MAPLETREE BRANCHES

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Headphone amplifier special issue

- **An update on the *Ear+ HD* series**
- **The *HD200* limited edition and what comes next**
- **Upgrades**

The *Ear+ Purist HD* series

Now that the 200th unit milestone has been reached in the *Ear+* series of headphone amplifiers, it is a good time to update the evolutionary description featured in issue 1 of *Branches.*

Ear+ Purist HD – This has become the best selling model over the past two years and has changed only slightly in that time. The current model has dual impedance headphones jacks with the low impedance output utilizing the 4 Ohm tap on the output transformer. Previously, the low impedance output had series resistors feeding from the 8 Ohm tap. The significance of the two impedances is often misunderstood. With an amplifier like the *Ear+ HD*, the output impedance looking back into the amplifier is quite low (less than 10 Ohms) so the output voltage delivered to headphones of different impedance is nearly constant (a drop of around 25% for 32 Ohm headphones). So as a first approximation, the output power is the output voltage squared divided by the headphone impedance. You can see that, all else being equal, more power will be delivered to lower impedance headphones. It turns out that with the different sensitivities of Grado (32 Ohm) and Sennheiser (300 Ohm) headphones, the Grados end up sounding only slightly louder than the Sennheisers connected to the 8 Ohm output transformer tap. With the dual output impedance jacks, approximately the same loudness level is available for either headphones. However, these and any other models can the connected to either impedance jack without sonic penalty. So you can simply use the one that gives you the right gain and loudness for your particular source output voltage and listening preferences.

The output coupling capacitors are now 47 µF, 160 V Black Gates (while they last!) instead of the original 33 µF, the change necessitated by reduced availability of these capacitors. Further, listening tests confirmed that the bypass of these capacitors with Auricap polypropylene types produced no sonic benefit so they have been dropped. The most critical resistors in the signal path are the plate resistors of the input stage and these are Tantalum film which are simply the best sonic performers in this application. Regarding the issue of "upgrading" the output transformers, the Hammond 119DA types are rated at 12 W with a 20 kHz bandwidth. Operating at less than 100 mW, they are extremely linear and nothing is likely to be gained by expending more money. As it stands, they are still the most costly single items in the unit, at over $50 for the pair.

Ear++ – The aim of the *Ear++* model development was to provide a line preamp as part of the headphone amplifier without impact on headphone performance. This necessitated the addition of a line output buffer stage using a 12BH7A. Various combinations of balance controls, level controls, and source selector switches were offered. The gain of the input stage of the *Ear+* is really too high for a line preamp. As a result, the *Ear++* preamp performance never came up to the standard of the Mapletree stand-alone designs and so was gradually phased out of the model lineup. A passive line output is still standard on the *HD* model.

Ear+ Purist HD150 Limited Edition – Probably the most radical departure from the original design concept was the special edition commemorating the 150th unit. Besides shoehorning everything into a 1" high chassis with a distinctly non-Mapletree styling, the circuitry was re-designed to use only currently manufactured tube types: JJ ECC99 or 12BH7A dual triodes for the output and a 5751 or 12AX7 for the input stage. Initial listening tests showed a subtle increase in detail and texture over the stock *HD* and measurements confirmed a greater maximum available output power. A very effective blend control was also included.

Twenty of these were completed and met with generally positive response. A few customers who already owned a model based on the *HD* circuitry insist that the latter still has the overall sonic edge.

Ear+ Purist HD2 – Based on the *HD150* experience, a modified version of the *HD* using an ECC99 output tube and 5751 input was developed in a physical package comparable to the *HD*, and selling for the same price. As well as providing increased available power (useful for high impedance headphones), and an even lower output impedance, the use of easily obtained tubes has appealed to some customers. Some people have carried out A-B listening tests with the *HD* and *HD2* and the results indicate a difference too close to call.

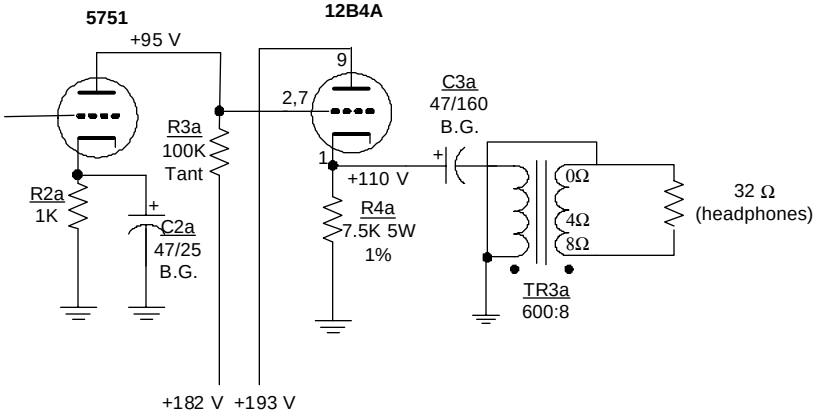
As of Nov. 1/07 the *Purist* label has been dropped and the two current models are simply the *Ear+ HD* and *Ear+ HD2*.

