



**Julius Futterman OTL, 6 x 6LF6 PP, 1954/56**

It is impossible to get around Mr. Futterman in an analysis of the history of audio amplifiers. I fully understand why the thought of getting rid of the large and expensive output transformer emerged. Futterman's ideas and circuits were excellent, in particular considering the impossible task. The famous and best known amplifiers by Futterman were based upon pentodes as output tubes. The circuit above is actually another Williamson. Very high gain 6EJ7 pentode at the input and a concertino/split load phase splitter. But then it turns from Williamson to Futterman in that the output configuration are the so called "single end push pull". From a DC point of view the two output tubes ( actually made of 2 x 3 6LF6's in parallel ) are in series. But from a AC point of view they are in parallel – and that is the trick. In a conventional PP, the output tubes are AC vice in series and DC vice in parallel. The exact opposite operation. Having the output tubes in parallel rather than in series drops the matching load to 25% of the conventional. But even this is very far from the 16 Ohm speaker load, hence Futterman added further output tubes. 6LF6 was made for horizontal

deflection mode and it therefor a current strong and low ri pentode. Some 6-8 k Ohms – three of these in parallel makes about 2-3 k Ohm and again parallel with the other stack some 1 to 1,5k Ohms. There is still a loong way down to a regular speaker Ohms load and this is where the OTL designers plays their final card; lots and lots of global negative feedback and we now understand why Futterman wanted all that gain to begin with. The cathode of the lower tubes are grounded, hence fixed. But the cathode of the upper tube are riding on top of the plate at the lower tube. This means that upper drive should ad the AC swing of the lower tube in order to be balanced. In reality the lower tube works fine, but the upper produced the weirdest possible distortion signature – lots of constantly changing very high upper harmonics. Futterman partly solved it with the use of two HV supplies. The open loop distortion of single end PP amplifiers are dramatic, due to the just as dramatic unbalanced drive. Feedback is not a choice, tons of fb are mandatory. It is ironic that the unbalanced drive could have been solved by a two secondary winding transformer. But I guess that this would have ruined the concept OTL.

Futterman also used 12B4's in some circuits, and 6336's as far as I remember, but I don't think he ever made these on a commercial basis. Julius build all his amplifiers himself\*, and sold directly to the customer. He was a genuine Joe...When a customer wanted a Futterman amplifier, he had to show up in person and pay an upfront of about 20% and wait 2 years for delivery. The Futterman designs are crazy difficult to adjust and no one, besides Futterman himself apparently learned to do the job.The final adjustments were carried out with the help of friends or the actual customer, as Julius Futterman himself had a hearing issue. In case of service or change of tubes, the customer had to sent the amplifier back to Futterman himself.

\* Harvard Electronics; RCA, Westinghouse, Tech Instruments and others made Futterman's amplifiers on a license for a while. But rumours has it that Futterman constantly changed the circuits – small, but significant details in the design. Due to this and the difficulties in adjustment, hence stability, these companies cancelled the production. It have to be mentioned, that the amplifiers that were build by Julius himself , according to the saying are very reliable and stable.

Futterman was on a constant look for tubes better suitable for OTL. He changed output tubes every so often. Futterman had a dream of using FET's at the output as soon as such would be available as high power devices. Such power FET's became available about the time of Futterman's passing away. ( 1981 ) NYAL made Futterman's MOSCODE in the following years.

The original designs of Futterman were all class B. Due to the excessive global feedback they acted as Voltage output sources, just like solid state amplifiers and op-amps. This meant that the available power depended highly upon the impedence of the speakers. It is difficult to connect 8 Ohm speakers to Futterman's amplifiers with good results. From 16 Ohm and up, they do 4 times better and so on. The perfect match to the Futterman designs are electrostatic speakers, I am told.

OTL is a dead end in my opinion. My advice is that if you want to make an OTL – don't use tubes. Do as Futterman always dreamt of. Use FET's or similar transistor based output. It is a LOT easier, it is cheaper and it sounds better than tube OTL – at least in my opinion. I would personally prefer a genuine tube amplifier, but that is an endless ( and uninteresting ) discussion without winners or losers. Anyway, if you insist on making OTL designs, here is what I learned before I gave up.

1) Avoid all the cascode/series, so called parallel Push Pull. ( The Futterman, Philips etc. ) These circuits are notoriously asymmetric and the open loop distortion are extreme.

2) The best solution for Push Pull seems to be the Circlotron.. At the risks of frying your speaker – but that comes with any OTL, that does not swap the transformer to a large capacitor/electrolytic.

3) The obvious candidates for OTL operation are cathode followers, but do not ignore the potentials in genuine *anode/plate followers*, despite that these are very difficult to calculate. Perhaps the best solution are inverted power grid applications.( See **Stephie Bench** )

4) I suggest to go for current or power drive.( See my article “Power distortion” , 1998 or so. A copy may be found at the **PEARL** archive, Canada ) In a current/power drive application the high  $r_i$  of valves may even come in as an advantage.

Despite all this, I am a dedicated fan of Julius Futterman. I love his circuits and insisting design. I like the way he dealt with his passion and customers. Tremendous imagination and excellent ingenuity.

But after all, the end goal was audio, not clever engineering. And OTL amplifiers are a difficult specimen. Would good and poor at the same time be a suitable phrase ?

Sadly they ARE all better with a transformer exit...

Luxman, Philips, Stephens, Technics, RCA, Stephens, Coulter, National, Peterson Sinclair and many many others tried to walk the OTL path – with just as little success. I myself spend almost 10 years trying to get rid of that large, heavy and expensive OPT, before I realised just how good transformers really are and how much good they do in assisting the “valves and tubes”... . It is hardly ever the trannie that needs to be blamed – it is simply poor design ( transformer and/or circuit ). Valves does not maid good with 2 to 30 Ohm’s speakers. Period.

As much as I like Futterman’s designs, I am now at the total opposite side of the road. The more iron the better.( This was why I got in to the transformer business ) Master Tapes is iron, vinyl is made through iron, PU’s are iron – Heck, even my speakers, guitars and the valves themselves depends upon iron.

Julius – you meant well and you did GOOD....you pushed the tubes to the limit of their capability, yet a Futterman amp never wears out the tubes.

Below is a circuit I had drawn many years ago, when I studied Futterman’s designs.Unfortunately I do no longer remember if it is an original design by Futterman or one of the countless Futterman based versions from my hand – or if it is indeed a Futterman version I have copied from someone else ? If you have info about this, please do not hesitate to contact me. The 16 Watts specification are rather optimistic, despite the 16 Ohms load. Never the less, it is a Futterman design and it looks nice.

