

## The most important tube in your amp? The Phase inverter!

Many people think that V1 (the first gain stage) is the most important tube in an amp. This is true in some cases but not in all cases. V1 (usually the preamp tube closest to the input jack) has the largest impact on your tone and gain but has less impact on your output distortion touch dynamics and output stage distortion than the phase inverter. The phase inverter is generally the preamp tube that is the most close to your output tubes in most amps.

Let's think about this for a moment. Today's amps come in many "flavors". There are three basic amp topologies looking at things from one viewpoint.

- Non Master volume amplifiers
- Master volume amplifiers
- Channel switching amplifiers

In master volume amps we have pre and post phase inverter master volume controls. These work differently but for this piece of writing I will put them in the same master volume category. Rolling down the master does what? It allows the front end to be driven harder and thus we hear our front end distort. At some point we can drive some amps so hard in the front end that the tone becomes so compressed and distorted that even I can sound like a decent player! Your mistakes are covered up in the mush and distortion of it all. This distortion is passed down the signal chain where it is reproduced and amplified by the output stage of the amp. This has nothing to do with output stage distortion. This type of distortion is not touch sensitive. This type of distortion is not something that most articulate players would favor for a sweet tone, blues tone, or even classic rock tones. This is NOT what people refer to as the "brown sound".

Channel switching amps. Many of these amps have so much "junk" in the signal path that hearing tube changes in V1 is a pretty hopeless endeavor. When you do hear a change it is because the tube is closer to industry spec than another tube may have been. If you want to hear different great tones from swapping out V1 then listen to the tube under test in a more classic amp design.

Channel switchers continued. I get calls and letters all the time where people have a "bonzo-3 channel gripmaster Mk III recto" or whatever. Many owners of these amps say: "the owner's manual says that V3 is used for the turbo channel" or whatever. Remember, V1 feeds EVERYTHING else down the line, EVEN IN THESE AMPS. The "turbo channel" generally does not use JUST V3. The chain is fed by V1. V1, even in multi channel amps is still the most important tube in the TONE AND GAIN stage of most amps. If you want to **change the ratio** of preamp tube distortion to output tube distortion then we change V1 in some cases. Going from a 12AX7 to a 5751 will reduce front end gain. Going down to a 12AY7 will reduce the front end gain further and generally give one more clean headroom.

Back to the phase inverter. Taking a simple classis non-master volume amp (but this is the same for master volume amps as well actually).

I will try to keep things simple here with a few basics. If you have questions on all the complex versions feel free to contact me.

Fender Tolex era amps – These generally used a 12AT7 in the phase inverter.

Marshall type amps – These generally used a 12AX7 in the phase inverter.

There are many other differences in these amps but I will stick to the PI (phase inverter).

## Some basic tube facts

- 12AX7
  - Has a published spec gain of 100
  - Has a published spec current output of 1.2 milliamps
- 12AT7
  - Has a published spec gain of 60-70
  - Has a published spec current output of 10.0 milliamps (ten times that of the 12AX7 as a side note)

As a third example, a 5751 has a gain which is almost identical to the 12AT7 but its standing current is 1.0 milliamps (about the same as the 12AX7). But, there is a third factor, **transconductance**, to be considered. The 5751 has a transconductance of about 1200. A 12AX7 has a "TC" of about 1600 and a 12AT7 has a TC over 5000. These three tubes act quite differently. A 5751 and 12AX7 are much more closely related than the 5751 and 12AT7.

We will stick to the basic 12AX7 and 12AT7.

**When you push your amp hard it is not as much the output tubes distorting as it is the phase inverter breaking down and distorting.** We are talking output stage distortion here. We are not talking about how you may have messed up the signal with preamp tube distortion and compression already. **The phase inverter may be the hardest worked tube in most amps.** I cannot begin to count the times when I have found phase inverters that were long past their service life. When you change your output tubes change that phase inverter. At the least change it every other output tube change.

Many folks think that when they want to have their amp have more clean headroom they can insert a 12AT7 in place of the 12AX7. Very true. (By the way, the 12AT7 in a first gain stage is an awful tone generator in a guitar amp. If you want to drop front end gain use a 5751 (gain of 60-70) or a 12AY7 (gain of 40). The 12AY7 was the first gain stage in the classic Fender Tweed Bassman, Deluxe, etc.

