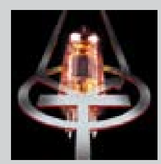
INNOVATION. AMPLIFIED.™

# Chapter 3

# TransTube®

by
**Hartley Peavey**



## TRANSTUBE

Back in 1964, when I decided that I wanted to manufacture guitar and bass amps, the decision was that my new products would use transistors instead of tubes. At that time, transistors had just started to become available in the hi-fi- market and only a very few companies had gotten involved with transistor guitar amps. During that time, there was endless debate in the trade press re: which was "better" for audio: tubes or transistors. Most of this occurred in the hi-fi- stereo area and the discussions usually centered around elimination of the output transformer with solid-state designs, freedom from hum, lower distortion, etc.

My first transistor amplifier was actually designed by a company in Opelika, Alabama… Orrtronics was a division of Orradio who made "Irish Brand" recording tape. The company's founder (J. Herbert Orr) obtained the information for making recording tape at the end of WWII from a German engineer who worked on the first tape recorder called the Magnetophon. Orr came back to the U.S.A. with the information he had gotten and started a tape manufacturing company at an ex-POW camp at Opelika, Alabama (near Auburn).

In the late 50s and early 60s, Orr had gotten involved in a "format battle" re: eight-track tapes with Bill Lear. Orr lost that "battle" so he was looking for "outside work" for his engineering staff. That's when I saw his ad for "engineering services." They did my entire design in just under six weeks… I brought the first prototype back to Meridian and let a few of my "guitar buddies" check it out… Most were fairly impressed, but wanted a little more power… This prototype was built using GERMANIUM transistors in the preamp, but used (then) new silicon transistors for the power amp. I designed a wooden case for the chassis and discovered shortly thereafter that after a few minutes of operation, the prototype started sounding awful and got worse from there… We discovered that the Germanium preamp transistors were "drifting" as the heat built up inside the chassis. We then redesigned the preamp to use silicon transistors and thus solved the "heat problem" in the preamp.

My first product was a 35-watt amplifier based on two RCA 2N3055-power devices. I selected 35 watts since this was about what most of my tube type competitors were getting out of two 6L6 tubes. I quickly discovered that a solid-state amp would loose in A/B comparison with a tube amp of the same power. I worked with a friend of mine (Jim Askew) to increase power to 60 watts, which at least gave me a "fighting chance" albeit with somewhat less reliability from the output stage.

## A 'SOLID' STATE?

During this same time (1965/66), a number of my competitors introduced solid-state guitar and bass amps often with disastrous results (reliability wise). Almost everybody back then was used to designing amplifiers using the data given in so called "tube manuals"… Each manufacturer supplied technical data for designers and this data had PROVEN VERY RELIABLE for decades and everybody involved in design of audio amplifiers assumed (wrongly) that the info in the TRANSISTOR MANUALS was "just as accurate" as the TUBE MANUAL data had been… IT WASN'T! Everybody (including Peavey) had reliability problems with their early solid-state amps… At that time, most transistor power amps utilized "driver transformers," and there was little or no "short circuit" protection and very little effort made to stabilize the output circuitry (thermally)… In short, everybody depended on their "traditional" methods of design using data provided by the device manufacturers as the "basis" for their solid-state amp designs…

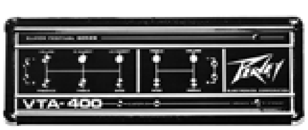
Most "transformer driven" output stages suffered from marginal reliability. In the late 60s, RCA developed a series of power transistors specifically designed for audio purposes and invented several "ground breaking" power amp circuits and configurations. Almost everybody in the business jumped on those designs, which also provided the basis for my 120-watt designs. With 120 watts, I could more than "hold my own" against Fender's 40 watt Super Reverbs and Bassmans, as well as, other competition.

