Subject: Re: Glossary
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My definitions may not be the best, as I sure ain't the sharpest knife in the drawer. Regardless, here's a "tube primer" that will hopefully be of some benefit, in my own words, without getting too awful far out technically. SET - Single Ended Triode, an amplifier whose output tube or tubes per channel amplify the entire signal 100% of the time. It often uses the simplest feasibly possible driver stage that is adequate to correctly drive the output stage. It's concept is based on the "less is more" principle. Less stages and components in the signal path means less corruption of the signal. It's sound is marked by a characteristic openness, with increased "air" and "space" between the instruments, voices, and parts, with liquidity, smoothness, and a natural, lifelike character. One reason for this is that it's distortion products are almost exclusively second order, which is a harmonic one octave above the actual signal frequency. In small amounts, it is perceived to the ear as a "fluidity," or "sweetening" of the amp's tone. It's less objectionable to the ear than the harsh sounding higher order distortion series, which are produced in greater amount by pentode push pull amps. It's disadvantages (usually) are very low output power, soft or rolled off bass, and sometimes finicky speaker compatibility problems. Top grade output transformers (OPTs), and choke input power supplies built with the best componentry can alleviate these problems greatly.PSE - Parallel Single Ended, a SET amplifier having two or more output tubes per channel operated in parallel. All the output tubes in a given channel operate the same and amplify the signal together in an identical manner. A parallel single ended amplifier using two power tubes has exactly twice the output power of a single power tube single ended amplifier, and so on. PP - Push Pull, an amplifier having a pair of output tubes per channel, that operate in an opposing "seesaw" fashion. This amplifier uses an additional tube stage as a "phase inverter," which takes the AC signal and splits it into two identical signals that are 180 degrees out of phase with one another. The in-phase signal is fed to one power tube, while the inverted-phase signal is fed to the other. The concept is akin to that of two people rowing a canoe. One person rows on one side, then the other rows on the opposing side, and it repeats over in a rhythm. The two signals are summed together in the output transformer to form the signal that drives the speakers. A major advantage of this is that all second order distortion created in the output stage is eliminated by phase cancellation in the output transformer.A push pull amp usually has better weight and "slam" than a single ended amp. It is also far more efficient and capable of much higher power output. It's disadvantages are a usually less open and less lifelike sound than a good SET. Much of this can be overcame with a proper choke input power supply and top grade componentry.Parallel Push Pull - A PP amp using multiple pairs of power tubes per channel for more wattage. Whatever the number of output tubes, it must be even.NFB - Negative Feedback, a sample of a signal taken and reinjected in an earlier location where it is 180 degrees out of phase. It was first used to reduce distortion in the repeater amplifiers in early long distance telephone service. Negative feedback reduces distortion, flattens and extends the frequency response, decreases output impedance, and increases the damping factor significantly, therefore tightening the bass response and control. It's disadvantages are reduced gain, time smearing, lack of focus at certain frequencies, and a lifeless, "closed in," and "homogenized" sound. Many vintage amps used around 30dB of NFB to make their THD and damping factor specs look good on paper, but this muddied and smeared the sound. Today, most hi-end amps using NFB limit it to around 10dB, with many using only around 6dB. In a proper circuit designed for it's use, it's benefits can be realized without too much sonic penalty, as long as it is used in this very strict moderation. The

modern trend in amplifier design has been zero feedback, which requires tubes and circuit designs of good linearity, as there is nothing to lower the distortion without NFB present.Local Feedback is negative feedback which is reinjected into the same amplifier stage. Global Feedback is injected into a former stage, usually from the OPT to the first stage's cathode, or sometimes the phase inverter in a push pull amp. UL - Ultralinear, a method of operating tetrode or pentode output tubes using local feedback from a special tap on the OPT primary. The tap is usually located at 43% of the distance (or 18.5% impedance) between the power supply connection and the plate tap. This has proven to be the most effective point. The special tap connects to the tube's screen grid, and provides a constant ratio voltage feedback between it and the plate that linearizes the tube in a manner not otherwise possible. The tubes opearate in a near triode-like state, with almost the same sonics and low plate resistance as pure triode, but with almost the "weightiness" and about 75% of the output power of pentode operation. Intermodulation distortion is also lower than with either pure triode or pure pentode operation. Ultralinear operation also does not exhibit the phase shifts or "closed-in" sound associated with other types of feedback. It is highly stable in operation, and has a warm, triode-like tone with excellent clarity. 