MOJO ZINE

THE DIY ZINE
FOR DIY BUILDERS

VOLUME 1
ISSUE 4

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WHAT DOES THIS THING DO?
PART IV

BY *DAVE HUNTER*

There are a lot of mysterious components within any guitar amp, many of which remain puzzling even to hobbyists who have built a DIY project or two. In the tenth part of Mojotone's new series What Does This Thing Do? we're examining **output tubes**, **output tubes bias circuit and another thing.**

OUTPUT TUBES

Despite all the technological advances made in the eight decades since guitar amplifiers first brought players out from the shadows of the rhythm section and into the spotlight, that archaic component the tube continues to rule the roost for optimal sonic splendor. Even ultra-modern digital modeling amps achieve their binary magic by emulating or replicating the sound and function of tubes in one way or another, so they remain at the heart of our sound even when we're not actually using them in our rig. For those interested in probing the workings of the real deal, however, and possibly building such tone tools for themselves, a little knowledge of these miraculous glowing bottles is essential.

Any Genuine All-Tube Amp Carries Two Breeds Of Signal Tubes: preamp tubes, which we covered in "What Does This Thing Do? part I," and output tubes, which we'll discuss here. (In Pt2 we covered the third type of tube that is found in many amps, the rectifier tube.) The vacuum tube—tube for short, or "thermionic valve" (valve for short) in the UK—is itself technically known as an "amplifying device," and indeed the output tubes are the part of the guitar amp that really performs the duty of making your guitar signal louder. Everything else in there—the resistors, capacitors, transformers, and the wire that connects them all—is responsible for shaping the tone of the signal and providing the correct voltages to the tubes. In short, the guitar signal that has been amplified to a slightly higher voltage by the amp's preamp stages enters the input of the output tubes, where it is amplified much further and sent along to the output transformer. The output transformer (discussed in Pt7) translates the high-impedance amplified signal from the output tubes to a low-impedance one that will drive a speaker.

The Reason We Love Tubes So Much, However, Is That They Don't Just Make A Guitar Louder, They Make It Louder With Style.

Tubes handle the signal peaks (the surges) in a way that is musical to the ear, with a natural roundness and degrees of compression and frequency attenuation that flatter the amplified electric guitar. Where solid-state amplification devices, or at least ones without a lot of added circuitry designed to make them sound "tube-like", rise smoothly up toward the peaks but clip hard and harshly when pushed into distortion, tubes—used in an amp that is designed and built well—smooth out the transition into distortion, and offer a distortion that is relatively more musical and harmonically appealing as a result.

That's the basic 101 on the functional characteristics that all output tubes share, but there is an enormous variation in the sound that different tubes make in the course of doing their job, so let's also explore some of the archetypal tones associated with specific types of output tubes. To be clear, no output tube will result in "a tone" all on its own, and the sound it helps to put out is just part of a bigger overall system. But classic and common varieties are generally associated with certain known styles and sounds, and these do help us to form a base level of what to expect from any specific type of output tube

6L6GC - The larger of the output tubes traditionally seen in American-made amplifiers, it has a bold, solid voice with firm lows and prominent highs, which can be strident in loud, clean amps, or more silky and rounded in softer,

"tweed" style amps. A pair of these will generate around 40 to 50 watts in an efficient class AB amp, and a quartet (with two pairs working in teams on each side of the phase-inverted signal) can put out up to 100 watts. This is the tube of anything from the Fender tweed Bassman and blackface Twin and Super Reverbs, to early Marshall JTM45 heads and "Bluesbreaker" combos, to the Mesa/Boogie Mark Series and beyond. Amps designed for 6L6GCs can usually also use 5881 output tubes and the European KT66 is also swappable for either type, and is a little bolder, fatter and louder.

EL34 - This is the classic big-amp tube from the other side of the pond, commonly found in larger British amplification from the mid 1960s onward (and occasionally before). The EL34 can be driven to produce a little more output than the 6L6GC, and it sounds somewhat different, too, characterized by a fat and juicy but softer low end, sizzling highs, and a midrange that exhibits a classic crispy-crunchy tone when pushed into distortion. This is the tube of post-1966 Marshalls like the JMP50 "plexi" and "metal" panel amps, the JCM800, and the majority of modern models; they also appear in the classic Hiwatt models, and plenty of modern amps seeking a big Brit-rock sound. (Note that some Marshalls distributed in the USA years ago carried 6550 output tubes instead of EL34s. The 6550 is probably best described, in brief, as a "bolder, louder 6L6").

6V6GT - Smaller and mid-sized American-made amps of the 1950s, '60s and '70s most often carried 6V6 tubes, which are known for their juicy, well-rounded tone and smooth, rich distortion, which occasionally exhibits an element of grittiness that is not necessarily unappealing. They produce about half the output of their big brother, the 6L6, and are therefore more easily driven into distortion. The 6V6 was used in all versions of the Fender Deluxe, Princeton and Champ, the Gibson GA-40 Les Paul amp of the 1950s and early '60s and others, and countless great American-made amps besides.