I had refined my solid-state preamp to the point where it was very close to a tube amp as far as so called "CLEAN SOUNDS" are concerned. At that time, guitar amps were increasingly judged on how they sounded in the "distortion mode." It was recognized very early that some amps had a great clean sound, but a lousy distortion sound. Companies introduced solid-state "fuzz boxes" to try to duplicate certain pleasing tube distortion sounds. DISTORTION-BAD FOR HIFI-GOOD FOR GUITARS.

The first recognizable "distortion sound" recording occurred on a country song by Marty Robbins. During the recording session on that song ("Don't

Worry Bout Me"), their bass amp supposedly "malfunctioned" and produced a pleasing "fuzz" type effect. Shortly thereafter, Maestro (Division of Gibson) introduced the first effects box I ever saw… Interestingly enough it was called the "Fuzz Tone"… Of course, I had to order one and when I got it in, it was so noisy and had such a crappy sound that I thought it was defective. Nevertheless, Marty Robbins' "Don't Worry Bout Me" started a revolution in the guitar amp business that continues until to this day.

After I had been in business for a few years, it became clear that I had to offer not only good "clean sounds" but also good distorted sounds. In those early years, almost everyone assumed that some sort of "fuzz" would do the trick. Unfortunately, a "good distortion sound" was extremely hard to achieve with transistors. Peavey and all of its competitors assumed (wrongly) that it "all" could be done in the preamp… Incredibly, most of today's leading suppliers of "digital modeling amps" STILL take that approach… To achieve a good distortion sound with solid-state devices is an incredibly complex procedure involving a wide range of characteristics occurring SIMULTANEOULSY and DYNAMICALLY with at least five "INTERRELATED ACTIONS" taking place at the SAME time… It took Peavey just over a quarter of a century to learn the subtleties of producing a solid-state amp that responds, sounds, and "feels" like a tube amp.




VTA 400

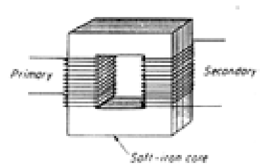
Vintage

As you probably know, Peavey has built many models of tube amps. Starting in the late 60s, with our first two examples being a 200 watt amp using four 6550s called the VTA-400. This is the first amp that had a facility for patching the output of one of the two channels into the input of the other. Shortly thereafter, we had had so many requests from our dealers and customers for a Tweed 410 guitar amp like the one that Fender discontinued in the early 60s. I decided to build an even better amp called the "Vintage." Instead of 40-watts, it had 100-watts plus built in reverb! It was an instant success but because of the greatly increased power, and the much more efficient Eminence 10" speakers, we had terrible problems with tube "microphonics" in the preamp. By this time, American manufacturers of vacuum tubes had started to "wind down" production. The quality of the preamp tubes became extremely questionable, and that led Peavey and many of its competitors to utilize "hybrid designs" using solid-state front ends (for no "microphonics" or hum) with a tube powered output stage. We produced these "hybrid designs" for many years culminating with our Mace (SS preamp and six 6L6GCs). By this time, RCA and Tung-Sol had ceased tube production. We had found GE tubes to be generally unreliable and the only tube manufacturer left in the U.S. was Sylvania. It seemed obvious (to me at least) that long term manufacturing of vacuum tubes in the U.S. was a very "uncertain thing."

The uncertainty re: U.S. tube manufacturers and the fact that tubes themselves were becoming poorer in quality and much higher in price led me to conclude that we needed to began a major research project to figure out how to make solid-state devices perform, sound, and "feel" like tubes. Hopefully, you realize that a transistor and a tube perform very similar functions, i.e. they are both a kind of "electronic valve." The important point: while they perform a similar function, the way each operates is very, very DIFFERENT! A valve (tube) is essentially a "high voltage, low current" device having a relatively high input and output impedance. Equally important, a valve is what engineers call a "single ended device" that operates off a positive voltage on the anode with the cathode being much closer to ground potential.