50 years after it was invented by David Hafler and Herbert Keroes, partners at Acrosound and later Dynaco, IMO it still stands as the best topology ever for pentode push pull amps.OTL - Output Transformerless, self explanatory. The theory of an OTL amp is to eliminate the phase shifts, signal loss, colorations, frequency response anomalies, and the third order distortion caused by the OPTs. The sole functions of an OPT are to provide an inductive loading for the power tubes and to match the tubes' very high output impedance to the speakers' very low impedance. Though there are several variations on the original Futterman OTL design, they all use the same concept: In place of the OPT, several low plate resistance power triodes are paralleled together to lower the output impedance to an acceptable figure, one that can drive the speakers successfully. This is based on the fact that parallel impedances and resistances add in reciprocals, in this case 5 triodes will have 1/5 the impedance of 1 triode. Their advantages are low phase shift, fairly low distortion, and the resulting sonic purity in the mids and highs. The disadvantages are (usually) soft, rolled off bass, high power consumption and LOTS of heat output, poorer reliability than most OPT designs, and expensive retubing costs.DC Coupled - Direct coupled, or Direct Current versus Alternating Current coupled. A method of interstage coupling in a tube amplifier that uses no interstage transformer or DC blocking capacitor. Normally, a coupling capacitor is used between two tube stages. This is to block the plate's high voltage DC from reaching the next tube's control grid, which would send the tube into bias runaway and fry it in seconds if present. In a DC coupled section, the second stage's cathode resistor and plate voltage must be tailored so that the tube will operate correctly with the high DC voltage on it's control grid, which in an AC coupled stage is at zero volts DC.Transformer Coupling - A method of interstage coupling in a tube amplifier that uses a special interstage transformer to interface two stages. The turns ratio of the transformer may be adjusted to increase the drive voltage to the next stage if necessary, but drive current will be reduced as a result. A special transformer is often used in place of a tube as a phase inverter in very hi-end push pull amplifiers, and can sound excellent, but requires very expensive and well made transformers for best performance.Parafeed - Parallel Feed, an output stage topology in which the power supply is fed to the power tube through a load resistor or large value choke (inductor), and the amplified signal is fed to the OPT through a capacitor. It's major advantage is that no DC current flows in the output transformer. This means the OPT be made smaller, and will therefore exhibit lower capacitance and leakage inductance in relation to it's primary inductance (higher Q factor). It also means the output transformer in a single ended amplifier will need no air gap in the core to reduce saturation due to offset DC current, since there is none. The smaller, non-gapped transformer means better frequency extension and flatter response with better

coherency and lower quiescient excitation current. Quiescient excitation current is the lowest signal that will create the minimum level of magnetic flux that is required for full bandwidth inductive coupling between primary and secondary. Another advantage is high PSRR (power supply rejection). Since the DC current from the power supply does not flow through the output transformer, much less power supply hum and hash are fed to the speakers. As a matter of fact, the parafeed geometry forms a voltage divider that slashes residual power supply ripple as it's being fed to the tube, lowering power supply hum. The major disadvantage of parafeed coupling is the necessary additional componentry, in the form of a large choke or high wattage rating resistor. Also, a very high quality (and usually expensive) capacitor must be used for optimal performance. Since there is a very large AC current flowing through the cap into the OPT, more distortions are added by the cap that at low currents.Let me see now, different types of tubes.... Triodes (three electrodes) have three elements, a cathode, a control grid, and an anode, usually called the plate.The cathode is the negative element. It may be directly or indirectly heated. An indirectly heated cathode is a hollow nickel tube containing a heater filament. The cathode is coated or "doped" with strontium and barium oxides to give it emissive capabilities. When heated to a temperature of almost 2000 degrees Farenheit, it boils electrons off it's surface, called "thermionic emission." The directly heated cathode is when the heater filament itself is used as the cathode. It's usually made of tungsten, with either thorium added and/or an oxide coating similar to the indirectly heated cathode to give it thermionic emission capabilities. An uncoated thoriated tungsten filament must be heated very hot, in excess of 4000 degrees Farenheit, so that it glows white like the filament in a light bulb.The anode or plate is the positive element, and is where the high voltage DC is applied. Electrons from the cathode are attracted to it by electrostatic attraction from the unlike charges, from negative to positive. It's the gray, black, or silver metal structure you see inside the tube. It's usually made from nickel, or sometimes titanium, with various coatings. The control grid is usually a spiral wound tube of hair fine wire that surrounds the cathode, between it and the plate. It functions as a gate that allows electrons to flow from cathode to plate when a signal is applied to it. It is what gives a tube it's European name, "valve," since it functions as a valve for electron flow. When a signal is applied to the control grid, it opens the "valve" and allows a correspondingly large amount of electrons to flow to the plate, amplifying the signal. The tube's bias voltage is what sets the idle point of the tube, and keeps it from running wide open all the time. This is done by applying a small negative voltage to the control grid, thereby making it more negative than the cathode. This prevents electrons from flowing, since like charges repel. This is called "grid bias." It's also known as "fixed bias" or "adjustable bias." The terms seem to be in contradiction to one