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Postcards from the rabbit hole...



Every month in *G&B*, our Senior Product Specialist Huw Price goes boldly into the geekiest and least-charted territory in Guitardom. Whether it's designing and building a low-cost power attenuator or exploring the way that clear nitrocellulose lacquer coats check and yellow over time, Huw is your man when it comes to tackling the in-depth subjects that make *Guitar & Bass* the most unflinchingly and unapologetically

detailed guitar magazine in the business. Here, in this 132-page deluxe edition, we've collected Huw's writings on a broad range of guitar-related topics in order to provide you with an essential one-stop guide to some of the most interesting and misunderstood areas of our many-fretted world. Before you read on, don't forget to visit us at guitar-bass.net or on social media for even more guitar goodness. See you next time...

Chris



ABOUT THE AUTHOR HUW PRICE

G&B's Senior Product Specialist spent 16 years as a pro audio engineer, working with the likes of David Bowie, Primal Scream and Nick Cave. His book *Recording Guitar & Bass* was published in 2002. He also builds and maintains guitars, amps and FX.

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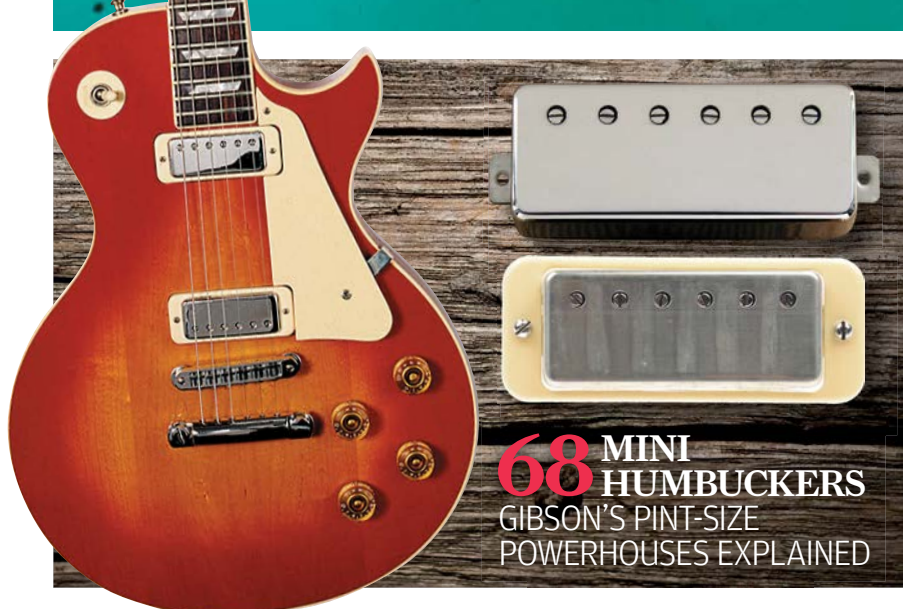
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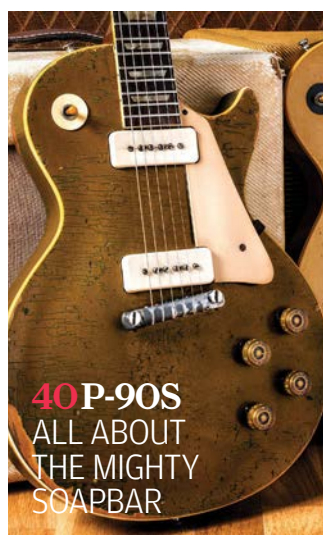
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Neck profiles



What we think of the overall feel of a guitar neck is the result of many factors, which all interact with each other. Here, *G&B* demystifies the often-overlooked properties that make up a guitar's neck profile

The word 'profile' is one of those catch-all terms in the guitar world – much like 'action' – which may mean different things to different people. When considering what neck profile actually means for us as guitar players, it's helpful to break the concept down into its constituent parts and see how they interact with each other.

You might imagine that playability and player comfort have always been the determining factors behind neck profiles, but that presupposes that we all find one particular profile to be the most comfortable and playable. Besides this, a neck's basic structural stability and the whims of fashion have also played a part.

Feel the width

Recently, I used the throwaway phrase 'fat neck' on a forum and somebody picked me up on it. He wanted me to clarify whether I meant wide or deep and, on reflection, I had to concede he had a point.

We routinely provide neck dimensions with our guitar reviews and the vast majority of electric necks are the same width at the nut and 12th fret – 43mm and 53mm, or thereabouts. These dimensions have been fairly constant since the 50s, but there are exceptions. Some players, particularly shredders, come from a classical background and feel more comfortable with wider

necks and string spacing. It stands to reason that seven-string guitars will have wider necks. Some of the vintage Gretsch models, such as the Super Chet, can also be wider at the nut, because they were designed for fingerstylists who prefer more space between the strings.

During the mid 60s, Gibson necks went in the opposite direction and you can find electrics and acoustics from that era with nuts narrower than 40mm. Slimmer 'fast' necks gained popularity for a time after the 1950s, but most agree this is when Gibson took the slimmer-

fact, many players commission custom builds precisely because they can't always get the dimensions they want from factory-made instruments.

In depth

Although ambiguous, when such terms as 'fat' and 'thin' are used to describe necks, they're generally assumed to refer to depth – the measurement from the highest point of the fingerboard to the centre of the back. At first, neck depth was predicated on resisting string pull, so greater depth was required to prevent steel strings

Things settled down through the 70s to be less characterful – even nondescript, if you prefer – but super skinny, yet often wide, necks were all the rage through the 80s.

Since then, the 'fashion' element of neck measurements has become less of a factor and neck depths have become like denim jeans – whether bootcut or super skinny, it's more about personal taste. Consequently, there's no 'standard' neck depth and the major guitar manufacturers offer all their main models in a variety of shapes and sizes.

Over time, various gems of received wisdom have gained general acceptance. Examples of these include that skinny necks play faster and are better suited to players with small hands, or that fat necks are good for rhythm players but no good for soloing. Don't believe a word of it... If you haven't tried a fat 50s-style neck, then go and try out a Gibson Collector's Choice or an early 50s Telecaster reissue to discover what you're missing.

At first, a really well carved, fat neck may feel daunting, but you may be surprised how quickly it begins to feel crazily comfortable. After 10 minutes or so, you may wonder why your fretting hand feels no fatigue whatsoever and when you do eventually tear yourself away to play a skinnier-necked guitar, you may discover it's like a flimsy toy in comparison. Then again, you

The general trend from the early 50s to the mid 60s was for progressively skinnier necks

neck concept too far. Seasoned guitarists who have played countless guitars can usually adjust quickly to any shape or depth. However, nut width – or rather, the string spacing at the nut – can cause experienced players problems. Banging out some rhythm or playing solos is usually fine, but when fingerpicking, a millimetre or less either way can be enough to throw technique into disarray.

Dedicated acoustic players seem more attuned to this and they can be very exacting about neck width and string spacing. In

from bending necks upwards and rendering the guitar unplayable.

Eventually, manufacturers started reinforcing necks with ebony or steel bars embedded into the wood. Later, truss rods counteracted this string pull and even provided the possibility for adjustment. Consequently, guitar makers were able to carve thinner necks – and marketing departments had a field day.

Although some companies were slower to react than others, the general trend from the early 50s to the mid 60s was for progressively skinnier necks.



The Gretsch Custom Shop offers a variety of neck profiles



might not, but you can have a lot of fun trying.

Shape up

This is the big one: the factor that can really distinguish one neck from another and most profoundly affect the feel and vibe of an instrument. When it comes to classifying shapes, broadly speaking, various neck profiles are designated letter codes roughly corresponding to their shape (see diagram, p8).

Most of the early steel-string flat-top and archtop guitars had V- and Deep C-shaped profiles, although the rigidity of the multi-ply laminate necks employed by some archtop makers gave them sufficient strength to be carved thinner.

V necks can be likened to tall, thin back braces in an acoustic. The depth maintains rigidity and as a result of material having been removed from the sides, the

C and U. You can also get Hard Vs, Soft Vs and hybrids that transition from Soft V or Flat C to D or U as you move up the neck.

Some makers even carve asymmetric profiles, designed to enhance comfort and assist fretting-hand positioning. Some prefer the bass side to be more rounded and some prefer roundness on the treble side. You can even get 'progressive' asymmetrical necks, where the apex point is closest to the bass side at the first fret and gradually moves closer to the treble side.

Effect on tone

Relatively few discussions of neck size seem to touch on the implications for tone. Yet all things have a resonance frequency and if the weight of the body has a bearing on tone, it stands to reason that neck mass must have some influence, too. A friend who owns an almost

Of all the classic profiles, the V is perhaps the one that's seen least on reissues, but to a certain type of player, a V can feel fantastic

neck feels like less of a handful. Of all the classic profiles, the V is perhaps the one that's seen least on reissues, but to a certain type of player, a V can feel fantastic.

It takes considerable skill to carve fat and rounded necks that feel slipper-comfortable, rather than merely an unwieldy handful. Although the term 'baseball bat' is swung around in the guitar world, it really doesn't do justice to the considerable craft that goes into carving really good fat necks.

The secret seems to be in avoiding square shoulders, and back in the 50s nobody did it better than Gibson. Fortunately, Gibson is getting it right again on some of its vintage reissues. You should always look for visible binding or fretboard lines when the neck is viewed square-on from the back. If you can't see the lines, it means the curve begins from the bottom of the binding and not from the top.

Other neck variations include D, Wide C, Flat C, Flat D, Modern

identical T-type to me was always commenting on how much he preferred the tone of mine. His was the same age, had a similar swamp-ash body, was virtually the same weight and even had the same frets and hardware – but his had a very fat and rounded 50s profile compared to the slimmer and skinnier neck on mine.

Where mine had a warmer, thicker and more midrange-y tone, his was clearer, snappier and brighter, with better sustain. Rather than allow him to fall down the rabbit hole of pickup swapping and hardware upgrades, I suggested we might try swapping the necks.

Since both guitars came from the same builder, the procedure was straightforward and the conclusion was inescapable.

The sonic characteristics of the two guitars migrated with the necks and the builder subsequently shaved down the fat neck for reasons of tone, rather than playability.



The client was happy with the outcome, but in retrospect, I should have offered to swap necks, because the original was a doozy and I preferred the sound! Since then, I've carried out numerous neck swaps and they've always resulted in a tonal change – though not always for the better.

In the late 80s, I recall Jerry Donahue explaining how he assesses Fenders. Before even playing them, he taps the neck, then taps the body to determine whether they're compatible. He looks for tap tones that are in unison, thirds or fifths, and if

these two fundamental building blocks of the instrument do not ring in harmony, he knows that no pickups or fancy hardware will ever elevate it to the status of a great guitar.

You can draw your own conclusions, of course, but experience has led me to believe that neck size (and therefore mass) does affect tone. It's about sustain, snappiness, clarity and frequency balance more than frequency range, but opinions will quite rightly vary on whether the difference is significant enough to justify compromising feel and playability. 🎸

A Gibson technician
working on a neck at the
company's Nashville
Custom Shop



Fretboard radius



The curve of a guitar's fretboard can vary quite considerably, and the feel of a radius can make all the difference to the playing experience. Here's G&B's lowdown on the key things to consider about fretboard radius

In your encounters with guitars thus far, you'll have no doubt noticed that fretboards (aka fingerboards) often differ. Some are flat, some are almost flat and some are very curved. This convex curve is known as the fretboard radius and it's one of the key features that determines how a guitar plays and feels.

Flat 'boards

I guess everybody is familiar with the chicken-and-egg conundrum, and you could pose a similar question about flat fretboards and the imperative of playing with your thumb positioned dead centre of the back of the neck at all times.

Let's try an experiment. Tuck your thumb out of the way, then form an imaginary barre chord with your left hand and observe the index finger. Most likely, it will be curved. Now, position your thumb approximately where the apex of the neck might be and almost instinctively, your index finger will straighten. If it doesn't, you're probably a drummer and you're reading

the wrong magazine. Sorry. Most classical guitars have flat fretboards, and this suits the classical playing technique as well as low-tension nylon strings. These days, you can get nylon-strung 'crossover' instruments with curved 'boards; these are designed for steel-string acoustic and electric players who want the nylon-string sound without the necessity to develop a whole new way of playing.

Some fretboards are flat, some almost flat and some very curved. The radius is one of the key features that determines how a guitar plays

Flat and nearly flat fretboards are also popular for heavier rock, fusion and shredding. Often, these go hand in hand with light-gauge strings.

Most guitarists using these techniques find it easier to play at warp speed when the action is low, because relatively little pressure is required to fret a note or hammer on and pull off.

In addition to supersonic scales, these playing styles often involve a lot

of string bending with wide vibrato, so ultra-low action can be problematic. If you try to picture it, you'll probably see why.

With a curved 'board, the outer strings will be lower than the middle strings (assuming the saddle height conforms to the curve). When you bend the first and second (top E or B) strings, you are essentially pushing the string 'uphill'. Since the saddle height remains constant, instead

of angling upwards towards the saddle, the bent string actually levels off, or even takes a downward angle when it's moved towards the apex of the fingerboard.

This means the string can potentially come into contact with higher frets that inhibit or terminate the string vibration. This is known as 'choking' or 'fretting out' and the only sure-fire way to get clean bends with ultra-low action is to have a flat or relatively flat fingerboard. Check the specs on various 'metal' guitars, such as Charvels,

Jacksons, Ibanez and so forth, and you'll typically see a radius which ranges from 12 inches to 16 inches.

Vintage curves

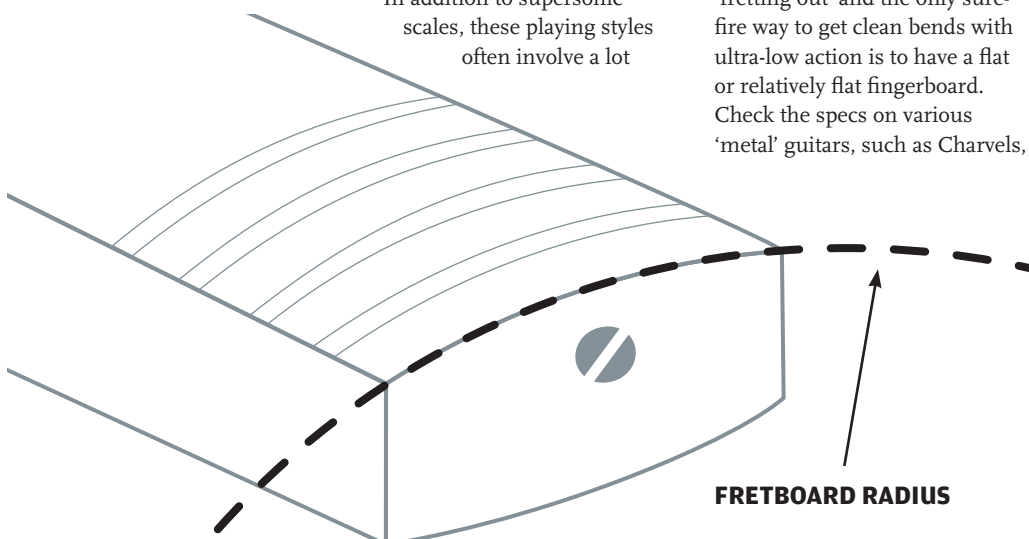
Low action and clean bends must mean that flat fretboards are the way to go, right? Well, not necessarily, because player comfort is an issue, too, and many players prefer the feel and tone that comes with a higher action. Think back to our air-guitar barre-chord experiment and you may recall how your index finger naturally formed a curve. To form a straight line, you need to push the middle part of your index finger forward, and pushing takes effort.

As much as some of us might like to be continually soloing, whether we're jamming or gigging, we're likely to be playing chords most of the time. Many players find a more curved fretboard radius makes chord playing easier, and if string bends aren't involved, there's nothing to prevent the action from being set low. Of all the big American manufacturers, Fender had the tightest radius. Until the 1980s, Fender's radius was 7 ¼ inches, but 9 ½ inches has become the company standard and you'll find 9 ½-inch 'boards on over two thirds of current Fender models.

Although Gibsons with 10-inch radius 'boards have been reported, the company is more closely associated with a 12-inch radius. PRS hedges its bets with 10-inch 'boards; Danelectros had a 14-inch radius and Martin has always used a 16-inch radius.

Compounding the issue

A compound-radius board is carved to have a tight radius





 Gibson guitars typically have a 12-inch fretboard radius



Paul Reed Smith's 'boards
usually have a 10-inch radius

Here's a 1950s Fender neck with the customarily curvy 7.25-inch radius fingerboard



towards the nut that flattens out as you move up the neck. The basic idea is to make chording easier down the neck, while allowing for lower action and easy bending up top. The clearest way to envision this is to think of a fretboard shape cut out from a cone.

Our pet theory is that the earliest compound 'boards came about by accident. These days, we're more cautious about levelling vintage fingerboards when a guitar is being re-fretted, but luthiers of old didn't have today's range of specialist tools to work with and some were just a bit gung ho.

If you try to sand out divots at the top of the neck with a flat block rather than a radius block, the upper area of the 'board will probably end up flatter than it was. So it ends up with a compound radius by default. Then, when the re-fret job is complete, the action can be set lower than before and the guitar is easier than ever to play.

Perhaps some clever luthier noticed this, figured out what was going on, then spread the word. In fact, it's well known that Stevie Ray Vaughan's favourite

neck underwent so many re-frets that it ended up having a compound radius.

You don't even need to re-radius the 'board to achieve this. Instead, a pseudo-compound radius can be created when fresh frets are levelled, if they're filed flatter over the apex across the upper frets. Most decent techs

In other words, the string radius at the nut and the fretboard radius are more or less identical.

When you're starting out on performing your own setups, adjusting bridge saddles to match the string radius to the fretboard radius is a reasonable way to begin. This isn't a practical approach with bar-style bridges

and buzz. Then, if you raise the bridge to make the middle strings ring true, the outside string action will feel too high.

In practice, setting the string height at the bridge to a slightly flatter radius than the 'board makes sense. After all, the strings are generally 2mm or so above 'board level at the first octave, so you can double that at the bridge. That means the string radius can actually be almost a quarter-inch greater than the 'board radius. When you're dealing with a tight radius like 9 ½ inches or 7 ¼ inches, slightly flattening the string radius – even if it's just for the first and second (B and E) strings – is often essential to prevent fretting out.

Understanding fingerboard radius is important, because it can make a guitar more or less suitable for the style in which you play. Making the right choice can facilitate your playing.

As with most things in the guitar world, personal choice is everything, so the best radius is the one that works for you. So, next time you're buying a new guitar, consider the fretboard radius as well as the pickups, hardware and colour. 

Understanding fretboard radius is important, because it can make a guitar more or less suitable for the style in which you play

should be able to do this for you if the new fret wire has enough height.

End-to-end stuff

The fretboard radius has a bearing on string-height settings. Although attention should largely focus on the bridge, you shouldn't overlook the nut slots. If you look at any pro-quality guitar, or a guitar with a pro setup, you'll notice that the nut slots are cut to create a curve for the strings, so their heights above the fretboard remain consistent.

and tune-o-matics, however, because they don't allow for the adjustment of individual string heights.

If you're lucky, the preset radius will be pretty close to the fretboard radius; but if they're quite different, you may have problems making the guitar play well. Vintage Gretsches are notorious, because the bar bridges are often too flat.

When you lower the bridge to make the outside strings feel right, the middle strings can end up too close to the 'board

Strings



Acoustic strings

Picking the right acoustic strings is like picking the right pickups for your electric guitar – and there are many factors to consider. *G&B* takes bronze...

String theory

The drivers behind the evolution of acoustic guitar strings have been much the same as those that drove the development of guitar amplifiers – namely, the quest for improved clarity and higher volume.

The six-string guitar as we know it began to become standardised only towards the end of the 18th century. Prior to that, octave and unison string pairs were used to achieve fullness and volume, and the practice continues with mandolin-style instruments. During that era, strings were made from animal intestines

– hence the name ‘gut strings’. The plain strings were dried, scraped and twisted gut, while bass strings had gut cores wrapped with silver wire to add the mass necessary for low-frequency vibration without making them too stiff to be playable.

Genuine gut strings are still favoured by musicians who play early styles of music, and they are available from Aquila, Damian Dlugolecki, Pyramid and others. Some still use the term ‘gut-string guitar’ to refer to any classical-style instrument, but nylon plain and wire-wrapped nylon silk core strings are far more commonplace today.

During WWII, a shortage of materials prompted New York luthier Albert Augustine to try nylon line as a guitar string. He persuaded DuPont to start making nylon guitar strings and, despite a slow start, they became the classical string of choice after Andrés Segovia began using them.

By the mid-19th century, European and American acoustic-guitar designs were evolving independently. Most classical guitars are still based on the fan-bracing pattern perfected by Antonio de Torres. However, Christian Frederick Martin developed an X-bracing pattern that was conceived for gut strings but only realised its full potential half a century after his death, with the advent of steel strings.

From the 1880s, improved wire drawing technology led to the development of steel strings known initially as ‘mandolin wire’. These new strings made instruments from the mandolin family and banjos louder than ever before. The small-bodied gut-string

guitars of the era couldn’t compete, and for a while they were relegated to the parlour.

Orville Gibson and the Larson brothers were amongst the first guitar makers to respond. They developed archtop guitars built more like violins, that had the inherent strength to withstand the increased tension of steel strings. Although the basic structure of the X-brace was almost strong enough to cope with steel strings, Martin remained cautious until 1922 when it reintroduced the Style

Steel-strung archtops powered the rhythm sections of the jazz age and steel-strung flat-tops did the same for country, blues and folk

17 with a heavier-braced mahogany top and steel strings. It was such a success that the Style 18 and 28 models were soon similarly outfitted – and by the mid 1920s, steel strings were standard on Martins, and gut strings had become optional.

Steel-strung archtops powered the rhythm sections of the jazz age and steel-strung

flat-tops did the same for country, blues and folk players. Before long, the guitar buried the banjo, and it has remained the most popular stringed instrument. Let’s, then, take a closer look at the way steel strings are made.

Core strengths

Drawn wire has a round cross-section, and for the first few decades, steel string sets had wound strings that were manufactured much like the old gut strings. However, instead of a gut or nylon core, the windings were wrapped onto a round steel core.

Unfortunately, the smooth and slippery round core wire provided a less than ideal surface for holding the windings, and it was common for wound strings to loosen or even unravel and go dead. String manufacturers solved the problem

by developing a method to draw core wire with a hexagonal cross-section that provided more grip for the outer windings.

Hex-core strings have a brighter and clearer tone and they are less prone to mishaps when stringing up, but they lose their initial brightness quite quickly. A hex core doesn’t allow such a pure orbit of vibration, and some feel that round-core strings have a nicer tone.

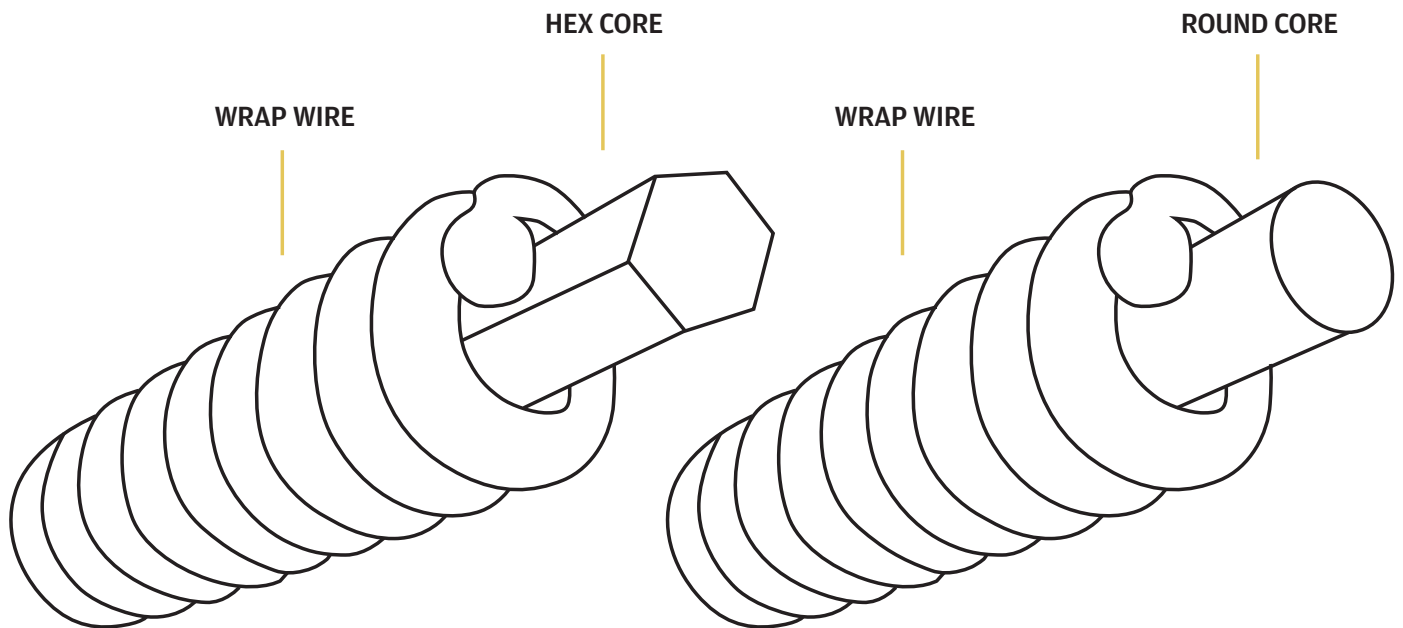
Also, the spaces between the wrap wires and the core are much smaller, so dirt and contaminants don’t build up as quickly with round cores. They may not be as bright to start with, but round cores maintain the same tone for longer and many guitarists find that they are easier to play.

Remember those great acoustic tones from the 50s and 60s all came from round-core strings. They won’t suit everybody, but if you want to try some, check out Newtone, Pyramid and DR Strings.

Alloys

Although the plain strings and cores are always made from corrosion-resistant steel wire, the wrap wires can be made from different alloys that all have specific tonal characteristics. The most common alloys are designated phosphor bronze and bronze. The difference is in the alloy composition, which is a mixture of copper and tin. Phosphor-bronze strings have a higher





proportion of copper, and are sometimes described as 92/8 (92 per cent copper, eight per cent tin). Bronze strings have a higher proportion of tin, with an 80/20 ratio – and some companies, such as D'Addario, make 'in-between' sets with an 85/15 mix.

Bronze strings generally sound bright, but also fatter and bassier than phosphor bronze. In contrast, phosphor bronze has more clarity, definition and sparkle, but doesn't sound quite as full in the midrange. Strummers might prefer the 80/20s, but 92/8s should suit fingerstylists and dropped open tunings.

A naturally occurring alloy containing 67 per cent nickel, 32 per cent copper and some iron was found in an Ontario mine back in 1906 and named 'monel'. Gibson used it to make strings in the 1930s, due to monel's high resistance to corrosion.

Monel is used most commonly for bass strings, but several companies have reintroduced monel acoustic strings for players chasing old-school tone. On the right guitar, they offer superb clarity without excessive brightness, they're full without sounding tubby and bass definition is superb. String-to-string balance is very smooth and they maintain their tone far longer than the usual alloys.

Live long and phosphor

When you're playing an electric guitar, you can always turn up the treble once new strings have lost some of their brightness. When you're playing an acoustic guitar (acoustically) there's nothing that can be done about dull string tone.

If you wear out strings quickly but prefer brighter guitar tone, the cost of regular string changes can be prohibitive. One option to consider is using a set of long-life strings

coated with Gore-Tex, such as Elixir Nanowebs. You can find coated bronze and phosphor bronze strings, and the coatings come in various thicknesses. Some manufacturers coat the entire string and others coat the winding wire before it's wrapped onto the core.

Coated strings – particularly those with thick coatings – are naturally a little duller-sounding than equivalent non-coated strings, but they retain their 'out of the packet' tone for longer. You may also notice less friction and string squeak as a result of the coating. This aspect divides opinion, as some dislike the 'feel' of coated strings.

Of course, not everybody likes the bright tone of fresh strings. If you're one of those players, there's not much point in paying

able to generate sufficient energy to drive the top and make the guitar sound its best. Conversely, heavy-gauge strings can be too much for lighter guitars.

When steel strings became standard, Martin found itself busy repairing pulled-up bridges and bellied tops. The bridges and bracing were beefed up to cope with the extra tension of increasingly heavy string gauges, and scalloped bracing was eventually phased out altogether. The whole vintage guitar thing really started in the early 60s as folkies discovered the superior response and dynamics of Martin's pre-war models.

You should also consider playability when selecting string gauges. The best guarantee of good tone is a guitar that feels good to play, and it's pointless to struggle with overly heavy strings for the five minutes of sonic nirvana you'll enjoy before your fretting hand starts to cramp up.

If the string-to-string balance sounds a little uneven on your guitar, you should consider fitting a custom string set. For inherently

well-balanced designs such as an OM or 000, some may appreciate sets where every string exerts a similar tension when tuned to pitch. Or you could try lowering the gauge of the wound strings while retaining heavier plain strings if your dreadnought sounds too boomy. Using heavier low strings can also help to retain definition and volume if you regularly play in dropped tunings. Some manufacturers market string sets that are designed specifically for DADGAD players, and many provide tension information for those aiming to assemble even-tension sets. It's also worth checking out some of the low-tension sets that combine big-string tone with thin-string playability by changing the core-to-wrap ratio. 

Bronze strings generally sound bright, but fatter and bassier than phosphor bronze. Phosphor bronze has more clarity, definition and sparkle

extra for coatings that will maintain the characteristics you dislike for even longer. Some miss the fresh-string zing that most coated strings don't provide, but take a view that they sound better over a longer period.

The pragmatic player may choose coated strings for practising and gigging, and non-coated strings for recording. Although they're not for everybody, coated strings are certainly worth a go, but be sure to research the specs before buying.

Feel the tension

Like so much in the wonderful world of guitars, not all acoustics are created equal. Some have thick soundboards and/or heavy bracing, and light-gauge strings may not be

Electric strings

They have a huge effect on your overall sound, so it's time to turn the spotlight on the evolution of electric-guitar strings – from 1930s New York to the present day

We can identify acoustic and electric strings at a glance because of the colour differences. Most acoustic strings have a brass or bronze look, whereas electric strings have a shiny silver appearance – at least when they're new. Nevertheless, both types are called 'steel strings', so why can't you put acoustic strings on an electric guitar?

The answer is that you can, but the sound won't be quite the same. Acoustic strings are designed solely to drive a soundboard into vibration, but electric strings generate an alternating current within a pickup's wire coil by disrupting its magnetic field. The disruptions caused by a string's vibration generate an alternating electronic current within the pickup's coil that is analogous to

restricted the choice of metals to nickel and various types of steel. The variety of electric guitar strings is now wider than ever, but the basic construction is the same as acoustic strings, with round or hexagonal core wires.

Metallurgy

Obviously, there were no 'electric strings' before the electric guitar was invented. However, since the operating principle of guitar pickups was so clearly understood, it didn't take long for manufacturers to conclude that steel rather than bronze strings were needed for pickups to operate properly.

During the 1930s, New York luthier John D'Angelico and string manufacturer John D'Addario teamed up to develop an electric string. To combat raw steel's tendency to

could try some Martin Retros on your archtop – even if it does say 'acoustic' on the packet.

Nickel and chime

By the mid-1950s, string manufacturers such as Pyramid were making pure nickel strings, and nickel remained the metal of choice for much of the early rock 'n' roll era. This continued throughout the 1960s with US manufacturers such as Fender and Gibson introducing their own pure-nickel sets. The tone is rich, warm and balanced, and since it isn't especially bright to begin with, it remains consistent for a long time.

Fortunately for jazz, blues and roots-rock players, pure-nickel strings are easy to find once again, and you can get them with both round and hex cores. The hex cores are a little bit brighter and tighter, but some find the round cores easier to bend and appreciate their looser feel. With round-core strings, you must take care to tune them to concert pitch before snipping off the excess length at the tuner posts.

During the 1930s, New York luthier John D'Angelico and string manufacturer John D'Addario teamed up to develop an electric string

the amplitude and frequency of the string. In order to do so, the string has to be made from a magnetic material. Consequently, nylon guitar strings would generate no electric sound whatsoever, and a magnetic pickup can respond only to the steel core of a wound acoustic string. Brass, zinc and bronze-type alloys are non-magnetic and therefore do not affect the magnetic field. So if you put acoustic strings on an electric, the pickups will respond only to the core of the wound strings and signal level will be weak.

Even so, magnetic soundhole pickups are now commonplace and you can get specialised strings such as the Newtone Master Class Electro-Acoustic set with phosphor bronze on the three low strings and a nickel wound G to smooth the transition between wound and plain strings. The DR Zebra set has alternate nickel and phosphor bronze windings to optimise piezo pickup tone and magnetic pickup response for each of the wound strings.

Getting back to electric strings, the necessity for magnetic materials until recently

rust, they used 'Bethanized' steel windings with a corrosion-resistant zinc coating. Meanwhile, in Michigan, Gibson's catalogues featured Electric Spanish Guitar Strings known as Mona-Steels. These were named after a naturally occurring alloy called monel, which contains nickel, copper and iron. Its corrosion resistance made it a suitable choice for acoustics and electrics, and if you're interested in Charlie Christian-era tone, you

Steel works

US military involvement in Korea and Vietnam has been linked to an increase in the price of nickel, and by the late 1960s, string manufacturers began moving to stainless and nickel-plated steel. It was the same scenario for the cobalt component of alnico speakers, so it could be said that the Pentagon inadvertently influenced the sonic evolution of rock guitar.



Nickel-plated steel strings sound brighter than pure-nickel strings, but that airy treble is shortlived and after a few days of playing, they can sound much the same as pure nickels. Play them for a few weeks and they may even sound duller than pure-nickel strings of a similar age.