A transistor also serves to control the flow of electrons and act as an electronic valve, but instead of depending on a heated cathode to emit electrons into a vacuum, the transistor's action is controlled by operating two diode junctions at different potentials. Both a tube and a transistor "modulate the flow of electrons." Unlike the high impedance tube, a transistor is essentially a low voltage high current device, which is directly opposite of the tube's high voltage low current characteristic…

Both tube and solid-state amplifiers have to drive loudspeakers, which are inherently LOW VOLTAGE, HIGH CURRENT devices. While transistors can comfortably drive a loudspeaker DIRECTLY, a tube requires a MATCHING (output) TRANSFORMER to match the HIGH IMPEDANCE tube to the LOW IMPEDANCE speaker and understanding this is one of the first "keys" to achieving a "tube like" response from a solid-state amplifier.



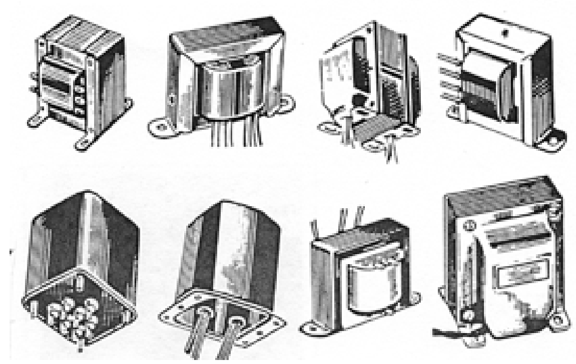

**Basic Transformer**

A transformer is called that because its function is to "change" the nature of the voltage/current fed into the primary to something different in the secondary. First of all, it must be understood that transformers work by enabling the signal in the primary to "magnetize" the steel core, which then "induces" a signal into the secondary… There is no actual "connection" from primary to secondary since they are totally isolated from each other and "connected" only by the magnetic field in the steel core of the transformer. Modern transformers are extremely efficient usually significantly better than 95% transfer efficiency.

Transformers have been around well over 100 years. Our AC power grid is based on the use of transformers that transform the ultra high voltage of transmission lines down to a voltage level that is usable in our homes and businesses. Transformers are all around us, in our lighting fixtures, in virtually all AC powered electronics, in fact, "life as we know it" would not be possible without transformers. These useful devices are available in many configurations, and transformer design is a very "mature science."

## CAN AN INEXPENSIVE TRANSFORMER SOUND GOOD?

Guitar amplifiers have always utilized transformers that were relatively inexpensive. An output transformer for a 100-watt tube/valve guitar amp is just a fraction of the size of a comparable output transformer for a hi-fi amp… Why? Because each device is designed for its specific purpose. The truth is, the WORST sounding guitar amp output transformer you can find is a "hi-fi" type unit… If you ever want to hear a lousy guitar amp sound, plug it into a hi-fi/stereo amp… It sounds sterile, bland, and unappealing… There are reasons for this, which we will discuss shortly. Just as the output transformer for a guitar amp is smaller than it's "hi-fi equivalent"… So is the power transformer. Guitar amps are notorious for having very poorly regulated power supplies whose output voltage "sags" when under severe drive conditions.



**General Transformers**

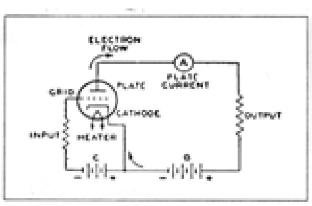
Thus far, we realize that tube guitar amplifiers need a matching "output transformer" to match their high voltage, high impedance characteristics to the inherently low voltage, high current loudspeaker. Above, I mentioned the fact that the way a transformer works is that the energy flowing through the primary coils magnetizes the "steel core" which then "induces" energy into the secondary in a somewhat "changed format" based on the particular characteristics of the transformer. One of a transformer's design features is called the "Turns Ratio." This term refers to the design of the transformer re: exactly what it is designed to do. It is vital to understand that the "steel core" of a transformer can only be magnetized up to a certain degree. That maximum is called "Magnetic SATURATION"… When the core "saturates," it cannot be magnetized any further regardless of the amount of power dumped into the primary.

