3. Magnetic Pickups

The first documented magnetic electric guitar pickup was made in 1931 by the Rickenbacker Company. This pickup was on Rickenbacker’s solid aluminum guitar, both the guitar and pickup were the creation of George Beauchamp and Paul Barth. The patent number (2,089,171) was not obtained until 1937. This pickup had tungsten steel magnets, but today’s cost for tungsten steel would make the pickup unbelievably expensive. This is the reason Rickenbacker no longer makes this pickup.

![Fig. 21 Early Rickenbacker pickup, top view.](image)

![Fig. 23 Early Rickenbacker pickup, side view.](image)

![Fig. 22 Elements of early Rickenbacker pickups.](image)

In 1934 or ’35, the Gibson Company began to make electric Hawaiian guitars and electric banjos. The drawing shown is of an early Gibson pickup believed to be a prototype made in about 1932. In 1935, Gibson electric Hawaiian guitars started to become popular, but it wasn’t until 1937 when Gibson introduced electric Spanish guitars that electric guitars started to become popular. The Gibson ES 150 guitar with the Charlie Christian pickup was the electric guitar that won the respect of musicians and the admiration of audiences.

Paul Bigsby, was an independent musician/inventor, and made the first modern solid body electric guitar in 1947. By the word ‘modern’, it is meant that this was the first solid body electric Spanish guitar rather than a Hawaiian slide-type guitar. Paul made his own pickups and most of these pickups used a bar magnet wound with copper wire. It was this instrument that ushered in the era of the modern electric guitar and subsequently contributed greatly to the birth of rock-n-roll.

In 1948, the Fender Company produced the world’s first mass produced solid body electric Spanish guitar. This guitar, the Broadcaster, had pickups consisting of six alnico cylindrical magnets wound with copper wire. Because of legal complications surrounding the name, Fender soon changed the name to Telecaster, perhaps the most famous guitar name in the whole world. Now, over thirty years later, this guitar is still a popular seller.

![Fig. 24 Early Gibson pickup.](image)
MAGNETIC PICKUPS

In 1952, Gibson unveiled their Les Paul electric guitar. Les Paul, a renowned guitarist, was the designer of this instrument. The first Les Paul guitars had single coil pickups which were nicknamed soap-bar pickups. The name is derived from the shape of the pickup.

Around 1956, Les Paul began to make his pickup with humbucking pickups, these pickups are the world's most famous. They are the esteemed P.A.F. “Patent- Applied-For” humbuckings.

Magnetic Pickups: Design

In principle, magnetic pickups are related to dynamic microphones. That is, both use electromagnetic forces; but in a magnetic pickup there is no physical coupling of a vibration and the pickup.

A dynamic microphone is coupled to a sound source through vibrating air and the moving air actually causes the microphone element to move. A magnetic pickup picks up magnetic motion, not air motion. It is a changing magnetic situation that results in an output of changing electricity. This is how it works: If an iron string vibrates over a coil of wire that is wound around a magnet, strange things happen! All of a sudden the coil of wire is being cored with a flow of electricity. When the strings move down to the coil/magnet, the current moves one direction; and when the string moves the other direction, the current reverses. This alternating current can be directed into an amp which will reproduce all the vibrations of the string. In other words, the vibrating string pulls and pushes against the invisible magnetic force of the magnet. This causes the magnetic lines of force to move. A way to see these magnetic ‘lines’ is to place a magnet under a piece of heavy paper and sprinkle iron filings/powder on the paper. Now gently shake the paper and watch the iron filings form a pattern. If a nail is then moved under the paper near the magnet, the pattern will change. A string can effect a magnetic pickup the same way. It moves the magnetic force. If you recall the dynamic microphone operation, you will remember that if you quickly move a wire through a changing magnetic force, the wire will respond with a flow of current. What does this have to do with a string vibrating over a pickup? Well, if a string is moved and the magnet remains still, the wire coil around a magnet in a pickup will also become filled with a flow of current.

Magnetic pickups are very simple in theory and they can also be very simple in practical usage. For this reason, many people have made and are making magnetic pickups. One of the first discoveries about magnets was that they can be made out of a lot of materials. Magnets made? Yes, they are. Naturally magnetic lodestone do exist, but virtually all magnets used today are man-made.

A magnet is made by subjecting suitable material to a strong current which pulls all the magnetizing forces in one direction. Ordinary iron has its magnetic forces evenly mixed, and therefore nullifying each other’s forces. Applied current can change this evenly mixed condition so that the “north” forces are at one end, and the “south” forces are at the other end. The forces of a magnet are measured in Gauss and oersteds. Gauss is a unit used in measuring magnetic intensity; whereas an oersted is a unit used to measure magnetic reluctance, or in terms applicable to pickups, a magnet’s ability to resist demagnetization.

Pure iron doesn’t make the most powerful magnets because the mixed forces in iron cannot retain the alignment as effectively as other metals. One very useful mixture in magnets contains: Aluminum, Nickel, and Cobalt. Notice the underlined letters, Al Ni Co - Alnico; a most important magnetic material because its properties are more conducive to magnetization than any other material. The formula of alnico 5 is the most famous. There are many alnico formulas and each formula produces different gauss and oersted figures. Many people can hear the different sound resulting from the use of different magnets. The replacement of a full strength alnico 5 magnet by a full strength 8 magnet, will create a noticeable increase in treble response. A ceramic magnet increases treble response even more than an alnico 8 magnet. Therefore, the difference in sound may be more detectable when magnets of ceramic materials are used because ceramic magnet pickups are generally more sensitive than simple alnico.

This results in getting greater output and more trebles. Ceramic magnets are becoming the most popular due to low cost of the materials. The rare earth magnets, such as samarium cobalt, are very strong – that is, they have a very high oersted figure. Unfortunately, these magnets are very expensive. Ceramic magnets can also be obtained in many formulas.

Pole Pieces

A pole piece derives its name from “pole” of a magnet. A pole piece is a device that acts like a pole of a magnet and it serves as an emanating point of a magnet’s flux. A pole piece acts to concentrate and direct the magnetic field so it is in an optimum shape and direction to sense (be affected by) the vibration of the strings. When speaking of magnetic pickups, a pole piece is any structure on the top of the pickup that “aims” the force of a magnet(s) at the strings. Pole pieces can be of many shapes and sizes.

1. SEE PAGE 125

GUITAR ELECTRONICS

A pickup may have a single metal bar as a pole piece (the Les Paul or the 1961 ‘Christian’ pickup), or six individual adjustable height, slotted-screw pole pieces (the Gibson "Laid Back" pickup), or twelve adjustable height, allen screws (the DiMarzio "Super Distortion" pickup), or more than twelve (the Carvin and John Birch pickups). Even if a pickup does not have visible pole pieces (the Sacher Superrock), it will still have unseen internal pole pieces.

Wire Coils

The windings of wire around a magnet, the more the magnetic pulsations will be sensed, i.e., more windings increase amps, and so the more powerful a pickup will be. Keep in mind that the closer the wire is to the magnet, the more sensitive the coil will be. This is because the magnet’s field of effect doesn’t extend too far out from it. If a coil of large sized wire were used, the resulting bulging coil would have a wire turn a good distance away from the magnet. For this reason, small diameter wire is used which allows for a small coil to be tightly wrapped around a magnet.

3. SEE PAGE 125
Bare wire cannot be used because the coil windings would soon cause a reduction in inductance and therefore, output. The wire must conduct like one very long wire.

Fender Stratocaster = 6K
Fender Starcaster = 12K
Lawrence AT-170 = 14K
Barclin Acoustic = 2K
Gibson "Original" = 7.8K
Gibson S-1 = 5.3K
Scheeter Z-1 = 10K
Scheeter FS00T = 7.5K & 14K
DiMarzio X2 N = 14K

When to use #43 wire and when to use #42, can be a very important decision. For example, if #42 is substituted for #43, and the pickup is wound to the same d.c. resistance, a pickup is liable to have a thinner, more treble sound with less power. This occurs because the higher resistance of #43 will mean that the pickup coil would have less windings to equal the same d.c. resistance, and therefore, it would be smaller than if #42 were used. It is interesting to note that the first Telecaster lead pickups had a wire gauge of #43, later this was changed to #42 wire.

High frequencies have a harder time flowing than low frequencies because high frequencies use up a lot of energy with their fast wave fluctuations. What all this means is that if you make a big coil winding of small size copper wire, you could have a powerful loud pickup, but the trebles won’t all get through. Remember this: high output pickups have many windings and a lot loud sound, but some trebles will be lost. If a minimum of winding is used, the pickup’s output will be lower, but the sound will be quite clear with increased treble. Some companies use high induction magnets to reach out for trebles, but this doesn’t completely solve the problem of treble loss. Bill Lawrence, founder of Lawrence pickups, recommends using low magnetic induction with a high Q coil for a more balanced tone.

Impedance

Impedance is the resistance to alternating currents and the output of a pickup is an alternating current. The measurement of a pickup's impedance is important because it reveals the tonal quality of a pickup. Impedance is determined by the constraining influence of a magnet's field on a coil. If the magnet is put in sideways instead of vertical, the magnetic field will form around a coil differently, and this will affect impedance. One problem with impedance is that as frequencies rise, trebles are impaired. This impedance/resonance problem is most evident in humbucking pickups since they use two coil bobbins. Humbucking pickups have more windings than single coil pickups and the added windings increase the impedance and resistance.