A friend recently observed that he used to be hooked on nickel-plated strings and would change sets once a week or so to retain the brightness. However, since discovering how microphonic pickups can open up treble response to cut through a mix, he has switched to pure nickel and often leaves sets on his guitars for several weeks, despite a very busy gigging schedule.

Even so, many country and rock players find that steel strings deliver the cutting tone with the high output levels that they need. Drop tuners may prefer heavier wound strings to retain definition, and some metalheads use string sets such as Dunlop Heavy Core and GHS Heavyweights that feature thicker core wires with thinner wrap wires for the tone and tension of heavier-gauge strings without 'bass' string diameter.

Adventurous alloys

Pure nickel and nickel-plated strings aren't an option for players who are allergic to nickel. Fortunately, there are other materials to choose from – and you don't require a medical condition to try them. For maximum brightness, you should check out stainless-steel strings with hex cores. Most players

report that they retain their brightness for some time, but be aware that stainless steel is harder than nickel and it will wear down frets faster than usual.

Like nickel, cobalt is a ferromagnetic metal, so it can be used for strings as well as speaker magnets. Users report impressive dynamics, rich harmonic content and high output, combined with longevity and an easy-playing feel. Maraging steel comes from the aerospace and defence industries and it's described as "a superalloy used in high-stress applications". The Ernie Ball M-Steels promise rich tone, beefy lows and improved tuning stability.

If you're prepared to change pickups, valves and speakers in your quest for tone, surely it makes sense to experiment with your strings, too

Considering America's aforementioned military activities and a looming uncertainty over its future foreign policy, cobalt and maraging steel string enthusiasts may consider stockpiling a few sets while they still can!

It's a wrap

The vast majority of electric players use roundwound strings regardless of the alloy. However, flatwound strings have always been popular with jazzers. Some may find it strange that country and rockabilly pickers

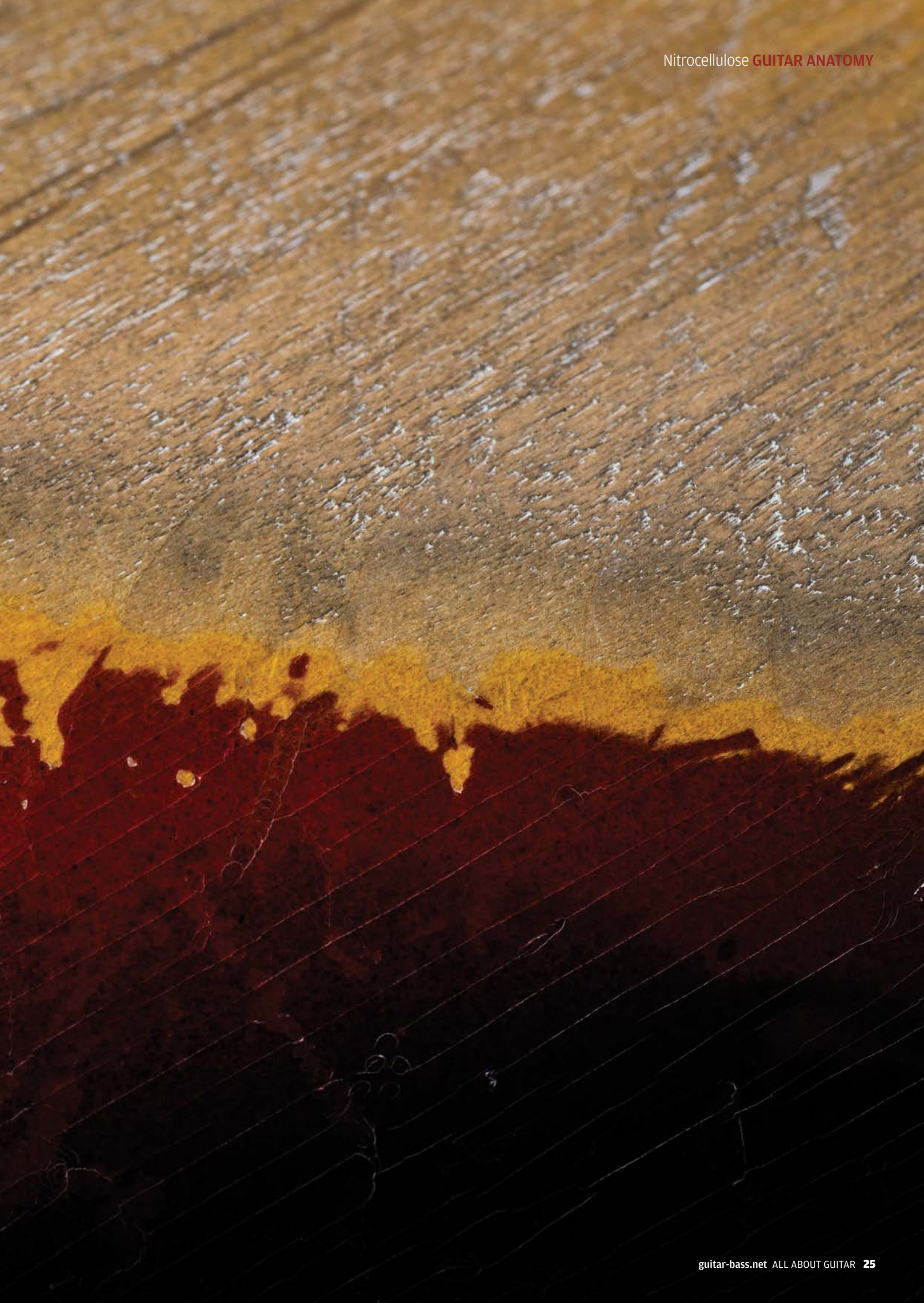
who prefer mellower 50s-style tones often use flatwounds, too. Flatwounds on a Tele may seem as incongruous as a BC Rich through a Roland Cube, but a set of Thomastik-Infelds or D'Addario Chromes will ramp up the retro twang appeal. If they were good enough for Buddy Holly and Cliff Gallup, they're good enough. Period. If you like the idea and tone of flatwounds, but find the feel and lack of treble a bit off-putting, consider groundwound and half-flat strings for a smooth feel, even response and a tone that's right between roundwound and flatwound.

It has often been said that people move house and get divorced with greater regularity

than they change bank accounts. The same is probably true of guitar strings – both electric and acoustic – and if you ask most players why they use 'Brand X', the answer will probably be "because I always have". Hopefully, this article has demonstrated that strings can have a big influence on the output level, tone and feel of your guitar. If you're prepared to change pickups, valves and speakers in your quest for tone, surely it makes sense to experiment with strings, too, because it's just about the cheapest and easiest guitar mod of all. 



Nitrocellulose



When Edmund Flaherty invented nitrocellulose lacquer in 1921, he could've had no idea how big a role it would play in the guitar industry. *G&B* explains...

Henry Ford once remarked that customers could order a Model T in any colour they wanted, so long as it was black. The reason was that 'Japan Black' lacquer was one of the few widely available metal coatings available at the time and its fast-drying characteristics were indispensable on Ford's assembly line.

That changed with the development of nitrocellulose lacquer in the early 1920s. The new lacquer dried even faster, and it could be applied using spray guns. Best of all, an infinite colour palette was opened up. Nitrocellulose was adopted quickly by the car industry and remained the finish of choice through to the late 1950s.

Furniture and musical instrument manufacturers also switched to nitrocellulose lacquer, and mostly it was referred to simply as 'lacquer'. Pretty much every collectible acoustic and electric guitar made up until the mid 1960s left the factory with a nitrocellulose lacquer finish.

What is it?

Cellulose is an organic compound comprised of carbon, hydrogen and oxygen. Found in the cell walls of plants and algae, it's the most abundant organic polymer on earth. The human body uses cellulose as a dietary fibre, and cellulose-derived products have been used in the photography, clothing and explosives industries since the mid-19th century.

In 1862, Alexander Parkes treated cellulose with nitric acid and a solvent to create the first man-made plastic – nitrocellulose. The process is virtually identical to the way in which trinitrotoluene (aka TNT or dynamite) is produced, which is not unrelated to the authorities' keenness to limit its use in industry.

A DuPont employee called Edmund Flaherty invented



Pretty much every collectible guitar made up until the mid-1960s left the factory with a nitrocellulose finish

nitrocellulose lacquer in 1921. Nitrocellulose is dissolved in a solvent, which may comprise naphtha, xylene, toluene, acetone, various ketones, and plasticising materials that enhance durability and flexibility. The resulting liquid can be sprayed and the extremely volatile solvent thinner evaporates almost immediately, to leave behind a layer of nitrocellulose solids.

When subsequent coats are applied, the thinners melt the surface of the previous coat, allowing the fresh coat to bond with it. In that sense, nitrocellulose lacquer is very similar to shellac, which is another natural polymer lacquer with an even longer history. However, nitrocellulose lacquer is tougher and more scratch resistant.

Nitrocellulose lacquer also takes pigments and dyes very well, and it can be sanded and polished to a mirror finish.

Its enduring popularity as an instrument finish is based on its beautiful depth and lustre, its ability to protect wood without inhibiting resonance and a supposed ability to 'breathe'. It also enables you to perform drop-fill repairs to chips and polish out superficial scratches.

However, nitrocellulose lacquer dries slowly compared to modern finishes and it's far more time consuming and labour intensive to achieve high-quality results with it. In addition, the chemicals in the lacquer are hazardous to health and the environment, and – since it's highly flammable – it's dangerous to store nitrocellulose lacquer in large quantities.

Plasticisers

The word 'plasticiser' sets alarm bells ringing for nitrocellulose die-hards. After all, if nitrocellulose is meant to be more beautiful and toneful than plastic poly finishers, wouldn't

putting a plasticiser in the nitro defeat the object?

This is a misunderstanding, because plasticisers are not plastic. 'Plasticity' is defined as the ability to deform irreversibly without breaking. So plasticisers are solvents that evaporate slowly over several years to prevent nitrocellulose from becoming too brittle. They don't turn nitrocellulose into a 'plastic finish' because nitrocellulose is, after all, a type of plastic.

It's understandable that paint makers and guitar manufacturers wanted their finishes to look good for as long as possible. Plasticisers make nitrocellulose more durable and less prone to checking and chipping, so it's hardly surprising that their use became widespread.

Even back in the 50s and 60s, lacquer had plasticisers, and it became an issue only for those who prefer their finishes to age in the vintage style, or for would-be relic'ers who couldn't get their lacquer to crack.

Formulations

"They don't make 'em like they used to" is a general-purpose truism that is often applied to nitrocellulose lacquer, and two things are certain. Firstly, all the big guitar companies in the 50s and 60s were using lacquer from various manufacturers and the formulations were slightly different. Secondly, the balance of ingredients used in modern nitrocellulose lacquer has changed substantially from what it was back in the day.

Old lacquer was seen as having certain undesirable traits. It tended to yellow up with exposure to UV light; colour pigments often faded; temperature fluctuations caused cracking (checking) and sometimes, the lacquer would start flaking off the body. Curtis Novak is a man who knows as much about vintage

finishes as he does about pickup making, and he explained some of the changes to us.

“Over the years, they have ‘fixed’ the inherent problems with nitrocellulose lacquer, where it no longer yellows or cracks with age. Compared to the old stuff, they might as well call it acrylic lacquer, because that is more what it represents. The first test I do when shopping for vintage nitro is have them open the lid. The vintage stuff looks like tea, modern stuff looks more like canola oil.

“Many people think that the old nitro aged over time and, yes, that is true, but it was already very dark right from the can. Generally, if it passes the visual test, it is the old stuff and will crack very easily. The new finishes are softer, which is what prevents them from chipping and checking. As for the thickness, lacquer is forever gassing off, so over time, it gets thinner and thinner. The vintage ones were once much thicker finishes.”

Not all the changes were made to improve the lacquer’s durability. According to George Gruhn, the Occupational Safety And Health Administration in the US “forced makers of finishes to change their formulas over the years. While the new formulas may be less toxic, in most cases they simply don’t produce the same appearance or tonal results as the earlier formulations.”

Former Fender senior finish specialist Jonathan Kornau reports: “The old McFadden’s formula, with the exception of one maleic resin, is still available. Lots of companies still make nitrocellulose without acrylic resins. Sherwin-Williams Opex and the Mohawk lacquers are all nitro. The solvents and plasticisers are always changing due to EPA regulations; it’s possible to buy the old formulas, with only the solvents having changed. When cured, they would be the same.” Sadly, US-manufactured lacquer isn’t available in Europe, because it’s too volatile to ship internationally.

What lurks beneath?

Although the vast majority of vintage guitars had nitrocellulose

lacquer finishes, many didn’t. Some had finishes that were part nitro and part acrylic, nitro and polyester or even a combination of all three.

Around 1963, Fender began using a clear polyester sealer called Fullerplast. After dying the bodies yellow, they were dipped in Fullerplast, which dried rapidly to form a flat coating for nitrocellulose to be sprayed on top. This eliminated the need for grain filling and meant the expensive nitro could be sprayed thinner without sinking into the grain – so Fullerplast saved Fender time and money.

DuPont made nitrocellulose lacquer called Duco and acrylic lacquer called Lucite. Fender used both, and Olympic White, alongside all the Fender metallic finishes, was actually acrylic.

Mostly, Fender sprayed nitrocellulose clear coats over the acrylic coats, and because the clear coats yellowed and checked over the years, many people have assumed wrongly that these finishes were pure nitrocellulose. Fender also sprayed acrylic over rejected Sunburst finishes to fulfil custom-colour orders.

To complicate matters further, from possibly as early as 1956 DuPont started using acrylic binders in its nitrocellulose lacquer to prevent yellowing and colour fading, and to inhibit checking. Even more confusing is Gibson’s use of the word ‘poly’ to describe its metallic finishes, when they were acrylic like the rest of Gibson’s custom colours.

Although nitro-finished guitars are still available, the practice of spraying nitro over acrylic and poly base coats has continued. If you subscribe to the idea that a thin nitrocellulose finish is the best option for resonance and allowing the wood to ‘breathe’, it’s worth finding out if that lacquer finish is what it purports to be before paying a premium price for it.

DIY dos and don’ts

These days, we have to make do with whatever nitrocellulose lacquer we can get, and very few of us own professional spraying equipment. Fortunately, there are several companies in the UK that

BUYER’S GUIDE

For classic Fender and Gibson colours, you’ll need to go to specialist suppliers, but all the colours are available. The days when you could find nitro lacquer in car-accessories shops are long gone, but you can still get clear lacquer from furniture-finish suppliers. Here’s a selection...

MANCHESTER GUITAR TECH **£15 PER CAN**

Steve Robinson supplies a full range of classic colours and more besides. We have achieved some great results with Steve’s lacquer because it sprays evenly, is run-resistant and cracks only when you want it to.

ROTHKO AND FROST **£11.95 TO £16.75 PER CAN**

Another UK supplier that sells a wide range of coloured and clear lacquer. In addition to aerosols, Rothko And Frost sells brushing lacquer for those who prefer not to spray.

FIDDES & SON LTD BONEHARD **£13.04 PER CAN**

This Cardiff-based company sells a huge range of stains, base coats and finishes. Having used the Bonehard lacquer, we can report it yellows up nicely and will check easily, but spray thin coats if you want to avoid runs. Aerosols are made to order.

MORRELLS **\$9.23 PER CAN**

This is another clear lacquer that’s suitable for furniture and guitars and priced reasonably. Morrells lacquer is available in gloss, satin, semi-matt and matt.



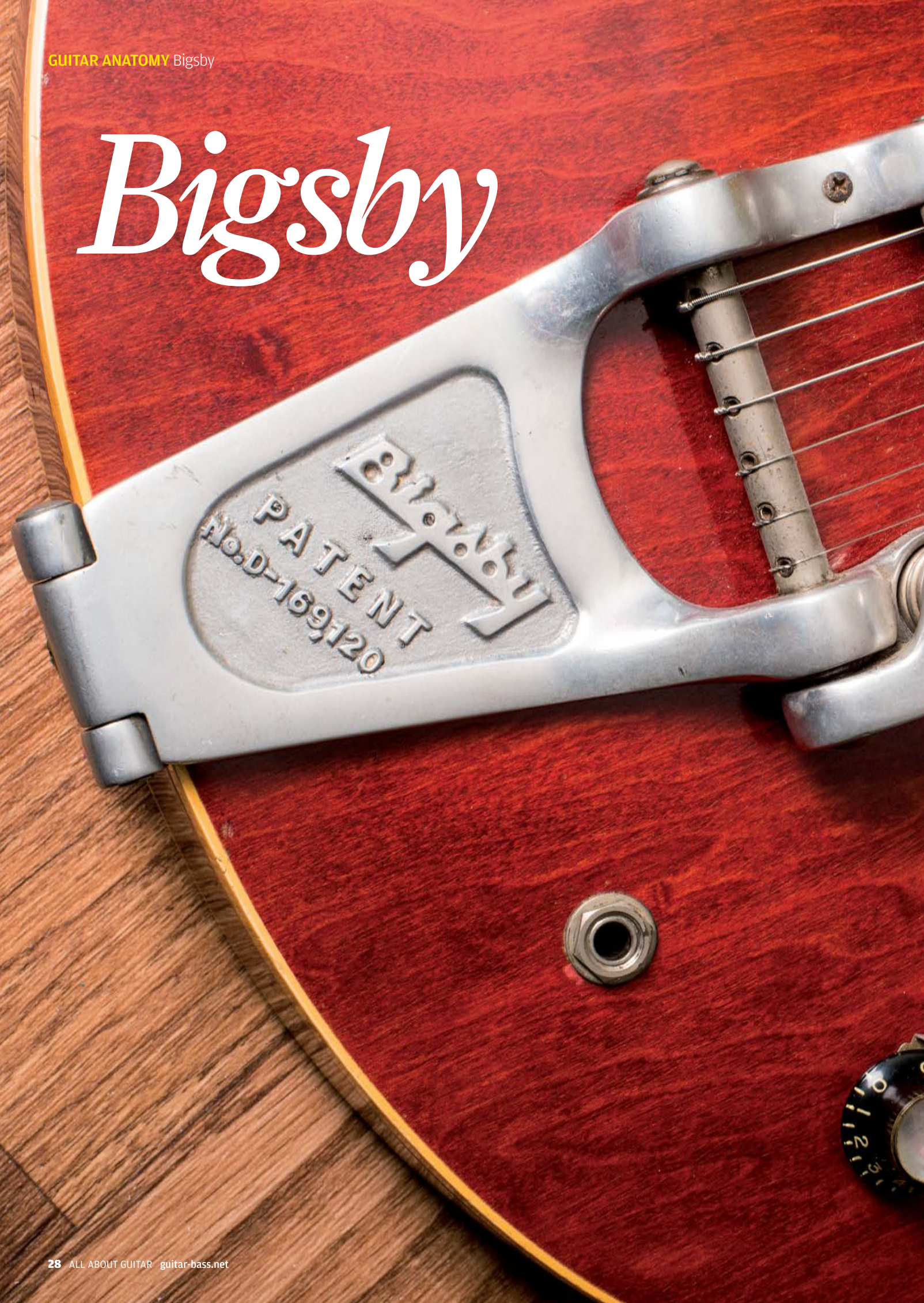
supply lacquer in aerosols, and most of the classic colours are available – along with clear and tinted varieties.

You must bear in mind that spraying nitrocellulose lacquer exposes you to some really nasty toxins. Ideally, you should set up a booth with a proper extraction fan if you plan to do a lot of spraying. It is also essential to wear a breathing mask that can block out vapour as well as airborne particles. If you go to a good car-paint supplier, they should be able to advise

you on the most suitable mask to buy. You will also find that spraying nitrocellulose without an extractor fan creates huge quantities of dust and isn’t healthy for anybody or anything. Spraying outdoors on dry days when there is little or no wind is ideal, but opportunities are few in the UK.

Spraying guitars is an absorbing hobby, and with practice and patience, you can achieve results that will rival the pros. And if you goof up the finish, you can always relic it. 

Bigsby





Although it may seem the most archaic of guitar accessories, we've been using Paul Bigsby's vibrato for 60 years because it looks drop-dead cool – and it works. *G&B* salutes the guitar world's original mover and shaker



The Bigsby name remains so current it's hard to believe the man behind the brand was born in the 19th century. Basically, Paul Adelbert Bigsby was the sort of old-fashioned guy who could disappear into his garage and make anything you wanted. Before getting into guitars, Bigsby designed and made parts for motorbikes; so he had a solid background in casting and machining metal.

During the 1930s, Rickenbacker made a cast-aluminium steel guitar that became known as the 'frying pan'. Bigsby probably figured he could do something similar, or better – and he did so. Bigsby made lap- and pedal-steel instruments combining figured maple with cast and tooled aluminium parts. Today, among collectors, Bigsby steels fetch serious money, and even as a non-smoker, my favourite feature has to be the built-in ashtray.

The guitars

Although it would be stretching things to say it inspired the Telecaster's 'ashtray' bridge, there

can be little doubt that Bigsby's six-string solid-body designs had a strong influence on his friend and neighbour, Leo Fender. Like his first steel guitar, Bigsby's initial six-string was completed in 1947, based on something Merle Travis had sketched out on the program sheet from a Pasadena radio station.

Bigsby guitars are incredibly rare and collectible because very few were ever made. Each one was essentially custom built,

When the word Bigsby is used today, it's almost always assumed to mean a style of vibrato rather than a guitar

with a price tag of \$600 and a two-year waiting list. Early 50s Telecasters cost around \$200 and there wasn't a waiting list. According to Deke Dickerson's estimate, the six-string electric guitars Bigsby made number in the tens, rather than tens of thousands. Fender was into low-cost mass production, but Bigsby was boutique. He also made five-string guitars, basses, double-necks and mandolin-style

instruments. Name-players who used them include Merle Travis, Grady Martin, Lefty Frizzell and Billy Byrd. If you check out recordings made with Bigsby guitars, you'll recognise a full, clear, woody tone that really has its own sound.

The pickups

Much of the Bigsby sound can be attributed to the pickups, which were quite innovative with a cast-aluminium housing that

helped shield the wide, flat single coils from hum. Plenty of pro players bought Bigsby's pickups to put on their own guitars, including Chet Atkins and Les Paul – who used an Epiphone with a Bigsby pickup to record *How High The Moon*. Of course, Bigsby made everything himself and this desire to handle every aspect personally meant that he would struggle to produce more than one instrument per

month. Keeping up with orders eventually became even more difficult, due to the runaway success of the product that keeps his name alive today – the Bigsby vibrato. So much so that when the word Bigsby is used, it's almost always assumed to mean a style of vibrato rather than a guitar.

The Bigsby vibrato

Bigsby was unequivocal about his device being a vibrato. Leo Fender's choice of 'synchronized tremolo' for the name of his Strat bridge design was probably an attempt to differentiate the two products. However, there can be little doubt that both men clearly understood the difference between vibrato and tremolo.

Either way, Bigsby's design probably pre-dates Fender's by several years, and came about as a result of an early meeting with that man Travis. He had brought his Gibson L-10 guitar to Bigsby because its Kauffman 'Vibrola' wouldn't stay in tune. At first, Bigsby agreed to fix the Vibrola but it wasn't a success. Eventually, with Travis' encouragement, he set about



While the name Bigsby is now associated most closely with vibrato arms, Bigsby guitars are much-sought-after. This Paul Bigsby Billy Byrd model was originally made for Jimmy Bryant, but was sold instead to Nashville-born guitarist Byrd

designing his own vibrato device. There may be numerous Bigsby vibratos available these days, but the operating principle remains identical to that earliest design. The Bigsby mounts on top of a guitar, with the strings wrapped around a roller bar. The ball ends of the strings are slipped over pins in the bar that hold them in place. The roller bar passes through the body of the unit and attaches to a bracket and arm. Pressing the arm downwards causes the bar to twist in the direction of the nut. Beneath the bracket is a coiled spring, which provides the restorative force needed to return the bar to its original position.

Early units had rubber stoppers rather than springs, and the arms were fixed. Later, Bigsby collaborated with Ted McCarty at Gibson, who devised the swinging arm. It's a simple mechanism that provides vibrato

The problem to address with the Tele was that its flat top meant there was no break angle. Bigsby devised a massive and complex casting that fundamentally altered the Telecaster geometry and completely replaced the bridge and saddles. A shim was necessary to create a back angle for the neck, and this unit was called the B16.

Later, Bigsby devised the B5 'horseshoe' with an added front bar to sharpen the break angle without having to shim the neck. This could be used on flat-top electrics such as Rickenbackers, Les Paul Juniors and SGs. With string notches cut into the bridge, a B5 can be used with Telecasters, too, and several companies sell pre-notched Tele bridges. Bigsby also sells a B5 Fender kit that includes a new bridge assembly and separate pickup plate. To fit a B5, you have to drill four screw holes in the top of the guitar.

Paul Bigsby's instruments are revered, his pickups prized and his vibrato a roaring success

with stable tuning, as long as the guitar is set up well and the player understands the Bigsby's limitations. A semitone is a fairly big deviation for a Bigsby, so Hendrix acrobatics and Floyd Rose-style dive bombs are well outside its abilities. To hear some 'extreme' Bigsby use, such as it is, try listening to Lonnie Mack and Neil Young.

Bigsby types

Merle Travis' Gibson L-10 was a big archtop, so the first Bigsby was designed to fit on guitars of that type. The shape of the top ensured that the string break-off point on the roller bar was lower than the bridge, so there would be a sufficiently high break angle. There was also plenty of space behind the bridge for the unit itself. The original-style Bigsby was called the B6.

This was fine for a while, but by 1952, Fender had the Telecaster and Gibson had the Les Paul – and the original Bigsby wouldn't fit on either of them. As a result, Bigsby started coming up with variations on his original design.

For small archtops such as the Les Paul and Gretsch Duo Jet, other solutions were needed. The jazzbox-style neck attachment of the Duo Jet made it an easy fix, and all that was needed was a shortened version that was called the B3.

The low-set Les Paul and ES series necks require the front roller bar to sharpen the bridge break angle, and the correct fitting is the Bigsby B7. Like the B5 unit, it also has to be screwed to the top.

Many a vintage guitar has ended up with tell-tale screw holes that indicate a Bigsby was fitted at some time. One of the most famous examples is Joe Bonamassa's 'Snakebite' Les Paul.

As electric-guitar pioneers go, Paul Bigsby is up there with Leo Fender. His instruments are revered, his pickups prized and his vibrato a roaring success. Sadly, Bigsby's health began to fail and he sold his company to former Gibson exec Ted McCarty in 1966, two years before he died. Gretsch has owned the Bigsby brand since 1999. 

BUYER'S GUIDE

It would be all too easy to list a bunch of Bigsby vibratos, but that wouldn't do the man's legacy justice and prospective buyers can get that information from the Bigsby website. Instead, let's check out a range of Bigsby-inspired products...

RC ALLEN BIGSBY REPLICA GUITAR £2,138

With originals fetching up to \$80,000, the most realistic option is probably a replica. The late RC Allen was a guitar maker in Southern California who also made guitars for Merle Travis. His work is highly respected, and at the time of writing there was one for sale on Reverb.com. Gretsch made a small number of Bigsby replicas, too.



TK SMITH C.A.R POLE PIECE \$320

This is a hand-built replica of a Paul Bigsby pickup, complete with a cast-aluminium housing. It looks the part, and it sounds the part as well. Some players have been putting these in custom-build T-types. You can custom-order a Bigsby-style guitar from TK Smith, too.

VIBRAMATE V7 STANDARD KIT £58

These days, you can fit a Bigsby to pretty much any guitar without drilling extra holes if you buy a Vibramate system. This is the kit you need to mount a B7 Bigsby on a Les Paul. It cleverly utilises the unused tailpiece stud holes. The Bigsby B7 costs extra.



TOWNER HINGE PLATE ADAPTOR £10

The Towner hinge plate adaptor enables you to use your strap-button screw to secure the hinge so there's no need to drill holes in the side. The company's Down Tension Bar (from £26.95) bolts onto the top in place of the stop tailpiece and is a lightweight, best-of-both-worlds solution allowing you to install a Bigsby that doesn't have an integral tension bar but retain the break angle of a stop-bar.



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PAFs



When it comes to PAF tone, myths and hype abound. Here, we examine the design and development of this revered pickup from guitar's golden era, and tell you what it's really like to play them...



History

Ted McCarty instigated the design process for Gibson's first noise-free pickup in 1955. Although Seth Lover is widely regarded as the main man, he worked on the project with P-90 designer Walt Fuller. Lover's involvement with Gibson stretched back to the 1940s and, having rejoined the company in 1952, he was responsible for the 'staple P-90', which helped keep the DeArmond-inclined Les Paul on-message.

While Ray Butts' Filter'Tron design was influenced by a hum-cancelling circuit used in Ampex tape machines, Lover was inspired by the hum-cancelling 'choke' (iron-core inductor) used in the power supply of some valve amps to filter out unwanted AC ripple. However, the 'hum-bucking' principle went back to 1934, when Electro-Voice invented the 'hum-bucking coil'. If you thought stacked humbucker pickups were a later development, you may be surprised to learn that A F Knoplaugh invented that in 1938, for Baldwin electric pianos.

Even so, Lover's adjacent coil arrangement was different enough for Gibson to apply for a US patent in June '55. Having appeared on steel guitars in 1956, the humbucker was fitted to the

Les Paul and various archtops from early 1957 and Gibson introduced a decal on the base plate reading 'Patent Applied For' in late '57: hence the familiar sobriquet. Although a US patent was granted in July of 1959, the 'PAF' decal lasted until late in 1962, when it was replaced by a decal carrying the (incorrect) patent number. Other changes were made around this time and although some early-spec pickups may have ended up with patent-number decals, the PAF era was effectively over.

How humbuckers work

String vibration and electromagnetic interference both generate alternating currents in guitar-pickup coils. Regardless of what your parents and grandparents may think, the former is music and the latter is noise. A vibrating string causes changes in the pickup's magnetic field, which induces an alternating current in the coil. Noise comes about because the pickup's wire coil acts as an antenna. To eliminate noise while retaining the musical signal,

Lover utilised two coils that were electronically out of phase. Both coils picked up noise equally, but when the noise currents in the coils were combined, the noise was cancelled out. The really clever part is how Lover ensured the string-induced signal wasn't cancelled out, too.

The polarity of the noise-induced current is solely dependent on the winding direction of the coils. In contrast, the string signal's polarity depends on the polarity of the magnetic field, as well as the direction of the winding.

Both coils had polepieces and Lover placed a single bar magnet between them. It was oriented so one set of polepieces would be north and the other south.

Combining reverse winding with reverse magnetic polarity is akin to having two phase switches activated – which is effectively the same as having no phase switches at all. So the reversed magnetic polarity functioned as a pseudo 'second switch', to put the string signals back in phase while having no effect on the noise cancellation.

Virtually every Gibson-inspired humbucker produced since 1957 has been made the same way. So the question has to be, what makes PAFs different to the humbuckers that came later? To answer that, we need to break down the constituent parts.

Magnets

All PAFs had rough sand-cast magnets with alnico grades used randomly. A2 and 5 are commonly reported; some claim A4 was also used, while others dispute whether A3 magnets were ever installed in PAFs. Many modern PAF replicas are made with A4, because it's a consistent and reliable way to replicate the tone of a weakened A5.

Like every other maker at that time, Gibson had to use whatever it could get hold of. The early magnets were 2 1/4 inches long and were shortened by 1/4-inch in 1961, when alnico 5 became standard. The shape of the magnetic field changed as a result. A black line was drawn to mark the north side and the 1/2-inch width and 1/8-inch thickness remained constant. The various grades of alnico and the ageing inconsistencies partly explain why the sound of PAF pickups varies so much. Gibson used the same magnets in P-90s and PAFs.

Virtually every Gibson-inspired humbucker since 1957 has been made the same way as Lover's design



A 1957 Les Paul Goldtop with early PAFs - note the lack of decal on the underside (opposite page) and the covers of brushed stainless steel rather than nickel

BUYER'S GUIDE

Virtually every pickup maker in the business has a PAF replica in the product range. Some offer several varieties and others make PAF replicas exclusively. Some are offered pre-aged and the quality of the ageing can be terrifying to behold. Even so, the likelihood is that relatively few pickup makers have even been in the same room as a vintage PAF, let alone played one. Here's a small selection of PAF replicas that are respected by those in the know.

STEPHENS DESIGN PG HD/59 HD \$785 (PAIR)

Based in Seattle, Dave Stephens is a bona-fide PAF authority and it's reflected in the way his PAF replicas are built. I haven't tried them myself, but friend and colleague Dave Hunter put it this way: "Let's just say... they deliver to the player wanting to go all out for real deal '59 tone, and leave it at that."



SHED PAF DADDIES £220 (PAIR)

Spencer Mumford uses vintage-correct components and applies his outstanding ageing skills to create a PAF replica that looks indistinguishable from a real vintage gig warrior.



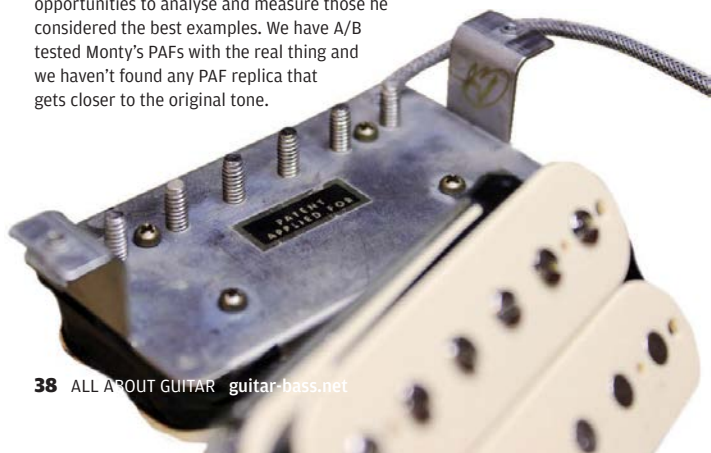
MOJO PICKUPS "VINTAGE" PAFs LOW OUTPUT £190 (PAIR)

Voiced to capture the early-PAF sound with a brighter and slightly lower output than Mojo's standard PAF set. Vintage-spec parts include butyrate bobbins, rough-cast magnets, two-stranded braid hookup wire and de-gaussed alnico magnets. Available relic'd.