As the core "approaches saturation," an interesting and important effect manifests itself. As the input signal pushes the core toward saturation, the "bandbass" characteristics (frequency response) change DYNAMICALLY, especially at the frequency extremes (lows and highs). The closer the transformer gets to saturation, the more the top and bottom ends "drop out" thus, effectively creating a DYNAMICALLY CHANGING "BANDPASS FILTER"… This characteristic is a major ingredient of the "tube distortion sound."

A widely held misconception is that tubes "clip" differently than transistors. Many think that tubes clip with a "slightly rounded waveform" while a transistor clips totally square… The FACT is that TUBES CLIP JUST AS "SQUARELY" AS TRANSISTORS, albeit usually tubes tend to clip asymmetrically (one side clips before the other) while transistors generally clip more "symmetrically." When pushed to maximum output, tube amps have a much more "pleasing" distortion characteristic precisely BECAUSE the saturating output transformer acts as a DYNAMICALLY CHANGING bandpass filter thus, filtering out many of the raucous Harmonics coming from the clipped output tubes… What's happening is that the output transformer "smoothes out" the distortion actually being produced by the tubes so that what the speaker "gets" is considerably more pleasing to the ear than what's ACTUALLY COMING FROM THE TUBES. The transformer rapidly changes its bandpass characteristics as the core itself nears saturation point. This is why a "good" (?) non-saturating hi-fi transformer generally sounds a lot worse than a (technically) "inferior" guitar amp output transformer in this application.

One of the first things that we had to do in our TransTube research project was to "synthesize" the dynamic bandpass characteristics of the output transformer itself. One of the main differences between transistor amps and a tube amp is the fact that tube type guitar amps ALWAYS have output transformers while transistors amps rarely do (there are exceptions such as our XXL which is a SS amp that has an output autoformer to match varying loads)…

The first task in our "TransTube process" was to emulate the saturation characteristics of a tube amps' output transformer… A tough job and subject of a patent that we filed re: our TransTube Project.



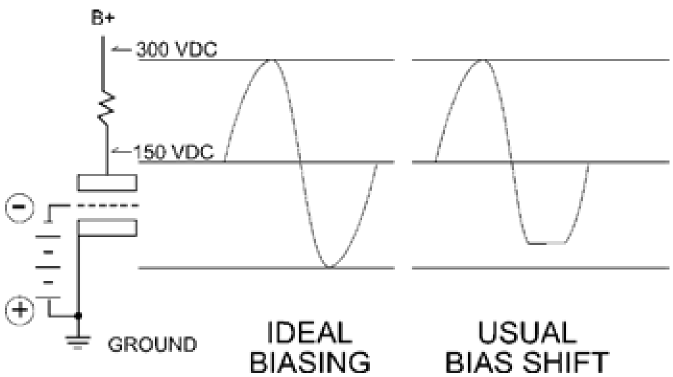

**Basic Triode Circuit**

## TUBE BIAS SHIFT

A vacuum tube (valve) operates using the principle of "Thermionic Emission" i.e. when the cathode gets hot, it "boils off" electrons which are attracted to the anode (plate) which has a high positive voltage (B+) applied. The flow of electrons is "modulated" by the control grid, which is positioned BETWEEN the cathode and the plate. The amount of negative voltage applied to the grid determines how many electrons reach the plate and by changing the negative voltage on the grid, "the flow" can be controlled. Tube designers determine operating characteristics in a number of different ways. Primarily by the "proximity of the internal elements" as well as, by their size… A tube designed as a voltage amplifier would usually be fairly small with the elements being very close together thus, producing high gain… If considerable power is to transferred or controlled, a considerably larger structure is usually required, and if higher voltages are utilized, the elements are positioned further apart… A simple look at 12AX7 and 6L6GC will quickly illustrate that the 12AX7 is a much smaller tube with the elements much closer together producing a higher gain…. The 6L6 is a power tube having an internal structure many times larger than the 12AX7 because it is designed to handle much larger voltages at significantly higher current levels, i.e. the 12AX7 is a PREAMP tube and the 6L6GC is a POWER tube.