Generally, the minimum amount of windings are those windings which produce a needed impedance figure that is compatible with an amp being used. Since d.c. resistance figures of pickups are fairly well correlated to the impedance (alternating current [a.c.] resistance) of most pickups, we can use resistance as an informative guide to a pickup's behavior. It certainly doesn’t hurt that d.c. resistance is a lot easier to measure. Few people have the necessary equipment to measure a.c. resistance. Pickups with a resistance of 6,000 to 12,000 ohms are generally considered high impedance, whereas 1,500 to 4,000 ohms is generally referred to as mid-impedance. Pickups around 2,000 ohms could be plugged into a low impedance or a high impedance amp, but they are not quite at home in either because they are neither high nor low. Below 1,000 ohms is generally low impedance. For information about the impedance of a particular amp, check with the manufacturer.

Hand Winding

The term "hand-wound" is rather misleading because a person is not employed to hand wrap magnet wire, turn by turn, around a bobbin. Rather, a person is engaged in hand guiding a wrapping machine. Due to poor operator training, it is common for simple winding machines to wind coils which are flawed. In order to produce coils of a desired shape, some manufacturers use hand guided winders, whereas other companies use new sophisticated machines which follow pre-set parameters.

Resonance Peaks

Virtually all electronic devices have one frequency that will cause them to oscillate more easily than any other frequency. This would be the natural resonant frequency of a device. The center of the resonant band is called a resonance peak.

Coils used in pickups have resonant peaks. If a pickup has a peak of 6,000Hz, the sound of the device will be more treble than if the device had a peak of 1,000Hz.

Some people feel that resonance peaks are the best indicator of the sound of a pickup. DiMarzio has said: "We feel the resonant peak may have more relevance than impedance or d.c. resistance because it definitely gives an indication of frequency response. It will provide a good idea of the type of timber a pickup will create. The voltage may then determine how prominent the effect will be."

For more information on the factors which raise or lower resonant peaks, read the sections on Bartolini, Lawrence, and Armstrong. Basically, more windings and lower gauges lowers the frequency of the resonant peak; less windings and higher gauges raise the peak.

Humbucking Pickups

A single bobbin of wire around a magnet will make a pickup. This device will pick up the motion of a metal string vibrating above it. Unfortunately, it can also act as an antenna and pick up nearby stray electrical wave, the hum of fluorescent lights, 60 cycle hum, radio stations, automobile spark plug systems, etc.

![Image of single coil pickup.](attachment:fig_34.png)

![Image of a single coil pickup diagram.](attachment:fig_35.png)

![Image of a dual coil humbucking pickup.](attachment:fig_36.png)

![Image of a humbucking pickup diagram.](attachment:fig_37.png)
conductor. This means that the top of one coil is magnetically north and the top of the other coil is magnetically south. If you look at the series and the parallel diagram, you can see that the positive pole of one coil connects to the negative pole of the other. You would expect that these would cancel the signal, but your expectations would be only half right. Half of the signal is cancelled – the hum half. The coils of a humbucking pickup are wired out-of-phase so that any signal received by the coil is cancelled, but the opposite magnetic polarity of the coil is not sensed, back into an anti-phase signal.

In summary, a humbucking pickup acts in the following manner: any signal (i.e. hum) is “seen” by the coil, cancelled, and any signal (i.e. string vibrations) is “seen” by the magnetic poles is accepted.

**THE LINKING OF COILS IN A HUMBUCKING PICKUP**

Traditionally, the two coils of a humbucking pickup are linked together in a series circuit; however, the coils can also be linked in a parallel circuit. When describing series or parallel wiring within a pickup, the only concern is with the paths of resistance and the actual electronic response to these connections. This is because these positive and negative points become inverted when passing through opposite magnetic polarities in the humbucking pickup's coils. The following diagrams show (1) the linking of two coils in a series humbucking mode, and (2) in a parallel humbucking mode. 

**Fig. 39 Schematic diagram of a humbucking pickup (series linked)**

**Fig. 40 Schematic diagram of a humbucking pickup (parallel linked)**

**The inside lead of the first coil is soldered to the outside lead of the second coil, and then an output wire is soldered to this junction. Then the outside from the first coil is soldered to the inside lead of the second coil. Another lead is then soldered to this junction.** This results in two output leads, either could be hot or ground, the choice is arbitrary. A parallel linked humbucking pickup is not mechanically linked as two series configurations. As previously mentioned, parallel linkage is not concerned with the actual electrical connection, but rather, the parallel relationship of the paths of resistance.

There are some drawbacks to both series and parallel linkages. In series linkage, there is a loss of high frequencies, and it is almost impossible to achieve an overall balance that is clear and delicate. In parallel linkage, the output level is reduced considerably, and it is virtually impossible to create a solid, beefy sound. A common double-pole double-throw switch can be connected to most humbucking pickups to enable the player to achieve both of these sounds on one guitar by flipping the switch. See the wiring section for instructions on installing a series/parallel selector.

**The Electronic Function of Series & Parallel Pickup Circuits**

When equal resistances are linked in parallel, the resultant resistance is one quarter of the sum total. When two resistances are linked in series, the resultant resistance is the sum of the two individual resistances. For example, if 10,000 ohm coil is wired in series with another 4,000 ohm coil, the total resistance of this device will be 8,000 ohms. In parallel linkage, if the 4,000 ohm coil is wired in parallel to another 4,000 ohm coil, the overall resistance of this device will be 2,000 ohms. Impedance measurements of these devices will react in a similar way to the resistance measurements. At this point, it is helpful to note that high impedance and resistance tends to impair treble and cause intermodulation distortion (lack of sound clarity). Also keep in mind that an increase in impedance often relates to an increase in inductance, and this inductance increase correlates very well with an increase in output.

**Fig. 41 Exploded view, a new Gibson Humbucker (series linked).**

**Series Linking**

Notice that a series humbucker has the white insulated outer coil leads from both coils joined together. The leads coming from the inner portion of both coils have black colored insulated wire, and the black wire from the coil with the solid slug becomes the hot output lead. The black wire from the coil that has the adjustable screw pole pieces is soldered to the base plate of the pickup. The braided shield of the coaxial pickup output wire is also soldered to the base plate. The base plate is used as a connection between the grounded shield and the black wire. This base plate connection effectively and efficiently forms a ground connection to the black wire and the entire metal case surrounding the pickup. Having the case of the pickup included in the ground circuit, helps to shield the pickup from receiving electro-static hum. Humbucking pickups can cancel 60 cycle per second hum, but not electro-static hum which is manifested at 120 cycles. Therefore, a pickup needs a metal shield to cancel electro-static hum.

**Parallel Linking**

Parallel linking of a humbucking pickup is as follows:

![Diagram of a humbucking pickup](image)

**Fig. 42 Parallel and series resistances.**

**Series vs Parallel Linkage**

Series and parallel each have their own distinctive sound. The series sound is characterized by high volume with a good degree of bass and a favorable signal-to-noise ratio. A parallel sound is characterized by less volume, very bright and clear trebles, and a less favorable signal-to-noise ratio.

**Placement of Pickups**

The location of a pickup will affect the tone as well as the overall volume. When a pickup is very close to a bridge, bass tones are greatly reduced. Pickups that are closer to the end of the fretboard than the bridge will give a fuller, less treble sound and vice-versa. The bridge pickups on Telecasters and StratoCasters are angled so that the treble side of the pickup is closer to the bridge than the bass side. If the bass side were close to the bridge as the treble side, the bass would be very thin and weak.

A pickup near the end of a fretboard is referred to as a rhythm pickup, i.e., the pickup is suitable for playing full-sounding chords and rhythm patterns. A pickup near a bridge is referred to as a lead pickup, i.e., it's suitable for playing sharp, clear single notes that stand out. When closer to the bridge, lead pickup positions yield less output because the energy level of a string is lower. If two identical humbuckers are used on a guitar, the lead pickup will have less volume than a rhythm position pickup. In order to equalize the difference in volume, guitars with two humbuckers often use rhythm and lead pick-ups which are different in tone and output. If there is a pickup in-between the rhythm and lead positions, it's referred to as a middle pickup.

Three humbuckers on a guitar are superfluous to many players because it can be difficult to find a place to pick the strings without having a pickup in the way because they fill the entire area from the bridge to the end of the fretboard. In addition, three simple humbuckers will give less tonal variations than a single tapped humbucker. One tapped humbucker could give ten distinct sounds. When two magnetically identical humbuckers are used, it's common to turn the lead pickup around. This is done so that the magnetic poles of one pickup don't interfere with the poles of the second. If pickups were both installed so that the south pole coil of one pickup was contiguous to the north pole coil of another pickup, the volume and full tone of the pickups would be impaired.