Going from a 12AX7 to a 12AT7 in the PI (phase inverter) will yield a change in output tube distortion, touch, and output dynamics in most amps. Is this because the gain is lower in the 12AT7? 10% yes perhaps. The lower gain is a factor but the larger factors are:

- We have almost 10 times the current available to drive the output tubes before the phase inverter starts to break down.
- We have a transconductance of 5500 vs 1600 of the 12AX7. Keeping this simple, it means it takes a lot less input signal for a given output signal.

**The output tubes are less important than many folks may think.** Think about this. In the Hi-Fi world there have been many amplifier designs. Some such as the Scott and Fisher lines used EL-84 output tubes. McIntosh used 6L6 and 6550 / KT88 tubes. Dynaco and some British amps used EL-34 tubes. All of these amps, when operated at the rated specs generally stated that from 20-20,000 cycles at .5% distortion or less they were considered "flat" by industry spec. The output tube type had very little to do with anything. In guitar amps we purposely push the output tube beyond their design limits to make them distort. The difference between a Svetlana 6L6 and an RCA 6L6 is the difference in the way the tube sounds when it is pushed beyond its design limits. Being in the "tube business" this is not a great subject. What I am basically saying here is: Before you go to a pricy output set of tubes and a possible need to rebias the amp think about a simple phase inverter change. There are no amp adjustments necessary when you change the phase inverter.

In real life we rarely get to the point of pushing our output tubes to their limits. Our front end is going into distortion. Our phase inverter is breaking down too. The ratio of this front end distortion to phase inverter drive and breakdown is determined by amplifier design topology. You cannot make a Marshall into a Fender no matter how many people tell you that this can be done. Putting 6L6 tubes in a Marshall will NOT make it sound like a Fender either.

There are many 12AX7 types of tubes available. They are all different even though they are supposed to have the same specs. Even when one looks at the same tube type from the same maker out of the same production run we find HUGE variances. +/- 50% off spec is common. Most 12AX7s today show a current output of 0.6-0.8 milliamps where 1.2 milliamps is expected. You throw a 12AX7 in your PI slot with a 0.8mA output and you are 30% down on what the amp can do right off the bat. Your amp is not as full, tight, responsive, or just plain "powerful" or dynamic. Many of today's high production amps use the Sovtek 12AX7WA short plate as a generic 12AX7. I have issues with these in the tone and gain stage but staying with the topic of phase inverters, these are just awful (12AX7WA Sovtek) for the most part. In tests these show very low standing current. The Ei long smooth plate also shows low standing current, even though a long plate. Generally, large plate tubes will show higher standing current but this is not always the case. The JJ ECC83S has the highest standing current of any current production tube. The JJ is a short plate tube. The JJ is an exception. You might think the JJ would be a good PI. Not from my personal taste. The way the JJ breaks down is not as musical to my ear in most amps and I do not care for the touch response and dynamics of the tube in the PI position in most amps. What do I like? I like the Sovtek 12AX7LPS and the GT 12AX7M. The GT 12AX7M is also available as a matched phase inverter from the SAG over at GT as the SAG-AX7-MPI. There is also an SAG-AT7-MPI. I have talked about matched phase inverters in other places prior to this piece of writing. The 12AX7M and 12AX7R2 (Sovtek 12AX7LPS) are both long plate designs. In either case I check these for specs because in all cases there is a wide range of variables from tube to tube and run to run in production.

There are a lot of great NOS tubes. They have advantages in the tone and gain stage but they are not as available as production tubes made today. When you are on the road or on tour these are harder to find. In the case of the phase inverter we do not want to stock a bunch of Mullards or Telefunks to burn up every output tube set change. There are great current production tubes that give us all we can ask for.

Other great phase inverters to consider are the 5751, 12AY7, and 12AU7.

The bottom line here is simple. The phase inverter is one of the most important tubes in your amp and the hardest worked tube in the preamp section of your amp. It is how this tube breaks down that provides your output stage distortion tone, character, and amp feel.

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