of the transducer.

Using mechanical winding strategies through SCATER, TABLE, EMULATE/CLONE modes we control the filling factor and increase the air between expirations and thus reduce the

distributed capacitance in a totally reproducible way. Increasing distributed capacitance decreases the ability of our transducer to transmit high frequencies and therefore also reduces the number of harmonics (their intensity) of our transducer and makes the dominant pitch of the transducer lower. That is why playing with the value of the filling factor allows us to vary the tone of our sound, allowing us to print and reproduce that personal tone we are looking for.

8. POST-WINDING TREATMENT:

Post-winding treatment by waxes or lacquers. It is, mainly, with these treatments to reduce or avoid the effect of microphonism. It involves immersing the transducer in a mixture of waxes or paraffins at ambient pressure or by subjecting to vacuum (to improve the penetration of the wax between the wire). Applying an appropriate winding tension, "waxing" or "potting" can be dispensed with, but we must assume the possibility of suffering microphonisms at high gain. A precise control of the winding tension will allow us to know in advance the behavior of the transducer and thus determine if waxing is required or not.

9. MODIFICATION OF THE INDUCTANCE (BASES OR COVERS):

The magnetic field, its shape, its intensity and the leakage currents (eddie), are intensely affected by all the ferromagnetic elements that form or are close to the transducer. We have the magnets, the guitar strings themselves, the metal bases and screws, and of course, the covers and trims of the coils, other ferromagnetic elements next to it.

Therefore, if we add a metal cover to a pickup, we are modifying the inductance of it, and therefore varying its final sound.