MONTY'S PAF £216.99 (PAIR)

Matt Gleeson has had his hands on countless genuine PAFs as a guitar restorer and repairer and he took his opportunities to analyse and measure those he considered the best examples. We have A/B tested Monty's PAFs with the real thing and we haven't found any PAF replica that gets closer to the original tone.



Coils

Gibson used purple 42 AWG plain enamel wire wound with non-automated machines. Due to the distance between the bobbin and the machine, the wire would jink about as the coil was being wound, which created a pseudo 'scattered' pattern. Operators would switch the machine off when bobbins looked full, which resulted in coil shape and size inconsistencies, as well as varied DC resistance. Roughly speaking, PAF coils in series ohm out between 7.5k and 9k, which is more or less in line with P-90s of the era.

Crucially, the coils were not evenly matched, and this 'offset' is considered a major factor in the characteristic clarity and definition of a good PAF. However, achieving the right degree of mismatch is crucial, as Matt Gleeson of Monty's Guitars explains. "If there's too much offset... they're thinner sounding. Then, if the coils are identical, all that clarity is lost. Maximum hum cancelling comes with maximum treble reduction."

Winding tension is also an important variable. Since PAF coils weren't wax potted, the coils had to be tight enough not to squeal. However, if they're too tight, you can lose the open sound quality and touch response. Finally, the coils were wound with #4 flatback insulation tape for protection.

Covers and plates

Seth Lover had initially wanted a closed cover, because he regarded adjustable polepieces as unnecessary. However, the Gibson high-ups insisted they were a key selling point. The very earliest Gibson humbuckers had brushed stainless-steel covers. This soon changed to nickel silver, with gold plating a later option. Most builders agree the cover should be as thin as possible to maintain an open sound and minimise treble roll off. In the mistaken belief they would get more volume, players often removed PAF covers.

In order to avoid disruption to the magnetic field, Lover specified a nickel-silver bottom plate. He chose brass-bobbin retainer screws for the same

reason, but Gibson later used steel screws.

Sound

While working as a tape op in the early 90s, I had a sneaky go on a famous '57 Goldtop, but at the time, I didn't know enough to appreciate it. Only recently have I had the opportunity to play a handful of PAF-equipped Gibsons and I hadn't anticipated how versatile, dynamically responsive and expressive PAFs would sound. They were more like Fender pickups on steroids than fat, hot-wound, balls-to-the-wall rock pickups.

PAFs are supposed to vary, but all the ones I played had a sweet and airy brightness. When I turned down volume controls, there was no loss of clarity or definition whatsoever. The bridge tone was transformed from a raucous metallic bite into something approaching country quack. Similarly, the neck pickups ranged from a flutey and vocal blues tone to a semi-acoustic woody jazziness. I also discovered you could jangle on a Lester.

They also sustain in the most remarkable way, even at fairly low volume and gain levels. As you hold a note, harmonic overtones drift in and out constantly, so the sound is never static. If you add finger vibrato, notes finally cross-fade into friction noise that's surprisingly loud and something I've heard on many vintage Gibson recordings.

The most surprising experience was comparing two Goldtops from '54 and '57. I found the PAFs brighter, subtler and more harmonically complex. The P-90s had gutsier mids, more bark and compression, and fewer harmonic overtones. Even so, the P-90s and PAFs were more notable for their similarities than their differences.

The PAF has come to be regarded as part of the Gibson tradition, but I would argue it was part of that tradition even when it was new. My ears tell me that Seth Lover was either shooting for P-90 tone minus the hum, or Ted McCarty had instructed him to do so, when he designed the PAF. He succeeded... and then some. 



PICKUPS P-90s

P-90s



Vintage PAF humbuckers may get all the plaudits, but many tonehounds consider the P-90 to be Gibson's greatest ever pickup. Find out why...



Meet the ancestors

Gibson didn't come up with the P-90 out of thin air. Although undisputedly the company's greatest single coil, the P-90 was actually part of a design process that began during the 1930s and (arguably) culminated in the fabled PAF of 1957.

Jazz guitarist Charlie Christian played a huge part in popularising electric guitars, and his name has even become synonymous with the pickup that was fitted to his 1930s Gibson ES-150 guitars. The pickup was gigantic, with a straight blade and two cobalt steel magnets. Its cumbersome mounting mechanism required three holes to be drilled through the front of the guitar.

The magnets had to be huge because the steel Gibson used had relatively low gauss, so the whole assembly weighed 2lbs. The 1930s saw the development of alnico. This alloy of aluminium, nickel and cobalt could be used to make very powerful permanent magnets. Equivalent magnetic strength could be achieved with much smaller components, which had a profound effect on pickup and speaker design.

By 1940, Gibson began fitting a new style of pickup to its ES-100, ES-125 and ES-150 guitars, as well as lap steels. Designed by Walt Fuller with alnico magnets, everything was housed under a compact rectangular metal cover with a height adjustment/mounting screw at each end. Some even had adjustable exposed polepieces, and all three versions of this pickup are known as the P-13.

Wound with 38-gauge wire, many Charlie Christian units have a DC resistance below 2.5k. Early P-13 pickups tend to be 6.5k or above, which suggests Gibson graduated to thinner magnet wire. These P-13s were later fitted to some Harmony

and Silvertone guitars, and they sound fantastic.

After the bombing of Pearl Harbor, the US joined World War Two and pickup development, along with guitar manufacturing, was put on hold as the Gibson factory helped with the war effort. Straight after the war, Gibson was back in the guitar business, and the Walt Fuller-designed P-90 made its debut in 1946.

Anatomy of the P-90

Gibson's marketing had made a big deal of the P-13's adjustable polepieces, so it's unsurprising that feature was carried over to the P-90. A coil of 42 AWG plain enamel magnet wire was machine wound onto a plastic bobbin. The coil shape was shorter but significantly wider than the coils seen on the Strat

and Tele pickups that followed. Like early PAFs, P-90 coils were wrapped with insulating tape and they were not wax potted.

Two sand-cast alnico magnets were placed below the bobbin, separated by a metal spacer (keeper), with both south (or sometimes north) poles facing towards the polepieces. The magnetic field flows through the centre of the coil and back around to the outer edges of the magnets.

Alnico 3 magnets were used until around 1957, when Gibson changed to alnico 5. Interestingly, since the magnets oppose each other, some push apart over time. This misalignment refocuses the magnetic field, and some believe it can affect tone.

Gibson used braided single-core output wire that was soldered to the two-coil output

wires on the underside of the metal baseplate. The baseplate had protruding extensions on those P-90s destined for Les Paul Juniors and hollow-bodied models. The vacuum formed plastic covers extended over the extensions, and this P-90 style was nicknamed the dogear.

P-90s for the Les Paul Standard, Custom or Special had screw holes in between the A and D string pole pieces on one side and the G and B on the other. The fixing screws went straight into the body, and these P-90s became known as soapbars because the rectangular covers look like bars of soap.

There are two other variations on the P-90 theme. P-90s with non-adjustable alnico rod magnets were also made around 1946 and fitted to some ES-125s.

Described by Gibson as "lost for a lot of years", this version was recently resurrected as the P-90ST and P-90SR for the Melody Maker.

The 'staple' P-90 was far more significant and has something of a cult following. Permanent magnets with a rectangular cross-section were used instead of magnets under the baseplate. The height of each of these polepieces could be adjusted individually using a small screw. In fact, the design is almost identical to that of the DeArmonds being used by Gretsch during that era.

There is an interesting, unsubstantiated story that Les Paul preferred the DeArmond's clarity and response to the P-90's, and Gibson was in the awkward position of having its main endorser using another company's pickups. Accordingly, the 'staple' was designed hastily to get the DeArmond tone from a Gibson-branded pickup.

They were fitted to high-end jazz models as well as pre-1957 Les Paul Customs – often in the neck position, with a regular P-90 in the bridge. Paul himself played >

The basic sonic signature of the P-90 is strong mids, full bass and harmonically complex trebles



This 1951 ES-5 is loaded with a trio of P-90 pickups

BUYER'S GUIDE

Pretty much every pickup manufacturer offers a P-90 these days, although some are more vintage-accurate than others. Try not to get too fixated on power, and consider the merits of both types of alnico – maybe with alnico 3 in the neck and alnico 5 for the bridge. It's also possible to swap A5 magnets for A3, or vice versa, if you want to tweak your tone. Modern twists include ceramic magnets for even more output and noise-cancelling designs.



SEYMOUR DUNCAN STAPLE DOG EAR \$225

This seems to be the only authentic-spec staple P-90 available. With unpotted coils wound to 9.2K and alnico 5 magnets, this Custom Shop product can be ordered in black or cream with nickel or gold plated metal parts. It's also available in a soapbar format.



MONTY'S GUITARS J90 £93

This one is included because we recently installed a J90 in a high-end Gibson Les Paul Junior Reissue. The improvement was dramatic, to say the least. Features include potted plain aluminium coils with alnico 3 magnets and a 7.7K DC resistance. The manufacturer recommends these for hollow-bodied guitars, but they're available in soapbar format, too.

KINMAN P-90 HX £129

Like all single coils, P-90s generate hum. Various hum-cancelling P-90 designs have been tried, but most lose some of the P-90's tone, along with the hum. Kinman's solution is amongst the most highly regarded, with 202 individual parts that include highly efficient magnetic shields around the upper coil and a lower coil of much thicker wire wound onto a laminated steel bobbin.



VINTAGE P-90 \$275

These were mass-produced pickups, so it's easy to find second-hand P-90s of 50s and 60s manufacture. If you explore this route, it might be advisable to buy from a reputable dealer. If it's wax potted or wound to 8.5K or above, the pickup has probably been re-wound. There are plenty of P-13s about, too, for around \$200.

Black Beauties back in the early 50s, so you can draw your own conclusions on the matter.

P-90 tone

The DC resistance of vintage P-90s varies between 6.5K and 8.5K, with most somewhere in between. They were nominally hotter than P-13s and Charlie Christians, however inductance readings provide a more reliable indication of output level and tone than DC resistance.

Inductance accounts for wire gauge and magnetic strength, and therefore represents the system as a whole rather than a single element in isolation. Jason Lollar describes inductance as "a measure of the physical property to induce a current",

alnico 5 with the hot blues of Freddie King or the punk grind of Johnny Thunders and Mick Jones.

The alnico 3 may be more closely equated to 50s jazzbox tones or the early rock 'n' roll stylings of Scotty Moore. The earlier pickups sound brighter, softer and sweeter with lower output. Even so, if someone asks what P-90s sound like, you'd have to say much depends on the guitar they're mounted in and the amp you're playing through.

That's the essence of what makes the P-90 perhaps the finest all-round pickup ever created. The basic sonic signature is strong mids, full bass and harmonically complex trebles. They can sound woody

They can sound woody and mellow or utterly brutal; you can use them for jazz, blues, country, punk and metal

and pickups are – after all – current generators. Generally speaking, higher inductance equates to more output and increased low end.

Vintage-spec Strat pickups usually have an inductance of around 2.25 Henries and PAFs read around 4.25 Henries. Charlie Christians were generally around 3 Henries and vintage P-90s were closer to 6 Henries. Compare these readings with hot humbuckers, which can have inductance readings of 8 Henries or more.

Stronger alnico magnets tend to increase a pickup's inductance, so the later alnico 5 P-90s are considered to have a more aggressive, snarly and powerful tone than the earlier alnico 3 versions. You may associate the

and mellow or they can be utterly brutal; and you can use them for jazz, blues, country, rockabilly, punk, heavy rock and metal.

From 1946 until 1957, the P-90 reigned supreme as Gibson's premier pickup. Although it may have occupied the throne ever since, there are still many guitarists who consider the PAF as the 'young pretender'.

Walt Fuller's enduring triumph was the creation of a pickup that combined a wide frequency range, superb clarity and player-friendly dynamics with high output. What's more, it's equally effective on solid- and hollow-bodied guitars, and it delivers the goods in any musical genre. No other pickup ticks all those boxes quite as effectively as the P-90. 





Stratocaster pickups



Despite – or perhaps because of – their relatively simple design, Fender's original Stratocaster pickups are still revered for their sonic properties. Here, *G&B* explores their timeless, magnetic attraction for guitar players



George Fullerton recalled that Fender built several types of pickup for Bill Carson to test out in the Stratocaster prototype and the ones that made it into production were those Carson thought “had the most hair on their chest”. Carson also wanted four or five pickups on the Strat, but fortunately, Leo had the good sense to veto that suggestion.

Compared to Filter’Trons, PAFs, P-90s and even Telecaster pickups, Fender’s design for the Stratocaster’s pickups was by far the simplest. They’re about as stripped back as pickups can be – the only parts involved are two ‘flats’, six magnetic slugs and some magnet wire.

Given that there are so few variables, it’s interesting to ponder why the tone of Stratocaster pickups varies so dramatically. Breaking one down into its individual components and examining manufacturing inconsistencies may provide some clues.

Flat work

Vulcanised fibreboard, aka Forbon and ‘fish paper’, was Fender’s default substrate material for circuit boards and pickup flats. Since the magnetic slugs were of a consistent diameter, holes were made in both the top and bottom flat that were tight enough to hold position on the slugs through friction alone.

Initially, the fibreboard was black, but this changed to grey around March 1964. Later in the 1970s, the grey got darker. It’s very unlikely that the flats have any influence on tone, but the colour can be helpful when determining the age and provenance of vintage pickups.

I have never seen a pencil date on the base of a pre-CBS Strat pickup with black flat work. Fender started using a yellow date stamp when the grey bottoms appeared; however, this changed to a handwritten date around 1966 and, by the late 60s, Fender was using a black date stamp.

The height-adjustment screws were threaded into extended ears on the bottom flat. Vulcanised

fibreboard is pretty tough, but occasionally, the threads strip out and the screws won’t hold. If you grind up some fibreboard with sandpaper, you can mix it with Super Glue, fill the screw holes then re-drill. No guarantees, but it has worked for me.

Slugs and stagger

Until 1954, Telecaster bridge and neck pickups had slugs that were flush with the top flat, but Fender took a different approach for the Stratocaster. Presumably, this was an attempt to achieve better string-to-string balance – or at least appear to be doing so. Remember, Fender was competing against the DeArmond Dynasonic and the Gibson P-90 at the time, both of which had individually adjustable polepieces.

Fender’s initial Strat stagger had the D slug higher than the G slug. This soon changed as players began using plain G strings and the G slug came up to more or less the same level as the D slug. This is the stagger we’re most familiar with today, but

to be used throughout the vintage era, but around 1974, Fender stopped using staggered slugs. Fender also flipped the polarity in 1959 to 1960, from north-up to south-up. The early slugs also had hand-bevelled edges and it is generally assumed this was done to disguise the rough and uneven surface left by the sand casting. Later, Fender stopped bevelling and, according to Seymour Duncan, this had an effect on the magnetic field, as he explains: “The bevel causes the magnetic field to shoot out a little around the bevel area, but it results in a tapering of the field above that point. So, if you could, imagine the magnetic field shaped like the flame of a candle or a teardrop.”

Magnet wire

Magnet wire with two types of insulation coatings – heavy formvar and plain enamel – was used during the vintage era. The 42 gauge stayed consistent throughout, with the change to plain enamel occurring in 1964.

The number of turns varied considerably. Since everything

brighter and weaker than those of the early 60s.

The insulation layer doesn’t have a sound, but its thickness is a factor. Plain enamel provides a thinner coating than heavy formvar, so two coils with identical DC readings will have different dimensions. The formvar coil will be fatter and it will sound different as a result.

Coil shape

Take a look at a bunch of vintage and modern Strat pickups, and you will notice that the extent to which the slugs protrude beyond the plastic covers varies a great deal. Assuming the slugs are all the same length, this indicates that the gap between the two flats must vary.

It follows that if two coils are wound to the same DC resistance onto two pickups with different flat spacing, the coils will have different shapes. The wide-spaced flats will have a tall and narrow coil and the narrow-spaced flats will have the wider coil.

Jason Lollar explains: “You can get quite a different tone out of a Strat pickup by making the coil a little bit shorter or a little bit taller. It makes a measurable difference. You can hear the difference in as little as a 32nd of an inch.”

Generally, a wider coil will sound fatter and thicker, but the treble may be softened. A taller coil can sound clearer, brighter and more defined.

Coil winding

Hand winding doesn’t mean actually winding coils by hand. It refers to the method of guiding the magnet wire onto the bobbin by hand, while machine winding refers to automation of the wire-guiding process. In both cases, machines are used to spin the bobbin. Machine-wound pickups tend to be more consistent and they’re cheaper to manufacture, which is undoubtedly that’s why Fender ceased hand winding pickups after the CBS takeover, when it also changed to plain enamel wire with fewer windings. It’s now generally accepted that hand-wound Strat pickups can have superior tone regardless of the insulation material. ➤

Fender’s design for the Stratocaster’s pickups was about as stripped back as pickups can be

consider that it was designed for the vintage-style 7.25-inch string radius. These days, a 9.5-inch radius is common even on vintage-style instruments, but pickup winders persist with the vintage stagger nevertheless.

The ’54 slugs also had a 0.2-inch diameter, which was wider than the later 0.192-inch slugs. According to Tim Mills of Bare Knuckle Pickups, the slug diameter narrowed once again in 1963. This coincided with the veneer fingerboards and the diameter became 0.187 inches. This resulted in “a more focused magnetic field under the string and subsequently a brighter, tighter tone compared to the rounder bottom end of the earlier 50s coils”.

The magnetic alloy also changed from alnico 3 on the very earliest ’54 Strats to alnico 5 from 1955 onwards. Alnico 5 continued

was done by hand, there was much variation, but the general trend was towards hotter windings, from a 5.7k average in 1954 to 6.4k in 1963. Interestingly, Fender cooled down the coils in ’59 – so if Stevie Ray Vaughan did indeed have 1959 pickups in his ’63 Strat, they were hardly the hot-wound coils of popular imagination.

If that’s what you’re after, Bare Knuckle’s Tim Mills notes that: “I’ve found the hottest Fender coils appear from 1962 to 1964, with DC ranges of 5.6k right up to 6.5k-plus and never in any particular order. It’s not uncommon to find the hottest coil of three fitted in the neck slot.”

After plain enamel wire was adopted, Fender began using fewer winds, presumably in an attempt to cut costs. So the pickups of the early 70s sounded

BUYER'S GUIDE

Now you have the list of ingredients, you can mix and match to make an informed choice about the type of set that will give you the Strat sounds of your dreams. Here are four of the best aftermarket options...



BARE KNUCKLE PAT PEND '63 VENEER BOARD SET £175

This set is based on the best examples of the Strat pickups Fender was making when the fingerboards changed from slab to veneer. The slugs became slightly narrower in diameter and the extra space on the bobbin allowed the coils to be wound a little hotter, to add beef to balance the narrow slug's extra brightness. These are scatter-wound by hand, with heavy formvar.

HOUSE OF TONE HOUSE SPECIAL S TYPE 1960 SET £155

The House Special S Type 1960 (HSST 60) set was conceived as an 'idealised' 1960 Strat tone, based on readings taken from several genuine examples. Components include 42 AWG heavy formvar wire and hand-bevelled alnico V magnets. We haven't heard any set that nails the pre-CBS slab 'board sound better than these.



KLEIN 1969 EPIC SERIES STRATOCASTER PICKUPS \$240

Classic Strat tone can mean late-60s as well as pre-CBS, especially if you like Clapton, Gilmour and Hendrix. This set features grey baseplates, alnico 5 slugs and 'flash potted' 42 AWG plain enamel wire. Right-handed Hendrix fans can order left-handed pickups at no extra charge for the reversed stagger.

SHED '54S £180

Made with Shed's usual obsessive attention to vintage detail, this relic'd set is scatter-wound with heavy formvar and features alnico 3 magnets. A black wax formulation is used for potting and realistically aged round edge covers and slot-head screws come as standard.



When human hands are involved, there are two further variables to factor in – coil tension and winding style. Legendary Fender pickup winder Abigail Ybarra was considered to have such a knack for winding great-sounding pickups, she was coaxed back out of retirement to make pickups for the Fender Custom Shop.

'Scatter winding' is a hand-winding method in which the magnet wire is loaded onto the bobbins in a more uneven and randomised manner. The wire layers are not as tightly packed, which lowers the distributed capacitance of the pickup. This opens up the treble response and shifts up the resonant peak to achieve a clearer and brighter tone.

Magnet strength

According to Jason Lollar, "the actual recipe for the metal has a huge impact on the tone. You can get an alnico 5 from one factory... and an alnico 5 from another factory, and there can be a huge difference in the sound.

"Then old Fender pickups... you're going to find that the power of the magnet is about 20 per cent less than if you took that magnet, put it on the magnetiser and charged it back up."

Pickup manufacturers often deliberately weaken magnets in an attempt to emulate vintage tone. Another approach is to use

weaker grades, such as alnico 4 rather than alnico 5. Weaker magnets produce a softer treble response and exert less pull on the strings, so you may also notice a bit more sustain.

Potting

Potting refers to the practice of impregnating the coils with a substance that will solidify the magnet wire and prevent squealing. Fender has generally used wax, but some pickups were dipped in lacquer and set harder. Rock-solid coils can sound brittle and harsh.

Most potting discussions approach the subject in a binary way – potted or non-potted. This is an over-simplification, however, because skilled pickup makers will carefully control the potting process in order to achieve specific results. If you play loud, or use high gain, you will probably benefit from having heavily potted pickups. Yet I've never encountered a really good-sounding pre-CBS Stratocaster pickup that wasn't microphonic (tap the top with a plectrum and you should be able to hear it through the amp).

So, the 'vintage tone secret' is to pot the coil sufficiently to provide some squeal resistance, but not to over-pot and kill the chime, shimmer and airiness that only a degree of microphony can bring. 🎸



Small differences such as slug height, the number of windings and the winding method all add up to create telltale sonic characteristics in Strat pickups

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Telecaster neck pickups





Compared to their hallowed Stratocaster counterparts, Telecaster neck pickups are often maligned – but if yours doesn't cut it, there are plenty of mods and upgrade options on the market

Some have argued that the Tele neck pickup was an afterthought. The single-pickup Esquire pre-dated the Broadcaster, and most of the prototypes that survive have only bridge pickups. This seems to indicate that the neck pickup was added late in the design process. Other guitars of the era had two pickups, so maybe Fender felt compelled to do the same.

Judging by the wide coil and the exposed slugs, the neck pickup on the famous red prototype looks more like a lap-steel pickup than the unit Fender eventually designed for the Broadcaster. It probably sounded pretty fantastic. Instead, Fender came up with a much smaller pickup with a narrower coil and a plated metal cover.

It also decided to screw the pickup onto the body rather than suspend it from the pickguard, as it subsequently did on the Stratocaster. The reasons for this were probably aesthetic rather than technical – much like the 'ashtray' bridge cover that concealed the bridge parts and the pickup.

Unlike the bridge pickup, Tele neck pickup specs remained fairly consistent. Since the dimensions were tight, Fender used thinner 43 AWG wire so it could get enough turns onto the bobbin. The magnets might have changed from alnico 3 to alnico 5, but they were always flat rather than staggered. The change from wax potting to lacquer dipping occurred around 1967.

It's probably fair to say that Tele neck pickups are not universally admired. Even hardcore Tele players occasionally express some ambivalence towards the tone upgrade, and many have felt compelled to replace them with other pickups. Is there something

fundamentally wrong with the Tele neck pickup's voicing, or is it just a big misunderstanding? To answer that, we need to take a closer look at the way they're made and how the components and wiring influence the sound.

Judged by its cover

Most of us will be aware of PAF lore, which holds that Gibson-style humbuckers sound different with their covers removed.

The same is true for Tele neck

– namely woolly and soft tone. However, none of this would have been too much of an issue when you consider the way in which Fender's original wiring scheme for the Tele was derived from the Esquire's.

Although it had only one pickup, the Esquire's three-way switch provided three distinct sounds. Position one bypassed the tone control, position two re-engaged the tone control and position three activated a pre-set

When the neck pickup was added, positions one and two selected the bridge and neck pickups respectively – both with the tone control engaged. Leo Fender was very fond of the 'bass preset', so it was retained in position three. In 1952, it became even bassier when Fender swapped over to a 0.1uF capacitor. The classic Tele tone with both pickups engaged wasn't actually a stock feature.

Almost from the beginning, players rewired their Tele controls for neck/both/bridge with master volume and tone. Despite the circuit's unpopularity, and the phenomenal success of the electric bass, Fender persisted with the original Tele control wiring until 1967.

The 'Leo got it right the first time' mantra would be more accurate and believable if it was qualified with a strategically inserted 'sometimes'. Once

Is there something wrong with the Tele neck pickup's voicing, or is it just a big misunderstanding?

pickups, where the cover also rolls back some of the treble response and perceived loudness.

In a sense, this compounds the issues caused by the Tele neck's small and squat coil shape

treble roll-off for a very dark sound. Fender referred to this as the 'bass preset', and it was used by guitarists to emulate a bass tone in the years before the electric bass was popularised.



Tele neck pickups have been a problem area for guitarists since the first Broadcasters were produced, with the sound proving too dark and 'woolly' for many tastes. Happily, the picture these days is much more rosy

players started hearing how great Stratocaster neck pickups sounded, it would have been easy enough for Fender to upgrade the Tele neck pickup and reconfigure the controls. Although it would tinker around with minor stuff, Fender always seemed more focused on developing new models than optimising and upgrading old ones.

It's certainly possible to get a really good sound out of a Tele neck pickup, but part of the issue lies in the tonal contrast between the neck and bridge. Typically, a Tele bridge pickup is as bright as the neck is dark, so if you dial in your amp to sound good with your bridge pickup, the neck will inevitably sound muffled. Set your amp for a clear and articulate neck pickup tone and the bridge pickup will almost certainly sound painfully bright.

Stock solutions

There are a couple of simple and free modifications that can bring out the best from a Tele neck pickup. Most people blame the cover for the lack of clarity, so you

of Tele pickups is combining alnico 5 slugs in the neck with alnico 3 in the bridge. You could also request 43 AWG wire for the bridge pickup, along with flat slugs for an even frequency response with fuller bass. Hang on... it seems Leo Fender did something right from the get-go after all.

Sticking your neck out

Players have always modified guitars, and swapping Tele neck pickups for something entirely different is perhaps the most common modification of all. Although Keith Richards' humbuckered Micawber is the most famous example, Sinatra and Elvis guitarist Bob Bain is known to have installed a PAF in his '53 Tele as early as 1957. It's the guitar he played on Henry Mancini's *Peter Gunn* theme.

In fact, it was such a popular mod that even Fender got in on the act. In 1972, the company launched the Telecaster Custom, including a Wide Range humbucker designed by Seth Lover, who also came up

Players have always modified guitars, and swapping Tele neck pickups for something different is perhaps the most common mod

can improve things by snipping the little wire that connects the cover to ground. The difference won't be dramatic but you should hear it. Unfortunately, you'll get a slight buzzing sound if you inadvertently touch the cover.

The composition of the cover makes a difference, too. For minimum treble roll-off, it's best to have a thin nickel-silver cover. Thick brass covers are a bad idea, unless dull is your thing – nickel-silver replacements are available.

To really open out your tone, try removing the cover entirely. Modern pickups may have tape wrapped around the coil for protection, but vintage-style pickups are likely to have exposed coils. If you do decide to go topless, have a pickup repairer wrap an exposed coil to prevent damage. The final thing to consider when ordering a new set

with the design for Gibson's original PAF. All-round badass Danny Gatton favoured a Charlie Christian-style pickup before he started using Bardens, and country virtuoso Clarence White used a '54 Strat pickup in his Tele's neck position. Mini humbuckers sound incredible, too, as Fender demonstrated with its outstanding '52 Hot Rod Telecaster model.

These days, Filter'Trons and Gold Foils are popular and P-90s also work a treat. There are even alternatives that are voiced to sound like P-90s, Charlie Christians and so forth that will drop in without the need for routing the body. The bottom line is that everything seems to work pretty well in the neck position of a Tele – including the original pickup. Ultimately, it's just a matter of tonal taste. 

BUYER'S GUIDE

If all you want is a vintage replica, the choice is endless. Since vintage Tele neck pickups have never changed that much and there wasn't really a golden era, here's a selection of drop-in neck pickup alternatives for simple and reversible mods.

MCNELLY T-BAR £79

Although the coil is taller and skinnier than a regular P-90's, chunky ceramic magnets sit beneath the 43 AWG coils and height-adjustable polepieces. This pickup captures much of the P-90's rounded and flute-y quality and chords chime without sounding trebly.



FENDER CUSTOM SHOP TWISTED TELE £165 PER SET (PRICE INCLUDES BRIDGE UNIT)

Fender's own solution to getting Strat-like clarity from a Telecaster neck pickup involves a taller bobbin, alnico 5 magnets, 42 AWG wire and a nickel silver cover. It's a popular choice on Custom Shop guitars.



TV JONES T-STYLE \$125

Introduced at Winter NAMM 2016, Gretsch pickup guru TV Jones' offering is a set that's a hybrid of Tele and 50s-style DeArmond single coils. This one's wound to 7.32k and it's designed to work with regular Fender pots and caps.



VINTAGE VIBE VT-N-BL \$99

Even chopped-down Charlie Christian pickups require some routing work. This scatterwound CC sound-alike has a blade polepiece and large magnet assembly, but it fits into a regular Tele body and pickguard. Sounding fat and loud, it's also clear, exceptionally smooth, woody and jazzy.

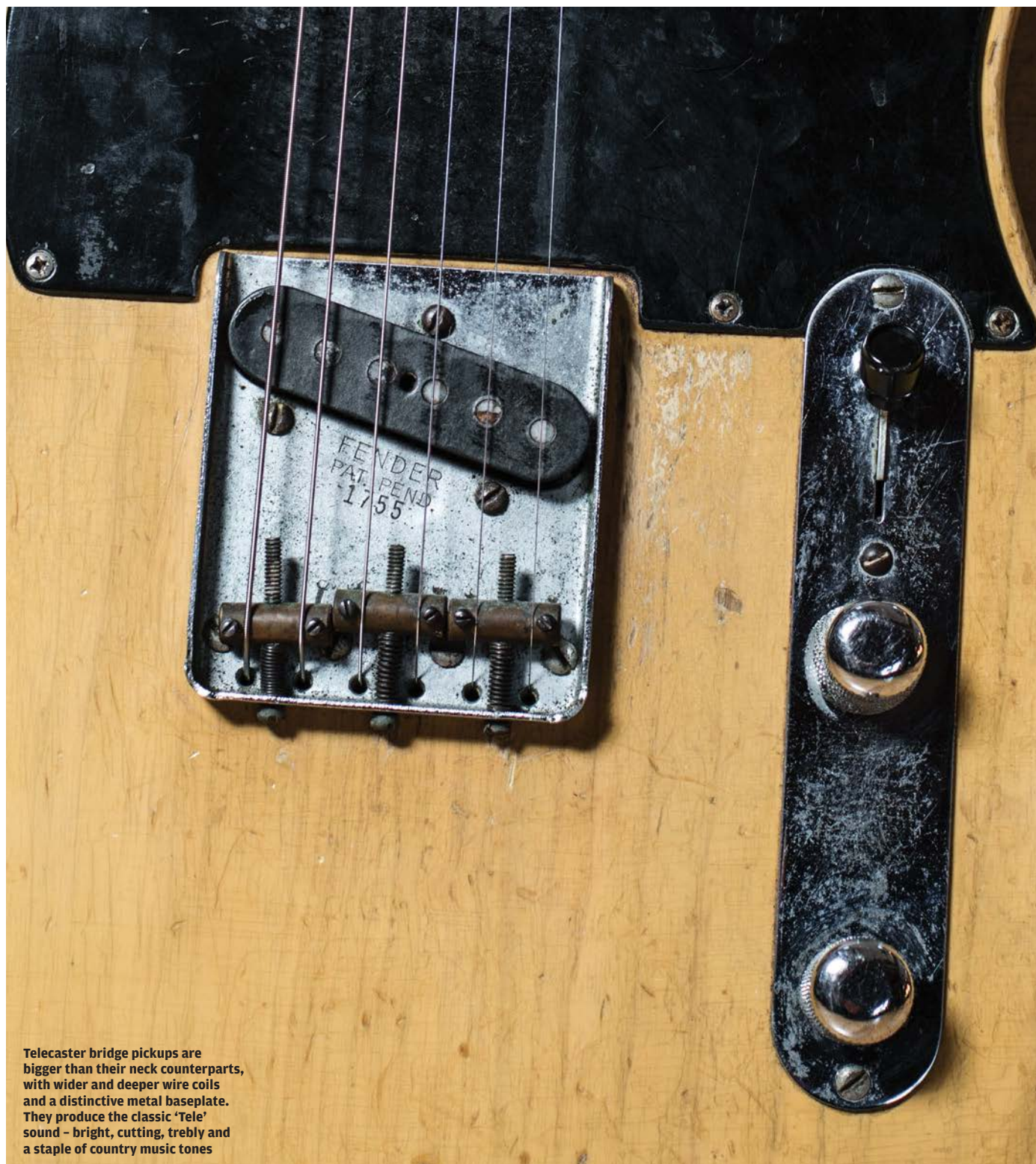




Telecaster bridge pickups



The bridge pickup of the Telecaster, adapted from Fender's lap-steel units, remains a unique-looking and sounding design that's left an indelible mark on music history



Telecaster bridge pickups are bigger than their neck counterparts, with wider and deeper wire coils and a distinctive metal baseplate. They produce the classic 'Tele' sound - bright, cutting, trebly and a staple of country music tones

When you think about it, Leo Fender didn't really have a sonic reference point for solidbody electric guitars when he was designing the guitar that became known as the Telecaster. All the electrified Gibsons, Epiphones, Gretsches and so forth were essentially hollow-bodied jazz instruments that produced big, mellow and woody tones. Only Paul Bigsby's guitars were true solidbodies.