**Fig. 43 Orientation of pickups on a Les Paul**
in the guitar business and had to consult guitar experts as to “how to improve” the guitar. It was natural for Ampeg to come to Dan’s guitar shop in New York and ask for advice, and after some discussion, it was realized that the smart move for Ampeg (a manufacturer of amps) was to make an electric, not acoustic, guitar. Because of Dan’s relationship with Ampeg, he became the designer, and he was assisted by Bill Lawrence. (Together, both men developed the sliding placement pickup.) Instead of having a separate rhythm and lead pickup, the guitars had modular pickups. The clear plastic body of the guitar came about through the suggestion of Mike Gurian. A few guitars were made of black plastic, but Dan feels that this material was too much like rubber. However, some people really love these black beauties and have a lot of respect for them.

- this pickup is battery powered.

MAJOR PICKUP AND GUITAR ACCESSORY MANUFACTURERS

DAN ARMSTRONG

Dan Armstrong is somewhat of a mystery figure. Most people that are into electric guitars have heard of him, but few know him. Dan has traveled a lot and has worked on electric guitar/pickup projects both in the U.S. and England.

In 1967, he was trying to remedy a short in a pickup and ended up making his own custom made pickup. In 1969, he met Bill Lawrence, and after they had a few talks together, Dan became more interested in working with pickups.

Many people think Dan Armstrong created the Danellectro guitars, but Dan states that they were created by Nathaniel Daniel. He did rework them however, and eventually owned the company. The Danellectros were made out of Masonite and 2 x 4’s. For the double cut-away model in copper and black, the supplier paid $30. The dealer paid $46 and the instrument was sold to customers for $55 at such places as Manny’s in New York. Today these same instruments sell for $200 to $300 or more. The pickup on Danellectro instruments is incredibly simple. It consists of handwound wire around a bar magnet and there is no bobbin. The loose scatter wound wire-turns produce higher peaks than those of tight even coils. This pickup is held together by wrapping of black electrician’s tape and it is stuffed into a short chrome plated cigar shaped container.

When Ampeg bought Gramer Guitars, they weren’t people to try to unravel and count the many thousand turns of a coil, but if “Oli” Dan is pulling our legs on this one, we’ll be embarrassed to be caught counting the turns. Anyway, Dan states that it’s the turns and the length of wire used that matters, not the d.c. resistance.

As for other pickup details, Dan feels that single coat PVC insulation is the best because a too-thick insulation can make the coil too bulky. As for magnets, ceramic has an advantage in that it doesn’t have the proximity effect that alnico has; that is, as a string moves closer to the ceramic magnet, it doesn’t accentuate the bass over the treble. So for exotic, rare earth magnets such as samarium cobalt, they are very expensive and they are too strong — “Dan nears the strings to them.” As for resonant peaks, more wire lowers them and so does using a smaller magnet.

Dan has known David Schecter for some time; and again, it was only natural for Dan to do design work for Schecter Guitar Research. The pickup system he has worked on is called the Z-5. The Z-5 is a patent-pending method of using a magnet between bobbinless coils. The total d.c. resistance (both coils) is about 10K. The impedance is higher than most other pickups, and it also has more treble; therefore, a .01 micro farad capacitor is used on the tone control.

BARTOLINI GUITARS

William Bartolini began making Hi-A (high asymmetry) pickups in 1974 and in 1980 he was producing over thirty models of patented single coil and humbucking pickups.

Bill has a strong background in electronics and this background shows in his pickups which offer features found in few other pickups. Some of these are: four coil humbuckers, hexaphonic guitar pickups, and pickups with built-in preamps. Bill has several concerns about pickup construction and operation:

1. Magnet or core material doesn’t make much difference in arriving at a certain type of sound; the interactions of a pickup’s components play the major role.

2. Capacitance effects are important in coil design. Capacitance results from turn-to-turn coil windings.

3. Flux linkage/leakage influences output. The strings above a pickup cause flux leakage. The motion of a string modulates this action, and any change in flux is monitored by the coil.

4. Pickups should sense vibrating strings in an asymmetrical fashion. Only the vertical motion of strings, not the side-to-side motion, should be sensed. If this is done, a more natural sound will result.

5. How a pickup interfaces with a guitar’s controls heavily influences a guitar’s final sound.

Some of the most unique Hi-A pickups are described in the following text.

Model 3-A Acoustic Guitar Pickup

This single coil pickup for round hole guitars is nearly as hum-free as a humbucker. Although its output is not tremendously high, the sound it has is very clear and clean. There is string-to-string volume

Fig. 44 Danellectro pickup.

Fig. 46 Mini size Beat II.

Fig. 47 Bottom of Bartolini Beat.

Model 36L – Hexaphonic

This Stratocaster size pickup has six leads and six turns which result in a separate output of each string. Bartolini also makes humbucking hexaphonic pickups as well as quadrophonic bass pickups.
MAGNETIC PICKUPS

Cook has worked with is to install a parametric equalizer as a tone control. When turned quickly this
done anything to update the pickups they designed in 1955, and the sound back then just wasn’t what the
guitarist wanted (today).”
Larry had designed many pickups years before
DiMarzio Inc. was formed. The company really got
going when Steve Kaufman joined forces with Larry.
Steve was the principal agent in S. Hawk Company
which specialized in sound modification/signaling
processing devices. Together, Larry, Steve, and later
Steve Blicher, made DiMarzio Inc, what it is today.

As for why people play DiMarzio pickups, Steve
Kaufman has stated: “The only reason anybody plays
DiMarzio pickups is for the sound. It’s not that there
is any single DiMarzio sound, it’s just that DiMarzio
pickups are versatile enough to allow the guitarist to
achieve the special sound he wants…” Endorsements
have helped us gain recognition, but they also make for
some serious credibility problems. For example, Al
DiMeola endorses DiMarzio pickups, but he doesn’t use
them exclusively. So, if a kid goes to a concert read
after reading that DiMeola uses our stuff and sees him
playing something else, his credibility is sometimes
shaken.” Professional musicians may use several brands of
pickups in the course of their work, but still feel they
would like to endorse just one.

Many companies offer their instruments with
DiMarzio pickups as an “optional extra”. Such is the
status of these pickups. When a DiMarzio pickup is
seen on a guitar that sells for about $200, it can be a bit
baffling because two of these pickups can equal half of
the price of the guitar itself. The reason that Hondo
and other makers of economy instruments can keep
their prices so low is that these are specially made
units.

All DiMarzio pickups are made in the U.S.A. The
DiMarzio pickups on economy imported instruments
are very similar to the more expensive standard
DiMarzio pickups. These economy pickups are simple
in design but there is nothing of lower quality in them.

DiMarzio’s expertise in pickup making is reflected in
three subjects which don’t receive much publicity.
These items may be subtle details, but they are
important to overall pickup quality:

1. Larry’s special skill is making pickups with a pre-
determined sound. Tension on coil winding is a major
factor in this regard. His company’s winders are not
simple friction control tension machines because these
can cause a breakdown of the insulation on the magnet
wire.

2. Single coil pickups were heated and then dipped
in a hot wax bath to help insure that the wax
penetrates deep. Recently DiMarzio switched to a non-
water process of coil solidification.

3. Lead wires used on all DiMarzio pickups are
Teflon coated for maximum durability and heat
resistance.

PICKUPS MADE BY DIMARZIO

The DiMarzio Company now manufactures a wide
range of magnetic pickups plus one contact model.
Other companies have copied his designs, but since

GUITAR ELECTRONICS

DiMarzio got the ball rolling; his designs have served as
the basis for so many other designs.

DiMarzio X2-N

This very high impedance pickup has solid pole
pieces and uses three ceramic magnets. The four wire
leads allow full wiring options: phasing, splitting,
parallel and series. This pickup has a very high output.

Super Distortion Humbucker

This ceramic magnet pickup is a replacement for
large Gibson style humbuckers, and its design is based on
that “hot” classic pickup’s design. The higher output
is achieved by more windings and greater magnetism.
Care has been taken so that high frequency response
still comes through. Note that the d.c. resistance is
13.68k ohms, whereas a Gibson “Original” is 7.8k
ohms.

Dual Sound Humbucker

This is basically the same pickup as the Super
Distortion but there is an added feature: the coils are
switchable so that the pickup is linked in series or
parallel. This gives different resistances and
impedances, and therefore – two sounds. The two d.c.
resistances are 13.68k ohms and 3.42k ohms. Note
that the parallel mode has ½ the resistance of the
series mode. It’s better than split pickups because
when it’s switched to its lower resistance – bright
mode – it’s still humbucking.

DiMarzio PAF

This pickup is modeled after the first Gibson
humbucker and its “old” sound is achieved as a result of
several construction features. The two most
important are a special winding of the coil and the use

JOHN BIRCH

John is an Englishman who developed the concept
of double screw pole pieces which are designed to
reduce dead spots between the pole pieces when
bending the strings. John has made many pickups of
this configuration of both humbucking and single coil
models.

PETER COOK

Cook makes finely crafted electrics. One feature

Fig. 49 Hexaphone pickup.

Model EVQ – Variable “Q” Electronic Pickup

This pickup has one active coil and one non-active, hum-canceling coil which together help to create
a narrow aperture (string sensing) system. The built-in
preamp allows the tone control to vary the band-width
Q factor from 5 to 15. This allows a wide latitude of
possible tones.

Fig. 50 Diagram of EVQ pickup.