another, but are not. It's called fixed bias because the voltage does not change in operation, and adjustable bias because it can readily be changed by changing a resistor value in the bias power supply. Biasing can also be achieved by making the cathode more positive than the control grid, which is the same as making the grid more negative than the cathode. (everything is relative) this is called "cathode bias" or "self bias." The cathode is connected to ground through a resistor. The cathode current being drawn through the resistor creates a positive voltage. If more current is drawn, the voltage increases and "throttles back" the tube and vice versa, thereby self-regulating the bias.Small signal tubes such as the 6922, 6SN7, 12AX7, etc, are most always operated with cathode bias. Power tubes may be operated either way. Generally speaking, cathode bias yields a more musical sound, while grid bias yields more power.The main problem with the triode is the internal capacitance between the control grid and plate. Due to a phenomenon known as the "Miller Effect," the capacitance "appears" to be multiplied by the gain factor (mu) of the tube. This can be a BIG problem in high gain triodes, as this Miller capacitance must be charged and discharged like any other capacitance. This slows down the tube, causes smearing of the signal, and also harms the high frequency

response.Tetrodes were invented to overcome this. They added a screen grid between the control grid and plate to "screen" the control grid from the plate, making it invisible to it, and thereby eliminating the Miller Effect. This meant that much higher power could be had than from a triode, and that the high frequency radio transmitter tetrodes could have much higher gain than triodes of similar wattage. The screen grid operated at or near the plate voltage, but was so small and fine that it didn't attract many electrons on their way to the plate. However, this new "beam power tetrode" had some problems of it's own. One arose from a set of beam forming/acceleration electrodes that were added to make the tube even faster and more efficient. The famed 6L6, designed in 1936 by RCA, was the first to incorporate these advances. The problem was that some of the electrons would bounce off the plate from due to their accelerated velocity and were pulled in by the screen grid, overheating it. The modern 6L6GC still has this radical beam acceleration, and is a major reason why 6L6GCs glow blue in operation. It's from electrons that have escaped the plate's electrostatic pull from sheer velocity and are then pulled back in.Another problem was that the radical beam acceleration caused a characteristic "kink" in the tube's performance curves, that made it very non-linear in certain areas of it's performance. The MOV Valve Co. of Great Britain, also known by their Genalex and Gold Lion brands, had been working on a beam power tetrode at the same time as RCA, but had grown weary of strugging with developing a proper manufacturing technique. A beam tetrode demands very precise alignment of the screen grid to the control grid for proper operation, and since the grids are tiny and their wire hair fine, it's not very easy! Soon afterward however, MOV introduced the KT66, based on RCA's 6L6. KT stands for "kinkless tetrode," and this was achieved by using less radical beam forming/acceleration and a longer electron path.Pentodes solved the problem of screen grid overheating by incorporating a third grid, the suppressor grid. It "suppresses" the bounced electrons from the plate, keeping them from reaching the screen grid. It's usually connected to ground, and stops the bounced electrons from going any further due to electrostatic repulsion. Actually, most all tetrodes today have a suppressor grid, but it is connected to the cathode internally, and is not externally accessible as it is with most tubes called pentodes. Additionally, only tubes classified as tetrodes today have beam forming plates. Among popular types, these include the 6L6GC, KT66, KT88, 6550, 6CA7, 6BG6, and EL509/6KG6, to name a few. Popular pentodes include the EL34, EL84, and SV83. Popular indirectly heated triodes are the 6AS7 and the cult favorites, the 1626, 12B4, and the unusual 6C33. Directly heated audio triodes include the 2A3, 45, 300B, and transmitter style triodes like the SV-572, 211, 811, and 845. Almost all commonly used small signal tubes are triodes, with the exception of perhaps the EF86, which is a pentode. Soundwise, the three are different. Triodes have a mellower, sweeter sound than other types, which is in part due to the very problem that plagues them, the Miller Effect. They also have low distortion, as each grid added to "improve" them also increased distortion as an unfortunate side effect. Directly heated triodes such as have a different tonality from indirectly heated triodes, being sweeter and more "euphonic."Beam tetrodes, especially high kink ones, have a brighter sound that is often harsher and less focused than triodes. Leo Fender exploited the bright, twangy sound of beam tetrodes to the fullest in his guitar amps of the late 50's and early/mid 60's, such as the Twin Reverb, Super Reverb, and Bassman. Low kink tetrodes such as KT88s can sound very good indeed if properly implemented. The KT88 was designed for ultralinear operation, as were the EL34 and EL84, and all excel when operated as such. Pentodes have a "harder" sound than triodes, and sometimes are muddy and unclear, even though they're usually brighter. They also have higher distortion. Most pentodes can be configured as triodes by connecting the screen to the plate (usually through a resistor), with the suppressor grid either connected to the cathode or left unconnected. Another method is connecting the screen and suppressor both to the plate. All sound different, and will sound different from a real triode. I hope you find this reference

beneficial. I would have had it up sooner, but I don't exactly type 110 words a minute..... :)
Thermionic