Linear tube operation requires that a "negative voltage" be applied to the grid of a tube with respect to the voltage on the cathode. If the driving signal's "POSITIVE swing" EXCEEDS the level of NEGATIVE voltage (called bias) on the control grid of the tube, the grid can itself become positive (with respect to the cathode) and thus, CEASE to be a CONTROL element (in fact) becoming a "secondary anode." A tube overdriven thusly can produce a flow of electrons from the gird itself since it can become "positive" with respect to the cathode. Any element inside the tube that is positive with respect to the cathode can (and will) draw CURRENT, and when this happens, this phenomena is called "GRID CURRENT" which, in turn, produces an effect called "bias shift." An overdriven vacuum tube produces a dynamic and varying (depending on the input signal) amount of BIAS SHIFT in this "overdriven" condition.

Above we have discussed the way tube type amplifiers overload by "saturating" their output transformers which causes the transformers to exhibit a DYNAMICALLY CHANGING bandpass characteristic especially at the upper and lower end essentially creating a "MIDBAND PASS EFFECT"… As the tubes themselves are overdriven, the positive going waveforms can and often do exceed the level of negative bias on the grid of the tube thus causing bias shifting which adds its own unique dynamic effect which of course is passed through the output transformer. These two things happen in an amazing (but serendipitous) "relationship" that very effectively colors the response and the tone from the amplifier. These effects are operational only when the amplifier is driven to distortion and their relationship is the key to much of the so-called "tube type sound," as well as, the so-called "feel" (we call it pushback) of an overdriven tube type amplifier. Please be aware that these effects happen mainly when the tubes and the output transformer are "overdriven"… When a tube amp is in the clean mode, there is certainly a difference in the tonality between tube amp and transistor amp, but much less difference than in the distortion mode. There are three more effects that differentiate the sound and "feel" of a tube amp from solid-state amps.




## ASYMMETRICAL CLIPPING

As mentioned earlier, a vacuum tube is essentially a "single ended device"… This means that the tube itself is located between a ground (earth) reference and a high positive voltage (B+). Ideally, the tube would be biased so that it's plate voltage is at exactly one half of the total supply voltage in order for its output to achieve maximum "swing" (headroom) to avoid the output waveform encountering the power supply voltage or the ground (0 volts) potential, i.e. if a tube is operating from a +300V (B+) supply, the tube should be biased so that its output terminal (plate) is at approximately 150V or one half the supply voltage. The theory on this works out just fine, but in practice, as the tube/valve swings toward the positive or ground potential, the tube almost always tends to "offset" and produce asymmetrical clipping, i.e. one side usually clips before the other. When this happens, every other "peak" of the waveform clips which is said to be "asymmetrical"… Another way of describing this effect is "second harmonic distortion," which, luckily, is generally pleasing to the ear.

I mentioned previously that there had been numbers of people who tried to emulate tube distortion by using variations of solid-state "clipping circuits"… The "fuzz tone" for example. One of the more popular and accepted devices for emulating the tube distortion was Ibanez's "Tube Screamer." Until the advent of this device, most of the "clipping circuitry" was "symmetrical," i.e. the tops and the bottoms of the waveform were clipped equally….pure distortion. Ibanez realized that tube amps tend to clip asymmetrically so, they introduced a solid-state asymmetrical clipper which did in fact emulate one of the major "mechanisms" that make tubes very different than transistors… While Ibanez's "Tube Screamer" did help somewhat, it fell way short of emulating tube amp's total response even though it was better than the conventional "symmetrical clipping circuits" previously available (i.e. better but "still no cigar" re: emulating a tube amp's dynamic characteristics under overload).

**Ibanez's "Tube Screamer"**

In recognition of the fact that tubes almost invariably clip asymmetrically, we incorporated an asymmetrical clipper on EACH STAGE of amplification since this effect occurs in each tube in an amp. Others have incorporated asymmetrical clippers into amplifiers in the past, but only at one point in the circuit (A'la the "Tube Screamer")… Since EACH tube in an amp clips asymmetrically, there must be asymmetrical clippers at each stage to properly synthesize that effect throughout. History has proven that putting an asymmetrical clipper at only one point in a transistor amp is better than none at all, but falls far short of emulating each tube's tendency to clip asymmetrically… TransTube circuitry includes asymmetrical clipping in every major gain stage in the amp… a vital difference between TransTube and other so called solid-state tube emulators.