The *Ear+ HD200* Special Edition

To commemorate reaching the 200th unit milestone (actually a conservative figure since it does not count the special editions of multiple units) a new limited edition is in the works. Based on the experience of five years of production, the continued use of the 12B4A output triodes seems fully justified. Also, the 5751 input tube has shown itself to be the best sonic performer of its type and upgrading to an NOS version is even better. The two performance related issues addressed by the *HD200* are increased output power (and linearity) and soft startup using a 12X4 cathode rectifier tube in a full-wave configuration. For added interest, two cathode ray indicator tubes (Russian EM80) are included and the chassis is finished in stainless steel or burgundy lacquer with solid maple end panels. Only five units are planned.

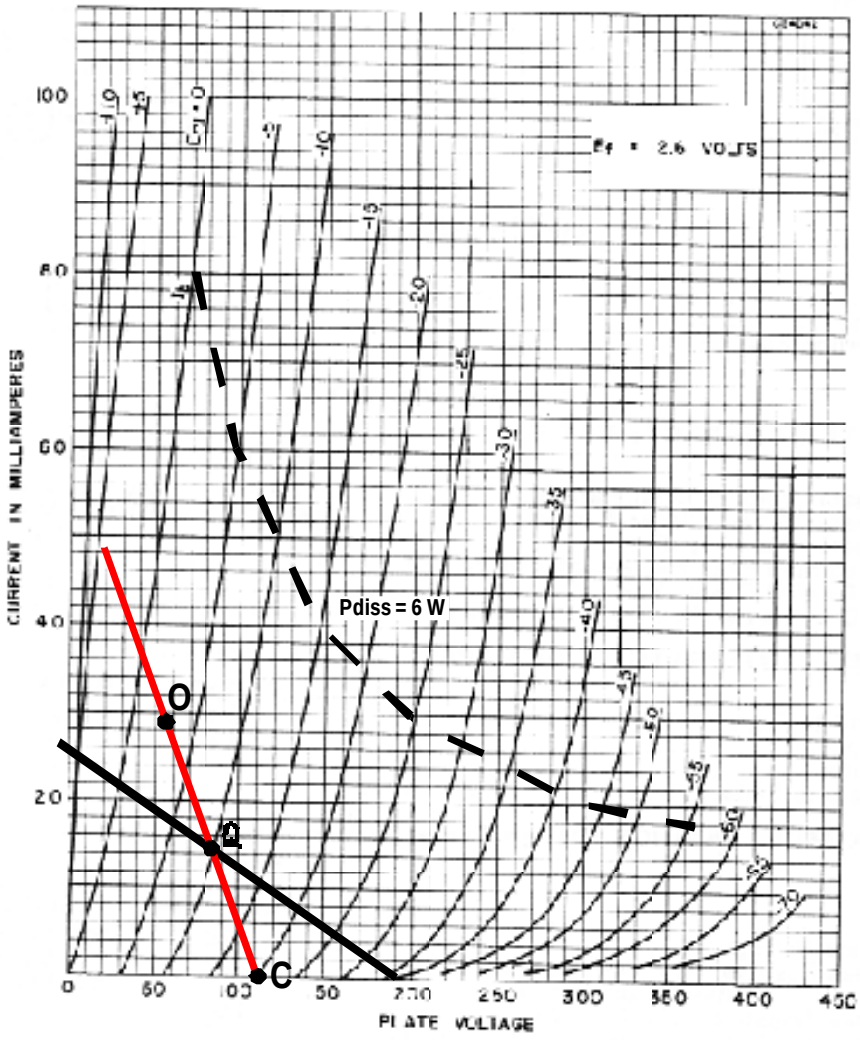
Technical details – To see what is at stake we need to look at the static (dc) and dynamic (signal) operating conditions of the output stage. The schematic below shows the measured static (dc bias) voltages. The plate supply voltage is 193 V and the plate voltage (referred to cathode) is 83 V. This gives a plate current of about 15 mA corresponding to a grid voltage of –10 V. These conditions are also shown on the graph of plate characteristics of the 12B4A as point Q. The range of other possible bias conditions for the given plate supply voltage and dc load resistance (7.5 kΩ) is given by the dc load line shown in black. Its slope is simply 1/7.5 kΩ.