EL84 - Best known for its appearance in classic Vox amps such as the AC15 and AC30, this tall, narrow, 9-pin output tube is most often used in nominally "Class-A" circuits. More correctly termed "cathode-biased," these seek to achieve a sweeter, more harmonically saturated sound at the expense of a little output efficiency. The EL84 can still exhibit a pretty firm, chunky low end in the right amp, but is most known for its chimy, sparkling highs and a midrange that is crunchy and aggressive when pushed. A pair in a cathode-biased output stage (a la Vox) will put out around 15 to 18 watts, and a quartet double that. These tubes also appear in many modern amps that emulate the "Class-A tone", including models from Matchless, TopHat, Dr Z and others. Gibson's unusual, wedge-shaped GA-79T stereo amp of the early 1960s also utilized these output tubes, as did Fender's later Blues Junior and Pro Junior.

In addition to having their own sonic characteristics according to type, different makes of the same types of output tubes will also sound slightly different. Once you have pinned down the right genre of tube amp for your style, it pays to experiment with a few different sets of quality output tubes to see which will work best for you. You'll be amazed to hear how simply swapping output tubes can take an amp, in some cases, from soft,

fuzzy and bluesy to bold, punchy and twangy. As with all things tonal, there isn't necessarily any better or best here—whatever suits your sound is best for you.

OUTPUT TUBE BIAS CIRCUIT

Most guitarists who have played tube amps for any length of time will understand that their output tubes need to be biased to function properly, and all contain an output-tube bias circuit of one type or another to get the job done. It's a lesson you tend to learn well before you decide to build an amp for yourself, and one that's a necessity to understand the importance of—even if you don't know how to do it yourself—any time you change tubes. Many amps on the market are cathode biased and don't require any adjustment when you change your output tubes, but these still have a simple bias circuit ("simple" perhaps being an understatement, since it generally consists of just one large resistor). The rest are usually fixed bias, a system which uses a more involved but still relatively simple circuit to enable the user (or his or her amp tech) to tailor the bias to each individual set of output tubes.

So, before looking at the circuit that achieves this in any amp and why we need it, what is bias in the first place? Put simply, bias is the means by which the output tubes are set to function optimally according to the DC voltage level that is being supplied to them by the power stage. Inevitable variables in tubes' manufacturing process mean they operate at slightly different levels of efficiency, performing slightly differently according to the voltage delivered to them by different amplifiers. At the same time, different amplifiers' power supplies can deliver considerably different voltage levels to the tubes used within them, further necessitating some means of adjusting how the output tubes handle that voltage.

Reputable tube dealers will usually match these output tubes into pairs and quads that at least operate together at something very close to the same efficiency and performance levels, but the inevitable differences between different new sets of output tubes means that for fixed-bias, Class AB amps it's impossible to set a one-time operating level that will work optimally with all possible tubes that might be used throughout its lifetime.

For this reason, most such amps include an adjustable bias circuit that enables the user—or their tech—to dial in each new set of tubes after a swap to ensure they are functioning their best according to the high levels of DC voltage they are seeing. (Some vintage amps were indeed made with a set, non-adjustable bias network that gave a "good enough" performance with different sets of tubes, and the quality of tubes used in the 1950s when these amps proliferated meant they often didn't vary too widely within acceptable parameters, either. Mesa/Boogie has also traditionally used non-adjustable fixed-bias circuits, preferring users purchase replacement tubes within a specific operating range to suit their amps.)

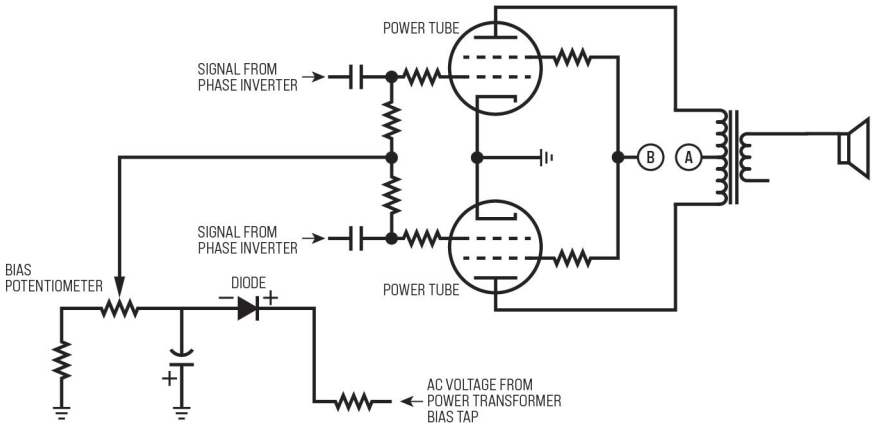
Fixed-Bias Circuits - The term "fixed bias" can be somewhat confusing, because this is the type of bias circuit that is actually adjustable in most cases. The "fixed" part indicates that the circuit is providing a set negative voltage to the grids of the output tubes, which determines their operating level relative to the much higher DC voltage that powers them and the incoming AC voltage—the guitar signal—which they will amplify. That is, it's not something you constantly adjust like a volume or tone control; it's more set-and-forget.

Most bias circuits of this type consist of a couple of resistors, an electrolytic (filter) capacitor or two, an adjustable potentiometer, and—crucially—a single diode (usually a 1N4007 in modern amps). Put in relatively simple terms:

The resistor at the start of the circuit helps reduce the incoming voltage from the transformer to a level that the bias circuit can handle,

the diode blocks the positive side of the AC voltage and passes only a negative DC voltage onward,

FIXED-BIAS CURCUIT



the small electrolytic capacitor smooths problematic ripple from the signal,

and the potentiometer fine-tunes the voltage to achieve the level at which the tubes will best operate.