Fig. 49 EVQ pickup.

Fig. 51 Peter Cook guitar.

control sounds like a wah-wah device because it is a
band-pass filter. The guitar has one knob that raises or
lowers the band, and another knob that controls the
volume. Anyone could take apart a wah-wah pedal and
put one in a guitar; however, many wah-wah pedals
have a poor signal-to-noise ratio as well as being fairly
expensive.

DIMARZIO

In a very short time DiMarzio pickups have gone
from being an unknown to being the most known.
Larry DiMarzio’s interest in pickups began one day
when his electric guitar burned out. Larry said, “I didn’t
take money to build a new one so I decided to make
my own.” That first DiMarzio pickup took Larry thirty-
six hours to build. However, he wasn’t satisfied with it,
and he continued experimenting. Being both a
professional musician and a repairman put him in a
unique position. Playing with a band offered him an
unparalleled opportunity to test out the creations he
made in his shop. As he says: “The only way to really
test a pickup is to take it on stage and use it.”

Larry got very intrigued with the fact that pickups
could be so individualistic. Also, he became aware of all
that a pickup could do. As he has said: “I heard a lot of
guitarists complain about their pickups. It’s not that the
pickups they were using were bad pickups, but rather
you just weren’t suited to the music that people were
playing. Some of the major guitar manufacturers hadn’t

Fig. 51 DiMarzio Super Distortion.
MAGNETIC PICKUPS

of an alnico 5 bar magnet. The tight coil winding is calibrated to the magnet used. The early DiMarzio pickups were rather unrefined, but now their pickups are a joy to take apart and examine. Everything is purposeful and nothing looks shoddy. The most obvious DiMarzio change from the Gibson design is the molding of little plastic feet into the bottom of #2 coil bobbin so that the bobbin sits in a level position. Note that in the photo of the PAF pickup that the ground does not connect with the coil. Both coils are wound in the same direction. The outside leads are used as the series link, and both inner leads are drawn out inside a two lead coaxial wire. One wire is black and the other is white. Either could be ground or live which means that it's easy to wire a phase switch. Also, it's easy to link the pickup in parallel or series with another pickup. Refer to the section on wiring for further details.

Acoustic Model II

This pickup is for acoustic steel string guitars and it mounts in the soundhole. Very thoughtfully, the mounting flanges are of non-scratching nylon. The tone of this pickup is more acoustic than most other magnetic pickups. This clear sound is the result of a lower impedance. The d.c. resistance is 5.83K ohms. This pickup slides on a track so you can adjust what portion of the strings you want it to sense.

SDS-I

These super distortion Strat type pickups offer several laudable features. First, they have fully adjustable pole pieces. Second, output is higher than common Strat pickups. The d.c. resistance is 8.66K ohms, whereas Fender Strat pickups are about 6K. Third, the combined design features of this pickup make for a more even frequency response. The magnetic string pull which causes uneven sound is 50% less in this pickup.

Seymour Duncan

Duncan possibly makes the most diverse line of pickups: high/output distortion, single coil and dual coil pickups, staggered-height (pole piece) single coil pickups for both right and left handed guitars. These staggered-height pickups resemble the first Strat pickups. Duncan also offers replicas of the '59 Gibson, Patent-Applied-For humbucker which are the most accurate copies of these pickups made to date. They are available with double cream, double black, and zebra bobbins. Duncan offers a line-up of pickups for all common instruments plus Duo-Sonics, Mustangs, and Musicmasters. Many Duncan pickups are available in a tapped configuration.

Seymour Duncan is involved with pickup rewinding and making new pickups as well as doing design work. He feels that rewinding has given him insights missed by many other people and that the years he spent dissecting a multitude of pickups, along with creating a vast array of "copies", have been a good teacher. His customers may want a pickup that sounds like a P.A.F. humbucker, an old Rickenbacker, or a hot vintage Telecaster, etc., and he has learned to track down the features which produce the distinctive tone for each model.

The oldest pickup that he has re-created is the 1930's Gibson ES-150 mid-impedance pickup. This pickup uses 04 gauge wire which is very unusual in this day and age because most pickups today use 42 gauge wire. His next oldest re-creation is his P-90 style model which is next of kin to the "real rock and roll" soap bar (single coil) pickup. If you have any other type of pickup in mind, he could most likely make it.

Some of Seymour's observations are:

1. Magnets: Ceramic magnets are too strong to give a pickup a "mellow" "vintage" sound; alnico 5 is best for producing this type of sound. Alnico 8 gives higher trebles, but it pulls the strings more and causes distortion.

2. Coils: Unless it is potted properly, winding too fast produces a sponga coil that squeals. When other people make Gibson copies, they always seem to use the same wire winding direction as Gibson, whereas Fender pickup winding direction varies. Sometimes Fender has a coil with the top coming and the bottom going, or sometimes it's the reverse. This means that if you mix Fender pickups from different years, you may create phasing problems.

3. Variances: It's very difficult to make pickups that are 100% identical. There can be a variance of -0.005 in cylindrical magnet slugs and this variance affects the strength of each. Bobbins can vary in dimensions, and wire is not always uniform in diameter. All of these aforementioned variances affect resistance, impedance and capacitance. Variances continue to occur even after a pickup is made. While it rests, the magnets lose their power; just two years can weaken a Fender pickup and three years can weaken a Gibson pickup. This weakening can produce an audible change in a pickup. Heat, shock, and alternating current fields can also play havoc with magnets. For example, an alternating current field of an amplifier's transformer can affect magnets.

4. Tension: The tension in winding can stretch wire and change the diameter and length which in turn affects the d.c. resistances. Seymour took readings on the resistance of five coils wound to an exact number of turns and found the following d.c. resistances: 13.79K, 13.85K, 13.72K, 13.69K, 13.65K. Yes, pickups are individual.

5. Layering: When wire is wound on a coil, it can be wound evenly in layers or it can be put on helter skelter.

6. Encapsulation: The encapsulation of coils and pickups can be hit or miss. Seymour took apart a Fender pickup to show me that the wax often doesn't penetrate the inside of a coil. On this particular coil, the inner windings were unwaxed and loose. To prevent this problem, Seymour uses a vacuum saturation technique to insure a solid pickup.

7. Sound: It is the age of pickups which causes confusion. When someone wants an "old" Tele sound, does he want the sound of an old Telecaster?
MAGNETIC PICKUPS

when it was new, or the sound of a 1950 Tele today with its weak magnets! Seymour provides both with his new "old-style" pickups, and "aged" old-style pickups. The following is quoted from Seymour who explains "new sound" vs "old sound":

"For perhaps the last five years, a certain phobia has been developing among guitarists and bassists throughout the land. They just don't make 'em like they used to", especially pickups. Both of the major manufacturers of electric guitars in this country, Gibson and Fender, have fallen victim to the scrutiny of the pickiest bunch of ears in the west - us, 'em guitar pickers'.

"So why the difference? (between old and new). Well truth is, the big '2' aren't out to destroy your (vintage) sound, and your '57 Strat or '55 Les Paul sound that way (vintage as compared to modern) because of the changes in the way the pickups are manufactured (now, as compared to 1955-60).

"A long time ago, the pickup coils were wound by hand on the equipment which seems antique, and stone age crudeness by comparison with today's pickup winders. Some of the reason for the advanced equipment is all the money spent on guitars in the early 60's helped the big manufacturers to afford good technical gear. Occasionally, coils wound in the old days were sloppy in their wrapping. Today, even though they are wound more consistently and the same gauge wire is used, the new pickups tend to have a thinner insulation resulting in a physically thinner coil and thinner sound. Old coils have wraps which go across each other, up and down indiscriminately due to hand winding, while new coils are neatly parallel around the coil bobbin. (because of advanced string winding machinery), and are staggered together from the first layer of winding to the next. What this means is that older coils have slightly higher voltage output, and are less resistant to due uneven space in the wrapping. They are more inconsistent from one pickup to the next in the same model, making it easier to get a lemon. New coils are much more consistently wound and have a little less voltage output, but a little more frequency response (a cleaner top end in your sound especially). They don't distort within the pickup as the winding of wraps is quite uniform.

"If you measure the d.c. resistance of the old coil and a new one, they will be quite similar. Real close is the best that the 'Big 2' do even today because the coils are wound to a certain number of mechanical turns and wire is chopped. However, for truly balanced coils, the wire should be wound a little more than necessary (20 turns too much) and then electronically metered and trimmed to balance exactly when cut. This difference in mechanically alike coils is due to inconsistency in the wire used to wind pickups which is either 42, 44 or 46 (or about the size of a human hair). The wire is usually stretched when it's being wound, producing this inconsistency.

"So, if you like that old nasty sound of 'X-150 Jazzstar Dumptuch' or whatever other kind of guitar, most often it is the sloppy coil that turns you on. Any pickup winder can be made to be sloppy, most aren't in the first place because it's considered to be undesirable among engineering and technical types. They will need to sound like '1957 Dogbreath', go find an old pickup and pay through the nose, or go get yours wound that way, or realize that other replacement gear will do the job."