The signal variations cause the operating conditions to deviate from those at point Q. The dynamic or ac load line shown in red governs this movement. Its slope if 1/*r* where *r* is the parallel combination of the 7.5 kΩ resistor and the headphone load impedance reflected back through the output transformer impedance ratio (600:8). If we use 32 Ω headphones as a reference, *r* turns out to be 1.8 kΩ. The dynamic load line is shown in red and intersects the static load line at point Q (quiescent point). It is from the dynamic load line that we can estimate the maximum signal swing for large signal excursions.



Ear+ HD dc operating conditions

On large negative grid voltage swings, the operating conditions move toward point C (cutoff) and in the other direction towards the 0 V grid voltage curve. In this case, large signal operation is limited by the cutoff condition and the corresponding point in the positive direction is point O. The maximum plate voltage swing is about 27 V peak or 19 V rms for a sine wave. The output voltage at the cathode also changes by a maximum of 19 V rms. The voltage step-down ratio for the output transformer is $(8/600)^{½}$ which leaves 1.6 V rms or 80 mW across the 32 Ω load. With higher impedance headphones, the slope of the dynamic load line moves closer to that of the static line which permits a greater maximum output voltage swing. However, at the same time, the output power goes down inversely with the headphone impedance, so the available output power is in fact less than 80 mW. With a sensitivity of 97 dB/1 mW, there is ample power reserve for Sennheiser headphones. For some medium to high impedance headphones with lower sensitivity, greater available power may be desirable. The only way to accomplish this is to increase the length of the dynamic load line segment O-Q-C which means changing the static operating conditions of the tube.

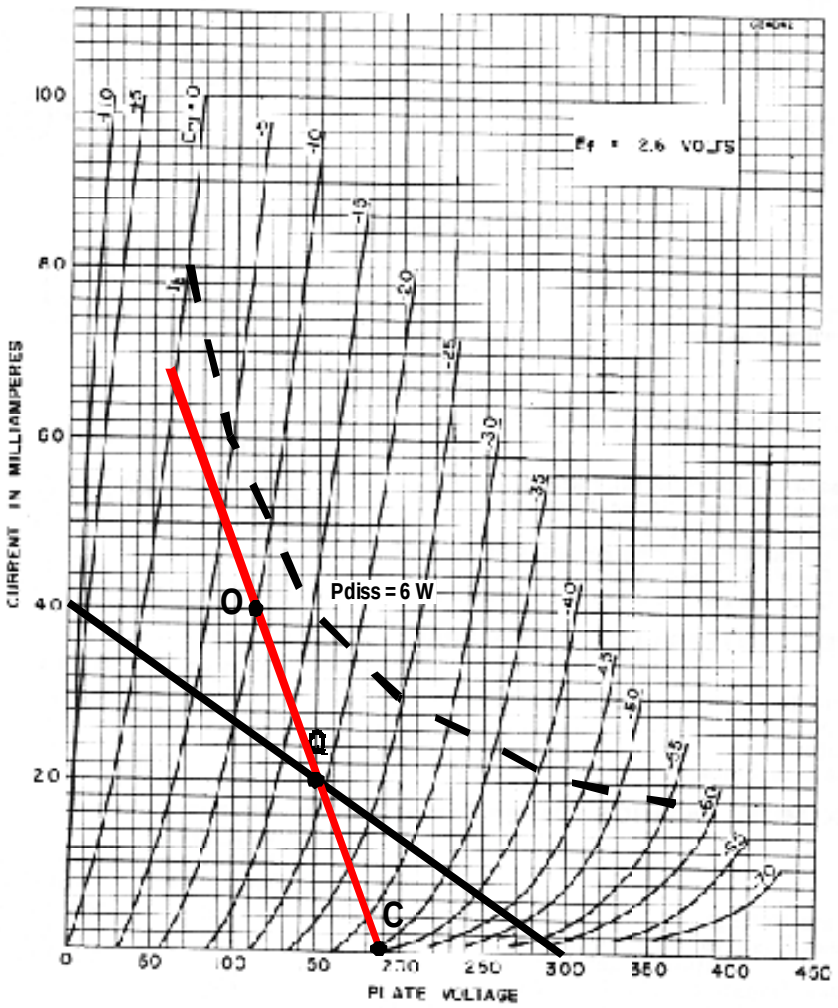


Ear+ HD static and dynamic load lines

For the HD200, a plate supply voltage of 300 V is obtained using a higher voltage power transformer to provide the necessary shift in operating conditions. If the dc load resistance remains at 7.5 kΩ, then the slope of the dynamic load line remains the same as before. The output capacitors are rated at 160 V which limits the cathode