Leo's personal musical tastes veered towards western swing and country, so his ears would have been naturally attuned to those big old archtops and the tones of pedal steel guitars. When you consider the stock sounds of a vintage-style Telecaster, that's sort of what you get – both sounds in one guitar. The pedal steel-like bridge pickup combines with the dark warmth of the neck pickup, and Fender's early wiring scheme accentuated the contrast.

This was achieved by having two very different pickups installed in a single instrument. Compare the Tele with almost

every other classic electric guitar and it's probably unique in that regard. Although most of us have a fairly clear idea of what Teles sound like, the construction of the pickups has changed quite a lot over the years.

In the previous section, we began our look at vintage-style Tele pickups by covering the neck, so let's move onto the bridge. For the sake of simplicity, I'm going to use 'Tele' as a

the earliest bridge pickups were adapted from a pickup Fender was already manufacturing for lap steels.

In fact, many old Fender Champion lap steels had their original pickups scavenged after Keith Richards' tech revealed that he had been installing them in his boss's guitars. Until recently, these easy-to-find pickups were an affordable way into vintage Tele tone. Depending on the

alnico 3 slugs that were level with the top of the flatwork. However, the diameter of the guitar-pickup slugs was slightly wider.

Metal plate

The metal baseplate made it easy to hang the pickup off a conventional Tele bridge using exposed screw heads for easy height adjustment. The black leadout wire was also soldered to the baseplate, which grounded the bridge and obviated the need for a separate bridge ground wire.

The original baseplates were made from steel plated in zinc or copper. These days, you can get plates made from other metals, such as brass and stainless steel, but they have differing effects. Bill Lawrence identified three areas of influence – ferromagnetic functions, electrodynamic functions and shielding. Since the shielding effect is fairly inconsequential, we'll focus on the others.

The ferromagnetic function stabilised and increased the magnetic force of the relatively weak alnico 3 slugs that were available to Fender at the time. Often called an induction plate,

Many vintage Fender Champion lap steels had their original pickups scavenged

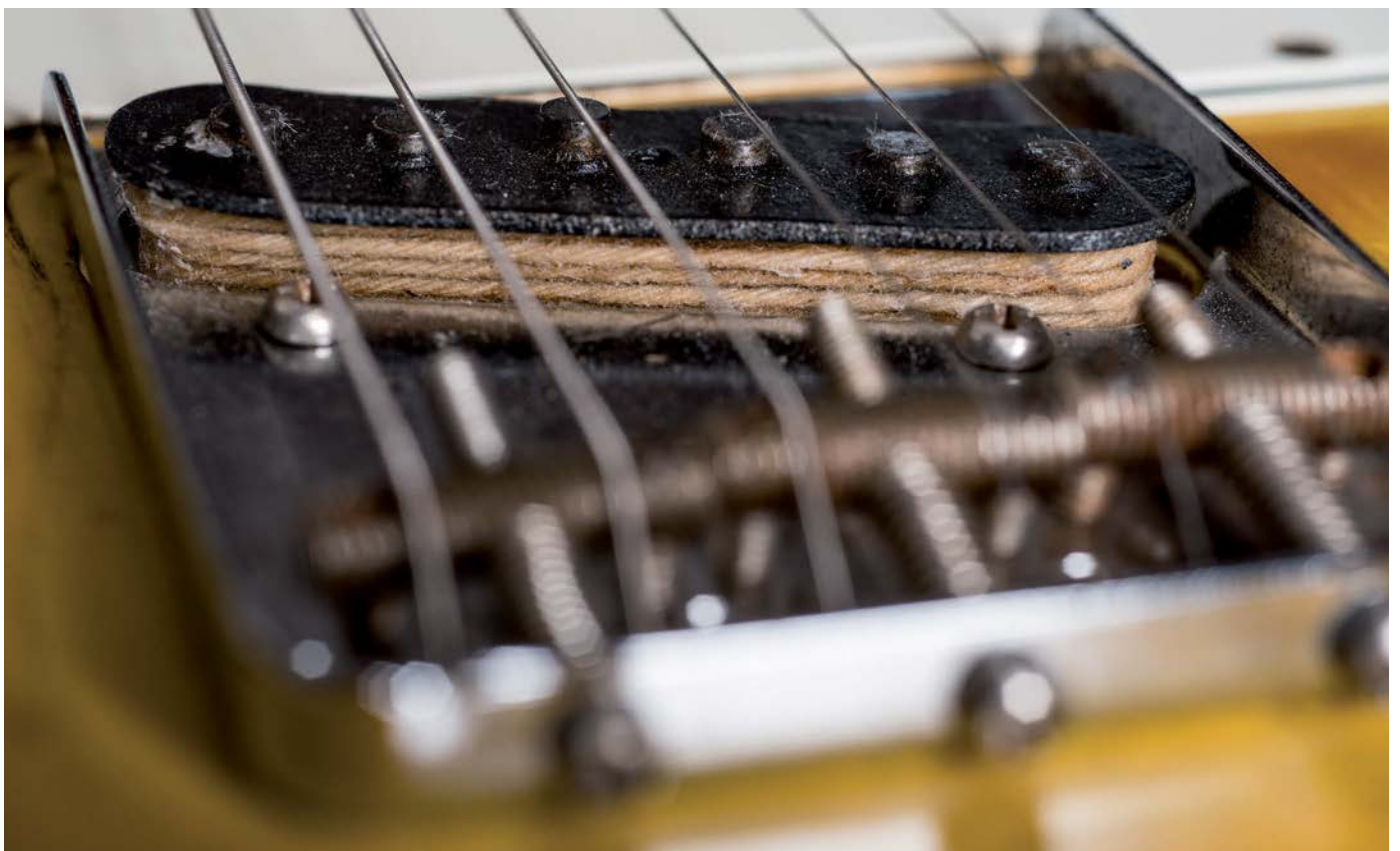
catchall term for the Broadcaster, Esquire, 'Nocaster' and Telecaster, unless otherwise stated.

Lap dogs

Tele bridge pickups are substantially larger than Tele neck pickups – and the Strat pickups that followed. The wire coils are both wider and deeper, and there's the curious issue of the metal base plate. Unlike the neck pickup, which was designed specifically for the Tele,

magnet wire, they ohm out between 5.8k and 8k. The lower DC reading equates to a clear, harmonically rich and trebly tone, while the hotter ones sound more like Broadcaster pickups.

The rectangular bottom flats have to be trimmed to fit and a metal baseplate must be attached, but otherwise, the specs are almost identical to the bridge pickups on many of the earliest Esquires and Broadcasters. These included 43-gauge wire and



the Tele's metal baseplate also increased the inductance of the coils – much like adding extra windings. The only metal that does this is steel, and increased inductance and magnetic strength combine to make a pickup more powerful.

Steel, copper and brass baseplates all cause eddy current interference. This electrodynamic effect alters the frequency response of a pickup, beefing up the bass and low-midrange response to balance out the trebly tone. So copper or brass plates can be used to warm up a Tele bridge pickup without increasing output. If you use steel, you get fatter tone and increased output. Baseplate swapping is a cheap and effective tone tweak, but plates thicker than 1/16" can make a pickup sound muddy.

On the wire

Many of the very early lap steel and Broadcaster pickups had plain enamel magnet wire, but this soon changed to heavy formvar. After about a year of production, the magnet wire gauge was changed from 43 AWG to the thicker 42 AWG. The changeover occurred at roughly the same time as Fender adopted the name 'Telecaster'.

have higher output, while the 43 AWG coil will have more midrange and compression.

Slug stuff

The next change occurred around 1954, when Fender started using stronger alnico 5 slugs rather than alnico 3. Initially, they were flush with the top, but by 1955, they protruded and were staggered like the slugs on the new Stratocaster pickups. This was the bright, cutting, twangy pickup that became synonymous with country picking.

With modern strings, they can sound edgy, but when they were introduced most players used warm-sounding nickel strings with round cores and a wound G. If you want to tame your Tele's treble, you could use the same, but the wound G is optional.

Post-CBS

Nothing much changed until around 1964, when Fender stopped using black flats on the bottom of the pickup and changed to grey. Around the same time, the company swapped from formvar to plain enamel magnet wire.

By the late 60s, Fender was dipping the pickups in lacquer to solidify the coils rather than wax

The DC resistance of the Esquire and Broadcaster bridge pickups can be around 10k ohms

This is significant because the thinner wire had allowed Fender to get more turns on the bobbin, so the DC resistance of the earlier Esquire and Broadcaster bridge pickups can be around 10k. Typically, this drops to about 7.8k with the thicker wire. Also consider that thinner wire has higher resistance for an equivalent number of turns, and the coils have lower inductance. The earlier pickups with the thinner wire sound beefier than twangier, brighter Tele pickups – like a Tele with a hint of P-90.

This ties in with the observations of Matt Gleeson from Monty's Guitars. He points out that coils of 42 AWG and 43 AWG wound to 10k will sound different. The 42 AWG coil will

potting. Since lacquer sets much harder than wax, this can result in coils that are very solid on the outside but loose inside. Pickups from this era can sound very lively and sensitive, but they can be prone to squealing.

By the late 70s, players were using higher gain and volume levels, which caused serious problems with excessively microphonic pickups. You can sometimes cure microphony by ensuring the plate is fixed firmly to the pickup's base and by using surgical tubing spacers rather than metal springs with the height-adjustment screws.

Instead, Fender chose to stop using baseplates altogether on some models: and those sound less Tele-like as a result. 

BUYER'S GUIDE

Bear in mind that all the tech specs and dates given in this article are approximate and there would have been inconsistencies. Since this article is all about vintage Tele-style bridge pickups, you won't find any stacked humbuckers or tapped coils in this selection. Instead, here's a handful of bridge pickups that cover every incarnation, from the prototypes to the CBS takeover.



SEYMOUR DUNCAN ANTIQUITY 1950 LAP STEEL £50 (APPROX)

Wound to 9k with flat alnico 2 slugs, this is a reproduction of the lap-steel pickups Fender made during the late 1940s. Since it's from the Antiquity range, these are convincingly aged, too. So if you fancy a go at trimming the bottom and adding your own metal plate, here's a good place to start.



THE CREAMERY CLASSIC '67 £69

Hand-made in Manchester, this pickup features late-60s spec staggered alnico 5 slugs, a copper-plated steel plate and an aged white string wrap around the coil. It's scatterwound with 42 AWG plain enamel wire to 6.4k with south-up magnet polarity.

MONTY'S RETRO WIND TELE £87

This pickup promises lively touch responsiveness for clean country and blues rock. It's scatterwound to 6.6k with 42 AWG wire and has flat alnico 3 magnets for open tone, with sweeter treble response than typical Teles. It's not aged, but the materials and cloth-covered wire are vintage-correct.



SHED ESQUIRE £75

A marvel from Wales, this pickup is made with 43 AWG magnet wire, aged alnico 5 and magnets, and has a zinc-plated baseplate. The pickup is dipped in black wax after wax potting, then the lacquered bobbin top is aged, along with the vintage-correct slot-head mounting screws, surgical tubing and baseplate.



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GRETSCH

Gretsch pickups

From after-market DeArmonds in the 1930s through to modern-day Filter'Trons, HiLo'Trons and TV Jones models, we chart the ever-evolving story of Gretsch pickups...



As one of America's oldest guitar manufacturers, Gretsch was there at the very beginning of the electric-guitar era. During the jazz age, the acoustic archtop reigned supreme – and back then, guitar manufacturers made guitars, while pickup manufacturers made pickups.

Players who wanted a guitar with a pickup had to order one factory-fitted to a new guitar, or attach a 'floating' pickup. Most archtop manufacturers and builders, including Gretsch, would buy pickups from specialist manufacturers to fulfil customer orders. Many a Gretsch archtop ended up with a DeArmond Rhythm Chief, and the Gretsch Django Reinhardt was pictured with during his time in New York in 1946 was probably fitted with a Leutone pickup – some of which were Gretsch-branded.

The Gibson company stood alone. Despite subsequent ridicule for its initial rejection of Les Paul's 'log' concept, at least Gibson had the foresight to begin manufacturing pickups in-house during the 1930s, and has continued to do so ever since.

It wasn't until 1957 that Gretsch started manufacturing its own pickups; so many of the iconic Gretsch electric-guitar tones were actually derived from pickups that Gretsch bought in. In this article, we'll be taking a look at the pickups fitted to Gretsch guitars from the beginning to the present day.

DeArmond Dynasonic

During the 1930s, Gretsch marketed a line of archtops with built-in pickups and controls. These were the first-generation Electromatics, and they were actually manufactured by Kay in Chicago.

Maybe Gretsch was just testing the water, because in 1949, a new Gretsch-manufactured Electromatic was introduced. The model was the 6185 and it had a single DeArmond pickup.

The association between Gretsch guitars and DeArmond stretched back to the 1930s. Harry DeArmond invented some

of the first after-market guitar pickups (or 'mikes' as they were called) and teamed up with Rowe Industries in Toledo, Ohio to manufacture them. DeArmond pickups featured in 1940s Gretsch catalogues and the two companies even collaborated to develop a playing technique for the 'electric Spanish guitar' called the Gretsch-DeArmond Method.

The really big deal about the 6185 Electromatic was the way in which the pickup was installed directly onto the top, along with the controls. This was made possible because DeArmond had just designed its first pickup for fixed installation. The Dynasonic, or 'Fidelatone' as it was sometimes called, would remain standard issue on all Gretsch electric guitars until 1958.

From the outside, it's a clean, compact and advanced design with individually adjustable magnetic polepieces. Take a look beneath and you'll see protruding screws, slug holders and springs. Most people are surprised

to learn that they have a DC resistance around 14k, but they're not over-wound. Dynasonics were made with 44 AWG plain enamel wire, which is far thinner than the 42 AWG wire that's standard on most modern pickups and even the 43 AWG used on the earliest Fender single coils.

Although you could adjust polepiece height, the pickup itself was fixed to the guitar top by four screws. To balance out the pickups on two-pickup guitars, Gretsch had to get the bridge pickups closer to the strings. It achieved this by shimming up the bridge pickup using celluloid spacers.

The Dynasonic is clear, sensitive, powerful, twangy and dynamic. Famously used by Duane Eddy and Cliff Gallup, it's also the preferred pickup of punk legend Billy Zoom. It was a popular choice for jazz back in the day, and modern jazz virtuoso Bill Frisell has a pair in one of his favourite Telecasters. For many, the DeArmond Dynasonic

produces the definitive tone for Gretsch guitars, and it's undoubtedly one of the finest pickups ever designed.

Filter'Tron

Chet Atkins was, in the 1950s, Gretsch's most famous endorser – despite the fact he never really liked the DeArmond Dynasonic. Chet was Gretsch's answer to Les Paul, so it's ironic that Les' love of the Dynasonic obliged Gibson to design the staple P-90 just to keep him happy.

Chet objected to the Dynasonic's single-coil hum, but more importantly, he wanted a better-balanced tone for his thumb-and-fingerpicking playing style. Chet also felt the strong Dynasonic magnets reduced sustain by exerting too much pull on the strings.

Ray Butts was known as an electronics wizard around the Nashville music scene. Chet had met him when he bought one of Butts' EchoSonic amplifiers with a built-in tape echo, and they worked together on amps and studio equipment. Unbeknown to Gretsch, Chet decided to ask Butts if he could design a pickup that wouldn't hum.

Butts was aware of the transformer-based hum-cancelling circuits that the American tape-machine manufacturer Ampex used for recording heads and realised the same principle could be applied to pickup design.

He built a prototype with white bobbins and Chet installed them in a sealed-top black 6120 prototype that he used as a test-bed guitar. Photographs taken at the Grand Ole Opry in September 1956 show Chet playing the black 6120 with Butts' prototype pickups. Suitably impressed, Chet duly suggested presenting the idea to Gretsch.

The timing was perfect. Gretsch had decided to explore other options, because DeArmond was supplying pickups to competitors such as Guild and Epiphone as well as 'down-market' manufacturers such as Harmony. Gretsch was concerned this would reflect poorly on the company. Rather

For many, the DeArmond Dynasonic produces the definitive tone for Gretsch guitars



than buying the pickups directly from Butts, Gretsch opted to manufacture them in-house and agreed to pay Butts a royalty. Butts then worked closely with Jimmie Webster at Gretsch to create a production version of the pickup, which Gretsch christened the Filter'Tron Electronic Guitar Head.

So did Ray Butts or Gibson's Seth Lover invent the humbucking pickup? The most plausible answer is they both did, and at more or less the same time. Guitarists everywhere would have been complaining about hum, so the race was surely on. Both men adapted hum-cancelling principles already proven in other audio equipment to address the same issue.

The Filter'Tron was announced in 1957 at the summer NAMM show in Chicago – just as Gibson was exhibiting the first of its PAF-loaded Les Pauls. It's reported there was some dispute between the two companies regarding the rights to the design, but Gibson's Ted McCarthy and Fred Gretsch eventually reached a gentleman's agreement.

Both companies applied for patents and both companies made humbucking pickups marked 'Patent Applied For', but the very earliest Filter'Trons had no lettering on the covers and they're associated with late-'57 and '58 manufacture. In his *Manual Of Gretsch Guitars*, Ed Ball refers to them as 'pre-PAFs'. The 1959 Filter'Tron covers were stamped 'Pat. Applied For' and by the end of 1960, the covers were stamped 'U.S. Pat 2892371'.

Although some Gretsch fans attach kudos to PAF Filter'Trons, it's most likely a carryover from Gibson lore. Unlike Gibson, Gretsch continued to produce pickups unchanged, and the patent-numbered Filter'Trons of the late 60s were the same as the PAF and pre-PAF Filter'Trons. Any variations were due to supply issues and manufacturing inconsistencies rather than redesign. The only exception was a brief period during the mid 1960s, when Gretsch ran out of Filter'Tron covers and had to use open-top HiLo covers instead.

Vintage Filter'Trons generally have a DC resistance between 4k



Filter'Trons are smoother and more compressed than Dynasonics, with extra growl but less twang

and 5k; the coils were machine wound with 42 AWG plain enamel wire onto plastic bobbins 2 7/16 inches in length and Gretsch didn't wax-pot them. The design called for 1/4-inch alnico bar magnets that were double the thickness of those used in Gibson's P-90s and PAFs. Grades of alnico varied depending on what was available, but many attribute the Filter'Tron's growly twang to the combination of a strong magnet with low-wind coils.

Alnico became expensive, so, having taken over Gretsch, Baldwin installed cheaper ceramic magnets from 1970 onwards. Baldwin also reverted to the open-top HiLo'Tron casing and concealed the polepieces under a black plastic cover. These are called 'blacktops'.

When Gretsch production resumed in the 1990s,

Filter'Trons came with 43 AWG wire and ceramic magnets. These examples are not very highly regarded, and Gretsch started changing the specs back to 42 AWG wire and alnico 5 magnets in 2002, around the time that it hooked up with Fender.

You can identify ceramic Filter'Trons from this era by the rounded heads of the polepiece screws. The alnico versions had the vintage-style screws with a squared-off 'shoulder'. The latest version is the ceramic FideliT'ron that first appeared on 2013 La Cabronita Telecasters.

Vintage-style Filter'Trons are smoother and more compressed than Dynasonics, with extra growl but less twang. Brian Setzer has been demonstrating their versatility for decades, and you've probably heard them on countless Who and AC/DC recordings. They're equally well suited to

clean country and jazz styles, hard rock and even high gain. Jan Akkerman had sussed that out by the early 1970s and put one in his Les Paul. In recent times, the rest of the world has been catching on to this amazing pickup.

HiLo'Tron

There was a short period between late '59 and mid '60 when DeArmond stocks had run out and Gretsch fitted a rare pickup known as the Clipper Transitional. It was a single coil that came with both black and white covers, that lasted until Gretsch introduced the HiLo'Tron in mid 1960.

The HiLo was intended for entry-level and mid-priced models such as the Clipper, Anniversary and Tennessean. Lower-profile than the Filter'Tron, the HiLo was designed to sit on top of the body rather than within a cut-out, which streamlined the production process and lowered costs. Some of the parts Gretsch used were stock items, but it's incorrect to assume the HiLo is essentially half a Filter'Tron.

The only feature they share is the plastic bobbin. The HiLo'Tron is wound with thinner wire and has different polepieces. The bar magnet is mounted on an angled steel plate with a vertical steel magnet keeper on the other side of the magnet. The bridge HiLo'Trons were also jacked up on wood spacers.

Famed for its soft treble, woodiness and twang, this was the pickup fitted in the Tennessean George Harrison used on the *Beatles For Sale* and *Help!* sessions. The intro to *House Of The Rising Sun* by The Animals is another clear example of HiLo tone. It's a quintessential 60s sound, but even amongst Gretsch fanatics, the HiLo'Tron divides opinion like no other Gretsch pickup. In fact, the first Gretsch guitar I played was a vintage Tennessean, and it was so wimpy I assumed there had to be something wrong with it. Filter'Trons aren't exactly high-output pickups, but with a single coil wound to a DC resistance between 2.9k and 3.4k, the HiLo's output is even lower.

However, it's unfair to dismiss HiLos as the poor relation. Like



many others, TV Jones is a big fan, although he recommends careful adjustment to bring out the best tone. Rather than raise the polepieces, he suggests shimming up the pickup on foam to bring the coil as close as possible to the strings. This raises output, improves clarity and widens frequency response.

Super'Tron

Although it's the same size as a Filter'Tron, the Super'Tron has full-width laminated blades rather than adjustable polepieces. Gretsch regarded the Super'Tron as a premium pickup, and it was fitted to various models – including the Viking, Monkees, Roc Jet, Astro Jet, Streamliner and some basses.

Maybe Gretsch was responding to a demand for more powerful pickups when the Super'Tron was introduced in 1964. The blades were also intended to maintain output level when strings were being bent. Although it's probably the most obscure of the classic-era Gretsch pickups, the Super'Tron has a loyal following amongst Gretsch players, who praise its sweet treble, full body and higher output.

Michiel Helsloot of Elektra Amps is a long-time fan, describing them as “full and articulate, without getting woolly or muddy like many humbuckers do. The note separation is better than Filter'Trons, due to the increased clarity of the pickup. Interestingly, the surface of the blades that faces the strings isn't radiused. Despite that, I've never noticed a clear difference in string-to-string output level. It sounds very well balanced the way it is, both with the modern TV Jones version on my Country Gent and the vintage ones with laminated blades that are on my '70 Viking.”

The mod squad

Until fairly recently, TV Jones was the only after-market pickup maker specialising in Gretsch-style pickups. Having worked on Brian Setzer's guitars for many years, he was the right person for the job and TV Jones pickups deserve their fine reputation.

This didn't go unnoticed, and Gretsch made a very shrewd

move. Unusually for a big-name guitar manufacturer, Gretsch was happy to acknowledge that someone else was making high-quality versions of its own pickups and installed TV Jones units on its top-of-the-line models. The relationship continues to this day.

The TV Jones product line has expanded enormously. These days, the company sells a full range of vintage-style replacements for Filter'Trons, HiLos and DeArmonds. There are hot versions, Filter'Trons in Dynasonic cases and Dynasonics in Filter'Tron cases. A Setzer signature Filter'Tron features unmatched coils with no wax potting – just like Brian's Stray Cats originals. The Duo-Tron is a recently introduced recreation of a never previously manufactured Ray Butts prototype from '57, featuring polepieces and blades.

Thanks to guitars such as Fender's La Cabronita, and various boutique builders, Gretsch-style pickups have never been more popular. Now, there are countless variations on the Filter'Tron and scores of manufacturers making them.

Relatively few companies offer authentic Dynasonic replacement pickups. Besides TV Jones, there's Seymour Duncan with the vintage-spec Dyno and a humbucker-sized Dynobucker. Both are expensive Custom Shop products, but very well regarded.

Fender has owned the Dynasonic name for some time and made two types of pickup that look like the Dynasonic. Former Fender pickup expert Bill Turner has explained the difference as: “The DeArmond 2K and 2000 are wholly different animals. The 2K is configured like a P-90 with steel polepieces. The 2000 uses only ¼-inch alnico 5 polepieces in the bobbin, the sound is bright with that great rockabilly snap.”

These days, players in a wide variety of genres are chasing the Gretsch sound by installing Gretsch-style pickups in all kinds of hollow and solidbody electrics. But be warned: it's a slippery slope and before you know it, you'll be twanging away on your very own G-branded axe. 

BUYER'S GUIDE

Here are four of the best currently manufactured repros of the most important and well-loved vintage-era Gretsch pickups. There's plenty of crossover with some of these manufacturers, too, so do check their websites for the full range of Gretsch-inspired pickups on offer.



TV JONES T-ARMOND \$160 TO \$170 EACH

This vintage-spec Dynasonic is available in original vintage, humbucker-size and P-90 soapbar formats. Made with American cylinder magnets, sets are calibrated for bridge and neck placement with DC resistances of 12k and 8k respectively. The T-Armond is available with chrome and gold plating.



MCNELLY SPARKLETRON £99 EACH

The SparkleTron is manufactured in Canada by McNelly Pickups and features wax-potted coils hand-wound with 42 AWG plain enamel wire, full-sized alnico 5 magnets and ¼-inch wood spacers. The set we reviewed absolutely nailed the vintage Filter'Tron tone, and you can also order the coils without wax potting if you prefer.

MOJO PICKUPS MOJOTRON BLADE £150

Made in the UK, Mojo's version of the Super'Tron is available in both vintage and humbucker-style formats. It features 42 AWG wire, a vintage-correct ¼-inch custom-made alnico magnet and solid rather than laminated blades. The neck and bridge are wound to 4.2k and 5k respectively.

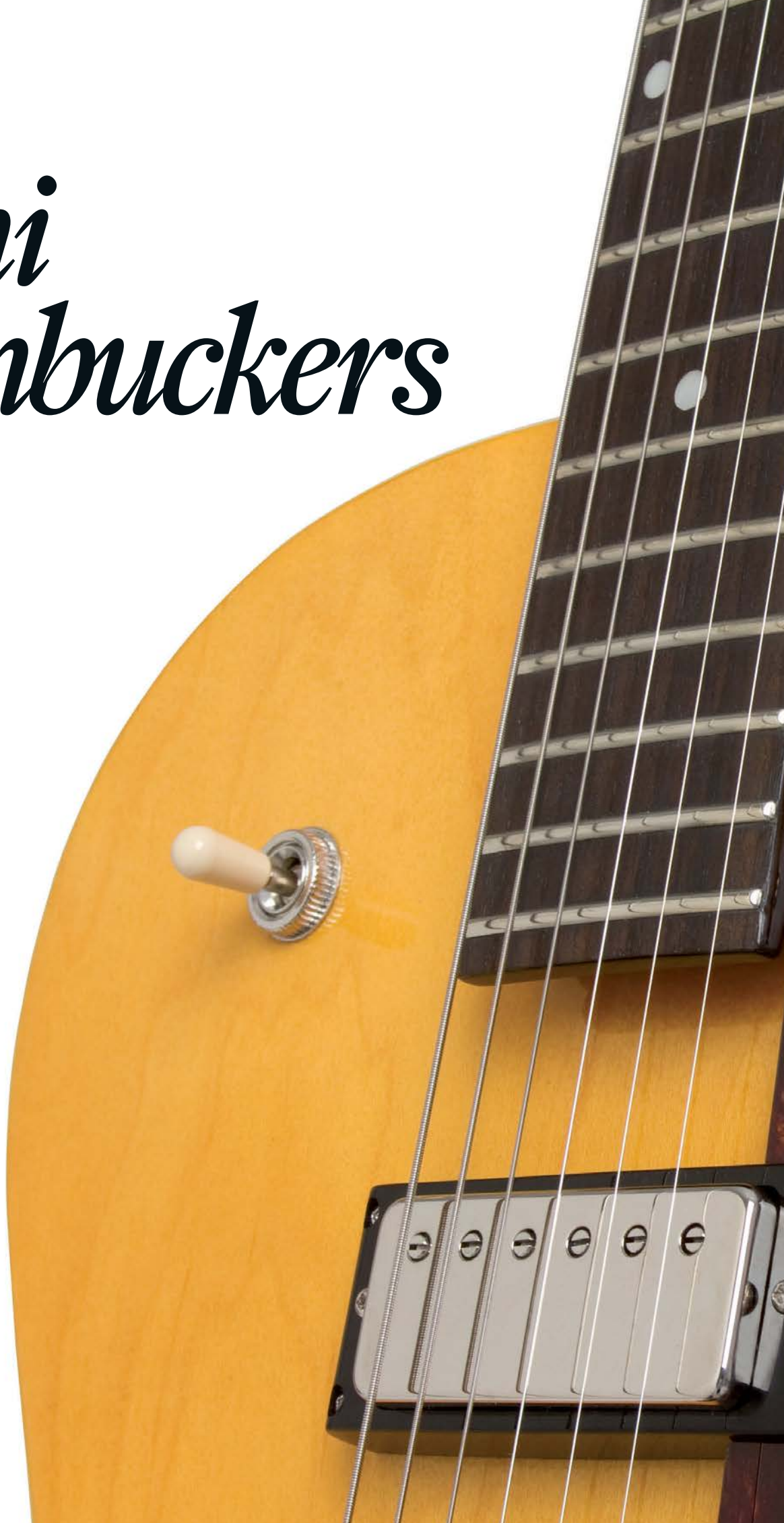


GRETSCH HILO \$114 EACH

Granted, it's no surprise that nobody really bothers with HiLos because the market must be tiny. TV Jones has a version but you can buy Gretsch's own HiLo repro from Angela Instruments – along with lots of other groovy Gretsch-related pickups and products.



Mini humbuckers





Mini humbuckers started appearing in Epiphone guitars before the company was taken over by Gibson. Gather round as we tell the story of a little pickup with a distinct sound...

Here's a guitar-quiz question for you: besides being owned by the same company, what did the Gibsons and Epiphones of the early 1960s have in common? The answer is that many of them were fitted with PAF pickups.

You would be correct in thinking that none of the Epiphone models were equipped with the same full-sized PAF humbuckers fitted to top-of-the-range Gibsons. However, some Epiphones did come with mini PAFs that were also designed by the legendary Seth Lover. They even had 'Patent Applied For' decals on the baseplate.

Apparently, Lover had always felt that the full-sized PAF was somewhat bigger than it needed to be, and his mini-humbucker design actually predates Gibson's

acquisition of Epiphone. Some of the first Epiphones with mini humbuckers were the Sheraton and Sorrento models, and they later found their way onto the Riviera and Wilshire.

Had the mini humbucker remained exclusive to Epiphone, it may have been little more than a footnote in pickup history. Despite the undeniable quality

construction is quite different, but we'll get on to that later.

Having dropped the initially unsuccessful Les Paul model by 1961, Gibson responded to popular demand from customers who were obsessed with the blues-rock tones of Bloomfield, Beck and Clapton. In 1968, the Les Paul was reintroduced... albeit with the

Paul pickup issue that wouldn't require extensive woodworking or expense. Gibson had access to a plentiful supply of Epiphone mini humbuckers, and Deurloo realised they would fit into P-90 routs. A P-90-shaped cream ring was designed to fill up the gaps, and from 1969, the Epiphone mini humbucker was the standard-issue pickup for the Les Paul Deluxe, until the model was dropped in 1982.

If you have ever heard a mini humbucker on record, it was probably residing in a Les Paul. Both Scott Gorham and Brian Robertson used them in Thin Lizzy, Pete Townshend used Les Paul Deluxes extensively during the 70s and Gary Rossington used mini humbuckers to cut many of Skynyrd's seminal tracks before his '69 Goldtop was stolen in the early 70s.

Despite having played its part in creating some legendary guitar tones, the mini humbucker has been overshadowed somewhat by its big brother. So what are the differences between them?