Fully understanding how to use this adjustment is a matter for another article. In many amps, it's also a job that should be assigned to a qualified repairperson if you're not experienced in working safely with the high voltages that are present within tube amp circuits, even when they are unplugged from the wall outlet. (This article also doesn't intend to explain all the differences in sound between fixed-biased and cathode-biased circuits, either, which is another installment's worth of amp exploring.)

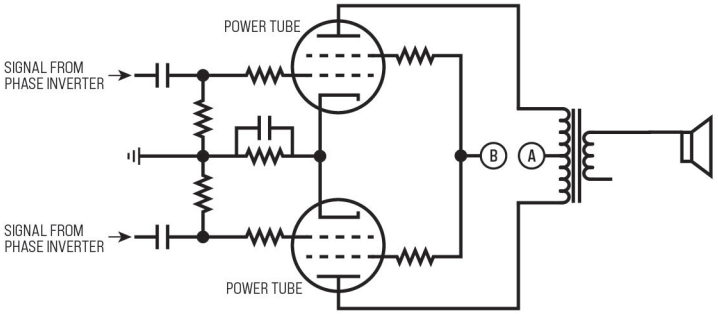
Cathode-Bias Circuits -

As simple as the fixed-bias circuit above is shown to be, the cathode-bias circuit is considerably simpler still. In essence, it consists of just one component: a large, high-powered resistor connected between the cathodes of the output tubes and ground. As the voltage flows through the tube during normal amplification duties, the way in which it is drawn through this resistor to ground via the cathode determines its bias voltage. As most readers with at least a little bit of experience with cathode-biased amps will realize, this is a less-efficient and somewhat less-stable biasing method than the fixed-bias circuit, and isn't particularly suitable to very high-powered amps either. But it's also a very easy means of biasing a set of output tubes, it requires no adjustment during tube replacement, and it enhances particular tonal characteristics that are a big part of several classic types of amplifiers—the Vox AC30 and AC15 and Fender tweed Deluxe among them, alongside many other classics and modern reproductions thereof.

The cathode-bias resistor is usually partnered with another component, a relatively small electrolytic (filter) capacitor that is wired parallel to it between cathode and ground. This is a cathode-bypass capacitor (discussed in detail in What Does This Thing Do? Part 6), and strictly speaking it isn't participating in biasing the output tubes, but is instead helping to voice them while the resistor alongside it covers the task of biasing.

Hopefully this installment of the series has helped you recognize the two major types of output-tube bias circuits in use in guitars amps today, and at the very least, enables you to point to the small network of components in the fixed-bias circuit or single large resistor with bypass capacitor in a cathode-bias circuit and say, "Hey, I know what that thing does!"

CATHODE-BIAS CURCUIT



CASCADING GAIN STAGES

Many installments of What Does This Thing Do? have focused on an individual component, while others have occasionally examined a portion of the circuit that helps to make up the whole. This time out we are firmly in the latter camp, checking out a portion of the preamp circuit in many amps—and one that might be slightly different each time you encounter it, as used variously by different manufacturers, but which generally aims to achieve the same thing wherever it's used.

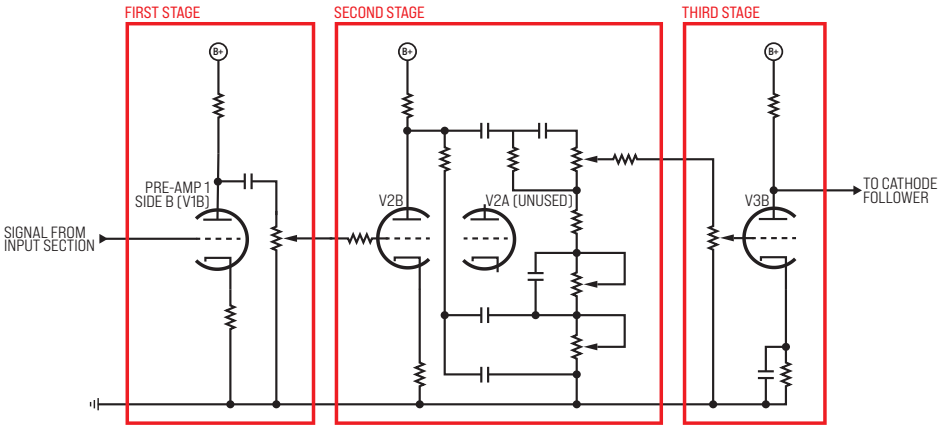
The term cascading gain refers to a method of using multiple gain stages within the preamp stage as a whole to ramp up the gain of the signal higher and higher by passing it along to one preamp-tube stage after another, ultimately creating the singing, sustainful, saturated lead tone that is popular in many forms of modern rock. The result is a lot more preamp-generated distortion than traditional preamp stages are capable of generating, and an easy route to cranked-up lead tones when used in partnership with a master-volume control, which these circuits almost always include.

As seen in any of a number of popular circuits, cascading gain is achieved by feeding the signal into a triode from one half of a conventional preamp tube (usually a 12AX7/ECC83), then from there to another triode, and possibly another, and even another, usually with a potentiometer (commonly labeled Volume, Gain, Drive or the like) between each stage to rein in the gain levels as desired. While most amps other than the simplest designs use multiple gain stages anyway to help preserve signal levels through potentially gain-draining extras such as multiple EQ controls, the cascading gain stages do it purely to ramp up the signal level to ultra-high levels, providing such gain or drive controls between them so the player can govern how "hot"—and therefore, how distorted—the end result is, rather than having the signal depleted by another fixed network such as a tone stack.