SPECIFICATIONS ON THE 42 AWG MAGNET WIRE:
(SINGLE BUILD INSULATION)

<table>
<thead>
<tr>
<th>Diameter/Inches</th>
<th>Nominal</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Nominal</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>(.024&quot;)</td>
<td>.023&quot;</td>
<td>.025&quot;</td>
<td>.026&quot;</td>
<td>.026&quot;</td>
<td>.026&quot;</td>
<td>.026&quot;</td>
</tr>
<tr>
<td>(.032&quot;)</td>
<td>.031&quot;</td>
<td>.032&quot;</td>
<td>.033&quot;</td>
<td>.032&quot;</td>
<td>.032&quot;</td>
<td>.032&quot;</td>
</tr>
<tr>
<td>(.040&quot;)</td>
<td>.040&quot;</td>
<td>.040&quot;</td>
<td>.040&quot;</td>
<td>.040&quot;</td>
<td>.040&quot;</td>
<td>.040&quot;</td>
</tr>
</tbody>
</table>

Nominal ohms at 1000' (feet) 20° cent. 1.659 ohms Nominal ohms per pound. 20° cent. 84.510 ohms Pounds per 1000' (feet) .0196 lbs Feet per pound 50.940 (feet)

(HEAVY BUILD INSULATION)

Minimal increase in film insulation .004" Overall diameter inches .028" (minimum) .030" (nominal) .032" (maximum) Nominal ohms per 1000' (feet)/20° cent. 1.659 ohms Nominal ohms per pound/20° cent. 82.290 ohms Feet per pound 49.600 (feet)

PLAIN ENAMEL - (OLEO-RESINOSIL) normally a dark maroon color (used on the newer Strats)
POLYURETHANE - comes in a variety of colors, RED, GREEN, CLEAR, BLUE ETC., FORMVAR (POLYVINYL FORMVAR) used on the older STRATOCASTERS BONDABLE POLYURETHANE (HAS A FILM OF THERMOPLASTIC ADHESIVE) reacts to heat or alcohol.
BONDABLE FORMVAR (HAS A THERMOPLASTIC FILM ADHESIVE)

OLD VS NEW

See the new information for comparing Strat pickups. Although Strat pickups have undergone a great deal of change, there are subtle differences. The "Formvar" insulation on the magnet wire was thicker than what is used today. If two coils are wound with the same gauge wire, and to the same number of turns, the one with thicker insulation will produce a faster coil. The outer windings of this coil will be further from the magnets. The amount of windings on Strat pickups has varied, as the comparisons show. Seymour says: "Many people think that it's the number of turns alone that can make this pickup have its unique sound, but it is mostly the varying lengths of the magnetic core pole pieces which give it its sound. Due to the magnets being of varying lengths, there is an inner phasing of the pole pieces which gives it that sound."

A Comparison Of Old And New Stratocasters

<table>
<thead>
<tr>
<th>Feature</th>
<th>1954 Stratocaster</th>
<th>1978 Stratocaster</th>
</tr>
</thead>
<tbody>
<tr>
<td>OHMS</td>
<td>6.05 K Ohms</td>
<td>5.66 K Ohms</td>
</tr>
<tr>
<td>FLATWORK MATERIAL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top</td>
<td>Vulcanized fibre (black)</td>
<td>Vulcanized fibre (black)</td>
</tr>
<tr>
<td>Bottom</td>
<td>Vulcanized fibre (black)</td>
<td>Vulcanized fibre (black)</td>
</tr>
<tr>
<td>FLATWORK THICKNESS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top</td>
<td>.064&quot; (inch) 1/16 inch</td>
<td>.064&quot; (inch) 1/16 inch</td>
</tr>
<tr>
<td>Bottom</td>
<td>.097&quot; (inch) 3/32 inch</td>
<td>.097&quot; (inch) 3/32 inch</td>
</tr>
<tr>
<td>MAGNET DIAMETER</td>
<td>.192&quot; (inch)</td>
<td>.197&quot; (inch)</td>
</tr>
<tr>
<td>MAGNET LENGTHS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E 6th</td>
<td>.684&quot;</td>
<td>.656&quot;</td>
</tr>
<tr>
<td>A 5th</td>
<td>.687&quot;</td>
<td>.656&quot;</td>
</tr>
<tr>
<td>D 4th</td>
<td>.717&quot;</td>
<td>.656&quot;</td>
</tr>
<tr>
<td>G 3rd</td>
<td>.718&quot;</td>
<td>.656&quot;</td>
</tr>
<tr>
<td>B 2nd</td>
<td>.636&quot;</td>
<td>.656&quot;</td>
</tr>
<tr>
<td>E 1st</td>
<td>.657&quot;</td>
<td>.656&quot;</td>
</tr>
<tr>
<td>MAGNET FEATURES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rough sandcast markings</td>
<td>Slightly tumbled</td>
<td></td>
</tr>
<tr>
<td>Ground end</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BOBBINS LACQUERED</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>COIL DIRECTION</td>
<td>Start/Left (wound clockwise)</td>
<td>Start/Left (wound clockwise)</td>
</tr>
<tr>
<td>MAGNETIC POLARITY</td>
<td>North (first few years of production; changed to south)</td>
<td>South</td>
</tr>
<tr>
<td>MAGNET WIRE GAUGE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>42 heavy Formvar</td>
<td>42 plain Formvar</td>
<td></td>
</tr>
<tr>
<td>INSULATION</td>
<td>Above</td>
<td>Above</td>
</tr>
<tr>
<td>TURNS</td>
<td>8.350</td>
<td>7.600</td>
</tr>
<tr>
<td>BLACK LEAD WIRE</td>
<td>Ground/beginning of coil</td>
<td>Ground/beginning of coil</td>
</tr>
<tr>
<td>WHITE LEAD WIRE</td>
<td>Hot/finish of coil</td>
<td>Hot/finish of coil</td>
</tr>
<tr>
<td>POLE SPACING</td>
<td>.407&quot; center to center pole</td>
<td>.407&quot; center to center pole</td>
</tr>
<tr>
<td>WINDING LENGTH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Outside of E 6th to E 1st)</td>
<td>2.225&quot; outside E 6th to E 1st</td>
<td>Same as 1954 Stratocaster</td>
</tr>
<tr>
<td>TOP LENGTH OF FLATWORK</td>
<td>2.616&quot; - ends are filed</td>
<td>Approx. same as 1954 (all below not filed)</td>
</tr>
</tbody>
</table>
### Typical Properties Of Cast Alnico V Magnets Used In Stratocaster Pickups

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical Residual Induction (Br)</td>
<td>12,400</td>
</tr>
<tr>
<td>Typical Coercive (H)</td>
<td>640</td>
</tr>
<tr>
<td>(Bd H) max Megauss Oersteds</td>
<td>5.50</td>
</tr>
<tr>
<td>Average Density – Pounds per cubic inch</td>
<td>264</td>
</tr>
<tr>
<td>Coefficient of Thermal Expansion</td>
<td>11.6</td>
</tr>
<tr>
<td>Tensile Strength – pounds per sq. inch</td>
<td>5,450</td>
</tr>
<tr>
<td>Transverse Modulus of Rupture – pounds per sq. inch</td>
<td>10,500</td>
</tr>
<tr>
<td>Hardness – Rockwell C</td>
<td>50</td>
</tr>
<tr>
<td>Resistivity – Micro Ohms per cm per cm² at 25 degrees C</td>
<td>47</td>
</tr>
</tbody>
</table>

### Average Ohms Of Stratocaster Pickups

<table>
<thead>
<tr>
<th>Year</th>
<th>Front</th>
<th>Middle</th>
<th>Back</th>
</tr>
</thead>
<tbody>
<tr>
<td>1954</td>
<td>5.8K</td>
<td>5.38k</td>
<td>5.85k</td>
</tr>
<tr>
<td>1955</td>
<td>6.02k</td>
<td>5.96k</td>
<td>6.01k</td>
</tr>
<tr>
<td>1956</td>
<td>6.13k</td>
<td>6.34k</td>
<td>6.28k</td>
</tr>
<tr>
<td>1958</td>
<td>6.41k</td>
<td>6.39k</td>
<td>6.65k</td>
</tr>
<tr>
<td>1960</td>
<td>5.96k</td>
<td>5.85k</td>
<td>6.31k</td>
</tr>
<tr>
<td>1963</td>
<td>6.26k</td>
<td>5.98k</td>
<td>6.11k</td>
</tr>
<tr>
<td>1965</td>
<td>6.29k</td>
<td>6.09k</td>
<td>6.19k</td>
</tr>
<tr>
<td>1966</td>
<td>6.34k</td>
<td>5.98k</td>
<td>6.06k</td>
</tr>
<tr>
<td>1970</td>
<td>5.60k</td>
<td>5.50k</td>
<td>5.31k</td>
</tr>
<tr>
<td>1973</td>
<td>5.52k</td>
<td>5.55k</td>
<td>5.52k</td>
</tr>
<tr>
<td>1974</td>
<td>5.11k</td>
<td>5.45k</td>
<td>5.52k</td>
</tr>
<tr>
<td>1976</td>
<td>5.65k</td>
<td>5.71k</td>
<td>5.64k</td>
</tr>
<tr>
<td>1980</td>
<td>5.91k</td>
<td>5.80k</td>
<td>7.23k</td>
</tr>
</tbody>
</table>