The mini-humbucker pickup design actually predates Gibson's acquisition of Epiphone

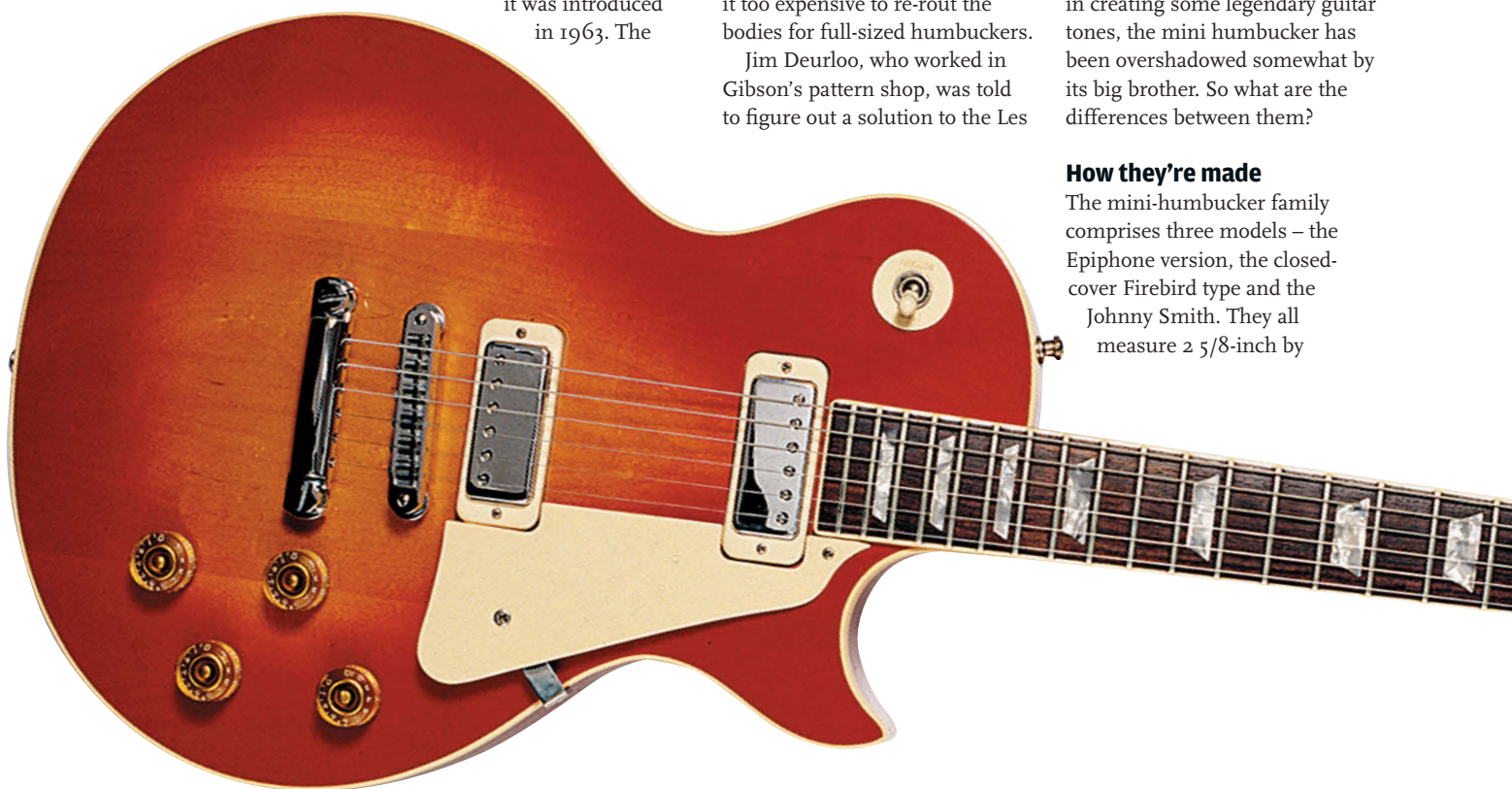
of Epiphone guitars, the mini humbucker made its mark because Gibson began using them. At this point, it might be useful to make the distinction between Epiphone's mini humbuckers and the ones fitted to the Gibson Firebird when it was introduced in 1963. The

'wrong' pickups. Bewildering as it may seem, Gibson decided to go with the earlier-style P-90s and proceeded to cut and rout a year's supply of Les Paul bodies. Pretty soon, it figured out that P-90s weren't what players of that era wanted, but the company deemed it too expensive to re-rout the bodies for full-sized humbuckers.

Jim Deurloo, who worked in Gibson's pattern shop, was told to figure out a solution to the Les

How they're made

The mini-humbucker family comprises three models – the Epiphone version, the closed-cover Firebird type and the Johnny Smith. They all measure 2 5/8-inch by



1 1/8-inch, but the construction differs. We're focusing mainly on the Epiphone mini humbucker and as it's the original version, it's unsurprising that its design is closer to full-sized PAFs than the others.

An alnico 5 bar magnet is placed beneath two coils wound with polyurethane-coated 42-gauge wire. The bobbins are made narrower to fit under the covers and one coil has adjustable ferrous polepieces that protrude through holes in the cover, while the other has a ferrous-metal bar. Firebird pickups have alnico 5 magnetic bars in both coils and closed covers.

Johnny Smith types have a bar magnet in one coil and a steel bottom plate that's tapped and threaded for adjustable polepieces. The magnetism passes from the bar magnet

shorter length, producing a more focused and brighter sound.

While we tend to fixate on magnet types and DC resistance when discussing pickup specs, inductance is equally important and it's what makes the Epiphone mini humbuckers sound distinct from the Firebird type.

Alnico magnets and steel have different inductance properties, and the presence of the steel bar and polepieces in the Epiphone mini humbuckers increase inductance. This boosts output and fattens the bass, which gives mini humbuckers more sustain, smoothness and body than the weaker and brighter Firebird pickups. The magnetic field strength and shape is also different, which influences tone.

Although they're not as fat and powerful as full-sized vintage-spec humbuckers, the Epiphone

Epiphone mini humbuckers remain popular with jazz players and work superbly for blues and classic rock

through the steel plate and up into the adjustable polepieces that pass through the second coil.

Each mini-humbucker coil has around 4,250 turns of wire, and the combined DC resistance usually measures between 6k and 7k. So a hot mini humbucker just edges into the cooler end of the full-sized vintage PAF spectrum.

Sound

Mini humbuckers are known to produce a fairly high output, with extended treble response and a more open tone than a typical full-sized humbucker.

Much like a Gretsch Filter'Tron, the reduced field senses string vibration over a

mini humbuckers sound sweet, clear and very articulate. They've remained popular with jazz players and work superbly for blues and classic rock.

Modern players may find the inherent clarity, combined with their noise-cancelling attributes, makes mini humbuckers ideal partners for cranked-up, low-power valve amps, as well as pushing through effects-heavy signal chains. They have also started making more regular appearances on boutique guitars, so maybe this long-overlooked classic is beginning to find itself a new niche. Could the Epiphone mini humbucker be the new Gold Foil? Time will tell... 



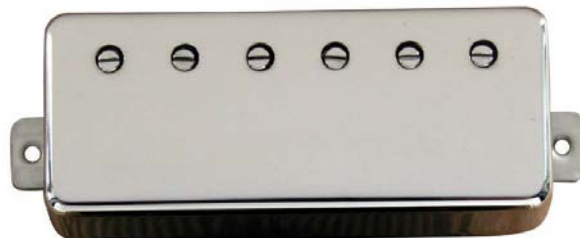
Gibson's Les Paul Deluxe model sported a pair of mini humbuckers in adapted pre-carved P-90 pickup cavities

BUYER'S GUIDE

For such a niche pickup, it's surprising just how many manufacturers offer mini humbuckers with authentic vintage components, contemporary tweaks and various others options. Here are a few examples...

MOJO PICKUPS MINI HUMBUCKER £70

Coils are hand-wound with 42 AWG wire and the magnet is vintage-spec alnico 5. Unlike some calibrated sets, both the neck and bridge fall within vintage spec, at 6.2k and 7.2k respectively. You can even order a calibrated set of three.



HOUSE OF TONE SPECIAL MINI HUMBUCKER £70

Made in the UK, these mini humbuckers are wound to produce the bright mini humbucker sound with a fuller bottom end. They're available with chrome or gold covers and a choice of vintage outside braid wire or four-conductor hook up. A matched set reads 8k at the bridge and 7.6k at the neck.



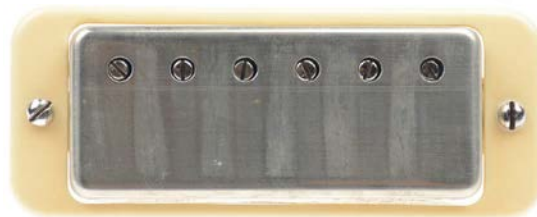
GIBSON ORIGINAL MINI HUMBUCKER £89

Yes, Gibson still makes them, but the magnet is now alnico 2 rather than alnico 5. It ships with a cream surround, and a DC resistance of 6.5k puts it into the 'medium' category for mini humbuckers.



SEYMOUR DUNCAN ANTIQUITY II ADJUSTABLE MINI HUMBUCKER £137

If you want a mini humbucker that looks vintage from the get-go, the Antiquity II version may be worth considering. The bridge version is wound to 8.1k, but if you prefer vintage specs, just order two of the 6.7k neck pickups.





Gold Foil pickups



Guitarists searching for an alternative sound to the classic pickup triumvirate of single coils, humbuckers and P-90s have turned to Gold Foil pickups for a fresh tonality.

Here's a potted history and some buying info and recommendations...



Pretty much every classic guitar pickup we can think of achieved legendary status in association with the guitars they were installed in. Consider PAFs, Filter'Trons, P-90s or DeArmond Dynasonics and you can probably name a bunch of classic guitar models that are inextricably linked with those pickups. In that sense, the Gold Foil is an aberration, because they were generally consigned to bargain-basement American guitars and the junk guitars the Japanese produced before they got really good at it. Subsequently, Gold Foil pickups remained under the radar for all those not obsessed with obscure blues artists and arcane 60s punk bands.

When it comes to thinking outside the (guitar) box, few can surpass David Lindley. As an extraordinary multi-instrumentalist as well as a guitarist, Lindley has played with just about everybody who is anybody and has been a lifelong collector of unusual instruments. He's also closely associated with his friend Ry Cooder.

By Cooder's account, the sound of his Daphne Blue Stratocaster had bothered him for years and he eventually embarked on a quest to sort out his electric tone. His first step seemed logical,

because Cooder liked the sound of lap steels, but he didn't like playing lap-style.

So he removed the pickup from a Valco lap steel and had it installed in the bridge position of a reissue Sunburst Buddy Holly Strat body. Cooder liked what he heard, but he needed a neck pickup to broaden his guitar's tonal range and complement the lap-steel pickup. This is where Lindley stepped in to recommend that Cooder should try a Teisco

the enthusiasm for Gold Foils has only become widespread and mainstream in the last decade, thanks to the likes of Dan Auerbach. Let's take a closer look at what makes Gold Foils look and sound so distinctive.

East meets west

This is where things get complicated, because not all Gold Foils were created equal – or indeed in the same factory, or even continent. American

'S-Grille' and 'Diamond-Grille' types, which were fitted to so many Silvertone and Harmony guitars during the late 50s and throughout the 60s. Specialist pickup maker Curtis Novak regards these as the best-sounding of all the Gold Foils and winds his own DeArmond replicas.

Here in the UK, Marc at Mojo Pickups makes a wide variety of Teisco-style Gold Foil pickups and is consequently something of an authority on the subject. He kindly filled us in on some of the technical aspects that distinguish Gold Foils from other pickups, and how the American and Japanese versions differ.

Marc believes that Teisco was possibly copying DeArmond because it wanted eye-catching pickups that would distract customers from the poor quality of its guitars. There were certainly some similarities between the two types.

Although S-Grille and Diamond-Grille DeArmond magnets varied, the majority were ceramic. However, the Moustache DeArmond and all of the Teiscos had rubberised ceramic magnets. These magnets are cheap to manufacture and are commonly used for cupboard-door catches and bendy fridge magnets. DeArmond magnets were also

Since Howlin' Wolf had played a guitar with Gold Foils, Ry Cooder didn't need much persuading

Gold Foil. Since Howlin' Wolf had played a guitar with Gold Foils, Cooder didn't need much persuading. He had one installed a tad further away from the neck than is usual for a neck pickup, to tighten the sound a little, and the resulting guitar has become known as 'The Coodercaster'.

Cooder described the Gold Foil sound as "an enormous bubble of resonance" and countless Cooder fans have since attempted to build their own version of his guitar. The Coodercaster was up and running by the late 80s, but

Gold Foils were made by Rowe Industries (aka DeArmond) in Toledo, Ohio, while the Japanese ones were made by Teisco.

Every type has a metal cover with a variety of shapes stamped out to reveal a gold-coloured layer of metal foil positioned under the cover. However, not all 'Gold Foil' pickups have gold foil and you can find examples with black foil.

The shapes of these cutouts on the metal covers have inspired some commonly used nicknames: some examples include the DeArmond 'Moustache',



slightly longer and wider. Both manufacturers wound coils that were just about 1/8-inch high. The vast majority of industry-standard pickups have taller coils wound with thicker wire. In contrast, Teisco used 44 AWG wire and DeArmond used 45 AWG, which is so delicate it can be very tricky to wind. It's also the reason why you can't presume they will produce a hot output level, despite the apparently high DC resistance. The coils were wound quite loosely and since neither manufacturer wax potted its coils, vintage Gold Foils are notorious for microphonic squeal at even moderate volume levels.

Although opinions differ on which Gold Foils sound best, the Cooder connection means that the Teisco versions are most sought after – in particular, the ones with the tiny adjustable polepiece screws positioned along one side.

However, if you pop off the cover, you'll see the screws are nowhere near the coil or the magnet. According to Marc, they provide a tiny bit of inductance, but their role is primarily

decorative and you needn't bother trying to adjust them.

Golden sound

Guitarists don't tend to have as much experience of Gold Foils as other pickup types. For this writer, the adjectives that spring to mind are 'brightness' and 'clarity'. However, the extended treble is devoid of shrillness and the tonal character has a comparatively flat response and an almost 'hi-fi' quality. Basically, it's like having little microphones strapped to the top of your guitar and they're remarkably sensitive to playing touch.

Played clean, they're capable of really pretty tone – almost like a jazz pickup with added wiry spank. They also have a woodiness that enhances and balances the brightness. With overdrive, they can growl nicely, but the top end always cuts through and can develop into quite startling harmonic complexity. Primarily, they seem to appeal to players who are into roots tone but are looking for something a little different to provide inspiration. ⚡

BUYER'S GUIDE

Want Gold Foils? Start with these...

Given their current levels of popularity, it may be surprising to learn that you can still pick up vintage Gold Foils cheaply. Even Cooder-style Teisco ones are readily available on Reverb.com for around £100 or even less. However, it's worth remembering that, as ever, buying cheap may involve a compromise on quality somewhere down the line: Marc from Mojo warns that finding a really good-sounding vintage Teisco pickup involves some degree of luck.

Fortunately, vintage isn't the only option. As their reputation grew over the years, demand for Gold Foils naturally increased and they're now commonplace on modern boutique and handmade guitars. They're also popular on Jazzmaster- and La Cabronita-style builds, and as a Telecaster neck option. Several pickup winders now include Gold Foils in their catalogues and, in addition to vintage-correct repros, there are Gold Foil varieties that will fit Strats, Teles and even PAF-sized rings.



MOJO PICKUPS TEISCO GOLD FOIL £90

Handmade here in the UK to vintage 60s Teisco spec, this is the Ry Cooder model with a 44 AWG wire coil and rubberised ceramic magnet. The neck and bridge are wound to 6.1k and 7k, with a relic version for an extra £5. This pickup is also available as a drop-in replacement for P-90, Firebird, PAF and Jazzmaster pickups.

CURTIS NOVAK ROWE/DEARMOND- STYLE REPOS \$155

Novak's Gold Foils are reproductions of the USA-manufactured pickups and come in three flavoured toppings – moustache, S-Grille and Diamond Grille. You can also choose different-coloured foils and specify your preferred DC resistance within the range 5k to 13k.



LOLLAR GOLD FOIL \$190

Jason Lollar's Teisco-style Gold Foil pickups are made with authentic rubberised ferrite magnets, 44 AWG wire and a 1/8-inch-tall bobbin. Since proximity to the strings is critical to bringing out the best from these pickups, Lollar also sells shims for these pickups, in various thicknesses.

VICTORY LOWRIDER VINTAGE GOLD FOIL £46

Although not modelled on any vintage Gold Foil, the Lowrider is a compact version. Smaller in every dimension, the Lowrider is only 5/16-inches tall and is designed for top-mounting on guitar bodies, with minimal modification. This could be a good choice for fitting to resonators and cigar-box guitars.



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EL34-M	£19.20	£21.60	6V6GT-R	£19.20	£21.60
EL84-S	£14.40	£16.80	6V6GT-S	£24.00	£26.40



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The thermionic valve was one of the most significant inventions of the 20th century and the vast majority of guitarists agree that valve amps are superior to their solid-state rivals. Here, we chart their history...

Although the silicon chip probably reigns supreme, few other recent technological innovations can be said to have changed our lives more profoundly than the thermionic valve. Without them, we would have been without home audio systems, computers, recorded music, long-distance telephones, radar, television, cinema and radio for most of the 20th century. Space exploration would have started a lot later and, most concerning of all, rock 'n' roll would never have existed.

Technology marched on and by the mid 1960s transistors had taken over many of the functions performed previously by valves. Lower production and running costs, combined with improved reliability, made this shift both sensible and inevitable in many applications, but in high-end audio, the valve lived on.

Although some claim that solid-state electronics can match valve performance, and even improve upon it, many hi-fi enthusiasts, recording engineers and musicians remain steadfast in their belief that valves simply sound better. Rightly or wrongly, the vast majority of electric guitarists prefer valves.

Although there are countless types of valves, or tubes as they're known overseas, they mostly serve two functions in guitar amps. Rectifier valves are used in power supplies to help with the process of turning an alternating current into a direct current. Preamp valves and power-amp valves both increase amplitude – in other words, they turn low-level audio signals into higher-level audio signals.

In this feature, we'll be focusing on triode and pentode preamp valves.

How triodes work

Although you can get diode, triode, tetrode and pentode valves, only triode and pentode preamp valves are found in the signal path of guitar amplifiers. The triode is by far the most common variant, and almost every preamp valve contains two triodes.

Each triode will have three components – an anode (aka

and heats up the cathode. When heated, the cathode begins to emit negatively charged electrons, which flow towards the positively charged anode. This is called 'thermionic emission', which is why valves are sometimes referred to as 'thermionic valves'. The electrons are able to flow because there's a vacuum inside the valve's glass tube – hence the term 'vacuum tube'. Charge

electrons. When the guitar signal is in a positive phase, the grid becomes positive, which attracts electrons and ensures that more of them reach the anode. This increases the plate current.

Conversely, a negative phase in the guitar signal will repel the electrons, causing current to drop because fewer electrons reach the anode. The direct current that flows when there is no guitar signal on the grid becomes an alternating current when guitar signal is present.

Remember the anode resistor I mentioned? The alternating current causes the voltage across the resistor to vary, and that voltage variation far exceeds that of the guitar-signal voltage. The upshot of all of this is that the frequency and wavelength of the alternating voltage appearing at the anode will be identical to the guitar signal, but amplitude will be greatly increased. Therefore, amplification has been achieved.

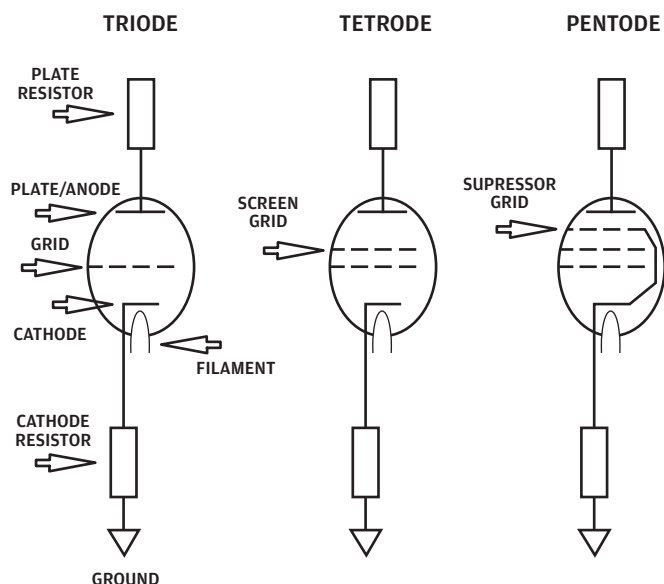
Put the 6SL7 and 6SC7 in the right circuit and you get the dirtiest and fattest Billy Gibbons grind

plate), a cathode and a control grid. The cathode is wired to ground, usually via a bias resistor and/or a bypass capacitor, so it's negatively charged. The anode is connected to a high-voltage DC power supply via a plate resistor.

The valve also contains a heater (aka filament), and it receives a lower voltage supply that is typically 6.3 volts AC or, very occasionally, 12.6 volts DC. The heater gets hot, glows orange

flowing between the cathode and plate completes the circuit, so a direct current flows.

The clever bit is the control grid. A guitar pickup produces a tiny alternating current output. Alternating currents move between positive and negative phases, so when that guitar signal is applied to the grid it causes the grid's charge to vary between positive and negative. The grid can now attract and repel the



How pentodes work

Triodes exhibit a problem known as the Miller Effect, whereby capacitance between the plate and the control grid leads to oscillation when gain is pushed beyond a certain level. Adding a second grid, between the control grid and the anode, with a positive voltage that's slightly lower than the anode's, solves the oscillation problem because it acts as an electrostatic shield. It's known as a 'screen grid'.

This type of valve is called a tetrode, but it also has issues because electrons striking the plate at high velocity can cause more electrons to be emitted from the plate itself. This is known as secondary emission.

These electrons released from the plate are attracted to the

positively charged screen grid, which results in a loss of plate current. So in this instance, the 'screen grid' functions as an unwanted second anode and amplification is lowered.

So, engineers added a third grid located between the screen grid and the anode, known as the 'suppressor grid'. It's connected to the cathode – internally or externally – and held at a negative voltage. It repels electrons released from the anode through secondary emission, so they can be recollected by the anode rather than the screen grid. With an anode, cathode, control grid, screen grid and a suppressor grid, a pentode has five component parts – hence the name. Although they can be noisier, pentodes are more efficient than triodes and are capable of even higher gain.

Octal triodes

Up until the mid 1950s, most guitar amps had octal preamp triodes. By far the most common are the 6SC7, 6SN7 and the 6SL7 found in pre-war Gibson amps, early Fender tweeds and Ampegs.

At first sight, they can be mistaken for a small power valve because they are much the same size as 6V6s and plug into

large eight-pin sockets – hence the name. With a gain factor of around 70, the 6SL7 and 6SC7 are pretty good performers.

Known for their full midrange tones and sweet treble response, they sound superb for jazz guitar and they even have a following in hi-fi circles. However, put them in the right circuit and you get the dirtiest and fattest Billy Gibbons grind without the edginess or fierceness of some later amp designs. Some are still in production, but NOS examples are becoming scarce and all types can be prone to microphonics.

Miniature triodes

These days, they look like 'normal' valves, but they were called 'miniature' to differentiate the newer nine-pin valves from the earlier octals. Since they're cathode biased, most of the common nine-pins are interchangeable, but they may not sound their best without circuit tweaks. The ECC88 is an exception to this rule because its pin connections are different.

The 12AX7 (aka ECC83 and 7025) is by far the most common preamp valve seen in guitar amps. Its gain factor should be around 100, and this is a great

general-purpose preamp valve with a tone we all know and love.

When Fender first started using nine-pin valves, a 12AY7 (aka 12AY7) was invariably used for V1 and sometimes V2. With a gain of 44, the 12AY7 lasted in many tweeds right up until the brownface era. If your amp is too quick to distort or you're looking for a more open tone with lower noise, try putting a 12AY7 in the front end of your amp.

The 5751 (aka 12AT7) and ECC81 (aka 6201) provide a nice halfway point with gains of 70 and 60 respectively. The 5751 is a great-sounding valve that's a straight swap for a 12AX7. The ECC81 has a cleaner, brighter tone, which limits its guitarist appeal somewhat. The ECC81 is more often used as a phase inverter or a reverb driver in guitar amps than as a preamp valve. With a gain of only 20, the 12AU7 (aka ECC82 and 6189) is seldom seen in guitar preamps. However, it makes a decent phase inverter and works well for effects loop buffering.

Pentodes

Most agree that the gain, clarity and brightness of pentodes are desirable characteristics for guitar

amps, but relatively few designs have utilised pentodes in the preamp. You will see the EF86 in early Vox AC30s, AC15s and AC10s, as well as Vox-inspired contemporary amps from Matchless, Top Hat, Dr. Z and 65.

Gibson amps of the 1950s often had a pentode called the 5879 in the front end. Although underappreciated, amps such as the GA40 sound incredible – and the 5879's fat, creamy and muscular tone is a big part of that magic. The recent Victoria Electro King is a fantastic-sounding repro of a late-50s GA40 with improved build quality.

The problem with pentodes is finding non-microphonic examples, and it seems only the boutique boys are prepared to test boxes of the things to select low-noise examples and back them up with a warranty. Most sound ringy and even if they start out quiet, they rarely stay that way.

The same can be said of oddball valves such as the ECF82 used in the original Vox AC10. Containing a triode and a pentode in a single enclosure, they can be a real drag. Also be aware that you can't replace a triode with a pentode because the pin connections differ. 🌀



The 6SC7 octal preamp valves in a 1950 5B4 Fender V Front Super



Power valves

Following the previous feature's focus on preamp valves, the spotlight now falls on the power valve – a major part of the sonic signature of any guitar amp. *G&B* explains all...

There are many misconceptions about power valves, and most stem from over-emphasising the sonic characteristics of the common types. Putting a pair of EL34s into a Twin Reverb will not guarantee you a classic British rock tone any more than installing 6L6s in a Hiwatt will make it countrified.

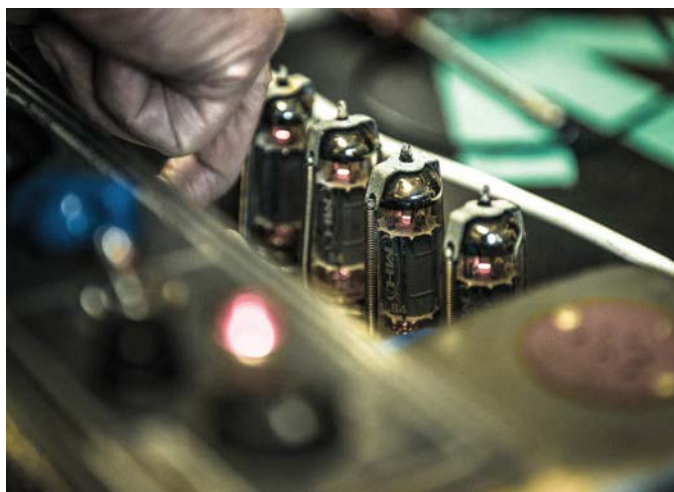
Granted, all the classic guitar amp power valves have sonic flavours, but the parameters are wide. To understand how power valves will sound, you need to consider the way they operate within an amp circuit, the design of the power supply and preamp, and the speakers and cabinet.

The classic blues and rock tones of the 60s were made with non-master volume amps, so the overdrive came from the preamp and power valves. This is the fat, touch-sensitive creamy tone many players love, but often there's not enough gain, punch or low-end tightness for modern rock styles.

Power valves that overdrive and compress nicely may sound good in retro-style amps, but aren't necessarily the best option in high-gain amps, where the ability to stay clean and deliver power are more valued attributes.

High-gain amps are designed to generate large amounts of gain in the preamp, and the power amp tends to run clean to maintain the tight and solid bass and fast transient response needed for more aggressive musical genres. If you can discern differences between power valves in these amps, they are more likely to be dynamic rather than sonic. Under normal playing conditions, it's unlikely you'll be able to push the master volume high enough for the characteristics to manifest.

Most valves work well in both classic and modern circuits, but much depends on the way



they're arranged and biased. Over the following feature, we'll give a broad overview of the various types of power valve used in guitar amplifiers and the different sonic characteristics of each of the combinations and biasing methods.

Triodes, tetrodes, pentodes

Various types of power valves are found in guitar amplifiers. We covered the workings of triodes, tetrodes and pentodes in the previous feature on preamp

thing by effectively removing the pentode's screen and suppressor grids from the circuit and making the valve less efficient.

Have you ever wondered why you can't simply pull the EL34s out of your Marshall and drop in KT66s to get a 'Bluesbreaker' tone? It's because the KT66 is a beam tetrode – just like the 5881, 6L6 and 6V6 valves traditionally used in Fender amps. Jim Marshall probably chose the KT66 because it was cheaper and more readily available in the UK.

Most valves work well in both classic and modern circuits, but much depends on the way they're biased

valves, and power valves operate on the same principles.

The earliest power valves used in audio amplifiers were triodes, and they are still highly regarded amongst hi-fi enthusiasts. However, power is very limited. Consequently, guitar amps with triode power valves are virtually non-existent, but many feature pentode/triode switching to reduce power.

Sometimes, this type of power switch is labelled full/half, but it's probably doing the same

swapping the output transformer, but KT66s draw more current, so you have to ensure your power transformer can cope with the demand. A rebias will still be required. KT66s also put out less power, so Eric's Marshall JTM45 combo was probably producing 30 watts rather than the 45 to 50 of a tweed Bassman.

The KT88 and 6550 are other examples of beam tetrodes found commonly in guitar and bass amps. Both have featured in various high-power Marshall, Hiwatt, Orange, Mesa and Ampeg amplifiers. The KT88 and 6550 are essentially beefed up versions of the KT66 and 6L6 and have been used with great success in bass amps and high-gain guitar amps.

Single-ended

The simplest way to configure the power stage of a valve amp is to use just one power valve. This is known as 'single-ended' operation and the power valve amplifies both the positive and negative phases of the audio waveform. Examples include the Vox AC4 and the Fender Champ, which are low-powered amps. The Carr Mercury is the best of all the modern single-ended amps we've tried.

Single-ended operation isn't particularly efficient, so some single-ended amps, such as the Gibson GA-8, were configured with two power valves working in parallel for higher output. It's known as 'parallel single ended'. The inefficiency, coupled with a tendency to produce ear-friendly even-order harmonic overtones when clipping, makes single-ended amps popular for practising and recording.

Push-pull

The vast majority of amps work in push-pull – meaning that one valve amplifies the positive side of

the cycle and the other amplifies the negative. For more power, the amp can have four, six or even eight power valves working together, so long as there are an even number of valves working on each side of the audio signal. This is 'parallel push-pull'.

In single-ended amps, the power valve is working all the time but in push-pull, power valves can potentially take a breather when they're not needed. Sharing the workload means push-pull amps are more efficient and powerful with less harmonic distortion.

Class distinctions

Typically, power-amp operating conditions are referred to as Class A and AB. These designations are descriptive rather than qualitative, so Class A is different rather than superior to Class AB.

Remember I mentioned how power valves can 'rest' for portions of the audio cycle? Basically, that's class AB and it's a relatively efficient setup that makes amps sound louder, firmer and punchier. Higher-power Fenders, Marshalls, Hiwatts and Mesa/Boogies all work in Class AB. In Class A, the power valves never shut down, so they're all working continually. All single-ended amps operate in Class A, as do many of the lower-power tweed classics such as the Deluxe models.

Contrary to popular belief, the Vox AC15 and AC30 are not Class A amps. This less-efficient configuration generates more heat and produces a creamier and softer overdrive with more harmonic complexity. Ultimately, it's not a binary thing. Amp designers manipulate DC supply voltage and bias to determine where on the A-AB spectrum an amplifier operates.

Bias view

Two methods of biasing power valves are used commonly – fixed and cathode bias. It's a complex subject, but fixed bias tends to be used in higher-power amps or when clean headroom is a priority. You'll find it in Fenders over 20 watts, Marshalls and most high-gain amps. A negative voltage from a power transformer

is 'half wave rectified' by a diode and connected to the power valve grids via bias and grid resistors. The bias is adjusted by altering resistor values, or by using a bias potentiometer.

Cathode biasing is simpler because it is, to an extent, self-adjusting. Just like the preamp valves, the power-valve cathodes are connected together and then connected to ground via a bias resistor and a capacitor wired in parallel. If you buy a new set of power valves for a cathode-biased amp, you can simply replace the old ones and you're good to go.

However, with fixed-bias amps you will need to check and adjust the bias with the new valves installed to ensure they're working within the recommended parameters. This is why straight swapping 'tone tests' with fixed-bias amps produce spurious results unless the amp bias is reset for each new set of power valves.

Both cathode-biased and fixed-bias amps can operate in Class A or AB. However, those biased in Class A (or thereabouts) are usually cathode biased. Therefore, Class A characteristics of harmonic richness and chime, soft low end and smooth distortion tend to be associated with cathode bias. Examples include tweed Deluxes, vintage Vox amps and modern classics from Matchless and Swart.

BUYER'S GUIDE

New, new old stock and used valves are readily available. Buying from an established valve retailer such as those below should allow you to get a refund if the valve fails within its warranty period. Some will test for low noise and microphony. Buying from private individuals may be cheaper, but is also riskier.



