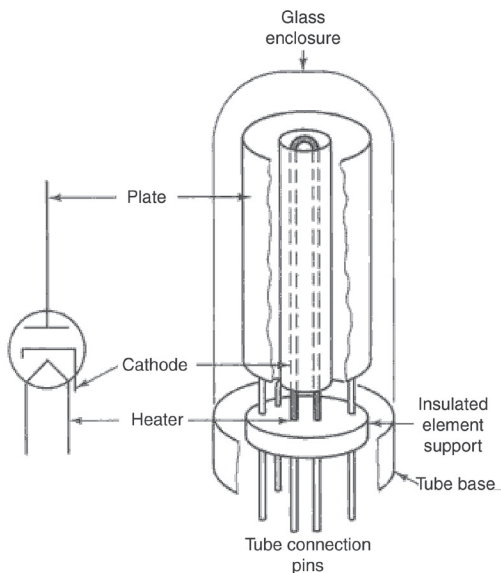


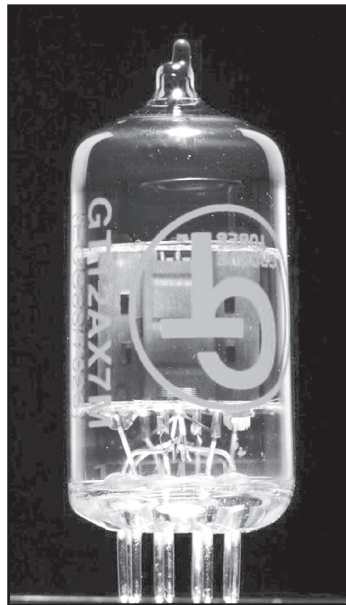
AMPLIFIER TUBES EXPLANATION

VACUUM TUBES - possibly the single most important component in a guitar amplifier as far as determining tone. Tone junkies love tube talk simply because there are so many options in choosing tubes. Although the *Blue Book of Guitar Amplifiers* is not dedicated solely to tube guitar amplifiers, a large part of this book contains information on this subject. We are not experts by any means in this field, but we thought a brief explanation about tubes would be helpful. NOTE: If you are seriously interested in tubes, modifications, and any other tube-related project you should refer to some other books. Several authors have written thorough books entirely on tubes and guitar tube amplifiers. Many magazines also run monthly columns and have featured articles on tubes. That said, the *Blue Book of Guitar Amplifiers* Tube Theory/Explanation section should not be taken any further than a novice view on guitar tubes. Also note that guitar amplifiers contain lethal amounts of voltage and if you don't know what you are doing, do not start poking around as you could get a nasty and even lethal shock.

Vacuum tubes were first used in electronic applications during the 1920s and 1930s simply because they were the only way engineers knew how to produce sound. All early radios, amplifiers, and related products use vacuum tubes to amplify sound. The same can be said about guitar amplifiers - vacuum tubes were the only means of shaping and amplifying sound. Little did these inventors know that over fifty years down the road vacuum tubes would be the preferred choice among tone junkies. Along with many years of improvements and adjustments, hundreds of different tubes are now available, and all of them have a unique sound. It is useful to know how a vacuum tube works first though.



Components of a Vacuum Tube
courtesy Justin Holdon



Groove Tube GT12AX7M Preamp Tube
courtesy Groove Tubes



Groove Tube GT6V6C Power Tube
courtesy Groove Tubes

A vacuum tube is constructed of a sealed glass tube with four active elements inside. The four main elements include the plate, grid, cathode, and heater (filament). Each of these components is connected to a series of pins that are all numbered. The tube works in this order: First the heater (filament) is warmed which in turn heats the cathode. When the cathode is warm, it begins emitting electrons that flow to the plate. The cathode has a negative charge and the plate has a positive charge. The grid controls the flow of this so electrons do not move too fast. All of these components are in a sealed vacuum tube with no air so none of them burn up. Needless to say, there is a lot of electricity that flows through these tiny tubes.

How does this translate into guitar sound? Well, when a small signal, such as the magnetic waves from a guitar pickup, is applied to the grid, it causes the electrons between the cathode and plate to flow at different rates. The plate end of the tube is connected to an output transformer that puts sound out to one or more speakers. There is a lot more that happens between all of this and a lot more technical information, but we'll let the more advanced authors handle that.