## VOLTAGE SAG IN THE POWER SUPPLY

Traditionally, guitar amplifiers have tended to have relatively poor "regulation" of their power supplies. As the amplifier is driven harder, it pulls more current from the power supply, and with most guitar amps, the power supply voltage drops significantly. It should be noted that a "proper" (?) power supply exhibits very little voltage drop under maximum drive conditions… A good hi-fi/stereo amplifier generally has fairly good regulation meaning that the voltage delivered to the tubes doesn't drop (sag) very much under maximum output conditions.

Back in the 1950s, amp designers did not realize that their products would be pushed to the maximum. Since the power and output transformers are the most expensive component in any amp (other than the speakers), designers tended to "compromise" figuring that their designs would rarely (if ever) be pushed to maximum… Obviously, they were wrong about that and what musicians found was that having a poorly regulated power supply created a kind of "compression effect" that was pleasing to the ear… Especially, when this "sag" and the power supply voltage combined with transformer saturation, bias shift, and the tendency of vacuum tubes to clip asymmetrically when overdriven.

It is an incredible reality that vacuum tube amplifiers create a unique "choreography" with these interrelated and dynamic effects combining to produce the "tonal magic" that we have become used to hearing from tube amps. The interesting thing about these four effects is that they occur primarily as, or near overload, and these effects occur in the preamp, as well as, the power amp. Our extensive research has taught us that these effects cannot be effectively synthesized in the preamp alone since the output transformer's action is so vital to achieving the tube sound. As mentioned earlier, several companies have attempted to digitally model a tube amp in the preamp while essentially using a "hi-fi" IC chip to drive the speaker. These amps can simulate some of the desired effects, but at high levels any "pretense" of emulating vacuum tubes quickly disappears and this is why you rarely ever see a so-called digital modeling amplifier used on stage live… "The FEEL" just isn't there.

## THE DAMPING FACTOR

There is one last very complex key to the overall "recipe" and it has to do with the fact that most amplifiers (tube and solid-state) utilize some degree of "negative feedback" to enable the power amp to have a higher "damping factor"… A proper discussion of damping factor would take way too much time (and paper) to cover sufficiently. Damping factor refers to the ability of the amplifier to control the movement of the loudspeaker cone, as well as present as low an output impedance as possible to effectively "short out" the voltage that the speakers generate themselves as their voice coils move through the speaker's internal magnetic field (gap).

Most of us realize that if you feed a voltage into a loudspeaker this will magnetize the voice coil, which is (in effect) an electromagnet which reacts with the speaker's own permanent magnetic field. It is generally known that a loudspeaker produces sound by the cone moving backward and forward by alternately attracting and repelling itself from the speaker's fixed magnetic field (i.e. the voice coil is an electromagnet that can change polarity with the input signal). Depending on the polarity of the voice coil, it is either attracted to or repelled from the speaker magnet. What is NOT generally known is that a loudspeaker isn't JUST a sound REPRODUCER, it is also a GENERATOR consisting of a coil of wire moving in an intense magnetic field. The interesting thing is that as the speaker operates producing sound, it is simultaneously generating what engineers call a "back EMF" (Electro-motive force), i.e. a voltage that is approximately 180 degrees out of phase with the input voltage.

I have found that very few people know about this, and even if they do, even fewer understand it… The simplest way to illustrate that this "back EMF" exists, is to illustrate the effect by using two loudspeaker cabinets with the grille removed from each and with a single patch cord going from one speaker input to the other speaker input (no amp connected)…just the two speaker cabinets "patched together"… If you manually push one of the cones in one box, you will notice that the speaker cone in the other box moves in the opposite direction, thus illustrating that a speaker does in fact create a voltage when the voice coil moves in the gap, and that this voltage is approximately 180 degrees out of phase because as one speaker goes IN, the other will come OUT, (if the cabinets are "in phase)."

