Of Tubes and Tube Sound

Like bad pennies, nuclear waste, tory politicians and other things that never go away, vacuum tubes seem to reappear from time to time in new guises. Let's have a look at these quaint anachronisms from the past and their latest re-emergence.

by Steve Rimmer

You can't rock and roll without tubes.. at least, not very well and not very authentically. Breathes there a guitarist who doesn't own a noisy, crackling vacuum tube amplifier with gaffer tape holding the case together and weird blue light emanating from the back, treasuring it despite its antiquity and propensity for detonation? There are few things more poetic than a digital guitar feeding digital effects run through a digital preamp driving a Marshall tube amplifier.

Even if the only instrument you play is the stereo, tube sound has been clawing its way back out of the slag heap of time recently. In a grand celebration of low-tech, a new generation of tube sound amplifiers has appeared... complete with little glass windows up from so you can see the tubes. While few people know why tube sound is supposed to be desirable... and perhaps fewer still actually understand what tubes are... these hybrid stereo components have been attracting a bit of a following of late.

In this feature we'll have a look at what tubes actually do and at some of the myths and realities of that most elusive of quantities, true tube sound.

Vacuum Cleaner

It's probably worth beginning at the beginning... with a bit of tube lore. If you're old enough to remember tubes as something other than museum curiosities you probably won't have to read this bit.

Vacuum tubes were the precursors of transistors. They served as diodes, amplifiers, gates and switches back when silicon was only used for making beaches. Significantly different in their approach to the universe than solid state devices, the physics of tubes is actually a whole lot easier to understand than that of semiconductors.

Perhaps the only justification for something as funky as a vacuum tube... at least at a theoretical level... is that you don't need a background in molecular witchcraft to be able to figure out how it works.

Vacuum tubes are shaped a bit like lightbulbs because that's what they started life as. The first electric lightbulbs were built with filaments about where you'd expect them, but with an additional metal element called a "getter," which was used in the process of evacuating the bulb. The structure of a prehistoric lightbulb, then, was that of a hot filament poised beneath a cold metal plate with a considerable amount of nothing all around.

It was discovered that with a lightbulb powered up and illuminating the universe, a current would flow from the filament to the getter if the getter was more positive than the filament was. What was actually happening was that electrons were being kicked off the hot filament and being attracted through the vacuum to the positive getter.

Because the getter was cold, the electrons would not make the return trip. As such, the lightbulbs were found to have the properties of a diode. The name "diode" comes from a parts count... it has two elements. Later techno-linguists were to name the filament of the lightbulb a cathode and the getter an anode.

Some time later, it was further discovered that if one introduced a bit of window screen or an unfolded paper clip into the gap between the cathode and the anode, the amount of current passing through the tube could be regulated by the voltage on this third element. The third element came to be called the "grid." Furthermore, if the position of the grid was chosen with a bit of care, a small change in voltage at

the grid would result in a large change in current through the tube.

With the addition of a grid, three element tubes... "triodes"... were capable of amplification.

In Britain, tubes came to be referred to as "valves," which is probably a much more descriptive name for them. You might want to think of them as such if it helps to understand what they're up to. A tube behaves very much like a valve regulating the flow of a stream of electrons.

Triodes encounter several problems in real life. As the frequency of the signal being amplified increases, the amount of time the electrons flying around between the cathode and the anode have to change direction begins to decrease. After a point they begin to grow confused... they cannot travel between the grid and the anode in the time between cycles of the waveform being amplified and the tube effectively ceases to work. One way around this is to make all the elements and the spaces therein smaller, but smaller tubes can handle less power. Another is to install a second grid.

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A tube with two grids... a tetrode... overcomes the capacitive effects of a triode by having a negative grid between the principal signal grid and the anode. The electrons passing the primary grid are repelled from the second grid and can make the trip in a shorter time than they would in a straight triode. Tetrodes can, thus, work at higher frequencies than triodes, all other things being equal.

Unfortunately, tetrodes have a number of peculiar linearity characteristics which can only be solved with... yes, another grid. The resulting tube, a pentode, gets around the frequency and power limitations of a triode without encountering any of the peculiarities of a triode. The majority of vacuum tubes in use at the onset of solid state technology were either triodes or pentodes. Tetrodes had been largely relegated to somewhat exotic radio frequency applications.

Megavolts and Nanoamps

The voltages applied to vacuum tubes would make most solid state devices nervous. A typical preamplifier tube, such as a 12AT7 dual triode, might have a hundred and twenty-five volts on its anode, or "plate," and a third of an amp coursing through its filaments to heat the cathode. Power output tubes such as the venerable 6L6 power pentode... the loud bits of many audio amplifiers... usually run with about three hundred volts on their plates and almost an amp of heater current. A typical amplifier would need at least two of them... my favourite guitar amp uses four.