AMP VALVES AMPVALVES.CO.UK
WATFORD VALVES WATFORDVALVES.COM
COLOMOR ELECTRONICS 01403 786559
TUBE AMP DOCTOR TUBEAMPDOCTOR.COM
HOT ROX UK HOTROXUK.COM

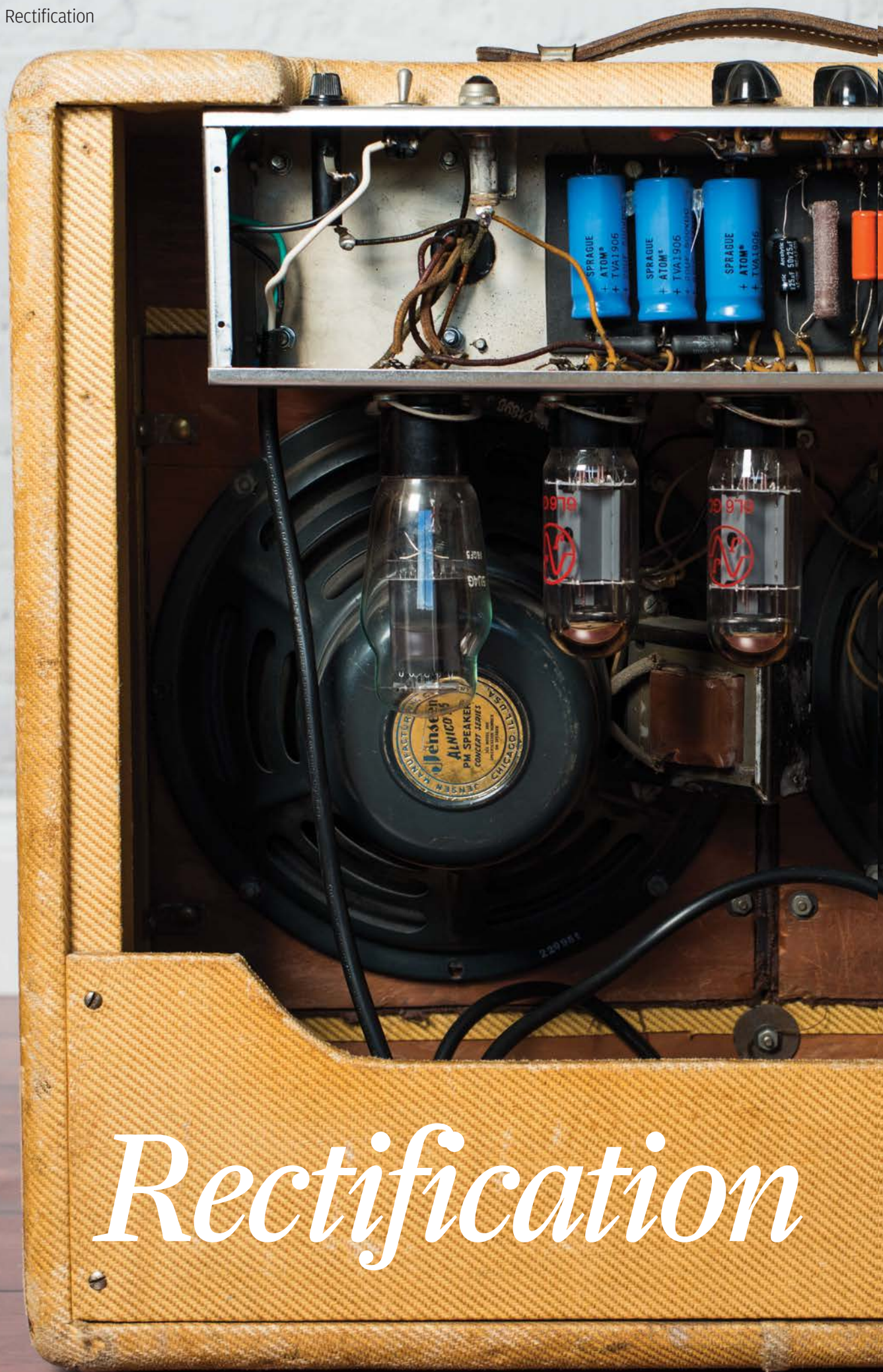
Fixed bias is invariably used for higher-power amps, where volume, punch and solidity are priorities for players who need this kind of backline. The tone tends to be more direct, less compressed, harmonically rich and touch dynamic. Fixed-bias Class AB amps also tend to have negative feedback, where a portion of the output signal is reintroduced to an earlier stage in the circuit. This further tightens the sound and dynamics, and prime examples are Marshalls, high-power tweeds, post-50s

Fenders, and all of the usual high-gain suspects.

Verdict

Telling you to buy EL34s for classic rock, 6550s for metal and 6V6s for blues would've been easy but misleading. Hopefully, we've shown that determining an amp's bias point, bias method and negative feedback gives far more reliable tone indicators than numbers printed on a glass tube or the brand on a box. Simple answers are lovely, but sometimes there aren't any. 





Rectification



No exploration of guitar amplification would be complete without a look at rectifiers. Here, we explain the twin functions of this vital, yet unheralded, amp component...

The word 'rectification' is used a lot in the pages of *Guitar & Bass*. We talk about valve rectifiers, solid-state rectification and even dual rectifiers, but what does it all actually mean?

The mains supply from the wall socket comes with an alternating current – AC. Guitar signal flowing through an amp also has an alternating current, so as far as your amp is concerned, the raw wall supply is both power and noise. Nevertheless, amps need power, so the 'noise' element must be eliminated. That means the wall AC has to be converted to a direct current – DC. No amplitude means no noise. For the most part, the conversion process takes place within a section of the amplifier known as the power supply.

Typically, a handful of components are used in the power supply. The mains is connected to a power transformer, which will have output taps for the various voltages needed for different functions within the amp.

The highest voltage taps, which are typically higher than the mains voltage, are connected to the rectifier. The rectifier's output connects to a network of dropping resistors and capacitors and, all being well, the power supply output will be clean and silent DC. Every guitar amp has a rectifier, and its role is twofold. It generally raises voltage levels and begins the AC to DC conversion process. The simplest 'half wave' rectifiers simply block either the negative or positive phases of the cycle. Full-wave rectifiers create a constant polarity, so the positive and negative cycles all become fully positive (or fully negative).

The rectifier output is actually a pulse, which is then smoothed

to flat DC by the filter capacitors. Although there are various methods of rectification, those found in guitar and bass amps fall into two broad categories – valve and solid-state. Let's take a closer look at each type.

Valve rectifiers

We've investigated pentode, tetrode and triode valves in previous features, but so far we haven't mentioned diode valves. Even so, many amplifiers will

control or suppressor grids, just a heater, cathode and anode.

AC from the transformer is connected between the anode and cathode. The heated cathode releases electrons and when the AC is in its positive phase, the plate attracts the electrons and current flows. When the anode is negatively charged, no electrons are attracted and no current flows. So diodes allow current to flow in one direction but not the other – just like a

triodes, pentodes and so forth. Incidentally, diode valves were also used to form logic gates, so they were pivotal in the development of computing.

Solid-state rectifiers

Solid-state (or semiconductor) diodes are just as old as diode valves. However, they remained less stable than valves for quite some time. Manufacturing technology improved and reliable long-life diodes were eventually developed, so solid-state rectification became commonplace in guitar amps.

Solid-state diodes are tiny in comparison to diode valves, many seem to last indefinitely and they simplify the manufacturing process because they don't need a separate heater supply and specially designed power transformers. They're also significantly cheaper. Ultimately,

*Every guitar amp has a rectifier.
It generally raises voltage levels and
begins the AC to DC conversion*

have one as the rectifier. Since all valves were diodes up until the triode was invented, they were simply called rectifiers. The simplest diode valves have no

non-return valve in a water pipe. That's why the term 'valve' was coined, and it's why Americans have a valid point when they say it's archaic when applied to



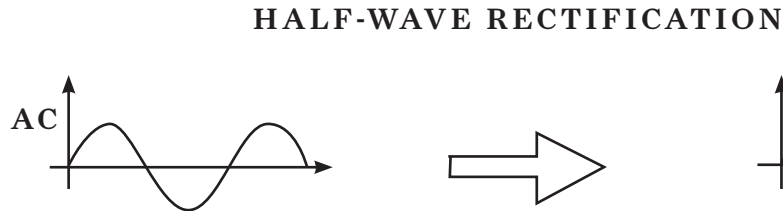
a solid-state diode has an anode and a cathode, just like a diode valve, and in a rectifier configuration they do exactly the same job.

Rectifiers and tone

It has often been said that rectifiers have no effect on tone because they are not in the signal path. The second part of that is true, but the first part is more complex, and much depends on how you perceive 'tone'.

Sound and tone are much like resistance and impedance. In some regards, they are the same, and the terms we use to measure or define them are often identical. However, tone, like impedance, is a more complex phenomenon.

My perspective is that tone obviously means sound, but it also encompasses dynamic response, breakup characteristics, transient response and bass frequency definition. While the rectifier doesn't necessarily influence the 'sound', it impacts everything else. The simplistic 'valves are good and solid state is bad' cliché doesn't apply to rectification. It all depends on the type of response you want from your amplifier. The technical



reduced. This is commonly called 'sag', a form of compression that can make an amp feel touch sensitive and smooth. It's a characteristic of countless vintage amps, and players who are used to rectifier sag often find it hard to play without it. The downside is that the bass end can be spongy and lacking in definition. In contrast, solid-state rectifier diodes have no internal resistance, so there is no current limiting and they can deliver a constant supply of voltage regardless of demand.

characteristics – in effect, playing the amp as well as the guitar.

Rectifier mods

Not all rectifier valves are equal. The common complaint about current ones is they're not as reliable or durable as vintage versions. What's more, they all put out different voltages, so one GZ34 will probably be different to another GZ34 – even if they're the same brand. Internal voltages have a bearing on tone, so the simplest mod is to try a bunch of rectifiers of the specified type.

Most rectifiers fit octal sockets, so some are interchangeable. Some players will replace the stock 5Y3 rectifier in medium-sized tweed amps with a GZ34 (aka 5AR4) to increase clean headroom and tighten up the bass. The 5V4 is another popular option, but you may want to have the bias checked with a new rectifier installed. If you want more sag, you can sometimes install a lower-rated rectifier valve. Some have tried 5Y3s and 5V4s in Princeton-style amps to make them less stiff, but if you're considering rectifier swaps, they must be compatible and capable of meeting the amp's current draw. The rectifier itself draws current from the power transformer, so make sure it's not going to be excessive.

Often, the safest way to determine these things is to consult old-fashioned tube charts. Total up the current draw of the preamp and power valves and compare that figure with the current rating of the rectifier valve. If the current draw exceeds

the maximum for that rectifier, you can't use it. If you really need to tighten up a valve-rectified amp, or simply avoid having to buy a valve rectifier again, you might consider installing a solid-state rectifier. Some, such as Weber Copper Caps, are designed to emulate the sag characteristics of the valves they're replacing, and they even have a warm-up time, so they're safe to use with non-standby amps. Others, such as the Mojotone Solid State Rectifier and the Yellow Jackets YJR, slot straight into a rectifier valve socket to provide solid-state rectifier performance without having to modify the amp.

Converting from solid-state to valve rectification is impractical because you'll have to install a new power transformer as well as another valve socket. Some builders simulate valve sag by soldering a 'sag resistor' between the output of a solid-state rectifier and the first filter capacitor. ⚡

The technical 'failings' of valve rectifiers are the very reason many guitarists prefer them

'failings' of valve rectifiers are the very reason that so many guitarists prefer them.

Michael Soldano explains the 'technical shortcomings' of valve rectifiers: "A tube rectifier has internal resistance. The more current that travels through a tube rectifier, the more the voltage drops. When the voltage drops, the power of the amplifier drops. The tube rectifier has the drawback of not being able to provide a consistent voltage when it's under load."

You may not notice any difference between solid-state and valve rectification when you're playing quietly. However, if you crank up a valve-rectified amp and hit a powerchord, the internal voltages drop with the extra current demand and the dynamic range of the amp is

Tighter and punchier amps are required for more aggressive styles such as modern rock and metal, so that's why amps with solid-state rectification are more popular with heavy-rock players. The transient response is quicker and the tone more consistent.

When valve rectifiers sag and voltages drop, there can be a subtle change in sound. Preamp and power valves may distort quicker at lower voltages with some diminution in treble response that adds a certain sweetness. As the transient attack is reduced and the level drops, you can hear a 'bloom' effect as held notes seem to sustain longer because volume increases as voltage levels recover. Experienced players who are into this kind of thing will dial in an amp to exploit those



Speakers





An often under-appreciated element of every electric guitarist's tone, the humble speaker is a vital component that colours and shapes the sound emerging from our amps. G&B explains all...

There is a world of difference between speakers intended for hi-fi or studio monitoring and those used in guitar amps. Flat and full-frequency response is undesirable for electric guitars and, instead, guitar speakers work best when colouring an amplifier's tone and dynamic response. Consequently, they come in various sizes and configurations – and understanding the variables is crucial.

How speakers work

Under string vibration, acoustic-guitar tops move backwards and forwards to create sound waves through compression and rarefaction. A speaker cone performs exactly the same function in pretty much the same way, but it's set in motion electronically rather than mechanically.

As passive devices, speakers have relatively few components, and you can refer to the diagram on the following page to identify the parts and see how they fit together. The top plate and the core are in physical contact with the magnet, so there's a strong magnetic field across the gap between them. The coil former and the wire coil 'float' in this gap without making physical contact, and this assembly is called the motor.

The amplifier output is connected directly to the wire coil. When current from the amp flows in the coil, it becomes an electromagnet and its magnetic polarity flips as the current alternates. The actual magnet's polarity is fixed, so it alternately attracts and repels the coil, causing the floating coil assembly to move back and forth. Since it's glued to the cone, the cone moves, too – and that produces sound waves.

Sensitivity (SPL)

I was in a band with a guitarist who used a Marshall head and 2x12 cab, but my old Vox AC30 with two original Celestion Blue speakers was considerably louder. Although the Marshall was the more powerful amp, the Blues had higher sensitivity than the speakers in the Marshall cab.

Sensitivity is measured by feeding the speaker one watt and measuring the sound pressure level (SPL) at a distance of one metre. Guitar speakers typically measure



somewhere between 93dB and 103dB, with 103dB being the most sensitive.

The G12 Greenbacks in the Marshall cab had a sensitivity of 97dB compared to the 100dB Blues. It might not seem like a lot, but every 3dB increase in sensitivity is equivalent to doubling an amp's power. The factors that determine sensitivity are the mass of the

If you're struggling to hear yourself over the drummer with a medium-powered amp, try installing a more efficient speaker

cone, voice coil and former, plus the length of the coil and strength of the magnet. Low mass and strong magnets bring high sensitivity.

If you're struggling to hear yourself over the drummer with a medium-powered amplifier, or you just want some more clean headroom, try installing a more efficient speaker. Conversely, less efficient speakers may allow you to crank up an amp that might otherwise be too loud.

Power handling

It's wrong to equate power handling with loudness, because all the figures give you is a guideline for matching speakers with amps. Common sense should tell you that a 50-watt amp is too powerful for a 25-watt speaker. In fact, a 50-watt amp will most likely be too powerful for a 50-watt speaker, because transient peaks always greatly exceed an amp's given power rating. You would be safer with a 75-watt speaker, or even two 50-watt speakers.

When pushed hard, guitar speakers can start to compress and add a gritty distortion that suits certain styles. Some speakers also lose cohesion in the low-frequency range, which is another characteristic that divides opinion. A heavier and stiffer cone, combined with increased damping and a wider-voiced coil, will enable a speaker to handle more power. However, the downside can be a tone that's bland and colourless, and feels stiff to play – plus lower sensitivity.

While pushing guitar speakers beyond their recommended capabilities can produce pleasing results, it's risky – and sooner or later you may end up blowing the speaker. This is a blanket term for a variety of unpleasant symptoms. You may notice that even at low volume, the speaker sounds grainy, scratchy or distorted. If the cone has been forced to travel beyond its limits, the cone can split, which results in fuzzy distortion – or classic Kinks guitar tones according to legend.

Prolonged overheating can cause the material fixing the coil in position to break down and the coil to unravel. With such a tight gap, the coil can rub against the edges, which produces more undesirable sounds.

The worst-case scenario is a coil that has overheated and burned out. When this happens, you'll get no sound at all and you should turn off your amp immediately or you may end up blowing that, too.

If you suspect a blown coil, set a multimeter to its lowest resistance setting and look for a reading across the speaker terminals that more or less matches the given speaker impedance. Alternatively, touch the terminals of a nine-volt battery against the

speaker terminals. If you can't get a resistance reading – or a popping sound from the battery – you can reasonably conclude that your speaker is toast. Your options are to have it re-coned or replaced.

Impedance

The voice coil is basically a wire-wound resistor, so all speakers have a load impedance rating given in ohms. The figure is nominal since the coil's resistance is not constant across the frequency range. The same model of speaker with different impedance ratings will have voice coil variations in inductance and mass. According to Celestion's Ian White, 16-ohm versions are typically brighter than their 8-ohm counterparts.

Amplifiers will have either a fixed or switchable output impedance and the speaker impedance should match the amp's for optimum performance and tone. An amp with fixed output impedance rated at 100 watts into a 4-ohm speaker will put only 50 watts through an 8-ohm speaker.

The amp will also run cooler and cleaner, so an improvement in tone doesn't necessarily accompany the drop in power. Connect the same amp to a 2-ohm speaker and it will attempt to run at 200 watts before possibly burning itself out.

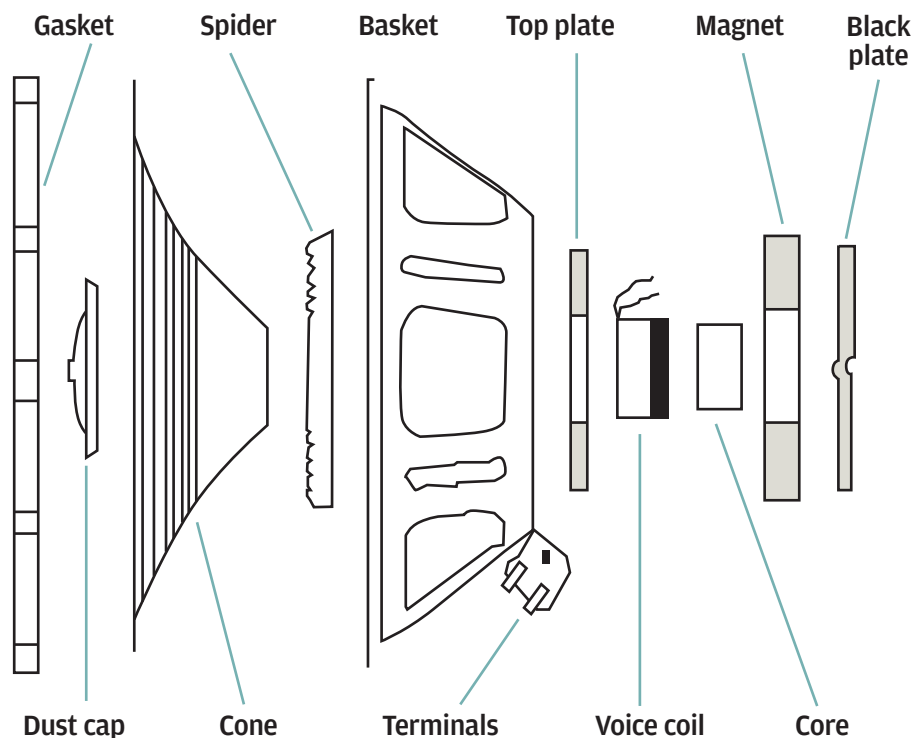
Like resistors, speakers can be combined in series or parallel. Two 8-ohm speakers in series present a 16-ohm load to the amp. Two 8-ohm resistors in parallel present a 4-ohm load. The rule is that you can go higher than the specified rating – if you have to – but you must not go lower.

Resonance

Speaker cones are not unlike drum skins, and they have a natural resonance frequency that plays a large part in voicing the speaker. Bass speakers will have a lower resonant frequency, and guitarists such as Paul Kossoff preferred them for a warmer and more rounded tone. Some drop-tuned metal players also prefer a lower resonant frequency. A light and loose cone suits players who like rootsy and retro tones because they tend to be more dynamically responsive and you'll hear more harmonic overtones. However, when pushed hard, the bass can sound blurry and indistinct and the upper frequencies may get harsh.

Manufacturers typically coat the corrugated edges of the cone with a silicon substance to control response by limiting cone excursion. This process is called doping and, in addition to tightening the bass, it minimises odd mechanically generated harmonic overtones called 'edge yowl' or 'cone cry'.

Doping reduces the resonance peak at the upper cut-off frequency for less chime



and complexity, but also means a reduced likelihood of harshness. Doped speakers are popular with rock players who prefer high gain and high volume. When buying speakers, consider the resonant frequency and the amount of doping to determine which ones will suit your needs.

Incidentally, the term 'breaking in' a speaker actually refers to loosening up the edge for slightly deeper lows, smoother treble and a more dynamic feel. You can accelerate the process by playing music through the speaker or using a noise generator; but simply playing through it works fine, too.

Cones

Almost all guitar speaker cones are made from paper pulp, but that doesn't mean they all look and sound the same. Ever-increasing power, and a tendency for guitarists to

not necessarily an issue. Consequently, some players have discovered that the smooth cones of early Jensens, ELACs and so forth provide interesting sonic characteristics. Modern manufacturers, such as Warehouse, are now offering smooth cone options for players who are into early-40s and early-50s electric jazz and Chicago blues. Warehouse describes the smooth-cone tone as "more vintage, woody, smoky and organic". You'll also get a bit less treble and quicker breakup.

Magnets

Three types of magnets are used in guitar speakers. From the early 50s, most had alnico magnets, but as the cost of the cobalt used in the alloy sky-rocketed, manufacturers moved to ceramic magnets. The latest neodymium magnets offer the highest magnetic strength-to-weight ratio. Ascribing sonic characteristics

to magnetic materials is problematic because so much depends on other elements, such as doping and cone design, as previously discussed. For instance, the Jensen P12R

and Celestion Blue both have alnico magnets and are even a similar colour, yet they sound totally different.

With that caveat, I would associate alnico speakers with chiming harmonically complex highs and soft bass. Ceramic speakers often have tighter and quicker lows, coupled with more upper-midrange bite and punch, but rolled-off highs. Neodymium combines elements of alnico and ceramic. 

Speaker cones are not unlike drum skins, and they have a natural resonance frequency that plays a large part in voicing the speaker

overdrive their amps, forced speaker manufacturers to stiffen their cones as well as their edges.

These days, most cones are ribbed for increased stiffness without increased weight. This reduces speaker breakup and prevents the cone from warping, so it's all good, right? Well, not entirely. Lots of early guitar speakers had smooth cones, and now that low-power amps are so popular, their limitations are



Attenuators

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YOUR OWN
ATTENUATOR!**
VISIT
[BIT.LY/ELEVENATOR](https://bit.ly/elevanator)
FOR THE DIY
GUIDE

**BRIGHTEN
ELEVENATOR**



All amps have sweet spots where they sound best, but it's not always possible to crank them up to gig-level volume. That's where attenuators come in. *G&B* explains...

It took electric guitarists a very long time to warm to the idea of attenuation. It's debatable whether the attitude change can be attributed to engineers continually telling us to turn down, increasing deafness and tinnitus, or the gradual realisation that cranking up 100-watt heads at pub gigs is no longer deemed acceptable by the general public.

Attenuators are generally used to make loud and powerful valve amplifiers quieter. Turning down the volume of a guitar amp achieves the same effect, but changes the sound and dynamics, too. Some would suggest using lower-power amps instead, but if you prefer the tone of a flat-out JCM800 or tweed Bassman, 18-watt Marshalls and 5E3 Deluxes won't deliver the goods.

If you always want to hit your amp's sweet spot but sometimes need to play at lower volume levels for smaller gigs or home practice, you'll have to place an attenuation device between the amplifier's output and the speaker. There are various types of external attenuator but, generally speaking, they transform excess electrical energy into heat or mechanical energy.

Tone changes

In an ideal world, attenuators would allow you to use any amp at any volume level without any adverse effect on sound quality or reliability. In practice, the use of attenuation does change tone, but blaming the attenuator isn't always justified.

Our perceptions of toppiness and bassiness change depending on volume level. So changes in tone that we may perceive when the amp signal is attenuated may not be a characteristic of the attenuator, but rather a function of volume and the way human

hearing works. This is why some attenuators provide bass and treble compensation. If you want to research this, search online for Fletcher-Munson curves and equal loudness contours.

Reliability

Getting back to the reliability issue, attenuators have sometimes been blamed for amplifier failures. While this may be justified in some cases, it's also worth remembering that attenuators allow us to run amplifiers flat out for extended periods of time. Let's use a car analogy and consider which would last longer – the car that's driven carefully and rarely exceeds the speed limit, or the car that's driven flat out all the time.

The point is you can expect your valves and components to

fail sooner if you continually use your amp at or near its limits. You might also consider it worth having your amp serviced thoroughly, to give it the best chance of survival, before you begin using an attenuator.

Matching up

Impedance matching is also important for reliability. Just as an output transformer with an 8-ohm output impedance needs to be connected to an 8-ohm speaker, that same transformer will need to see an 8-ohm load from any attenuator.

It's also vital to ensure that the power rating of an attenuator is adequate for the amplifier power rating. You wouldn't connect a 30-watt speaker to a 100-watt amplifier, and attenuators are no different. Always check the specs

and remember that the peak power of an amp always exceeds its stated power. So you can expect a 100-watt amp to blow up a 100-watt attenuator.

Lastly, ensure you use speaker cable to make connections between the amplifier and the attenuator, and the attenuator and the speakers. External attenuators can be active or passive and both can be reactive or non reactive.

Passive attenuators

This type does not require an external power supply. Most feature networks of high-power resistors, and purely resistive attenuators are sometimes referred to as power soaks. Some passive attenuators incorporate fans or bulbs that are powered by the amplifier signal.

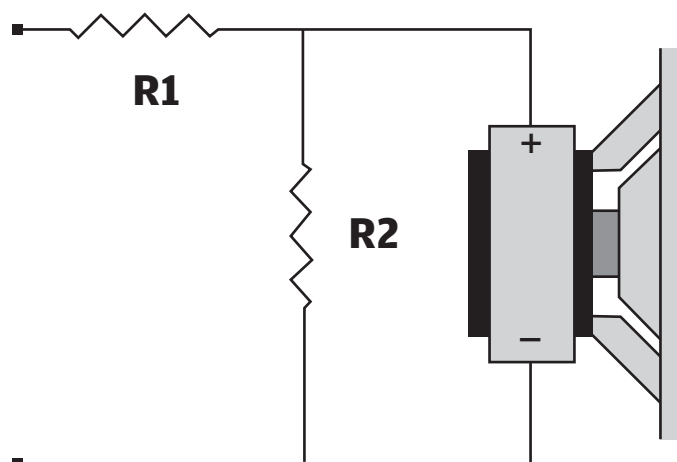
Passive attenuators can also be made using step down transformers with multi-taps for various output levels. This method relies on changing the impedance the power valves 'see', and some of the power travels back to the amplifier. As more attenuation is applied, the amp's frequency response can change, and there are reports of damage being caused to amplifier transformers with transformer-loaded attenuators.

Active attenuators

These attenuators require external power because they incorporate an amplifier stage. The signal from the guitar amp 'sees' a passive dummy load and a small part of the amp signal is then fed to an onboard amplifier that feeds the speakers. The Bad Cat Unleash and Fryette Power Station are good examples.

The big advantage of active attenuators is that they can be used to boost as well as cut the signal being sent to the speakers.

The big advantage of active attenuators is they can be used to boost as well as cut the signal



Most switchable passive attenuators are based on a simple two-resistor circuit, known as the L-Pad. Resistors R1 and R2 dissipate excess electrical energy as heat and the values can be adjusted to achieve various levels of attenuation while maintaining a constant load for the amplifier output. Alternatively, L-Pads with rotary controls are available with various impedance and power ratings. These are also used in commercially manufactured attenuators and allow continually variable control

POWER SCALING AND ATTENUATION

Although they are intended to achieve the same result – namely reducing level without compromising tone or dynamics – the methodologies are quite different. In a nutshell, power scaling works by varying the B+ voltage inside the amp. Unlike using a variac, this allows the full heater voltage to be maintained at all settings.

Power scaling can be applied throughout the amp, so all the valves produce less power. Alternatively, it can just be applied to the power valves, but a master-volume control may be required to prevent the preamp from driving the power stage too hard. Many amp builders are now using power scaling, and a big advantage over using external attenuators is that the life of the valves might be extended rather than reduced.



So, in addition to taming high-power amps, they can increase the volume level of small and medium-power valve amps, turning them into viable and versatile gigging tools.

Non-reactive loads

Passive-resistor networks fulfil two functions. They present the amp with a resistive load with the same rating as the speaker and they convert electrical energy into heat. Although a resistor and a speaker may both be labelled 4, 8 or 16-ohm, the speaker's rating is only nominal because it is not constant across the frequency range. This is why we refer to speaker 'impedance' rather than 'resistance', even though ohms are used for both.

In contrast, the value of the resistor remains constant regardless of the frequency content of the signal. So purely resistive attenuators are both passive and non-reactive. This is why some players find simple resistive attenuators adversely effect dynamic feel and tone.

The relationship between the output of an amp and the ever-shifting impedance of a speaker is complex and it contributes to the playing experience. If you remove the reactive element from the equation (ie, the speaker), your amp and cab will no longer interact in the same way.

Reactive loads

In reactive circuits, there is usually a combination of resistance, inductance and

capacitance. Guitar circuits are an obvious example, because pickups are both resistive and inductive, and there is always capacitance in a guitar cable. This is one reason why pickup DC readings can be relied upon only up to a point.

There are various ways to make a reactive attenuator. The easiest is to connect resistors in series and parallel with the speaker in order to preserve some of the speaker's reactive qualities. Weber MASS attenuators have coneless speaker frames. The voice coil is retained, so it converts electrical energy into mechanical energy, but is essentially a silent speaker. Dummy-speaker drawbacks are that the energy conversion is less efficient, so the dummy speaker dissipates more energy as heat – much like a non-reactive resistor – and the absence of a cone means the reactance is slightly different to that of a conventional speaker. Instead, an electrical fan or lightbulbs can be used to add reactance to resistive load attenuators, and since they are powered by the amp signal, such devices can still be called passive.

Speaker efficiency has a big effect on volume, so it's possible to achieve attenuation simply by using less efficient speakers. Repeatedly changing speakers isn't viable, but adjusting the flux density of the magnet is. Impedance and power handling are unchanged, but lower flux density makes the speaker less efficient and quieter. 

BUYER'S GUIDE

When choosing your attenuator, you must consider power handling and impedance – as mentioned earlier in the piece. Also decide whether a stepped attenuator control with preset increments will be okay for you, or if you'd prefer the finer range of a continually adjustable control. Other potentially useful features may include equalisation controls and impedance switching. Dummy load switching will safely silence your amp and the direct output can be routed to a power amp for re-amping.

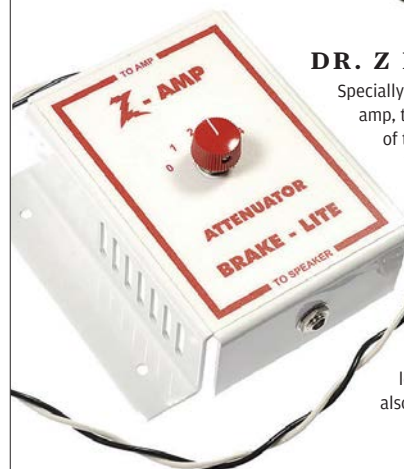
EMINENCE REIGNMAKER FDM £159

US manufacturer Eminence offers two speakers with flux density modulation. The Reignmaker is the British-voiced model and the Maverick is voiced for American tones. Available in 8- or 16-ohm impedance with 75-watt power handling, you can adjust the attenuation level by turning the rotary control at the back of the speaker itself.



DR. Z BRAKE-LITE £180

Specially designed to mount inside a combo amp, the unit is attached to an inside wall of the cabinet using two fixing screws. There are fixed wires and a jack to plug into the speaker out of the amp, and a jack socket where you can plug in your speakers. It works with valve amps up to 45 watts and can be used with 4, 8, or 16-ohm loads. A standalone version is also available.



WEBER MASS 100W \$257

Loaded with a 'silent speaker', Weber's most robust attenuator has a main volume knob and three-position treble compensation switch. The line out has a bypassable three-band tone stack and separate volume control. Impedance options are 2, 4, 8 and 16 ohms and the attenuation is continuously adjustable from -3dB to over -70dB. It can also be used as a dummy load and there's an attenuation bypass switch.

BAD CAT UNLEASH £349

This is one of those new-fangled active attenuators with a built-in 100-watt Class D solid-state amp. It's small and light enough to throw in a pedal bag, has two switchable level presets, direct out and an effects loop. This little beauty will make loud amps quieter and low-powered amps much louder.







Boosts

Since British players began trying to replicate US amp sounds in the 60s, boosting volume or frequency without unduly colouring tone has been an ongoing quest

When discussing landmark guitar tones, important factors are often overlooked. For instance, nobody ever seems to consider the ambience of the room in which the amp was placed, or indeed the microphone that was used to capture the sound. Most surprising is the way treble boosters have been written out of the history books.

Treble boosters were widely used by many of the big-name players during the 1960s and 1970s. Eric Clapton's sound on John Mayall's 'Beano' album was a game changer, but his Dallas Rangemaster treble booster was almost as crucial as the Les Paul and Marshall combo.

Then came Marc Bolan, Rory Gallagher, Ritchie Blackmore and Tony Iommi. Brian May has never stopped using treble boosters with his AC30s. He has been associated with various models, but one thing is certain – without a treble booster, even Brian May wouldn't sound like Brian May.

Bluesy boosts

It's perhaps no coincidence that these famous players originated from our side of the Atlantic and they all used British amplifiers.

By the mid 1960s, the brownface and blackface Fender amps that American players were using were plenty bright enough. In contrast, early British guitar amps sounded comparatively

dark – especially pre-top boost Vox amps.

Consequently, British players would struggle to replicate the sounds they were hearing on American recordings without buying a very expensive Fender

become obsolete once amp manufacturers figured out how to extend treble response.

Treble boosters lingered on because guitarists discovered they could be used to push the front ends of valve amps into cutting

boosters to choose from. John Hornby Skewes offered one to complement and brighten up its Zonk Machine fuzzbox and Ritchie Blackmore used it. Meanwhile Orange, Winston and Vox made them, too, but they're somewhat obscure.

Ultimately, the Dallas Rangemaster overshadows them all, so what made it so special?

The Rangemaster features a single OC44 germanium transistor, and the circuit is configured to provide a high-pass filter as well as a boost of up to 24dB. The boost isn't applied evenly across the frequency range, so if you play a low E, the fundamental frequency remains more or less at unity gain. As you play higher up the neck, the treble

booster effect becomes more pronounced, and it will be at its most extreme when you're soloing in the higher registers.

In addition, the way the germanium transistor was biased is crucial to the operation of the Rangemaster circuit. Biased near to its cut-off, the transistor starts to compress the signal more on one side of the waveform than the other. This adds gentle asymmetric overdrive that turns into distortion as higher signal levels push the transistor into full cut-off.

The way the Rangemaster interfaces with the grid of an amp's first preamp valve also differs from a regular guitar output. The Rangemaster's



The Klon Centaur is for many guitarists the holy grail of boost pedals. It has long been out of production, but has spawned many clones, and second-hand prices remain eye-wateringly high

Treble boosters were fundamental to the evolution of blues-rock and classic metal tones

amp. Treble boosters, however, offered a convenient and affordable solution.