### Standard Recommended Tensions Of Standard Magnet Wires Used In Guitar Pickups

<table>
<thead>
<tr>
<th>AWG</th>
<th>Tension Grams</th>
<th>Tension Ounces</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>53 grams</td>
<td>1.9 oz</td>
</tr>
<tr>
<td>42</td>
<td>52 grams</td>
<td>1.55 oz</td>
</tr>
<tr>
<td>43</td>
<td>52 grams</td>
<td>1.5 oz</td>
</tr>
<tr>
<td>26</td>
<td>26 grams</td>
<td>0.92 oz</td>
</tr>
<tr>
<td>22</td>
<td>21 grams</td>
<td>0.74 oz</td>
</tr>
<tr>
<td>17</td>
<td>17 grams</td>
<td>0.6 oz</td>
</tr>
<tr>
<td>13</td>
<td>13 grams</td>
<td>0.46 oz</td>
</tr>
</tbody>
</table>

### Using Strat Pickups

Duncan gives the following info so that Strat owners can get more from their instruments:

- There is a factor which determines the sound and output of a pickup. “Strat-itis” is often heard when playing high on the fingerboard on the lower strings. It is hard to distinguish the notes and impossible to get it in perfect pitch around the 12th fret. What I do to help cure this, is done in a couple of ways. First, I raise the back pickup quite close to the strings without hitting the pickup when pressing the string at the last fret. Then lowering the bass at the last fret, and then lowering the brass side of the middle and front pickups, keeping the treble side still up. The larger mass of the bottom strings becomes more magnetized because the pickups have the same magnetic polarity. This string then becomes magnetized at three points with the same field. Because like magnetic poles repel and unlike poles attract, there is a repelling of the magnetic field on the strings which causes the pickups to produce a very unattractive sound. Lowering the pickups on the bass side will help considerably. Another solution that helps, is to wind the middle pickup in the opposite direction and reverse the magnetic polarity. This does two things: (1) reduces ‘Stratitis’ and allows humfreeking linkage if coils 1 and 2 or 2 and 3 are used together.

- Fenders have always had a noise problem. When Strats were first made, guitarists used a heavier gauge of string than is used today. The result of this is that signal-to-noise ratio has worsened with the use of lighter gauge strings. The players today use such light gauge strings that a very hot signal is not generated. This means amps are turned up louder and hum is therefore louder.

### Fender

- In some ways, Fender can be thought of as the founder of rock ‘n’ roll. Although Gibson made electrics more than ten years before Fender, Fenders were unique in that they weren’t hollow like a normal guitar. In 1948, Fender introduced the “Broadcaster” guitar which had an ash body with two single coil pickups and a bolt-on, one-piece maple neck. The rhythm pickup had a d.c. resistance around 6.5K, whereas the lead pickup had a figure higher than this, and wire gauge numbers 42 and 43 were used. Many of these picks vary in d.c. resistance, some as high as 11K. Since Gretsch had the name Broadcaster in use, Fender’s guitar became the Telecaster. Teles made today are generally the same as those made thirty years ago.

- **Fender – Research and Development**
  Fender has a Research and Development Department that’s continually working on checking the quality of production, developing new ideas and evaluating new products on the market. One avenue of exploration is studying the science of hearing. One part of Fender’s studies of hearing involves placebo and Hawthorn effects. For example, when a listening audience is told that one Strat has a normal pickup, and another Strat has a “special” new pickup, the group will definitely hear the difference, but if they are told that both models are the same, there is a tendency for the group to not detect any tonal difference. This “confirmation” is very influential in marketing the aura of “vintage” instruments. Many people buy “vintage” pickups and then convince themselves that the sound unique.

- The subject of replacement parts has had Fender somewhat perplexed. Persons familiar with the guitar scene will note that many companies make custom parts advertised to fit on Fender guitars. Fender was greatly amazed because these companies took advantage of the Fender name, and Fender couldn’t figure out why these parts gained such popularity. It appears that the popularity is related to a person’s desire to individualize their guitar and not lose their possession.

As for pickup design, Fender is continually experimenting. The single coil pickup is best known as a “Fender creation” and therefore, it receives a lot of attention. One problem with a Fender single coil pickup is that it’s not humfreeking. A simple way to achieve humfreeking would be to wind a coil around three north polarity slugs and then wind a coil around three south polarity slugs. The two sections could then be linked to form a humfreecker, but it could look like a single coil pickup if put in one idea. If the idea of 3 and 3 pickup is given a little thought, it makes a lot of sense; however, further thinking will reveal that when two coils are series linked, the resistance doubles, and the tone is greatly altered. If they are linked in parallel, the resistance halves, and the tone is also altered. It’s difficult to make a humfreecker that behaves and sounds like a single coil pickup without hum.

The Fender electric 12 string used split pickups with each half mounted separately. The Precision Bass still uses this layout. The old Dutch electric, the Egmond, used split 3 and 3 pickups. On this instrument, each half of the pickup was put in a full width case. The case extended under all six strings. There were three dummy pole pieces in each case.

Fender uses a simple procedure for R & D testing the response of new pickup designs. A pink noise signal from a signal generator is fed into an amp, and a loop 12 gauge insulated wire is hooked up to the speaker wires of the amp. The loop is then placed around a single coil pickup, and the output of the pickup is then directed to a Hewlett Packard Analyzer with print-out capabilities. If a dual coil pickup is used, then half the loop (a length of straight wire) is laid on the pickup between the two coils. Since this method of testing does not use strings, it is not subject to their individuality, and this makes the test results more uniform. Heath Co. makes an inexpensive signal generator that could be used by amateurs.

### Fender Tele and Strat Pickups

These single coil, non-humfreeking pickups use six alnico magnetic slugs surrounded by a wire winding. The company has alternated in using staggered height.

### Guitar Electronics

<table>
<thead>
<tr>
<th>Features</th>
<th>1954 Stratocaster</th>
<th>1978 Stratocaster</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOTTOM LENGTH OF FLATWORK</td>
<td>8.312&quot;</td>
<td>approx. same as 1954</td>
</tr>
<tr>
<td>TOP WIDTH OF FLATWORK</td>
<td>.60&quot;, inside ends are filed</td>
<td>approx. same as 1954</td>
</tr>
<tr>
<td>BOTTOM WIDTH OF FLATWORK</td>
<td>.905&quot;, inside ends are filed</td>
<td>approx. same as 1954</td>
</tr>
<tr>
<td>TOTAL DEPTH OF PICKUP</td>
<td>.718&quot; top to bottom</td>
<td>656&quot; top to bottom</td>
</tr>
<tr>
<td>EXPOSED COIL UNDER COVER</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>LEAD WIRE MATERIAL</td>
<td>cloth braid (push back) 22 gauge plastic coating</td>
<td></td>
</tr>
</tbody>
</table>
MAGNETIC PICKUPS

magnets and same height magnets. The staggered height units give a better string-to-string volume balance. Nowadays, however, many people don’t feel staggered height is needed because the extra-light gauge strings being used by musicians today function very well with same height pickups. Even so, staggered height pickups are worshiped by some musicians and although these pickups are nearly thirty years old, they are still in demand.

The first Telecaster pickups were those on the 1948 Broadcaster. The lead pickup had three-sixteenths of an inch flat pole magnets in the lacquered bobbin which was wound with .043 gauge magnet wire and a black waxed string wrapping. In 1954, Tele lead pickups began to receive slightly raised pole pieces.

The switching tone control circuit of older Teles is different from newer models. Telecasters before 1953 had the following switch positions: Pickup (p.u.) #2, p.u. #1, or p.u. #1 routed through a large value capacitor. This third selection gives a very bassy sound because the capacitor has diminished the treble.

The plate on the bottom of a Tele lead pickup is composed of magnetically conductive metal, and it is used to reshape the magnetic field of the pickup and thereby boost the output. This plate also has a second function, that of being a shield/ground conductor. The shield function is the action of the plate shielding the bottom of the pickup and contacting the magnets. The ground conductor function of the plate operates in the following manner: A ground wire connects the plate to the ground output of the pickup, then three metal screws pass through holes in the bridge and are threaded into three holes in the plate. The screws continue the ground circuit from the plate to the bridge and on to the strings. The Telecaster offers one of the most clever string ground paths available. However, there is one penalty to this system. The plate can contribute to unwanted feedback and noise by acting like an unwanted antenna. With a pickup cavity painted with conductive paint (and connected to ground) this feedback can be substantially reduced.

Fender is now painting the cavities of their instruments with just such a paint.

Fig. 61 Old Tele lead pickup, top view.

Fig. 62 Bottom of old Tele pickup mounted on bridge.

Stratocaster

Hendrix made the sound of his Strat the sound of rock ‘n’ roll. Stratocasters haven’t changed much since they were first made in 1956. The only noteworthy change is that the coils are evenly wound – gone are the tulip or bell shaped coil windings.