A fairly sophisticated amplifier... at least by tube standards... may include a dozen tubes per channel. This, in turn, requires a large and exceedingly heavy power transformer to supply the multitude of voltages needed to run the beasts. Finally, power tubes are high impedance devices... you can't connect them directly to a speaker. Instead, the tubes must drive yet another large transformer.

Despite their almost mythical status as audio components these days, tubes are decidedly funky things. The pounding of electrons into a tube's anode creates noise. Vibrations travelling through the metal chassis of an amplifier in turn vibrates the elements of the tubes therein, producing all sorts of microphonic effects... occasionally feedback. The characteristics of tubes change as they get hot, and as they age. They ring, they clip, they oscillate and, having somewhat large metal pieces they frequently act as antennas and pick up local radio stations. Their frequency characteristics are irregular and they have non-linearity problems. Finally, just when you get everything working right, they burn out.

The distortion characteristics of tubes are actually what still endears them to musicians... that, and their ability to put out lots of sound. A straight electric guitar played through a straight amplifier isn't actually all that interesting. Tube amplifiers add "warmth" to a guitar by distorting the signal in subtle ways. The distortion of tube sound isn't as radical as that of a fuzz box, and because tubes aren't actually terribly linear... especially when they're driven to their limits... the nature and amount of the distortion they introduce can be controlled intuitively by the person playing guitar.

The other useful characteristic of tube amps for guitarists, their ability to handle large amounts of power, is actually what they're intended for in stereo amplifiers as well. When a transistor is driven beyond its rated output power, it clips the signal. Because contemporary solid state output devices are very fast, they clip very cleanly. Transients and other loud, short phenomena also get clipped cleanly. The result is the introduction of a lot of high frequency energy into the sound belting through the amplifier in question, which sounds harsh and unpleasant.

A tube amplifier, on the other hand, has a big inductor which stores energy for its output stage, this being the output transformer. When you drive a tube amplifier to clipping, the tubes tend to round out the clipped waveform... as well as adding some still more interesting distortion to it. The result looks like anchovies and catnip on a 'scope, but it sounds better.

Tube Sound

An electric guitar is only half an instrument... if you don't believe this, try playing one with no amplifier. A guitar amp is more than just a box to make the guitar audible. Guitarists choose amplifiers to some extent depending upon how they want the amp to colour their sound.

Admittedly, this is less true than it used to be. Many musicians use pretty bland solid state amplifiers and then lots of effects pedals to colour their sound.

Stereo amplifiers aren't intended to colour the sound they amplify. Most of the characteristics which guitarists cling to as they tape the shattered remains of their tube amplifiers together for just one more gig are quite the opposite of what one wants in a stereo. A lot of the things which

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proponents of tube sound laud as the virtues of vacuum tubes are really bugs which tube amplifiers never really managed to solve.

Tubes, for example, are said to have better bass. This is largely because they have sort of awful high ends... the impedance of the output transformer's primary goes up as the frequency passing through it does, and the efficiency of the output tubes starts to fall off in the treble as well.

The warmer, richer sound of tube amplifiers is largely distortion... you can get a similar sort of warm, rich sound by getting a really cheap stereo from Sears.

Oddly, the one thing that tubes do well, handling lots of power, isn't what the current generation of hybrid tube amplifiers seems to use them for. An amplifier with low noise, low distortion transistors in its small signal sections and a couple of power pentodes to drive the speakers would arguably combine the best features of the two technologies. However, perhaps because output tubes and transformers are too big and too expensive to fit into the confines of contemporary stereo equipment, most amplifiers with "tube sound" arrive at it by including a couple of tubes as preamps.

You can arrive at much the same power handling characteristics of tubes... at least for audio applications... by simply using a large enough solid state amp to handle any peaks and transients you're likely to encounter. Unless you specifically like the distortion, noise, hum, intermodulation, crosstalk, harmonics, microphonics, heat, short life span, power consumption, size, weight and expense of tubes, tube sound will probably be little more than a manufacturer's ploy to sell trendy stereo hardware.

The tube sound's already in rock 'n roll. It probably doesn't belong in most other sorts of music.

While tubes do have their places, even today, high fidelity sound probably isn't one of them. Manufacturers who tell you that nothing quite sounds like a tube probably hire the same advertising agencies who will tell you that nothing quite accelerates like a Honda Civic, tastes like Kraft cheese, makes friends like a pit bull or lies like Michael Wilson. All of these things may well be true, but they're hardly features.

The last time I went to retube my guitar amp, output tubes cost seventy-five dollars a pair... this was about five years ago. You might want to consider this, too, as another of the unspoken features of tube sound. ❐

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