These treble boosters were built into enclosures designed to sit on top of amps, but they were still connected between the guitar output and the amp input. Had their only effect been to make British amps sound a tad brighter, they would have

but creamy valve overdrive and sweet, singing sustain. As such, treble boosters were fundamental to the evolution of blues-rock and classic metal tones.

Classic treble boosts

There were relatively few guitar effects manufacturers during the mid-to-late 1960s, so there weren't many treble

output impedance is much lower and never goes above the 10k value of the output potentiometer. It's thought that this causes the valve to overdrive more smoothly.

Fall from favour

By the early 1980s, treble boosters were becoming a thing of the past. Players could get heavy overdrive and sustain using active guitars with built-in preamps. Hot-wound passive pickups, such as Seymour Duncan's Quarter Pounder and Invader and the DiMarzio Super Distortion, replaced plenty of vintage-style pickups.

Pedals were changing, too, with products such as the Ibanez Tube Screamer, DOD 250 and Boss OD-2 simulating a more valve-like overdrive. Players discovered

tended to sound murky, and touch dynamics didn't even come into it. But how can smooth and sustaining overdrive be combined with dynamic range, wide-open frequency range and tones that respond to playing touch and the volume knob on your guitar?

In addition to treble boosters, old-school players used tape echo and reel-to-reel tape recorder preamps as signal boosters. But what would happen if you used a high-fidelity, low-noise preamp rather than a crude old treble boost? Thus the Klon Centaur came to pass and, forsooth, nothing was ever the same again.

The Klon employed a charge pump power supply that doubled the operating voltage for extended clean headroom. The signal was also split, with selected

The Klon is to contemporary boosts what the Rangemaster was to treble boosts

that the best results were often achieved when combining diode clipping and boost from these overdrive pedals with an already overdriving valve amp. The overdrive also added compression and focused the sound in the midrange by rolling off bass and treble. Amps with multiple gain stages, master volumes and powerful equalisation sections were generating far more overdrive and distortion than vintage-style designs.

Back to boosts

The goals of effortless overdrive and endless sustain had been achieved, but not everything was hunky dory on planet guitar. By the end of the 1980s, some players had grown jaded with the shredding scene, complaining that guitars and amps had ceased to be dynamic musical instruments. High-output guitars had become mere tone generators and the hot-rodded amps were effectively tone shapers, but neither had much in the way of 'tone'.

Overwound pickups lacked clarity and 80s high-gain amps often had an artificial and processed quality. Even the overdrive pedals of the era

frequencies being sent into clean and overdrive paths to then be re-combined according to the user's preference.

Perhaps the most discussed, dissected and mimicked of all effects pedals, the Klon is adored and belittled in equal measure, but the only things you can reasonably gripe about are their scarcity and the astronomic used prices. The Klon is to contemporary boosts what the Rangemaster was to treble boosts.

Quality clean-boost pedals are now commonplace and popular examples include the Durham Sex Drive, Keeley Katana, Z. Vex Super Hard On and Fulltone Fat Boost. These boosts can raise signal levels to the realms of high-output humbuckers without any resulting loss of dynamic response or clarity.

You may also find that guitars and amps feel more touch sensitive and guitar volume controls have a wider usable range. Treble boosters were generally left switched on and many contemporary players are doing the same with clean boosts to stack them with overdrive and fuzz pedals. Isn't it funny how some things eventually come full circle? 🔄

BUYER'S GUIDE

Vintage-inspired treble boosters will colour your tone, but in contemporary stompbox form, you have the option to switch them off. Modern boosters generally focus on preserving or even enhancing the natural tone of your guitar and amp. Others replicate the circuitry of specific tape-echo preamps for more specialised boost flavours, and boost features are often housed together in pedals alongside reverb, tape echo and tremolo effects. Also consider compressors and low-gain overdrives.



BRITISH PEDAL COMPANY RANGEMASTER £175

If you want authentic looks as well as tone, you'd be hard pressed to beat this one for attention to detail. It's wired point-to-point on tag strip with authentic-spec components. The downsides are the same as the originals - no footswitching and a fixed frequency range.



EHX LPB-1 £23

Mike Matthews introduced his first booster in 1968 in an attempt to produce a distortion-free sustainer. Originally, the LPB-1 was housed in a box with a protruding jack that plugged straight into a guitar. The current production version is billed as a spot-on reissue, but it's housed in a stompbox enclosure with a footswitch and a boost control.

JRAD ARCHER £129

The original Klon has long been out of production and there are now countless clones. The JRAD Archer probably has the best claim to being the closest thing to a Klon because it was developed in collaboration with Bill Finnegan, the man behind the originals. Most agree it gets very close indeed for less than a tenth of the price.



XOTIC EFFECTS EP BOOSTER £115

Jimmy Page, Eric Johnson and Eddie Van Halen famously used the Echoplex EP3 preamp as a boost, but few would want to carry a bulky tape echo to gigs these days. The EP Booster is a mini pedal containing an EP3-style preamp with internal boost frequency and EQ setting switches.

Fuzz





Fuzz wasn't the first guitar effect, but it's probably shaped the sound and evolution of guitar music more than any other. Get ready to feel the buzz...

Have you ever wondered what makes fuzz different from distortion and overdrive? In its purest form, the fuzzbox is intended to create square-wave clipping, and technicians use this term because it's what the waveform looks like on an oscilloscope. It occurs when the harmonic overtones are more or less equal in volume to the fundamental frequency.

There is no single method to square the wave. Some designs allow the circuit to run out of headroom (voltage) so the loudest parts – ie, the fundamental frequency – cannot be amplified beyond a certain point and the transient peaks are sliced off. This evens out the amplitude of the fundamental and the harmonic overtones.

Diodes can also be used to force signal clipping at a chosen voltage. Some pedals combine both methods, and designers have even used square-wave generators, but the results are similar enough to fall under the fuzz umbrella regardless.

Things get more interesting when you start investigating dynamic response, picking definition, sustain and upper-octave effects because all fuzzboxes have unique characteristics – often inspiring cultish levels of devotion. Some believe fuzz is at its best without the softening effect of valve overdrive; so plugging into a clean valve amp, or even going direct into a mixer or interface, allows you to hear the full effect. This brings us back around to the fathers of fuzz tone.

Hip to be square

It's accepted that the Maestro FZ-1 was the first commercially available fuzzbox. Its origins can be traced to a Marty Robbins

country track called *Don't Worry*, featuring guitarist Grady Martin on a Danelectro six-string bass plugged directly into a valve mixing desk.

During the session, one of the console transformers started to fail, making the Danelectro sound distorted and fuzzy. Everybody liked it so much they even recorded a solo with the fuzzed-out bass. The record was a huge hit, and when Nancy Sinatra booked into the studio shortly after, she requested the same sound. Unfortunately, the 'magic transformer' had failed

riffs on the legendary Stones hit (*I Can't Get No*) *Satisfaction*, released in 1965. The Beatles, Frank Zappa, The Ventures and a handful of garage-band guitarists had already experimented with fuzz, but after the initial 1962 production run of 5,000 units, Gibson shipped only three pedals in 1963 – and none in '64.

After *Satisfaction*, everybody wanted to know how to get that tone, and soon Maestro sales were in the tens of thousands. Even so, interest in fuzz had been building on the London studio scene for a few years and many

also to have made fuzzboxes for Jeff Beck and Big Jim Sullivan around that time.

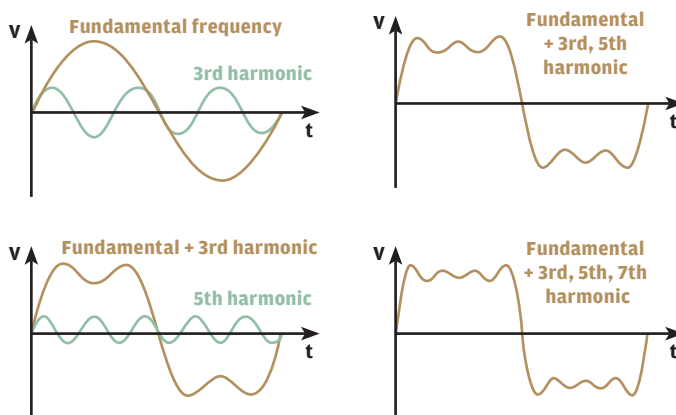
Mayer's upgrade on the raspy and percussive Maestro set a new standard for fuzz tone, and in the fuzz frenzy that followed everybody wanted some of the action. Rather than get into circuit specifics, it's probably more illuminating to associate various players and their landmark recordings with the fuzzboxes they used.

Gary Hurst had already built some custom fuzzboxes, and teamed up with the Macari brothers to design the Sola Sound Tone Bender. The MkI featured on *Rubber Soul* by The Beatles, as well as *Heart Full Of Soul* by The Yardbirds, featuring Jeff Beck. But the sound is most commonly associated with Mick Ronson, who used a MkI throughout his Bowie years.

Some players prefer the MkII and MkIII versions, with most of the MkIIIs carrying the Vox label. The Tone Bender was a hugely influential design, and many of its competitors – including the Marshall Supa Fuzz and the JHS Zonk Machine – were virtual clones. Some things never change in the pedal world.

The Dallas Arbiter Fuzz Face has an equally important place in the fuzz pantheon. Based on a Schmitt-trigger squaring circuit, the Fuzz Face was about as simple and cheap as a fuzzbox could be, but they were troublesome units. Good ones can sound sublime, as Eric Johnson and Stevie Ray Vaughan have demonstrated, but originals were wildly inconsistent.

Jimi Hendrix obviously thought so, because he asked Roger Mayer if he could sort out his Fuzz Faces. Mayer took a good-sounding example back to his workshop for analysis. His



All fuzzboxes have unique characteristics – often inspiring cultish levels of devotion

completely in the interim, so studio engineer Glenn Snoddy teamed up with his friend Revis Hobbs to recreate the effect using transistors. They pitched the idea to Gibson and the first fuzz appeared as an effect built into a bass in February 1962.

A floor-pedal version, known as the Maestro Fuzz-Tone FZ-1, followed soon after, but the product was a commercial failure, until Keith Richards came up with one of the definitive fuzz

of the most iconic fuzz designs would subsequently be developed in the UK.

Fuzz frenzy

A 1962 Ventures track called *The 2,000 Pound Bee* featured a custom-made fuzz, and so impressed a young Jimmy Page that he asked an electronics engineer called Roger Mayer to make him a fuzzbox with more sustain and smoother decay. This was in 1964, and Mayer claims

idea was to blueprint the circuit in order to make it stable and reliable, and before long Mayer had become Hendrix's dedicated full-time tech. Many of the fuzzboxes Mayer later produced under his own name were based on the Fuzz Face circuits he'd modified for Hendrix.

In their elements

Some people prefer the earlier Fuzz Faces with germanium transistors for their warmer and fatter sound. The brighter, more cutting sound of the later version, with BC108 silicon transistors, can be heard on *The Dark Side Of The Moon* by Pink Floyd.

Meanwhile, in America, Mosrite's Fuzzrite was used on Iron Butterfly's *In-A-Gadda-Da-Vida*, and is generally thought to be the fuzz tone on Sergio Leone's spaghetti western soundtracks. Out in Japan, Shin-ei developed the Super Fuzz with its upper-octave effect. Pete Townshend used this huge and brutal-sounding fuzz pedal on The Who's *Live At Leeds* album.

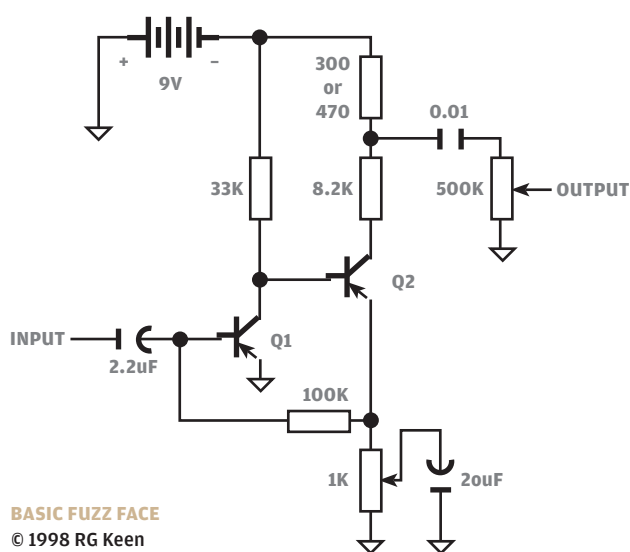
Fuzzboxes evolved as the 60s wore on, moving from crude and raspy sounds to smoother, fatter and more velvety tones. Perhaps the ultimate example of the latter-day fuzzbox is the Electro-Harmonix Big Muff, so beloved

of J Mascis, Billy Corgan, Jack White and even David Gilmour, who used a Big Muff during the late 70s.

In the days before cascading, high-gain valve preamps, fuzzboxes were the only way to get serious sustain. As the nature of fuzz developed, the music featuring it morphed from the garage-band pop of the mid 60s into psychedelic blues, proto metal, prog rock, jazz fusion, shoegaze and alternative rock. Fuzz has never really been out of style.

These days, most of the classic models have been reissued and specialist makers such as Analogman and D*A*M build fastidiously accurate replicas of the original circuits. DIY pedal builders have also found that fuzz pedals are usually quite simple to build, and commercially made kits are readily available.

For those players who can't choose between spluttery old-school sounds and creamy sustain, many of the modern boutique fuzzboxes have replaced preset components with controls on the exterior of the casing. Therefore, these days, there's no need to choose between one type of fuzz or another, because you can have every variety of the effect in the same enclosure. ⚡



BASIC FUZZ FACE
© 1998 RG Keen

The early PNP germanium transistor fuzzboxes were wired with a positive ground, which means you can't power them with a conventional power supply along with a bunch of negative ground pedals. You'll need a supply such as the Voodoo Lab Pedal Power 2 Plus, which has electronically isolated outputs. You may also like the voltage sag feature of this supply, because it simulates the effect of a worn battery and sweetens the fuzz tone. Fuzzboxes with NPN transistors can run alongside most modern pedals with no difficulties

BUYER'S GUIDE

Whether you want old-school square waves or the stuttering, spluttering and oscillating aural assault of modern fuzzboxes, it's good to know there are plenty to choose from. Here are four of our favourites...



Z.VEX FUZZ FACTORY £129

Muse's Matt Bellamy has this five-knob fuzz built into his guitars. Although it features two NOS germanium transistors, the circuit is not modelled on any classic fuzz. Controls include vol, gate, comp, drive and stab.

FULLTONE 69 MKII £155

A popular Fuzz Face replica that adds a range of features to the stock germanium transistor circuit. These include a variable input level control and contour, which adds midrange gain. An internal trimmer sets the bias of the transistors to fine-tune the sound. The new Dunlop Fuzz Face Mini pedals are more affordable; visit www.jimdunlop.com to find out more.

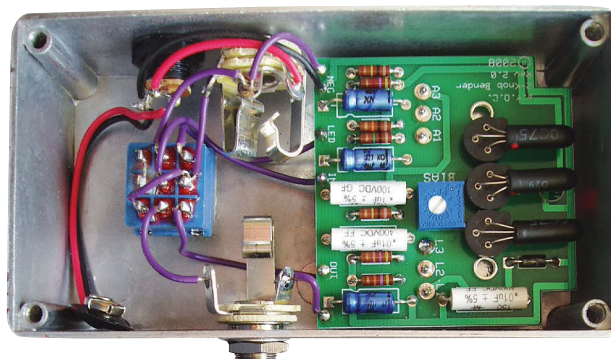


DEATH BY AUDIO SUPERSONIC FUZZ GUN £230

A new-school pedal, the Supersonic Fuzz Gun was created to produce an immense range of extreme, yet also usable fuzz sounds, ranging from extremely harsh and 'dirty' tones to all-out white noise, feedback and self-oscillation, alongside warm traditional fuzz. Controls include bias, density, filter, level and a gate/oscillation switch.

BYOC E.S.V. 2-KNOB BENDER £66

There are plenty of Mk11 Tone Bender clones on the market, but this one stands out from the crowd because you can build it yourself. We actually put one of these together a few years back, and it sounded absolutely fantastic. The kit features selected NOS Philips OC76 germanium transistors and carbon comp resistors. There's even a bias trim pot to fine-tune your tone.



Compression



At its simplest, compression reduces dynamic range – that is, it makes quiet notes louder and loud notes quieter. Used correctly, it has plenty of musical applications, yet it's often misunderstood. Here's *G&B's* guide for guitar players...

For many of us, compression remains shrouded in mystery. We more or less understand what it's for, but we're not quite sure how or where to use it.

Don't feel bad, because there are professional audio engineers who find compression just as confusing as guitarists – although they'd never admit it. As with all effects, there is no 'right' way to set a compressor, but lots of us get stressed about doing it wrong.

In this feature, we're taking a close look at compressors, how they work, what they do and ways that they can help your tone. Even if you've never felt the need for one, it's worth considering that every guitar sound you have ever heard on record has probably gone through two or three stages of compression during the production process.

Lowering the roof

The difference between the quietest and loudest parts of a piece of music is its dynamic range. With orchestral music and jazz, the dynamic range can be very wide and dynamics are

viewed as an integral part of musical performance and expression. However, as music production became increasingly sophisticated, it quickly became apparent that wide dynamic range was creating problems for broadcasting and recording media. Audio compressors were initially developed to perform an entirely technical function – to restrict dynamic range and avoid overloading transmitters, disc cutters and tape.

Simply put, audio compressors are like automatic volume controls that can 'turn down' peak levels and reset themselves as soon as the peak has passed.

Every guitar sound you've ever heard on record has probably gone through two or three stages of compression

They weren't designed to provide an 'effect' as such, and high-quality compressors were once considered to be those that could control dynamics unobtrusively.

That all changed in the 60s, possibly because so many pop and rock musicians felt their songs sounded better on the radio than they did on record.

No doubt somebody realised that broadcast compressors were changing the sound of records for the better by making them louder, punchier and more exciting.

But consider that last sentence. How can a device that limits volume actually make something seem louder as a result? Think about the dynamic range as being a scale from one to 10, with

10 being the loudest. Let's say the volume peaks reach 10 and are louder than the average level by a factor of three.

Once the peaks are flattened, you can theoretically raise the average level by a factor of three without exceeding the previous maximum. Our perception of loudness is based on the average level and not peak levels, so by making up the gain of a compressed signal, we make it seem louder to our ears, even if the peak level is lower than it was previously.

Studio engineers found compression useful because it allowed them to maintain

audio pros, compression is about as anal as analogue can get.

Even in the dark ages of digital, when everybody started using rackmounted reverbs, delays and modulation, compression remained exclusively analogue.

Guitar compression

As we've seen, compression can be used to overcome technical issues, improve signal-to-noise ratio and enhance sound quality. So there are various ways in which compressors can benefit guitarists.

Whether you're aware of it or not, if you play through a valve amp, your tone is getting some compression from the amp and speakers. This is most noticeable with valve rectification when the amp is turned up sufficiently to hit the sweet spot. Everything gels together, notes don't jump out and it feels easier to play.

Used subtly, a compressor can give you this sweet-spot response without having to turn up the amp. Picking sounds smoother, there are no transient spookers and you can get more sustain. Most country pickers find compressors indispensable – and in general, light compression can bring out the finer details in your tone and your playing, and you'll be able to hear yourself better.

Heavier compression can give clean guitars a very punchy quality, where funky chords and single-note rhythm patterns cut right through a mix at relatively even volume levels. Also, check out Roger McGuinn's 12-string Rickenbacker tone; there are many guitar sounds which depend on compression for their impact.

Very heavy compression can sound unnatural and make rhythm parts feel odd. However, some players use it to achieve fuzzbox levels of sustain with



clean tones. David Gilmour's solo sound on *Another Brick In The Wall (Part 2)* is a standout example. It works because the compressor squashes the front of the note so hard that it's barely perceptible. Then the compressor gradually releases its grip and fades up the volume while the note would normally fade away. This results in notes that barely seem to fade at all.

Regarding pedal order, convention dictates that compressors should be pre-boost/overdrive. This makes sense, because the compressor will resist any intended volume hikes if it is placed post-boost/overdrive.

However, applying compression post-boost/overdrive can provide really long sustain without the need for heavy overdrive or distortion. So long as the compression effect is light, it won't clamp down too hard when you do want more volume.

One of the simplest ways to understand how a compressor works is to examine each of the common controls. Although pedal makers still offer plenty of one-knob compressor pedals, some stompbox compressors are configured more like sophisticated studio compressors.

Threshold, compression and sustain

Regardless of the name, this control determines the level at which the compressor starts to work. Lowering the threshold – or turning up compression – means that the compression will be triggered at lower signal levels.

Ratio

This defines the strength of the compression, and a 2:1 ratio means that a 2dB increase in input level is needed to increase output level by 1dB. Similarly, a 20:1 ratio requires a 20dB increase in input for a 1dB increase in output. This control works in conjunction with threshold, but it's rarely seen on stompboxes.

Attack and release

These determine how quickly a compressor responds when the input signal exceeds the threshold and how quickly it resets once the input signal falls below the threshold.

Make up/gain/level

Heavy compression may reduce overall signal level. This control compensates for the level drop – or even provides some boost.

Compression types

Although all compressors do the same thing, they don't necessarily do it in the same way. Compressors can be roughly divided into four categories.

The earliest compressors were 'vari-mu' designs, where a valve was used for gain control. In fact, 'mu' is just old-school speak for 'gain'. The signal is split to form a 'side chain', which provides a control voltage to constantly re-bias a valve in the signal path. In principle, it's similar to bias tremolo, but the bias modulation comes from the audio signal itself rather than an oscillator.

Opto-electrical compressors have photo resistors placed in close proximity to a light source such as a bulb – or, these days, an LED. Again, the input signal is split to provide a sidechain signal that's routed to the light source. The light source glows brighter with higher signal levels, which increases the resistance of the photo resistor. The photo resistor acts like a light-driven volume potentiometer.

During the late 60s, engineers discovered that Field Effect Transistors (FETs) could be used as gain-control elements. Bill Putnam of UREI used FETs as voltage-variable resistors. A voltage derived from the audio sidechain is applied to the FET's gate, in order to alter the resistance value between the drain and the source.

VCA stands for 'Voltage Controlled Amplifier' and VCA compressors are renowned for lightning-fast attack and release times. The audio signal passes through an amplifier stage that's controlled by an external voltage derived from the audio signal.

Standing for 'Operational Transconductance Amplifier', OTA compressors are similar to VCAs, but the chip is used to generate variable current, not voltage. The OTA response works superbly for guitar, and many of the classic and modern boutique stompbox compressors use this type of circuit. 

BUYER'S GUIDE

If you are looking to add a compressor to your rig, there's no shortage of options, from the cheap and cheerful to pro-level units. Any one of this quartet would be a sound choice for your latest stompbox squeeze...



BOSS CS-3 £59

The CS-3 is the latest in the company's series of solid, affordable sustain/compression pedals. It's capable of normalising your loudness while also providing smooth sustain.

XOTIC SP COMPRESSOR £130

A quality tone shaper, the tiny SP is a great all-rounder with full-sounding vintage tones and impressive clarity. We're seeing more and more of these on pro boards, and with the small footprint and stellar performance, that's not at all surprising.



MXR M102 DYNA COMP £70

One of the most popular compressors in history, the internals of these affordable stompers are frequently modded to make them even more flexible. New units are fairly inexpensive, while the vintage boxes can fetch a higher price.



KEELEY COMPRESSOR £199

If you can't find a vintage Ross pedal, or if you don't want to pay the frequently terrifying prices they command, Robert Keeley's two-knob unit is a pro-level industry standard that some argue is even better.

Tremolo





Tremolo is the daddy of guitar effects and we've used it since the 1940s. But there has always been confusion about what it really is. *G&B* charts tremolo's ups and downs...

Those of us who experienced the unrelenting tedium of formal music lessons may recall long lists of Italian terms that had to be memorised for theory exams. Among them might have been the word 'tremolo', or perhaps even 'tremolando'.

The musical use of tremolo predates electronic effects by several hundred years – at least. Tremolo was almost certainly first produced by string players moving bows back and forth rapidly using very short strokes. Since sound is generated only when the bow is moving, it's clear that the volume level must drop as the bow changes direction.

This results in a series of volume peaks and troughs and, if the player's technique is good, then the effect will sound smooth and regular. Check out the intro of Bruckner's *Symphony No. 9* to hear this in an orchestral context. Tremolo is a key technique in mandolin playing, too. A plectrum is used instead of a bow, but the rapid back and forth movement is the same.

In both cases, a playing technique is employed to create the tremolo, but tremolo as an added effect was first heard on church organs during the 16th century. The effect was produced

mechanically, with a diaphragm opening and closing to modulate air pressure – but pitch fluctuated along with volume.

Rhythmic pitch fluctuation is called vibrato, which is different

Many aficionados regard the brownface-era 'harmonic vibrato' as Fender's best design



to the volume fluctuations of tremolo. Nevertheless, both terms have long been used interchangeably and incorrectly – in the musical world as well as the patent office. So Leo Fender can be excused to some extent. By the 1930s, electronic musical instruments were being developed, and the first electronic tremolo effect appeared on the market in 1941.

Electro-mechanical tremolo

Most electric instruments have volume controls so that you can create your own tremolo effects. Hit a chord and turn the volume knob back and forth and you'll get tremolo – but would you really want to do that all the way through an entire song? It makes a great deal more sense to automate the process, because it's far less exhausting, it sounds better and both hands are then freed up to deal with the real business of playing.

It's well known that DeArmond developed the first electronic tremolo, but they were initially installed in the electric Storytone piano during the 1940s. Before

The DeArmond 601 Tremolo Control (left). Devised in 1946, it was the first standalone unit



The Demeter Tremulator (middle) emulates classic Fender optical tremolo, while the Electro-Harmonix Super Pulsar (below) offers adjustable sine, triangle and pulse waveforms



long, DeArmond's 'Tremolo Control' became available as a standalone unit that can be claimed legitimately to be the first guitar effect.

A motorised spindle shook a canister containing electrolytic fluid. As the fluid sloshed around, it conducted varying amounts of signal to ground, which made the guitar volume fluctuate.

Many of these units were discarded after the electrolytic fluid dried up, but they can be rejuvenated with an injection of Windex cleaning fluid.

Bo Diddley and Muddy Waters used this tremolo, as did Duane Eddy on *Rebel Rouser*. Billy Gibbons is also a fan and tells some great DeArmond anecdotes, but it's wise to take most of what he says with a generous bucket of sodium chloride.

Amp tremolo

Mechanical tremolos, like tape echoes, require maintenance, and invariably wear out. This made the move to purely electronic tremolo inevitable. By the late 1940s, Danelectro, Multivox and Gibson were selling tremolo-equipped amps. Magnatone and Fender finally boarded the trem-train in 1955.

It's interesting to note how Fender's implementation of tremolo evolved over the years. In the 1955 Tremolux, a 12AX7 valve was used as an oscillator to generate a varying voltage that was applied to the cathode of the phase inverter valve. This varied the bias, which partially turned the phase inverter valve on and off and caused the volume to rise and fall.

For the later Vibrolux, the oscillator voltage acted on the bias of the power valves. Many aficionados regard the brownface-era 'harmonic vibrato' as Fender's best design. It achieved a pseudo-vibrato effect by splitting the signal into high and low frequencies and modulating one, with low-frequency oscillators working in opposite polarity. The result falls somewhere between tremolo, vibrato and phasing.

During the blackface and silverface eras, Fender used a photocell resistor – essentially a resistor that reacted to light. Simply put, the oscillator drove

the light source and the resistor acted like a light-driven volume control. This type of trem is characterised by an asymmetrical response, where the volume rises and falls occur at different rates.

Tremolo pedals

Amps with built-in tremolo tend to be bigger and more complicated. The tremolo circuits occasionally fail, and where there's a 'normal' channel and a 'vibrato' channel, the former is often considered to sound superior. If tremolo is an occasional treat for you, a tremolo pedal will be cheaper, less hassle and your core tone may be better if you're not obliged to play through a 'tremolo/vibrato' channel.

With amp tremolo, you are stuck with the basic characteristic of the circuit, but as we've discovered, tremolo is a more subtle and nuanced effect than simply a volume pulse. If you would prefer brownface tremolo with your tweed amp or optical trem with your Brit-inspired Class A combo, pedals allow you to mix and match.

Most amp tremolo controls are limited to speed and depth – or variations on the theme. Choosing the right tremolo is about feel as much as sound, so the waveform of the oscillator makes a huge difference. Some pedals enable you to set the waveform to taste, for a variety of tremolo sounds and feel.

Remember how Johnny Marr matched his trem speed to the tempo of *How Soon Is Now?* It's hard to achieve using an amp, but some trem pedals have tap tempo and even subdivision switching. Maybe you prefer a fast swell and slow decay, or vice versa? There are pedals that will allow you to do both, or even select a symmetrical shape.

Modern tremolo pedals come in many forms, with op amps, JFETs and even valves. Some of these pedals have photocells, just like blackface Fenders, and you can even choose between mono and stereo.

Unlike chorus and phasing, tremolo has a timeless quality, and the choice has never been better for occasional users and obsessives alike. 

BUYER'S GUIDE

Having identified the three main categories of amplifier tremolo, we came up with a stompbox for each type – along with a modern-style tremolo with user control – that cover just about every parameter. Here are four of the top tremolo units that we believe are worthy of your attention...

KINGSLEY BARD

\$275

The Bard is basically amp tremolo in a stompbox. Running a single 12AX7 valve at a full 275 volts, the circuit generates a Princeton-style bias-modulated tremolo effect. Controls are straightforward, with speed and depth. There's also a volume control to compensate for perceived level drop with tremolo engaged, or it can provide a clean boost.



CATALINBREAD PAREIDOLIA

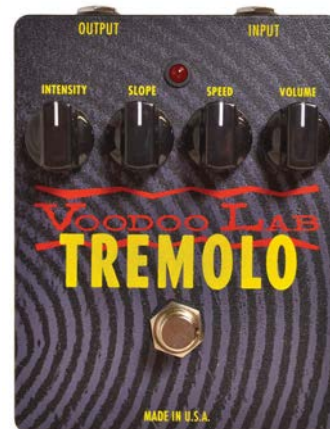
£153

With three valves and complex circuitry, the tremolo circuit used in the brownface Fender Twin, Pro and Concert didn't last for long, but this harmonic tremolo remains the ultimate for some. This pedal is designed specifically to replicate Fender's 'harmonic tremolo', and the controls include speed, depth and volume.

VOODOO LAB TREMOLO

£109

To recreate the blackface and silverface tremolo, Voodoo Lab used an identical lamp and photocell assembly. The slope control adjusts the feel from smooth and vintage to 'machine-gun stutter'. Along with speed and intensity, there's a volume control to cut or boost the output level.



SEYMOUR DUNCAN SHAPE SHIFTER

£199

One for the pathologically indecisive, because it promises to be 'every type of tremolo' in a box. Features include depth, rate, shape, wave and phase. It also has stereo inputs and outputs, plus tap tempo for easy synchronisation.





Reverb



It's the guitar player's go-to effect... But how many of us understand exactly what it is, or know all the options out there? *G&B* sets off in search of endless shimmer...

Considering human beings started out living in caves, reverb must have been enhancing our musical endeavours from the beginning. Unlike many guitar effects, reverb actually occurs in the natural world – so it's an acoustic phenomenon that it's possible to simulate electronically. But what actually constitutes reverb in the first place?

When I started out as a studio engineer, some of the old-timers would ask for 'echo' on a guitar or vocal. This caused confusion, because they often used 'echo' when referring to reverb – but when they actually wanted an echo effect, they preferred the terms 'slapback' or 'ADT'.

Technically, they weren't wrong – because reverb is created by multiple echoes that occur so close in time to the original sound, they aren't perceived as separate or delayed repeats. Instead, these multiple short echoes gel with the dry tone to form a composite sound, which lingers on after the original dry sound has faded to silence.

You can try this for yourself. If you have a slapback delay, tape-echo simulation pedal or even an actual tape echo, set the delay time to minimum and turn up the repeats control. You

should hear a reverb effect that sounds like the acoustics of a tiled bathroom or an empty room.

You can get a natural reverb in stairwells and big open spaces like churches and cathedrals, too. The effect should be intense and long lasting, due to the space's increased volume and the reflectivity of the stone surfaces.

To measure reverb, acoustic engineers refer to RT60, which is the time taken for the signal level to drop by 60dB – aka the 'reverb time'. When designing concert halls and public spaces, acousticians can fine-tune and control reverb characteristics through an understanding of how size, shape and materials affect sound.

This is important, because excessive reverb can obscure the

weekend's gig may sound dull and uninspiring in the corner of the pub this week.

The missing ingredient could simply be a touch of reverb and if you're not getting it from the room, you'll need to add some yourself. This is where things get complicated but also interesting, because the various devices used to create reverb effects all have their own sound and character.

In extreme cases, the reverb effect can define a piece of recorded music just as much as the arrangement and instrumentation. So let's examine the various types of reverb and find out how they work.

Although this article is primarily intended for guitarists, I'm starting with studio reverb because most of us have, at one

back out into the recording room and use microphones to capture the room sound during mixing.

You can try this yourself by placing a powered hi-fi speaker or active monitor and a microphone in a bathroom or any reverberant space. Two microphones could be used for a stereo effect and the monitor or amplifier should be fed from an auxiliary output of a desk or DAW.

Studios also traditionally used spring reverbs that were similar to the ones we find in amps, but far more sophisticated and controllable. The most famous was the AKG BX20, housed in a rectangular box the size of a cupboard. The BX15 and BX10 are smaller versions and they all sound fantastic on acoustic and electric guitars, offering a dark, rich reverb tone. Another device, called the Great British Spring also has a loyal following.

The big boy of classic studio reverb is the EMT plate – in particular the 140. A small transducer – a bit like a speaker motor – was used to set a sizeable metal plate in motion. The plate was tensioned within a frame and a contact microphone was used to sense the vibrations. Stereo plates had two microphones. Dampening pads were used to adjust the reverb time and if you were very fortunate, these could be operated by remote control.