If you're already familiar with the term cascading gain, there's a good chance you heard it in relation to Mesa/Boogie amps, which feature it as a cornerstone of their designs and are generally considered a pioneer of the technique. They were not the first maker to chain several gain stages one into the other, however, and some others employed their versions of cascading in the mid to late '60s to increase preamp gain in an age when heavier distortion was becoming a major feature of popular music. Hiwatt's cornerstone circuits of the late '60s, for example, included three gain stages before the phase inverter. These included a Volume control after the first gain stage, and a Master Volume after the tone pots (which followed the second gain stage) as the signal headed into the third full gain stage.

In many ways, even though their use became prominent as far back as the 1970s, cascading-gain circuits are kind of what separates modern amps from vintage: their arrival delineates the effort to generate overdrive within the amp itself and to rein it in at usable volume

GAIN STAGES OF A MOJOTONE
CUSTOM 50 AMP KIT



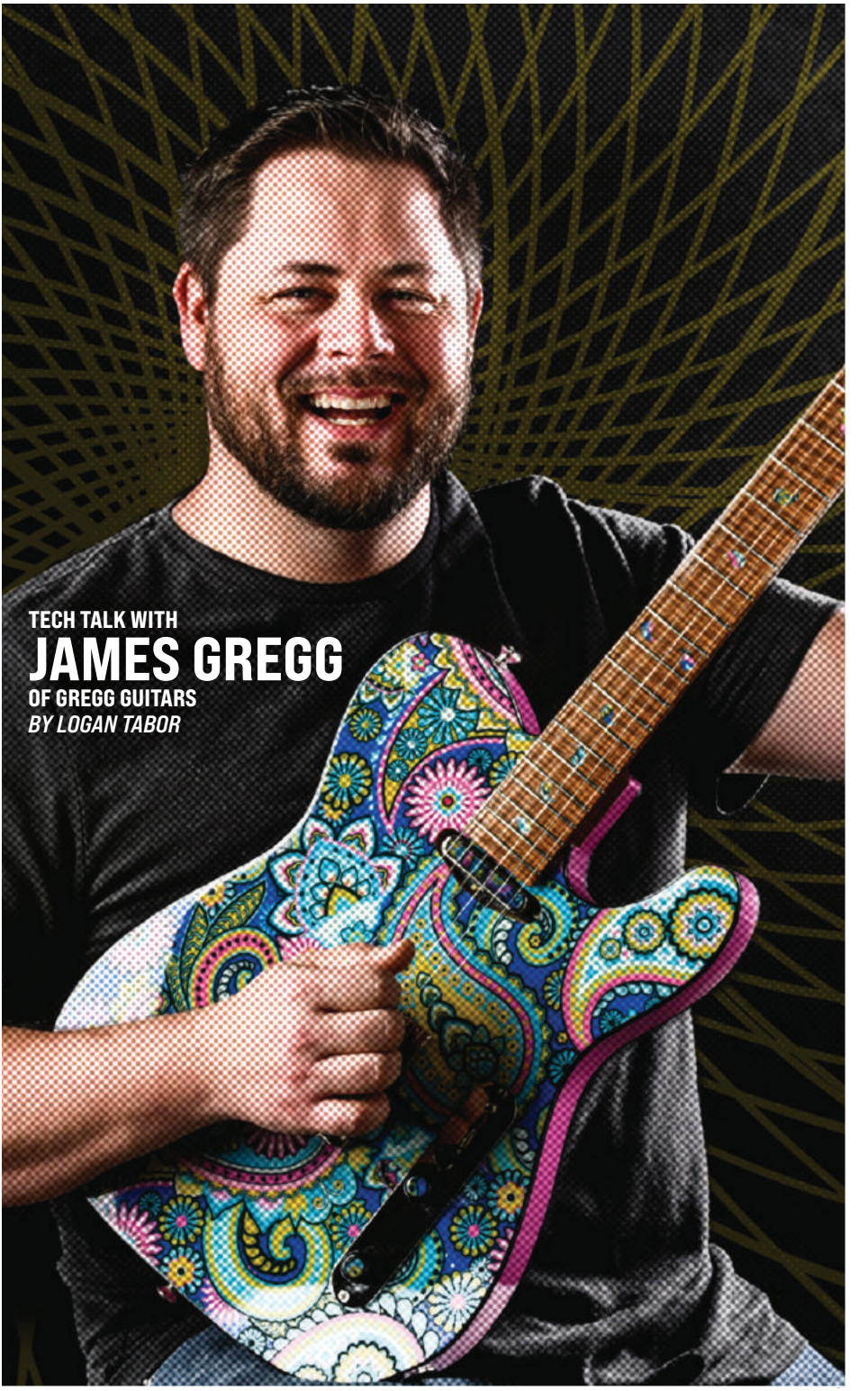
levels, rather than merely to make the guitar louder. With the Boogie's popularity ascending in a big way in the early '70s, Marshall adopted a form of cascading gain in the 100-watt 2203 JMP Master Model of 1975, and the design was made hotter for both the 100-watter and the 50-watt 2204 in 1977. Countless makers joined suit, and later makers like Soldano and Bogner—to name just two of many—would make their names on their own variations of cascading-gain circuits.

Some of the more legendary amps to have used cascading gain are those created by Alexander Dumble. While they obviously have a lot more going on besides, Dumble's best-known designs, like the Overdrive Special, essentially add a footswitchable two-gain-stage cascading lead circuit between a vaguely Fender-like preamp stage and the phase inverter.