BASIC PARTS OF A STRATOCASTER PICKUP

1. Magnets: A Stratocaster pickup has six cylindrical magnets, the centers of which are .407 of an inch apart. These magnets are flush with the bottom of the bobbin and protrude through the top fiber piece. These magnets are alnico V which is composed of the following parts: 8 parts aluminum, 14 parts nickel, 20 parts cobalt, 3 parts copper, and the remainder iron.

These six magnet/pole pieces were arranged in a staggered height configuration on the first Stratocasters. The very first Strat pickups had the G string magnet .725 of an inch long, whereas the 1961 and later pickups had a .555 string magnet .521 of an inch long. This variance is a result of musicians switching to string sets using an unwound and (and therefore louder) G string. Newer Strat pickups have used magnets which are all the same height and protrude slightly above the top of the bobbin.

Currently Fender uses magnets which are sand cast to about .200 of an inch and ground down to a diameter of .187 of an inch. The first Strat magnets were ground on the edge. The early 1960’s magnets were heavily tumbled to remove sharp edges, and they did not have a vintage look. Presently magnets are lightly tumbled.

Early Strat magnets were cast, had a rough exterior finish and were .192 of an inch in diameter, plus or minus .002. One end of the early magnets was ground so that the magnets could be easily inserted into the fiber pieces. Magnets used in the 1960’s were greatly tumbled to round the ends and therefore, do not have a vintage look. Recent Strat magnets are only slightly tumbled.

2. Fiber Pieces: The bobbin of Fender single coil pickups is composed of magnets held between two pieces of vulcanized fiber. These pieces are composed of paper material saturated with resin and pressed under high pressure with the application of heat. Blanks of this material are made into pickup parts through the use of a punch press. Holes are made for the magnets, eyelets, pickup height adjustment screws, and output wires. The holes for the adjustment screws are later tapped to accept #6-32 adjustment screws. The two fiber pieces are black on early Strat pickups, but mid-sixties pickups have bottom pieces which are dark gray and often have a date on them.

3. Coil: The coil of a Stratocaster pickup is wound in the following manner: One end of a copper wire is attached to the left eyelet of a bobbin, then a coil is wound in a clockwise direction. The finishing edge of the coil wire is threaded through the right eyelet. The wound bobbin is then immersed in a hot wax bath to saturate the coil and therefore, reduce microphonics and make the coil more solid and durable. A black lead is soldered to the left eyelet and a white wire is soldered to the right eyelet.

Magnet wire for pickups is composed of electrolytic tough-pitch copper. Magnet wire is also made from aluminum, gold, as well as other metals, but copper is the most practical for pickups due to low cost and availability. Magnet wire is formed by forcing/drawing a copper billet (usually 4” x 4” x 36”) through a series of dies.

Strat pickups use 42 AWG gauge wire which is completely covered with insulation so as to isolate it from the wire previously wound – this prevents short out. Care must be taken when the wire is sharply bent around the end of magnets one and six, because if the insulation is broken, oxidation and crystallization can occur (which can destroy the wire and ruin a pickup). Also, if a phase switch is used (and the coil inside lead becomes hot) and there is a break in the insulation at the wire contacts the magnets, the following situation will occur: (1) if a string contacts a magnet, the entire circuit will short out and which will result (if a string ground is used); (2) There will be a fair loud hum if a person touches a magnet.

Magnet wire comes with a classification that denotes the melting point of the insulation. Class 105 would mean a melting point of 105° C. Class 180 would equal 180°C. The insulation on wire used in pickups is normally Class 105 because heat is not a problem.

Fig. 64 Old Stratocaster pickups, note uneven windings.

Fig. 65 Strat pickup with even height pole pieces.

1. The top and bottom of a bobbin are joined together by six alnico magnets.
2. This assembly is dipped in lacquer to solidify it and insulate the magnets from the windings.
3. A coil of 42 gauge wire is wound on the bobbin.

Fig. 66 Making a Strat pickup.
MAGNETIC PICKUPS

4. The wound bobbin is immersed in a hot wax bath to solidify the coil.
5. One black and one white lead are soldered to the pickup.
6. A plastic cover is put over the pickup.

Fig. 66 Exploded view of a Stratocaster pickup.

[NOTE: Bill Lawrence has stated that low-strength alnico V magnets in some Strat pickups are simply full-strength alnico II. Not all early Strat pickups were type V; few people know this.]

GIBSON PICKUPS

Although Gibson was not the inventor of the electromagnetic pickup, they were the first company to make pickups popular. Before 1950, pickup manufacturing was not completely consistent. The old Gibson winding machines didn’t wind to an exact number of coil turns or d.c. resistances because the machine didn’t have an automatic shut-off feature. This resulted in coils of different sizes, and it’s possible to find Gibson single coil pickups (the model is now called “Laid Back”) with d.c. resistances from 7.5K to 9K ohms. As for magnets, no exact formula was adhered to: Gibson has used alnico 2, 4, and 8, as well as 5.

Fig. 67 Fender Starcaster.

Aldinco type 5 with specific characteristics wasn’t called for. Often, the only qualification was that the material be a "magnet".

After 1950 automatic winders were used to wind bobbins to a set number of turns for both single and dual coil pickups. In addition, wire gauge became standardized; the wide range of d.c. resistance variance in early pickups was reduced to 2.5%. Also, magnets became standardized: in the ‘50's and ‘60's, alnico V was used in almost all pickups.

There is a lot of controversy about whether or not to wind coils to a set number of turns or to a specific d.c. resistance. Gibson feels that winding to a specific number of turns is the most effective method of producing a specific tone that is free of hum. Old Gibson P.A.F.'s often had about 6,500 turns and this is thought to be a magic number by some people.

When linking multiple coil pickups, Gibson primarily uses series wiring. Some exceptions to this

are the Les Paul and Thunderbird bass. The low impedance pickups on the Les Paul Recording are low because of the large diameter/low resistance wire. These pickups' coils are linked in series.

Most Famous Gibson Pickups

The following are descriptions of the most popular Gibson pickups. For the most part, these pickups are introduced in chronological order. Recently, Gibson created a new line of pickups which are: Laid Back, True Blues, Dirty Fingers, B J B Jazz, and Super Humbucking.

Gibson 150 Pickup

This pickup is used on the ES-150 and the EH-150. This magnetic pickup was one of the first avidly sought after pickups and it’s still in favor today. It’s a single coil unit with an iron core which butts against two long bar magnets. The magnets are held in place by three screws in the top of a guitar and there is a notch in the pole piece so the string is not too loud. This pickup senses a narrow portion of the strings and produces a clear, clean sound favored by many jazz guitarists. Because of the scarcity of this pickup, some people made copies of it. This demand has become so great that Gibson has reissued it.

Fig. 68 Fender humbucking pickup.

POLE PIECE

Fig. 69 Diagram of ES 150 pickup.

Fig. 70 ES 150 replica made by Duncan (empty bobbin without magnets).

Laid Back

This design is one of the first ones to be mass produced. It has been around since 1937 and it’s sometimes called the “Dog Ear” or “Soap Bar”. This pickup uses two bar magnets under a coil wound around a clear bobbin. The magnets under the coil have like poles facing each other. The use of conductive

screens between the magnet’s pole overcomes the inherent repulsion of the like poles. These screens become one magnetic pole and serve to act as pole pieces. This non-humbarcking pickup usually has a blaic or cream colored plastic cover. It was used on many instruments, including the first Les Paul guitars in 1952.

Nowadays not that many people care for these non-humbucking Gibson pickups. At one time they were very popular for rhythm and blues as well as rock ‘n roll. Their popularity has since waned because they are non-humbucking and their output isn’t especially high. This isn’t to say that one doesn’t like them now, because there are a substantial number of musicians that do like the sound. It’s fuller than a Fender single coil pickup sound, but it’s cleaner than a humbucker. It has a clean sound that still packs a healthy punch. It’s a versatile sound and it can be mellow, or piercing. The fact that it isn’t a humbucker causes recurring noise problems for some musicians. Gibson offers this pickup on the Les Paul Pro Deluxe.