All the pro studios had EMT plates and nothing can beat the sound of a good one. It's the reverb you've most likely heard on every classic recording and it's my personal favourite by some margin. Plate reverbs sound so dense, lush and musical, it's hard not to pile it on.

In 1976, a trail was blazed for digital reverb with the EMT 250 – aka The Dalek. Other landmark digital reverbs followed, such as the Lexicon 224, 448 and PCM

The cutting-edge digital sounds of the 80s tend to sound more dated to our ears than the reverbs of the early 60s

dry sound, reducing intelligibility and creating a sonic soup. It may be fine for serious surfers or ambient rockers, but it's otherwise disadvantageous. Again, the type of reverberation synonymous with larger spaces can be simulated electronically, but more sophisticated devices are needed to do so convincingly. Why would we need to?

The simple answer is that pleasing acoustic environments inspire people to make music. Have you ever enjoyed singing while showering, or playing acoustic guitar in an empty room stripped out for redecoration?

Assuming the answer is yes, it's perhaps surprising that so many rehearsal spaces and recording studios are acoustically dry. The guitar amp that sounded amazing in the big room at last

time or another, been inspired by guitar sounds on records. We may discover what amp, guitar and pedals were used, but we shouldn't disregard studio processing. In fact, any guitar sound with added reverb on a pre-1975 recording is likely to have been sent through an echo chamber, spring or plate reverb.

To add room reverb to recorded sounds, early studio designers placed powered speakers inside acoustically reverberant rooms. Dry signals were sent out into the room, with microphones capturing the sound and returning to the mixing desk.

These 'echo chambers' were often specially designed and carefully tuned. Many are still in use in some of the great studios, such as Abbey Road. Another studio trick is to send sounds



models, the Ursa Major Space Station and the wonderful, though notoriously unreliable, AMS RMX 16.

All were used to great effect with guitars, but valve-amp tones and lesser digital reverbs didn't always combine so well. However, digital reverbs afforded engineers unprecedented control over specific parameters such as pre-delay, equalisation, reverb time and diffusion.

Although most of the great studio reverbs are too large, heavy, expensive, impractical (or all of the above) for gigging guitarists, they're most certainly worth trying if you have the opportunity in a studio. If you're mixing elsewhere, try to record some reverb returns so you can use the sound later.

I can also recommend some of the plug-in effects that replicate the great studio reverb devices in the digital domain. They may not sound identical, but you get much of the original vibe and I really enjoy Universal Audio's products. The spring-reverb pedal effect in Logic can also deliver good results.

Laurens Hammond's patent for a spring reverb device was granted way back in 1939, but it was impractical for guitar use. Everything changed in 1961 when a Hammond engineer named Alan Young developed a 'miniaturised' and enclosed spring-reverb tank. Reverb equipped amps from Ampeg, Gibson and Danelectro followed in 1961, along with Fender's standalone 6G15 reverb unit.

Although some regard the Ampeg Reverberocket as having the finest guitar reverb of all, the spring reverb sound is associated most closely with Fender. It's

the sound of surf, early 60s guitar instrumental groups and Spaghetti Westerns, and the electric blues players of that era would often crank the reverb control up to 10. It worked – most of the time – and it's the reverb sound that suits the majority of guitar styles. Some guitarists became distracted by digital rack-mounted reverbs in the 80s, but spring reverb has, for the most part, remained the de facto reverb of choice for electric guitar.

Bits in the box

It's amusing to consider that the cutting-edge digital sounds of the 80s tend to sound more dated to our ears than the reverb technology of the early 60s. The same cannot be said for DSP (Digital Signal Processing) technology, though – partly because so much of the design effort behind DSP effects is geared towards emulating classic analogue tones, in practical and affordable stompbox form.

Some pedals are dedicated to specific vintage effects, while others allow you to choose from a bewildering array of reverbs. If you can't decide between spring, plate, room or chamber reverbs, why fret over it when you can have them all in a single box?

Try using your amp reverb to provide a hint of space and three-dimensionality, and then augment it with a stompbox for more extreme and dramatic reverb effects. You may also choose to feed stereo reverb outputs to separate amps, or route the dry and reverb signals to separate amps. Reverb may not have been the first guitar effect, but it will probably be the last. 

BUYER'S GUIDE

Splash some atmospherics across your playing, from vintage surf sounds to vast swells, with our pick of four of the best...



ELECTRO-HARMONIX HOLY GRAIL NANO £79

EHX always adds a little extra to its pedals, so as well as classic hall and spring reverb emulations, the pedalboard-friendly Holy Grail Nano includes the love-it-or-hate-it Flerb flanged reverb. The newer Holy Grail Neo (£89) dispenses with Flerb in favour of a more useful plate sound.

STRYMON BIGSKY £429

Okay, so the price might make you wince, but for the more creatively minded guitarist, there's a world of inspiration in this fully featured blue box, from retro spring emulation right up to massive swells and psychedelic reverse-reverb textures. Post-rockers, prog-rockers and shoegazers alike will find this to be an indispensable creative tool.

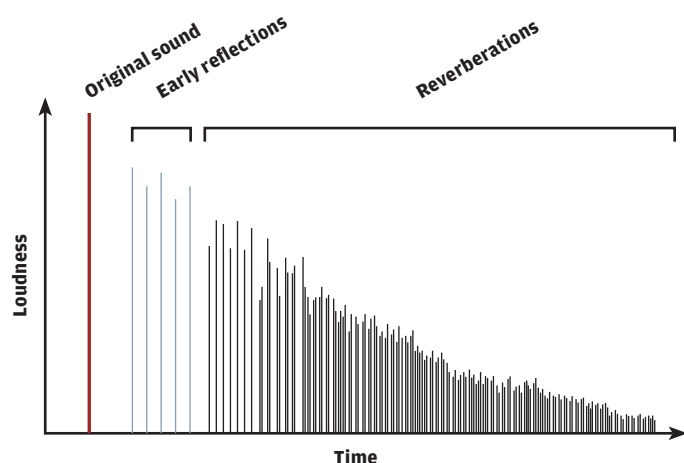
CATALINBREAD TOPANGA £160

This astonishingly convincing emulation of Fender's 6G15 reverb unit augments the dwell and tone controls with a mix control which can go from 100% dry to 100% wet and a volume control that provides a clean boost to push your amp harder.



FENDER '63 TUBE REVERB £863

Fender's iconic 6G15 tube reverb unit is back and available in classic brownface or lacquered tweed livery. It's unwieldy and far from cheap, but placed in front of a Fender-voiced 6V6 or 6L6 valve amp, this is the sound of vintage surf.



Echo





Whether it's rockabilly slapback, psychedelic feedback or crystalline delays, it's worth repeating that echo effects are a fundamental part of electric guitar's sonic history...

The term 'echo' is often used interchangeably with 'reverb'. Although related, they're really quite different. An echo is a distinct repeat of the original sound – like a handclap bouncing off a canyon wall – while reverb is comprised of multiple echoes that are so close together they sound continuous.

Since echo occurs in the natural world, it's hardly surprising it was amongst the first 'effects' engineers attempted to simulate electronically. There are several methods to achieve echo effects, but regardless of the technology, the parameters are usually the same and may include any combination of delay time, sustain/feedback, wet/dry, modulation and record level.

Reel echo

To create an echo, it's necessary to record the sound then play it back after the event. Reel-to-reel tape machines were the first high-fidelity recording devices, so they were used to create the earliest echo effects.

Tape recorders usually have two or more heads. One head 'prints' the sound to tape and another head plays it back. These heads are physically separate, so if you monitor the recorded sound rather than the audio input, there will be a delay before playback occurs.

Tape speed and the gap between the heads determine the delay time. Most tape recorders run at 7.5 or 15 IPS (inches per second), so if the gap between the print and playback heads is one inch and a machine is running at 15 IPS, the resulting delay is 1/15th of a second – approximately 66 milliseconds. Switch to 7.5 IPS and you get 133 milliseconds – perfect for rockabilly slapback.

For additional repeats, some of the playback signal must be sent back to the tape-machine input. Turning the return beyond a certain point will induce runaway

feedback, which takes us from the 50s into the BBC Radiophonic Workshop of Delia Derbyshire, the psychedelic 60s of Pink Floyd and beyond.

When the space between the heads is fixed, the only way to adjust delay time is to vary the speed of the tape machine and before long, engineers were building varispeed control units – Les Paul was one of the trailblazers for tape-based studio echo and pitch effects.

There are limits to delay times achievable with a single tape machine, because audio quality deteriorates as tape speed decreases. With the tape travelling between two tape machines, one can print the sound and the other play it back.

Print and playback heads placed 15 inches apart, with tape running at 15 IPS, produces a one-second delay time. Double the distance and you get a two-second delay. Studios often had long 'echo shelves' for this very purpose. The tape can also be looped, and exponents of this include Terry Riley, Brian Eno and Robert Fripp.

Tapes and drums

An Illinois music-store owner called Ray Butts built a guitar amplifier with a built-in echo effect running on a short loop of tape. By 1953, he was selling EchoSonic amps to big-name players. You can hear the EchoSonic on Chet Atkins' *Mister Sandman* and Elvis' *Mystery Train*.

By 1958, standalone echo machines were becoming commonplace. The WEM Copicat allowed the selection of various delay times by activating different playback heads. Used in combination, multiple heads can produce complex echo effects. The Maestro Echoplex had a very long tape loop in a replaceable cassette with a single, movable playback head.

Early machines were valve, but many prefer the sound of later solid-state tape-echo machines –



Today, we guitarists have the luxury of choosing the best type of echo for any given application



especially those with variable tape speed. Other notables include the Klemm Echolette, the Dynacord Echochord and Roland's RE series.

Other vintage devices used rotating magnetic drums rather than tape. David Gilmour made extensive use of the Binson Echorec and Hank Marvin used a Meazzi Echomatic.

Passing the bucket

Tape echos need regular maintenance, and eventually they wear out. Today, we can appreciate their quirky characteristics because other options are readily available, but by the mid 1970s, most guitarists were ready for something different.

Bucket-brigade devices (BBDs) are integrated circuits containing numerous transistor/capacitor cells. Transferring packets of charge from one cell to another takes time, which delays the signal, and the BBD output is mixed with the dry signal to create an echo effect.

BBD-based delay units were small, and needed no maintenance. However, they were noisy, lacked fidelity and delay times were very limited. Some classic BBD delays include Boss' DM series, the Electro-Harmonix Memory Man and the Ibanez AD9, and many remain popular with players.

On the rack

BBDs also provided the basis for countless flanger, chorus and phaser pedals, but for echo they were essentially a stop gap until full-on digital delays became more affordable.

It helps to think of digital media in terms of storage rather than recording. An audio signal is converted into digital information, where it can be stored in a buffer until required and converted into the analogue domain for playback.

At first, digital delays were expensive rackmount effects seen only in high-end recording studios. Like analogue synthesisers, they had switches and control knobs for every parameter – and no presets. The most exciting aspects of these units were unprecedented user

control, clear sound quality and long delay times.

LED panels showed the delay time in milliseconds. Most engineers carried delay charts in their personal organisers to match delays to the tempo of any song that had been recorded to a click track. From simple quarter beats to dotted triplets or 3/16s, setting delay effects became easy and exact. Previously, engineers had to rely on their ears to set delay times.

Effects loops became commonplace on guitar amplifiers, because rack effects worked at line level. Early examples seen in period guitar racks included the TC 2290, Roland SDE-3000 and the glorious but notorious AMS DMX15-80S.

By the mid 1980s, digital delay pedals were starting to appear on the market – most notably the Boss DD-2. Having such accurate control over timing enabled guitarists to build up rhythmic patterns of great complexity and sonic interest from the simplest of ideas. Edge from U2 is perhaps the most well-known exponent of this playing style.

New models

Consider how echo effects have evolved. The initial drivers were extended delay times and improved audio quality, then for a while, players were more concerned with convenience and reliability. Digital technology eventually provided users with outstanding audio quality, reliability and controllability, but we have come full circle.

Today, we guitarists have the luxury of choosing the best type of echo for any given application. Our own individual definition of 'best' is more subjective than ever and lo-fi audio, distortion and erratic pitch often win out. The use of cutting-edge modeling technology to replicate the sounds and peculiarities of yesteryear is one of the great ironies of our era.

Yet it's also the most fun, and we can thank Line 6 for blowing guitar echo effects wide open with the DL4. Now everybody's at it, with other digital players including Strymon, Catalinbread and Cicognani. 

BUYER'S GUIDE

Have you always fancied a tape echo? Perhaps you're a BBD enthusiast, or maybe you never really escaped the 80s. Whatever your style or taste, there is an echo effect that's perfect for you. Here are four of the finest...



FULLTONE SSTE £729

Fulltone isn't exactly coy about its latest tape echo unit being based on the Echoplex EP-3 – albeit with several improvements. It's a third of the size, noise levels are lower, dry and wet levels are individually controllable and there's a true-bypass option. The SSTE is also a cheaper option than Fulltone's valve TTE for any Jimmy Page or John Martyn fan.

GURUS ECHOSEX 2 £269

Designed and manufactured in Italy, this Binson Echorec-inspired pedal combines a PT2399 processor with a 12AX7 valve. The goal was to recreate the sound quality and the quirky characteristics of the original in a stompbox format, along with authentic styling and extended delay times. Early reports are encouraging, but will David Gilmour be buying one?



ELECTRO-HARMONIX DELUXE MEMORY MAN £204

The original is one of the most highly regarded of the bucket-brigade delays. Famous users include The Edge and Andy Summers. It's currently unclear whether the reissue features BBD technology or a modern chip with filtering. Even so, it does all the usual delay tricks with 550ms of delay, and chorus and vibrato.

TC ELECTRONIC ND-1 £165

Described as a compact evolution of 80s favourite the 2290, this stereo pedal has nine user presets and six delay types – dynamic, reverse, ping-pong, pan and slapback. Modulation, tap tempo and audio tapping can be used with all types. TC started out making pedals, and it's good to see the company back in the game.



Wah-Wah





Wah pedals helped shape the sound of psychedelia, defined the cop-show soundtrack and formed the foundation of funk. G&B explains what's what with wah...

There are various accounts of the wah's invention, but nobody disputes that Thomas Organ engineer Brad Plunkett worked on the circuit in 1966. Back then, Thomas Organ distributed Vox products in the US, and Plunkett adapted a midrange boost circuit from a Dick Denney-designed Vox Super Beatle amplifier.

He replaced the three-way switch with a potentiometer to reduce manufacturing costs, and employed an Armstrong oscillator on the advice of colleague Les Kushner. Session guitarist and Vox endorsee Del Casher liked what he heard when turning the frequency select knob and figured it could sound good with electric guitars.

Casher claims he suggested using a Vox organ volume pedal instead of a control knob so guitarists could use the effect while playing. After a day of swapping components, Plunkett and Casher ended up with the basic design for the wah.

According to Casher, that's when Vox/Thomas Organ CEO Joe Benaron dropped in for a listen. Drawing on his business experience in the mattress industry, Benaron decided the wah pedal was unsuitable for guitar. However, he was convinced he could sell millions of wahs to electric trumpeters.

Trumpeter Clyde McCoy was subsequently offered \$500 to endorse a wah pedal he had never used, and the earliest US-manufactured Vox wah carried McCoy's likeness on the baseplate. Later McCoy 'signature' wahs had just an inscription, and both are highly sought after – albeit not by trumpet players.

Thanks to Hendrix, Clapton *et al*, the wah quickly became

the accessory no self-respecting psychedelic guitarist could be without. As for early proponents, give yourself a treat and check out Earl Hooker's *Wah Blues* – Hendrix probably did.

The Vox V846 appeared in 1967, followed by the first Cry Baby in 1968, and soon the Thomas Organ and Vox wahs

were being made by EME in Italy. Brad Plunkett and Les Kushner's names appear on a patent application filed on 24 February, 1967, but the patent wasn't granted until 22 September, 1970. By that time, copies were being made.

During 1969, JEN Elettronica took over production of the

Cry Baby. These wahs are also collectable, and the various types of inductor used during manufacture are crucial to the allure of vintage wah pedals.

The circuit

The wah pedal is, first and foremost, a band-pass filter that rolls off the treble and the bass and creates a resonance peak at the low-pass filter frequency point. The result is a boost that's targeted at a very narrow frequency band. If you want to know what this 'stuck wah' sounds like, check out some of Mick Ronson's early recordings with David Bowie.

Moving the pedal sweeps the resonance peak up and down the frequency range and makes your guitar go 'wah'. It's not unlike a parametric equaliser boost with a narrow 'Q' setting, but most equalisers of that era switched between multiple inductors and capacitors to target various frequency points. The clever thing about the wah circuit is the way it moves the low-pass frequency point using a fixed inductor and a single capacitor.

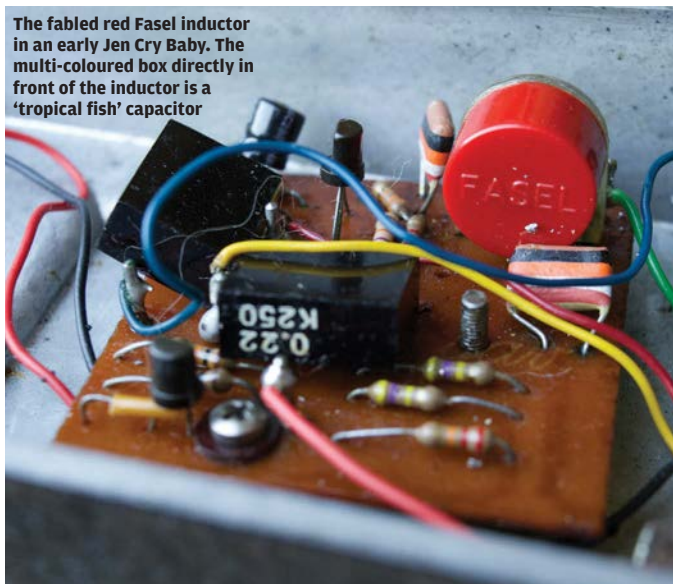
A potentiometer, transistor and fixed capacitor combine to trick the inductor into 'thinking' it's connected to a variable capacitor. The pedal adjusts the amount of current flowing through the capacitor, which makes the value of the capacitor appear greater than it really is, so the position of the resonance peak is determined by the amount of current passing through the capacitor.

Inductor types

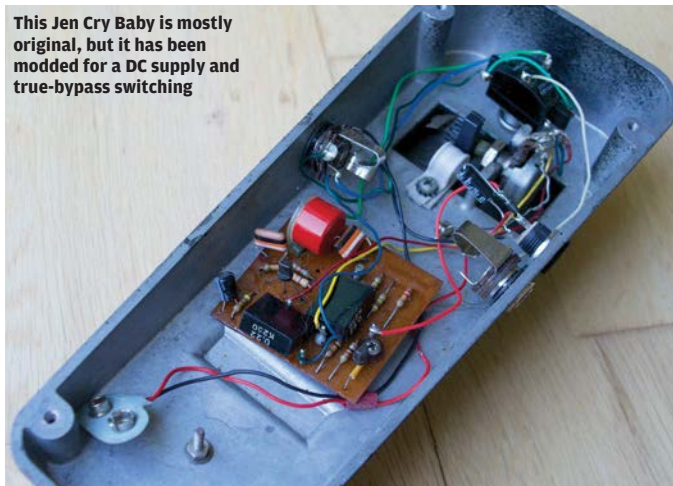
Various types of inductor have been used, and although none of the inductors were expensive or esoteric items, some have acquired legendary status.

The earliest inductor, and the one that was used in the Clyde

The fabled red Fasel inductor in an early Jen Cry Baby. The multi-coloured box directly in front of the inductor is a 'tropical fish' capacitor

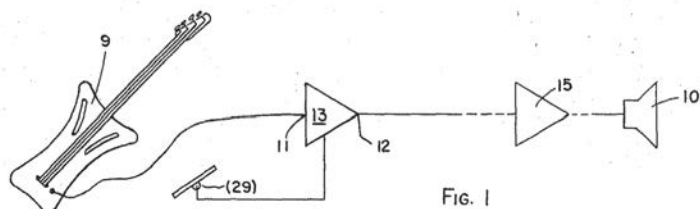


This Jen Cry Baby is mostly original, but it has been modded for a DC supply and true-bypass switching



Thanks to Hendrix, Clapton et al, the wah became the accessory no psychedelic guitarist could be without

Sept. 22, 1970 **B. J. PLUNKETT ET AL** 3,530,224
 FOOT CONTROLLED CONTINUOUSLY VARIABLE PREFERENCE
 CIRCUIT FOR MUSICAL INSTRUMENTS
 Filed Feb. 24, 1967 2 Sheets-Sheet 1



models and the earliest V846s, is called the 'halo'. A metal-cased halo inductor – aka the 'trash can' – was used in the earliest Italian-made wahs, but Jen wahs had red Fasel inductors. All three are highly regarded, just like the brown epoxy-covered 'stack of dimes' inductor, but the least popular of the vintage types is the cube-shaped TDK.

Copies of many of the vintage inductors are now being made, and upgrading wah inductors is a simple and popular DIY pedal tweak. You can get red and yellow Fasel from Dunlop, and halo types from Small Bear Electronics, Arteffect, Mojotone and others. Banzai Music sells halo and stack of dimes repros.

There are plenty of opinions on how each inductor sounds, and there are several other components that impact the tone of a wah pedal, too. Simply soldering in a replacement inductor is not a guarantee of tonal nirvana.

Key components

It helps if you can identify the various components and understand how they influence the wah response. After-market potentiometers can change the feel of the wah, and you can sweeten the characteristics of modern pedals by installing lower-gain transistors.

Resistors that have drifted in value can effect Q width, frequency response and signal level. Replacing out-of-spec resistors with ones that test well will restore the 'vintage' sound. Alternatively, you can use different values to 'tune' the wah to your taste.

Buffer issues

Vintage wah pedals were never true bypass, and the load they put on guitars sucks treble – even

when they're off. Wahs made from the mid-90s onwards have input buffers to cure this, and those wanting vintage specs often remove the input buffer.

Wah plus fuzz is regarded as being a classic combination, but the impedance mismatch when Fuzz Face and Tone Bender-type fuzzes are used results in a reduced wah effect and a squawking oscillation that sweeps with the wah pedal.

None of the various solutions are perfect. Much of the magic of vintage fuzz pedals comes from touch dynamics and their ability to clean up from the guitar volume control. Placing a buffered pedal between the wah and the fuzz, or installing a buffer stage inside the wah, may solve the squawking, but some of the fuzz's best qualities will be lost.

Modern wahs

Wah customising dates back to the beginning, when Hendrix retained Roger Mayer as his personal tweaker. Although most wahs are still based on the old Clyde circuit, modern pedal builders understand how to alter the voicing to create specific wah tones and responses.

These days, it's not uncommon to find Q controls and frequency range switches on the side of the casing; so you can go for bassy or trebly wah tones and emphasise the 'vocal' quality by narrowing the Q. You can even switch between inductors.

Some pedals feature switchable output buffers and LED indicators, and true bypass is commonplace. Since potentiometers and switches wear out, some manufacturers have dispensed with them altogether. However, one thing has never changed – they all go WAH! 🌀

BUYER'S GUIDE

Big or small, sweet or aggressive, trebly or bassy, vintage or modern, buffered or bypassed – whatever you need from a wah, there's bound to be one out there that's perfect for you...

VOX V846-HW £153

The company that started it all is still making wah pedals, and this handwired version of the V846 is top of the line. The circuit is constructed on turret board with carbon composite resistors and polyester film capacitors. There's a halo-style inductor, too, but the only concession to modernity is the true-bypass switch. This one is high on vintage mojo, but light on features – and it's battery only.



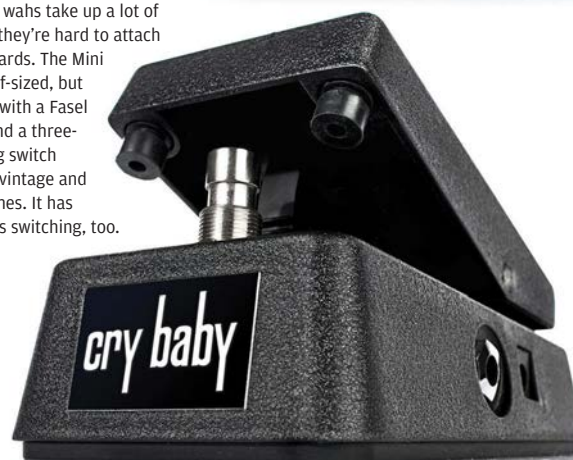
T-REX SHAFTER £168

Offering a much wider frequency sweep, quieter operation, greater durability and three distinct wah settings, T-Rex claims to have addressed "all the weaknesses of the classic wah point by point". Features include custom coils and inductors, boost and slope knobs, a hot spot switch for classic or 'heel to toe' sweep and potentiometer-free operation.



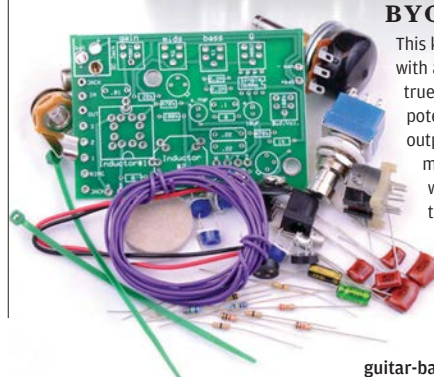
JIM DUNLOP CBM95 CRY BABY MINI £89

Traditional wahs take up a lot of space and they're hard to attach to pedalboards. The Mini may be half-sized, but it's loaded with a Fasel inductor and a three-way voicing switch for subtle, vintage and modern tones. It has true-bypass switching, too.



BYOC WAH KIT £67

This kit is basically a Clyde clone with a halo, BC108 transistors, true-bypass switching and a CTS potentiometer. There's an optional output buffer and the gain, bass, mid and Q resistors are replaced with trim pots so you can tune the tone. The board can be dropped into any Cry Baby-style enclosure to replace the original board, or you can buy a BYOC enclosure.



Modulation





A number of classic effects come under the umbrella of modulation. Here, G&B explains how to tell your vibrato from your chorus and your phaser from your rotary speaker...

Modulation, in stompbox terms, generally means adding inaudible electronic information to components in the signal path to create audible effects. In the feature on tremolo on page 110, we explained how an oscillator circuit generates a varying voltage to modulate valve bias or a light source alters volume.

This is called amplitude modulation, but when we use the term 'modulation', we're usually referring to pitch. Parameters such as phase, frequency and delay can also be modulated to create effects such as vibrato, chorus, phasing, flanging and more. So, let's look at the way modulation effects evolved.

Rotating speakers

Pitch modulation is commonly known as vibrato. Designed to be used with Hammond organs, the first electronic vibrato devices were rotating speakers. Introduced in 1940, Leslie speaker cabinets featured onboard valve

amplifiers with a spinning horn and a rotating cylindrical baffle for the bass.

Rotating speakers rely on the Doppler effect and the result is a spectacular and complex mash-up of pitch modulation, tremolo and phasing that sounds amazing on electric guitar as well as organ. Check out the arpeggios in *Badge* by Cream, Hendrix's *Little Wing*

RT-20 or the valve-driven Hughes & Kettner Rotosphere instead.

Vibrato effects

Like tremolo, vibrato can be produced electronically as well as mechanically. Just after World War Two, Hammond engineer John Hannert developed a vibrato using an electronic delay line to modulate pitch.

In their simplest form, vibrato pedals use an array of capacitors to create a very short analogue delay

solo and Buddy Guy's playing on Junior Wells' *Hoodoo Man Blues*.

Several other companies have made rotating speakers, with Fender's Vibratone having been used by some high-profile players and the Yamaha RA-200 a long-standing favourite of David Gilmour. Leslie fans who are not served by a team of roadies might check out the Strymon Lex, Boss

Although Gibson introduced a standalone vibrato effect unit called the GA-V 1 in 1956, most vibratos were built into amps and employed valve circuitry. Most revered is the Magnatone vibrato used by Duane Eddy and Lonnie Mack, but the effect sounds closer to a pitch-shifting tremolo or a rudimentary chorus.

Compared to tremolo, valve vibrato circuits were complex and expensive to make. Transistors made it possible to build smaller and cheaper vibrato effects into stompbox enclosures. Typically, these pedals had only speed and depth controls.

The Uni-Vibe was introduced as an attempt to recreate Leslie speaker sounds



In their simplest form, vibrato pedals use an array of capacitors to create a very short analogue delay. There will also be an oscillator that modulates the delay time. Much like the Doppler effect, as the delay time increases and decreases, the pitch changes accordingly.

Vibrato effects were popular with surf and 60s garage bands. For a vintage Magnatone-type vibrato, the Bigfoot Magnavibe has a lot of fans. Vibrato enjoyed a low-key comeback amongst shoegazers and Brit-poppers, with the Boss VB-2 featuring on a lot of 80s and 90s records.

Chorus

Many players have discovered they can get good vibrato effects from their chorus pedals because vibrato and chorus are so closely related. Chorus pedals are based on John Hannet's work during the 1940s when he created a simple 'chorus' effect for Hammond organs. The trick is to combine the pitch-modulated and dry signals.

The Boss CE-1 Chorus Ensemble was the first Boss stompbox, as well as the first commercially available chorus pedal. The circuit first featured in the Roland JC-120 amplifier, with the stompbox version following in 1976. The depth and rate controls still came under the vibrato bracket and the chorus/intensity control balanced the wet and dry signals. It even had a second footswitch to toggle between chorus and vibrato.

Before long, the sizeable mains-powered CE-1 enclosure had evolved into the smaller CE-2 – minus the vibrato option. By the end of the 1970s, almost every pedal manufacturer was making a chorus of some sort.

All this was made possible by the development of 'bucket



brigade devices' (BBD). These were chips that could store packets of charge and move them along a line like buckets of water. The number of storage cells and the clock frequency determine the delay time.

Previously, engineers had been forced to use multiple capacitors to delay the signal, but classic BBDs such as the Philips TDA1022 held several hundred stages on a single chip and so achieved longer delay times.

Many of the chorus pedals that followed were great in their own right, but all are derived from the CE-1. Chorus was intended to add richness and complexity to guitar tones, in much the same way that a 12-string guitar differs from a six-string instrument.

Thanks to the efforts of Andy Summers and others, chorus became one of the cornerstones of 1980s electric guitar tone. As such, it divided opinion like no other effect until the EHX Small Clone on Nirvana's *Smells Like Teen Spirit* made chorus cool once again. Well, sort of...

Flangers and phasers

Flanging started as a studio trick engineers performed with tape machines, and you may have heard it on *Itchycoo Park* by The Small Faces. With two reel-to-reel machines playing the same material in sync, one machine is slowed using gentle hand pressure on the tape spool. This introduces an extremely short time delay – much shorter than vibrato and chorus. Comb filtering results, where some frequencies are phase cancelled and others are reinforced. If the frequency response is plotted, comb filtering shows up as a

series of narrow notches – like the teeth of a comb. At this point, the effect isn't like flanging, but you can hear what it sounds like by using the 'filter matrix' setting on an EHX Electric Mistress.

Tape flanging worked because it's impossible to maintain consistent finger pressure and the delay fluctuates. To achieve a swooshing flanger effect electronically, the delay must be modulated and the delayed and comb-filtered signal is then mixed in with the dry signal.

Phasing is closely related to flanging, but more complex. Delay-induced phase shift is combined with all-pass filtering, so the delay time is not constant across the audio spectrum. Phasers generally have multiple stages that are added to the delay line – hence the MXR 45, 90 and 100. Modulating the filter frequency creates the phasing effect and as filters are capacitor/resistor networks, that means modulating the resistance value.

And the rest...

We've covered the main modulation effects, but there are others. The Shin-ei Uni-Vibe has played a huge part in the history of rock guitar and was a favourite of Hendrix, Robin Trower and David Gilmour. Although there was a chorus/vibrato switch on the front, it was also a four-stage phaser with photo resistors.

As perhaps the earliest attempt to simulate a Leslie sound in a stompbox, the Uni-Vibe is a modulation pedal that's hard to categorise. Honourable mentions must also be given to ring modulators, vocoders, auto-wahs, panners and octave generators. It's a mod mod world...

BUYER'S GUIDE

There's a nearly limitless range of modulation pedals on the market, made by all manner of manufacturers. Here's a roundup of a few essential pedals to try out, covering chorus, vibrato, rotating speaker effects and plenty more besides...

STRYMON LEX £249

Replicating the sonic qualities and mechanical quirks of a rotating speaker has always been a challenge for pedal designers. Strymon uses digital modelling technology for this stereo Leslie simulator. Controls include rotor speed, horn level, mic distance and preamp drive, and you can even attach an expression pedal with assignable control.



FULLTONE MDV-3 MINI DEJÁVIBE 3 £169

Built into a wah-style enclosure with side-mounted controls, this recreation of the Uni-Vibe seems to satisfy the purists. The photocells are specially made clones of the 60s originals and all the transistors are 'new old stock' and vintage-correct. The only change is made to the speed potentiometer value to improve the low-speed response.



TC ELECTRONIC STEREO CHORUS PLUS £240

TC has been making these for 33 years and Joe Bonamassa and Eric Johnson are known to use them, so this pedal qualifies as a classic. Best of all, the 'plus' bit means that it will cover your flanger and vibrato needs, too. Other features include input gain for clean boost and external bypass switching.

EVENTIDE MOD FACTOR £389

Eventide has been in the modulation game since the beginning, having produced the first electronic flanger. This box of tricks does it all and the effects list includes phaser, flanger, chorus, polymod, tremolo, pan, undulator, vibrato, q-wah, modfilter and ring modulation. It's mono/stereo, true bypass and can be controlled by an expression pedal or MIDI.



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