As touched upon previously, a cascading-gain circuit within any amp's preamp can be identified by the chaining of the individual halves of a preamp tube (or several) one into the other, generally using coupling capacitors but without any intervening tone controls to lessen the gain (though those will also come before or after their own gain-make-up stages).

Cascading-gain stages will almost certainly have a volume potentiometer between each stage or two, however, as a means of controlling gain levels from one stage to the next. Frequently, they will also have a resistor coupled from some point in the signal (often attached to such a potentiometer) to tap part of it to ground, as a means of reining in the signal strength to a fixed level at that point to avoid overwhelming the next stage, which could result in harsh, fizzy distortion. Brian Gerhardt of TopHat amplifiers, for one, uses this trick in his Emplexador, which has a lead channel based roughly on the Marshall 2203/2204 platform. A resistor going to ground off the output of the master volume tames the signal a little on its way to the phase inverter, without really reducing the volume noticeably, resulting in a smoother overdrive with less harshness when the amp is cranked up.

If you want to try adding cascading gain to your own existing or DIY amp build of a design that doesn't usually carry it, it's usually best to check out the circuits of a few known commercial amp that already us it and see what might be adapted to suit your own design. It's not the kind of thing that can be walked through in a sentence or two, but if your amp has a spare gain stage and you'd like to try creating a hot lead channel it usually isn't difficult to fold that into your own design by taking a page out of the approach used by some of the major names discussed above.



TECH TALK WITH

JAMES GREGG

OF GREGG GUITARS

BY LOGAN TABOR

It's no secret that we here at Mojotone absolutely adore our customers, their work ethic, and their creativity. In fact, it's that very work ethic and creativity that keeps pushing us to do what we do year after year. We love seeing people take an interest in something, learn as much as they can about it, problem solve, and persevere.

Today we're talking to a seriously gifted craftsman by the name of **James Gregg** (IG Handle @greggguitars). James is one of those people who was self-taught, and became a tech guru out of necessity. He took an interest in guitar early on and learned how to get what he needed out of his sound by figuring out how to modify his gear. Now he is what I can only describe as an all-around guitar tech wizard whose power knows no limits.


Brad Paisly holding a Gregg creation.

As always, let's start from the beginning...

"My dad played pedal steel guitar professionally so as a small child, I got drug to the rehearsal hall quite frequently and that piqued my interest in music in general. My first instrument was guitar (mostly because my dad would never let me touch his steel guitar). I also play bass and drums but those came later. My strongest artist influences would have to be Merle Haggard, Ricky Skaggs, Brent Mason, Brad Paisley, and Vince Gill."

I'm already enjoying how this triumphant tale leads off. But gregg is skilled in so many different aspects of the craft – carpentry, luthiery, electronics, etc. – So how did he get from point a to point b?

"Well, this journey is far from a straight path... Back in high school, I started going to pawn shops and finding old guitars that I could repair and flip for a profit. I went to college for music but like many musicians, I dropped out when I got a real gig. I started playing full time professionally in Branson, MO and needed a good tone at low volumes. That drove me to start tinkering with amps. From there, I started building my own amps to create the sound I wanted at the volume I needed. After the show ended in Branson, I worked as a full-time guitar repair man until I went on the road as a guitar tech for the Josh Abbott Band. For a while I tried to do both amps and guitars (all while touring) and that got to be too much. I had to choose what my true passion was, and I ended up focusing on custom crafted guitars. Eventually, I had to take the leap of faith to pursue Gregg Guitars full-time if it was going to be successful."

Hold up real fast, somewhere in there he mentions having been a touring guitar tech; I need to know more about this...


James with Vince Gill.

"I was a full-time touring tech for Josh Abbott Band for about 4-years. I've done contract consulting for specific shows for several other outfits over the years: Eli Young Band, Pat Green, and Aaron Watson to name a few. Road life has some glamor to it – you get to do big festivals, award shows, and night shows. But you spend a lot of time away, the hours are odd, and there is a lot of downtime between things. I actually taught myself to wind guitar pickups on the road out of sheer boredom."

You all seriously need to check out James' social media. He posts some really great content that can be extremely helpful to all of our fellow DIY-ers out there. You truly will not regret checking him out – I'm going to post some links and handles at the end of the article so please stick around until the end.

James has had the honor of building guitars for some of his biggest musical idols; Vince Gill and Brad Paisley to name a couple. He noted that it was pretty hard to beat watching Vince Gill play something that he had built for him on the Opry Stage...and I believe that's probably a modest way to describe that feeling!

Some of you may know by now that I always like to ask our subjects how they break through periods of subdued creativity.