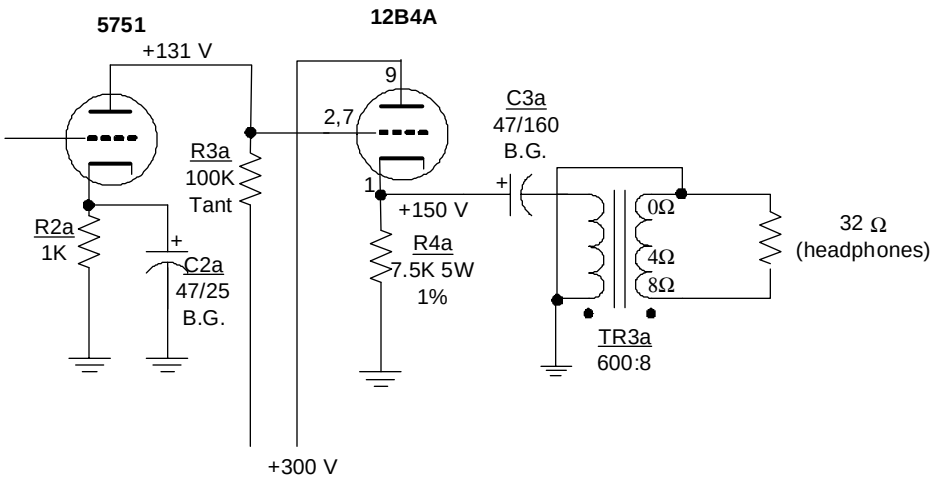
voltage (= 300 V – plate voltage) to around 150 V. The new dc load line is shown in black on the revised graph below. For a plate voltage of 150 V, the plate current is 20 mA and the grid voltage (which is set by the plate voltage of the input stage) is around –18 V. The slope of the dynamic load line remains at 1/1.8 kΩ and is shown in red.

The maximum signal excursion is still limited by the cutoff condition at point C but the signal swing has increased to 40 V peak or 29 V rms for a sine wave. At the headphones, this corresponds to 3.3 V rms or 340 mW—over four times that of the HD.



HD200 static and dynamic load lines

The voltage conditions for the *HD200* output stage are shown below. In terms of linearity, you can see by observation that the plate characteristic curves become more evenly spaced as the operating conditions are moved away from the origin. One would expect that this should result in lower distortion for large signal swings along the line segment O-Q-C under the operating conditions of the *HD200*. However, operating in the cathode follower configuration with 100% inherent regenerative feedback, this would be difficult to prove (or measure).



Ear+ HD200 dc operating conditions

What comes next?

It should be possible to obtain the benefits of the higher output power of the *HD200* in a version of the *HD* at only slightly higher cost. Solid-state rectification would be employed as in the current *HD* and *HD2*. The only change would be in the power transformer required to supply the higher voltage. So an *HD Super* may be in the works for next year. Keep tuned.

Upgrades

With hundreds of older models of the *Ear+* series of headphone amps as well as preamps and other products in use around the world, many customers are enquiring about upgrading their units to current or enhanced specifications. Here are some possibilities that offer meaningful sonic benefits.

Ear + Purist – Early kits and assembled units used generic electrolytic output capacitors and cathode bypass capacitors, as well as lower capacity (typically 47 µF) filter capacitors. All electrolytics deteriorate over time, developing higher series resistance, lower leakage resistance, and changes in capacitance. The current HD versions use three 100 µF/ 400 V Nichicon filter capacitors and Rubicon Black Gate output and cathode bypass capacitors. There is no polypropylene bypass across the output capacitors. This would be the minimum capacitor upgrade for older models. The first stage plate resistors should also be upgraded to Tantalum film type. The Black Gate filter capacitor option substitutes 150 µF/350 V Black Gates for the Nichicons.

Ear++ versions – If you are not using the preamp functions of your *Ear++*, it might be worthwhile converting to *HD* specifications, eliminating unneeded features such as switch inputs, balance controls, etc. A recent conversion of an *Ear++* to an *HD* with a high voltage tube rectified power supply (a "*semi-HD200*") is shown in the photo.

Preamps – Early *Line 2* and *Ultra 4* preamps used Solen polypropylene film capacitors. Upgrading to Auricaps improves imaging and is recommended. There are 10 capacitors to be replaced in the *Ultra 4* and 6 in the *Line 2*.