The Laid Back has an induction of 7.5 henries which is very high for a single coil pickup. This is one reason the output of this pickup nearly equals that of a humbucker. The d.c. resistance is 8.3K ohms and the resonant peak is 4.78K Hz. Note how low the resonant peak is. This gives the pickup a very full sound.
MAGNETIC PICKUPS

that other pickups do not possess. It. The P.A.F. style pickup is still made, but the materials and manufacturing methods have changed. Some of these changes have been imposed on Gibson by suppliers, while some have been the result of Gibson's efforts to create a pickup that is consistent in quality materials and tone. The question of "Why can't they make them like they used to?" is a bit of a cliché. Yes, current standard large Gibson humbuckers don't sound exactly like an old P.A.F., but despite this fact, many players do enjoy the new ones. Are the "vintage" P.A.F. pickups worth several hundred dollars? Is it snob appeal or a decisively different tone? The answer seems to be a combination of these elements. The price of these pickups is quite high because the open market has allowed persons with money to drive up the price of these pickups. The high prices are due to the limited supply and this has led to counterfeiting of these pickups. P.A.F. pickups are the standard humbucking pickups Gibson made from 1955 to the early sixties. The initials P.A.F. stand for Patented Applied For. These pickups were made after Gibson received a patent filing number from the U.S. Department of Patents but before Gibson received the actual granting of a patent registration. During this interim period a manufacturer uses the term "Patent- Applied- For" or Pat. Pend. (for Patent Pending) on their work to protect the design while the wheels of the Patent Office slowly turn. In Gibson's case, the official granting of a patent number didn't occur until the late fifties. The total number of P.A.F. pickups that exist is unknown. Some turn up every now and then, but there are a few cases where a pickup was considered a genuine P.A.F. Gibson is now open to question. An examination of a known P.A.F. will disclose the following features:

1. The four screws that mount the coils to the base plate are nickel plated, whereas later models have brass screws.
2. There is a small square hole molded into one end of each bobbin, whereas later models have a round hole.
3. There is a small decal on the bottom of the pickup that says "Patent Applied-For" whereas later models say "Patent Number 2,737,042".
4. Contrary to popular opinion, the color of the bobbins is not an indication that a pickup is a P.A.F. The first P.A.F. pickups had black colored bobbins, but then the supply of the black dye was interrupted so Gibson then started using cream colored ones. This was done in a typical way; the new cream bobbins were dumped in with the supply of black bobbins that was running out. When bobbins were needed, workers reached for any two bobbins which resulted in a number of pickups with one black bobbin and one cream bobbin. This was not thought of as wrong because a cover was to be soldered over the bobbins. At that time almost no one was removing covers from pickups, that is different from today when almost everyone uses their P.A.F. with the cover off. Eventually, pickups with two cream colored bobbins became the norm after the supply of black bobbins was exhausted. But there was a resumption of black bobbins when black dye became available. Therefore, the same mixed condition again resulted. The color story of P.A.F. bobbins can be summed up in the following manner: The original (first year) P.A.F. pickups were all black. Then cream colored bobbins were introduced. P.A.F.'s with two cream colored bobbins are presently more rare so they command the highest prices. The years 1958 through 1960 produced the most cream colored bobbins. Gibson returned to black bobbins after 1960 but cream bobbins have still been known to occur as late as 1965. The Gibson P.A.F. humbucker is now sold as the Gibson "Original Humbucking" pickup.

One point needs clarification: Not all P.A.F.'s are highly respected; in fact, only a portion of all P.A.F.'s are considered great sounding by guitar experts because these pickups were inconsistently made. A confusing fact is that a P.A.F. may sound good on one guitar but bad on another.

Small Humbucker (aka Baby Humbucker)

This is a junior sized version of Gibson's standard (large) humbucker. The pickup may look like the larger model but the inside and performance are different than the larger model. The most important feature is that the induction and d.c. resistance is lower than that of the larger humbucker, and it also gives a greater amount of treble and clarity. This is due to several factors; the most fundamental is the lower d.c. resistance. This resistance ranges from 6K to 6.5K ohms on various specimens whereas the larger pickups vary from 7K to 8.5K. The sacrifice for the increase in treble and clarity in the Jr. model is a lower output. This pickup would be a good rhythm position mate for a Tele lead because of the output match. Most humbuckers have a high output and are out-of-balance used with the lower output single coil pickups like the Tele lead. If you are considering hot-rodding this pickup, respect this word of caution: This is a delicate pickup so use a very gentle touch when taking it apart. If you replace the magnet holding it, here are a couple of ideas: First, put a solid soft-iron pole piece in each slot of the bobbin and substitute a ceramic magnet for the alnico one and then add four conductor shielded wiring (+ -); second, stack the coils and insert a re-ground and remagnetized magnet into the slots and then wire as a tapped single coil pickup and insert it in a Tele rhythm pickup case – it works!

Firebird

This is a powerful pickup designed for use on some Firebird models. Each coil contains its own magnet and because the magnets aren't threadable, there are no adjustable pole pieces. This pickup is powerful and clear but the clarity isn't noticed until you really crank up an amp. When played slowly it has a decidedly cleaner sound than most other pickups.

Les Paul Recording

This is a stacked double coil humbucking pickup. The strikingly clear sound of these low impedance pickups limits their popularity because it isn't a versatile sound. It's only clear and clean and it can't be driven into being fat and dirty. Also, the clear sound gives away clumsy fingering. For these reasons, they aren't popular. This is the pickup for the topnoch guitarist who wants to show his skills.

Series linking of multiple coils results in a higher impedance than parallel linking. The Les Paul Recording instruments follow the normal Gibson practice of series linking the coils of a humbucker. Les Paul Recording instruments are low impedance because they use low impedance pickups, not parallel wiring.

Fig. 73 Gibson Original Humbucker.

Fig. 74 P.A.F. exploded view.

Fig. 75 Iron filings showing the flux field of a humbucking pickup, side view.

Fig. 76 Flux patterns, top view.

Fig. 77 Mini Humbucker.

Fig. 78 Les Paul Recording pickup.
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Johnny Smith

This pickup uses coils like those in the mini humbucker on Les Paul Deluxe guitars. In a basic Johnny Smith model, the alnico 2 bar magnet is in one of the coils. The base for the pickup is a piece of soft-iron or 15% nickel steel and serves as a flux path to the pole pieces. These pole pieces extend through the other coil and screw in the base plate. This construction results in a very dimensionally thin pickup.

S-I

The individual S-I pickup is a single coil non-humbucking pickup that uses a single bar magnet inside the center of the coil. There are no adjustable pole pieces.

The S-I guitar has one of the most advanced pickup selections possible for electric guitars, the switching was designed by Bill Lawrence. The three single coil pickups are arranged so that there are a possibility of nine pickup combinations. Because nine selections would be too confusing to most people, Gibson has settled on four rotary selections plus an additional mode. The selections available now are:

1. Pickup #1
2. Pickups #2 & 3
3. Pickups #1 & 2 as a humbucker
4. Pickups #1 & 3 as an out-of-phase humbucker
5. Pickup #3
6. Older S-I guitars offered
   a. Pickups #1 & 2 Humbucking
   b. Pickups #2 & 3 Humbucking
   c. Pickups #1 & 2 & 3 Humbucking
   d. Pickups #1 & 3 as an out-of-phase humbucker
5. Pickup #3

The reason the S-I can get so many combinations is that the magnet to pickup #2 is of an opposite polarity to #1 and #3. This allows many humbucking possibilities, including the very rare creation of an out-of-phase humbucker. These combinations are achieved through the use of a four position rotary and a two-position toggle switch.

Super Humbuckers

This fairly new pickup uses three ceramic magnets under two coils. Solid iron cores extend through the cores and butt against the magnets and there are no adjustable pole pieces. The whole unit is encapsulated in resin. Some of these pickups have multiple leads so creative switching can be facilitated.

Gibson originally used the words “Super Humbucker” to distinguish any potted Gibson pickups that use ceramic magnets (numbers 5 & 7). Today, there are Super Humbuckers that use only #5 (index) ceramic magnets. It's not magnetic to tell a pickup which is a Super Humbucker by looking at the top outside portion. However, if the pickup is removed from a guitar, you can look to see if the pickup is filled with resin. Super Humbucked is in resin. Several guitars use Super Humbuckers, the S.G., L-65 Deluxe, the ES-335 (and ES 325 with mini Super Humbuckers), the EB3 (front), EB-0, and L-65 basses.

GUITAR ELECTRONIC

GRETCH

Gretsch, an old company, entered the electric guitar business in a big way when the company joined forces with Chet Atkins. Chet was and still is, quite possibly the best guitar player in the world. Gretsch welcomed all of Chet's questions and ideas. Chet worked with Gretsch's Ray Butts to develop the Gretsch Filtertron pickup. This pickup resembles two single coil pickups joined together. There are two coils that each have six magnet slugs. The Gretsch Supertron I has a conductive bar pole piece in each of the two coils and there is a magnet under the coils. The bar pole pieces are made of laminated iron cores to aid magnetic flux paths by reducing eddy currents and therefore giving an edge to the sound. The Supertron II has a piece of iron bar-shaped pole pieces and it has a more mellow tone than the Supertron I. All of these aforementioned pickups are humbuckers and were designed to produce a tone desired in country music.

In 1980 Gretsch came out with new solid body electrics suited for rock and country music. They use pickups designed by Bill Lawrence. They are special attenuated magnetic flux devices that produce a sparking clear tone and a lot of volume.

Supertron I

This humbucking pickup uses laminated steel cores to provide a clearer sound. These special cores offer reduced magnetic eddy currents which contributes to clarity. The d.c. resistance is about 1K.

G.R.D.

G.R.D. was founded by Charles Fox. The company makes instruments that are a bit unusual. They were one of the first to put a graphic equalizer in a guitar. Their equalizer is based on an MXR unit. The use of these devices in instruments has been very limited because all commonly available units small enough to fit into a guitar have a weak signal-to-noise ratio.

GuIllD

Standard Large Humbucker

This pickup is a real workhorse in that it does a lot and it doesn’t cost as much as many others. Its design is similar to a Gibson standard humbucker. This Guild pickup has a d.c. resistance of about 8.5K ohms.

BILL LAWRENCE

Bill has been working with electric guitars for a long time and has worked with or for Dan Armstrong, Framus and Gibson. Up until 1972, he operated Bill's Guitar Shop in Greenwich Village, New York and in