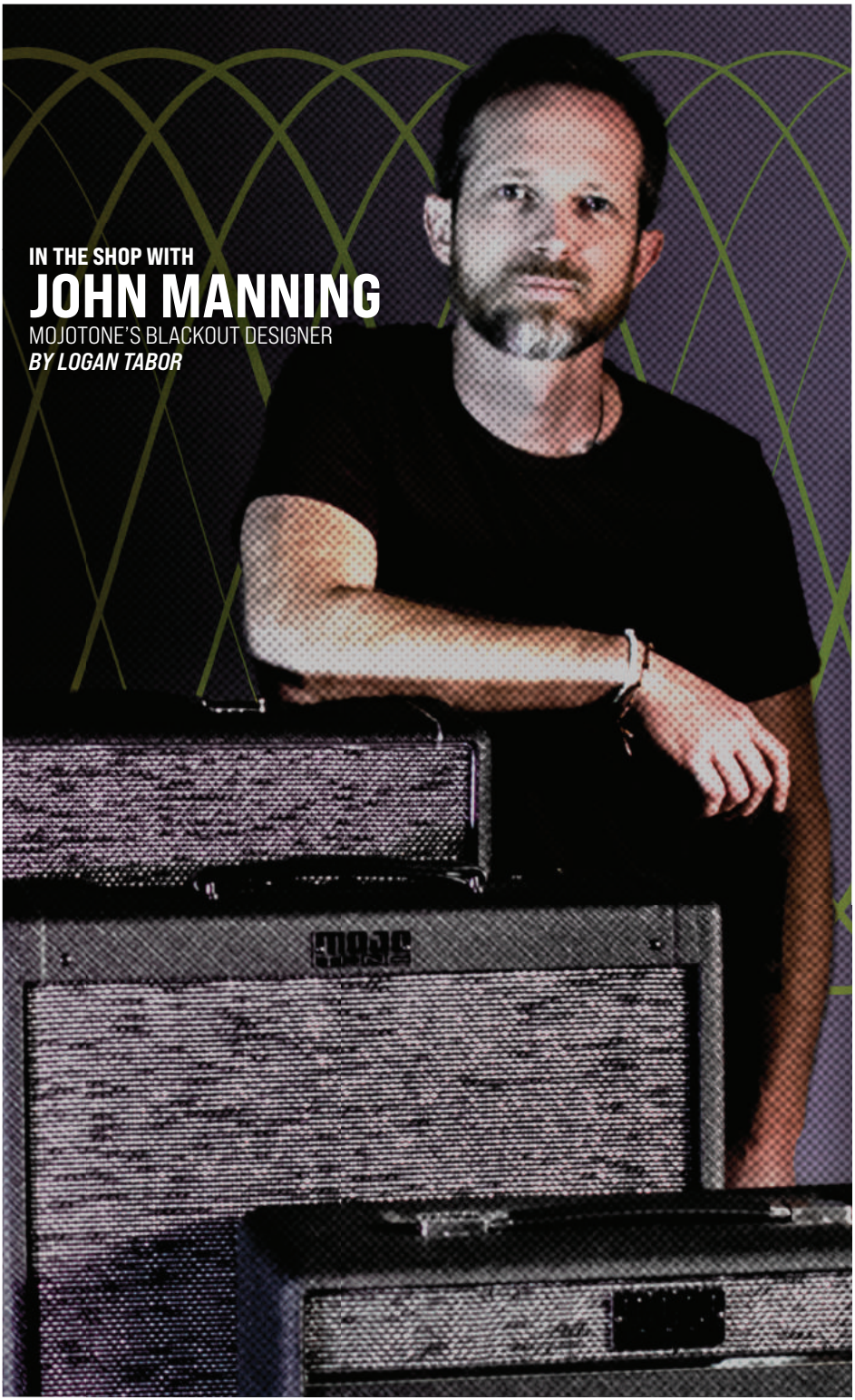
So what obstacles does james face in the midst of all this extremely cool work he does, and how does he overcome those obstacles?

"When I work too many hours to meet deadlines or my wife forces me to do the books or invoicing for the business, my creativity can definitely get drained. To break through it, it usually helps to take a break and actually play my guitar instead of focusing on the technical or business aspects of it all. It can also help to pour a cocktail (or three)."

You're darn right, man. I feel like we've covered a lot of good ground here, so let's figure out what James has in store for 2022 before we say "tata for now!"

"2022 is definitely a year of growing into my new shop and finding out ways to be more efficient without compromising the quality that is associated with the Gregg Guitars Brand. On the personal side, I'd like to find more balance with my life. Get outdoors more. Use my road bike that has been sitting idle for far too long."

As I said further up the page, James is a seriously gifted craftsman and I promise it behooves you all to go give him a follow on social media. I guarantee you'll learn something on day 1! He posts lots of great videos, photos, quick tutorials, you name it.



IN THE SHOP WITH

JOHN MANNING

MOJOTONE'S BLACKOUT DESIGNER

BY LOGAN TABOR

In our ongoing search for DIYers, artists, craftspeople, and tone connoisseurs of all kinds, it has occurs to us that – although there is no shortage of talented and deserving individuals out there in the world – we happen to have quite a few tech wizards right here under this very Mojotone roof!

With that in mind, it only seems fit for us to sit down and have a little chat with one of our very own master engineers, Mr. John Manning. John has been at Mojotone for twelve years now; he started out in our CADS department creating new parts such as chassis, faceplates (custom and stock), logos, eyelet boards, etc. He has since moved into a role where he is able to manage the 'amplifier parts' and 'amplifier kits' portions of our business.

John is an extremely valuable asset to our company and he has a ton of experience all across the board when it comes to electronics, so why not have a quick chat, right?

As Always, We Started At The Beginning...

"I've been playing the guitar since I was twelve. I came from a very musical area, i.e. the foothills of NC. There was a big mountain music influence there. My dad was a mountain musician. He gave me my first acoustic. Meanwhile, I was more interested in the 90's rock coming out, so I wanted electrification. I jammed on every type of solid state rig, but saved up and bought a JCM900 half stack from the Musician's Friend mail order catalog. I was cooking then. I'm left-handed, so I was stuck using low-grade strats mainly. I've gotten used to it. I moved to Wilmington, NC for college, and kind of got sucked into a black hole. I've been here since, pretty much. I joined up with some guys who were eager to be on the road, and so we toured around the country in a van for years playing Thin-Lizzyish, Deep Purpley, Judas Priesty type of original music."