There are three main types of guitar amplifier vacuum tubes: preamp, power, and rectification. Each serves a unique purpose in a guitar amplifier, and even the most basically designed guitar amplifier must have at least one of each. A guitar signal passes through the preamp tube(s) first, followed by the power tube(s) and AC current is converted to DC current with a rectifier tube. Early on, the U.S. and Europe used different named/numbered tubes, but they are very similar and identical in some cases. However, most tubes have unique sounds that players prefer.

PREAMP TUBES:

Once a guitar signal enters the amplifier, it must be amplified to a level the guitar amp can work with, which is what a preamp tube(s) do(es). This is sometimes referred to as line-level strength. Even though this stage of the amp only produces a very small volume, it is still louder than when it entered the guitar amplifier. If the guitar amplifier has tone controls, effects, and other features, more preamp tubes will shape the sound. This stage of the amplifier

is commonly referred to as the signal processing stage. The amount of features the amplifier employs will determine the number of preamp tubes. The most basic amp with no tone control will probably only have one preamp tube (i.e. Fender Champ, Harmony 303, etc.). Amps with two channels (separate bass, treble, and mid controls), tremolo, and reverb may have six or more preamp tubes.

Examples and conversions:

American	European	Industrial
12AT7	ECC81	6201/6679
12AU7	ECC82	6189/6680/7730
12AX7	ECC83	6681/7025/7729
12AY7	N/A	6072
12DW7	N/A	7247

POWER TUBES:

Once the sound of the guitar (or other instrument) has been shaped by the preamp tubes, it needs to be amplified to a level that is audible. Power tubes take the relatively weak signal from the preamp/signal processing stage and amplify it into several watts. This signal is then transmitted to a power transformer to match impedance with a speaker, and finally connected to a speaker(s). Power amp tubes are generally much larger than preamp tubes and they run a lot hotter because of the energy that passes through them. Small Class A amps may only utilize one power tube that is always on, but the majority of tube guitar amplifiers have power tubes mounted in pairs that work in a push/pull format. When one tube is on, the other one is off. Most tube configurations consist of either two (25W-50W output power) or four (50W-100W output power) tubes, but some larger amps may have six or even eight power tubes.

Examples and conversions:

American	European	Industrial
6AU6	N/A	6136/7543
6BQ5	EL84	N/A
6CA4	EZ81	N/A
6CA7	EL34/KT77	N/A
6L6	KT66	5881
6V6	N/A	5871/7184/7408
N/A	KT88	6550

RECTIFIER TUBES:

In order to convert standard house power (120V AC in the US) to power a guitar amplifier can utilize (DC), a tube or solid-state rectifier needs to be used. The rectifier provides power to the other tubes when they are being used. Almost all early and small tube amps will have a tube rectifier, while newer and larger amps have solid-state transistors. Since the rectifier has no direct contact with the sound, there really is no advantage for tubes in this section. However, a tube rectifier can sag when a large amount of power is needed at the other tubes resulting in a lack of power/sound that is actually desirable to some guitarists. A few amplifier companies, including Mesa/Boogie, use multiple tube rectifiers in their design to provide power to the tubes.

Examples and conversions:

American	European	Industrial
5AR4	GZ34/GZ37/U54/U77	N/A
5U4	GZ31/GZ32/U51/U52	N/A
5Y3	GZ30/U50	6087/6853

As the above charts indicate, many tubes have European and Industrial counterparts. Most of the time, tubes can be switched if desired with matching counterparts as long as they have the same pin layout. Experimenting with different tubes can provide many different sounds. For example, a schematic may call for 2 X 12AX7 and 2 X 7025 preamp tubes. By looking at the above charts, we can see that they are indeed the same tubes. Back in the 1950s and 1960s, industrial tubes were built sturdier and are regarded as more durable. Certain stages of the guitar amplifier may call for more durable tubes in a demanding position. There are many tricks to learning about tubes.

Replacing tubes often is recommended and sometimes necessary if they are too old. Tubes wear out after use, and after many years (like light bulbs) they can burn out. Tubes that are old or burnt out will make the amplifier sound really bad with a hiss, low output, or other unwanted sound. Replacing tubes and a correct bias job can make your amp sound like new again, but there are other places to look when it comes to trouble in the amplifier. Look for more information on tubes and tube maintenance in further editions of the *Blue Book of Guitar Amplifiers*.