By using negative feedback, an audio amplifier's output impedance can be minimized thus, presenting essentially close to a "short circuit" for the "back EMF" reflected back to the amplifier from the speaker. Generally speaking, guitar amps have a fairly low damping factor, especially tube amps.

Another aspect of our TransTube design is the use of special circuits to lower the damping factor of our solid-state amps to that of a tube amp… It is important to realize that when an audio amplifier goes into clipping, almost all the damping factor is destroyed. A vital aspect of our TransTube circuitry has to do with the way our solid-state power amps overload with regard to emulation of the output transformer's dynamic bandbass, emulation of bias shifting and the matching of damping factor characteristics.

Damping factor is an extremely complex subject that is beyond the scope of this paper, but it is important to realize that damping factor plays a large part in the sound and the "feel" of a guitar speaker system. We have discovered that it is possible to vary the damping factor in a "frequency selective way" essentially enabling us to vary the damping factor at the bottom end (resonance) and simultaneously at the top end (presence). As you know, we have included these controls on a number of our amplifiers over the last 15 years. Understanding the control of damping factor is vital to maximizing the sound of a guitar amp/speaker system.

### "THE PACKAGE"

I have attempted to briefly explain the FIVE factors involved in synthesizing a tube type guitar amp with solid-state devices. Each one of these characteristics must be included for the complete synthesis of the so-called "tube sound"… Any one of these phenomena will help a solid-state amp sound better for a guitar, but unless all five ingredients listed above are combined to react dynamically with each other and in the proper proportion, "the RECIPE" will NOT work. The Novelty about our TransTube process is that we had to emulate the dynamics of these phenomena in the proper proportion. Like a gourmet meal, the ingredients must be mixed and prepared in precisely the right way or the result will be unremarkable. Because of our many decades of experience, we have been able to find the "Holy Grail" of emulating almost all of the so-called tube sound with solid-state devices…

While we have been extremely successful with TransTube, it should be noted that we could probably convince 95% of players that they were listening to a tube amp rather than a Solid State amp. There will always be a small percentage of people that can perceive every tiny nuance of amplifier response and CAN discern the difference between a tube amp and a TransTube… For now though, I believe that 95 percentile is "a passing grade." Nevertheless, our research continues re: TransTube.

To illustrate the above point, several years' back, we set up a "double blind listening test" at a studio rental outfit in Nashville. We invited a half dozen of Nashville's finest studio "pickers" to come and listen to various amplifiers. They were told that the purpose of the test was "to pick out the transistor amp." There were five amps involved in the test and while these "golden ears" never decided which amp they liked best, their conclusion was 100% on which one of the amplifiers they thought was the solid-state (TransTube) amp… As it turns out, EVERY ONE OF THEM picked the SAME amp being the solid-state amp when in fact, their choice was a tube type "boutique amplifier." Simply put, every one of these "golden ear studio pickers" did NOT identify the TransTube amp as being solid-state, but in fact, picked an amp that sold for more than five times what our TransTube Bandit sold for as the "solid-state" amp… Interesting huh???

As you might imagine, we have tried to patent our TransTube circuitry and the huge amount of research that we've put into it. We have continued to refine the TransTube circuitry adding such features as our "TDynamics® control" which effectively acts like a "power regulator"… Most people ASSUME that our TDynamics control is nothing more than "master volume"… WRONG! The T-Dynamics variably engages a clipping circuit in the output stage that effectively lowers the power amp's headroom, thus emulating a lower powered amp. When the T-Dynamics control is turned down, it is not just acting as a volume control for the amp, it actually decreases the available voltage swing just as a smaller/less powerful amplifier would do while retaining all the vital TransTube overload characteristics that so effectively emulates a tube amp's sound and feel.

Our research continues and we have been steadily improving TransTube technology with new discoveries, and by including the latest semiconductors into our designs, as they become available. TransTube research continues today and is significantly refined over what we introduced in the early 90s.

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