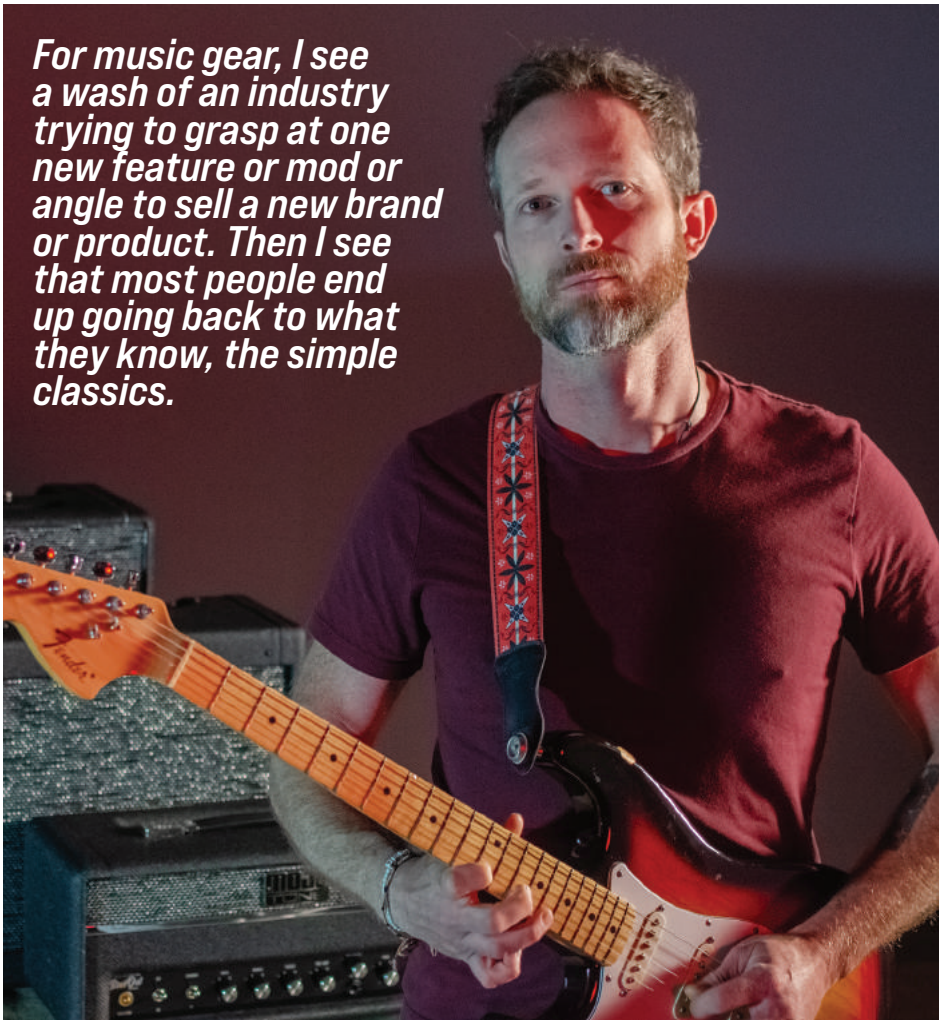
I can attest to this story's legitimacy... John is a Stratified lefty, and a rocker through-and-through. But how did he go from rockin' the stage to rockin' the tech bench? What got him interested in the inner-working of tube amps to begin with?

"Ah, yes, 'twas while I was on the road when my 1979 Marshall JMP kept breaking down that I started to wonder about that type of stuff. I knew of no one who could fix it in Wilmington. I had some friends in Raleigh who took it to someone they knew to get it fixed. I was frustrated about that. I'm the kind of person who can do anything with their hands, so I decided to get down to the bottom of it myself. I went back to school for electronics engineering. I came out with the goal to do repair work in Wilmington. I started up getting good business, but honestly, it's not the most lucrative thing to do. I probably should have gone into power generation or something like that."

An honest fellow it seems. Let's see just how honest he is. If you've been following along with this series, you likely know that I like to find out how these deeply creative and skilled people overcome the dreaded lapses in creativity and motivation.

So Here We Go...

"Sure, I often ask myself what the hell am I doing here? I have to step out of the routine, the mouse wheel, and wander around for a bit. For music gear, I see a wash of an industry trying to grasp at one new feature or mod or angle to sell a new brand or product. Then I see that most people end up going back to what they know, the simple classics. Then the cycle repeats. For me, sometimes it takes hearing a familiar sound, or seeing someone I know start to get somewhere with themselves to get me back in motion."



I think that probably rings true for many of us in this industry. It seems we constantly inspire one another, even when that wasn't our goal. But hey, maybe any one of you reading this article has created something that helped get John's mojo going again when he was feeling depleted.

So we are starting to get to know John and figure out what his journey has been like thus far. Now let's talk about some of the projects for which John has been responsible here at the Mojotone headquarters.

John, Tell Us What You Did, Big Guy!

"Man, there are a ton of things. I was behind a lot of our branding efforts for some of our electronic components. I veered a lot of our parts sourcing from China to better quality manufacturers around the globe. I produced the BlackOut series of amplifiers which has been a success. If you're a veteran kit builder, you may have noticed a difference in the overall quality/ approach to our kits over the past few years. That was me. I brought a bunch of new amp kits to the table, like the Vibrolux, Vibroverb, Custom

John on stage at Reggie's 42nd St. Tavern Wilmington, NC

100, Custom 50, and the venerable GA-5. There's a new one I'm working on right now called the British 50W which is a late 70's JMP 2204 model. I think it's going to be a killer setup. There may even be a new move with vacuum tubes in the near future."

...and a much-needed move that would be. John has really done a ton of great things for the company over the years, and I'm positive he's being modest even in that giant list above.

Let's close with some words of wisdom from the venerable john manning. Johnny boy, what can you say to help all of our beloved DIYers?

"Make sure you are having fun. Don't get discouraged on how your work looks in the beginning, just make sure it works well and functions properly. If you're dealing with high voltage, treat it with respect. Don't build something that's going to be dangerous for someone else later on. That means, take your time with electronics. Start small, work your way up. Don't cut corners. Don't do it if you don't have time. Make sure that you are learning the hows and whys while you are going along."

You can't really argue with that... definitely solid advice. I suppose after this round we can get back to interviewing those followers of ours who do not operate within the Mojotone shop, but I feel like we can all gain something from John's experience in the meantime.

Check out John's band **Mountain Thrower** and show him some love. And if you happen to have dealings with John after reading this article, let him know you enjoyed hearing what he had to say. And as always, we appreciate you stopping by!

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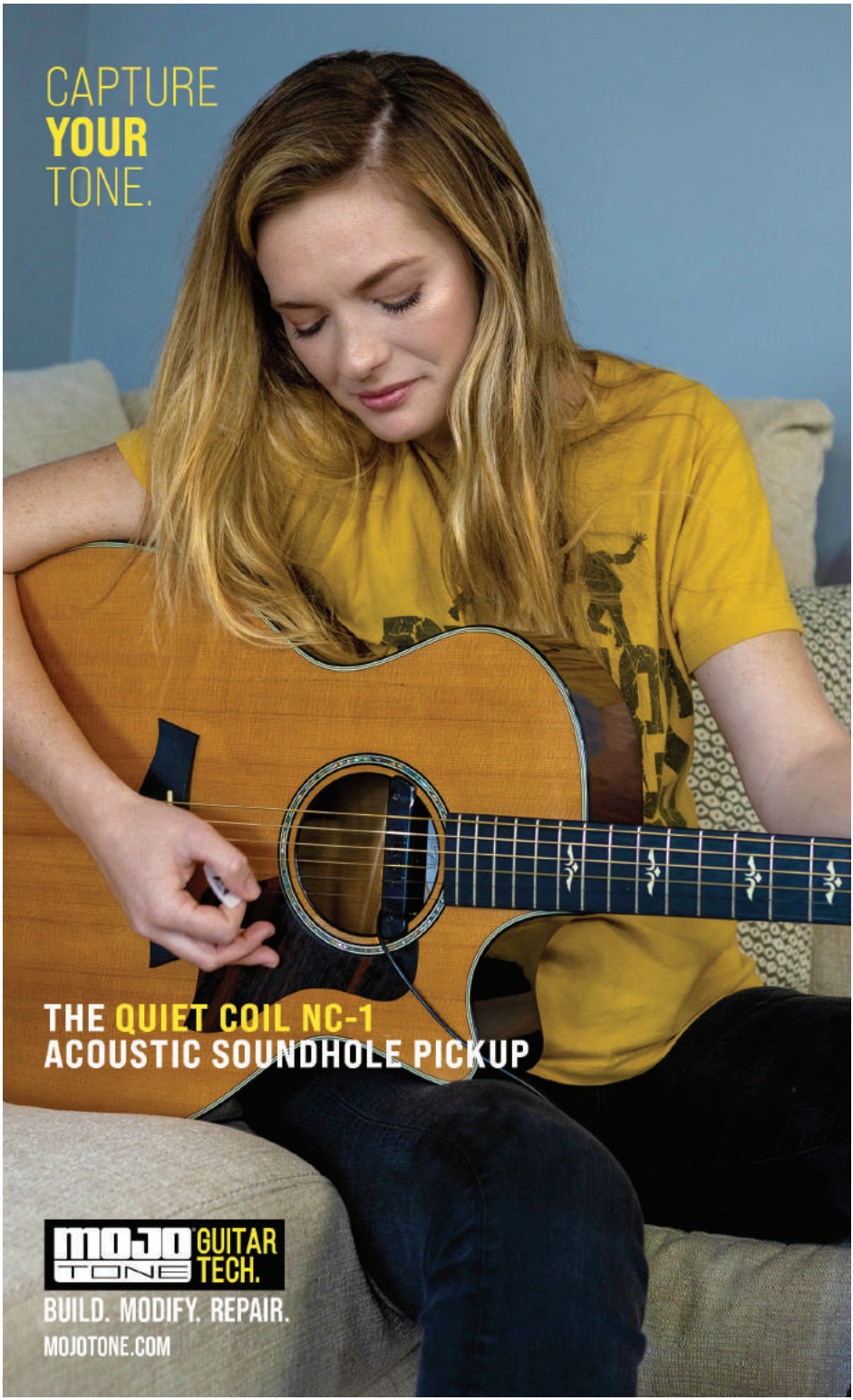
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