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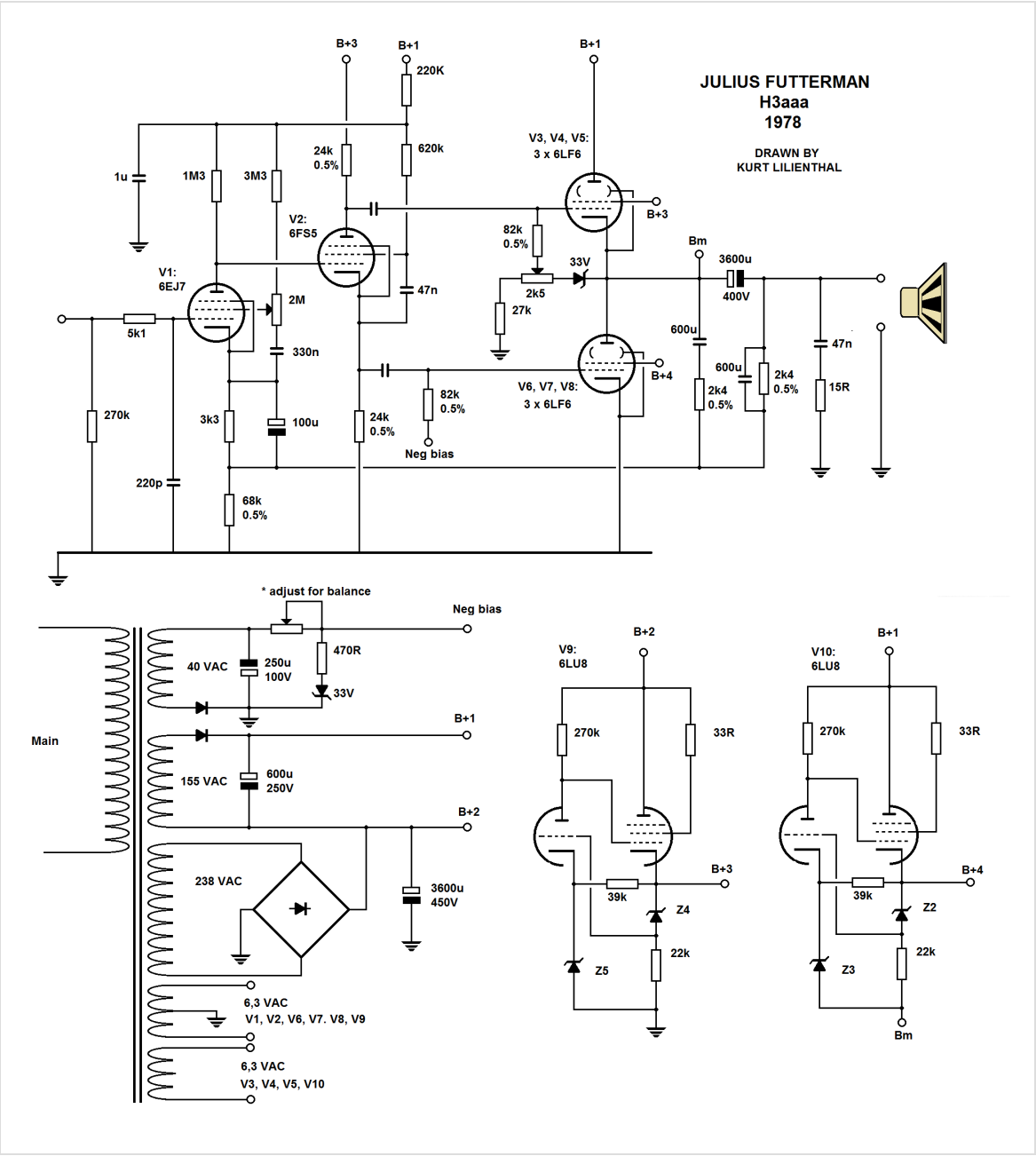
Lilienthal Engineering

Valve Amplifiers, Tube Amplifiers, HiFi, Recording Studio, Guitar

100 Amplifiers – Part 3 , 1955 – 59

100 amplifiers, part 3.

These pages represents an ongoing process. I frequently add more as I find the time to dig deeper into the circuits and I keep finding more interesting schematics for us hungry schematic analyst's. Comments are always welcome and if you have a favorite amplifier you would like to share with us, please write to me at: 100amplifiers at gmail.com. If you happen to have some pictures of the amplifiers in this compendia, please do not hesitate to contact me. The pictures will be accredited in your name. Thanks.



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 impedance 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.

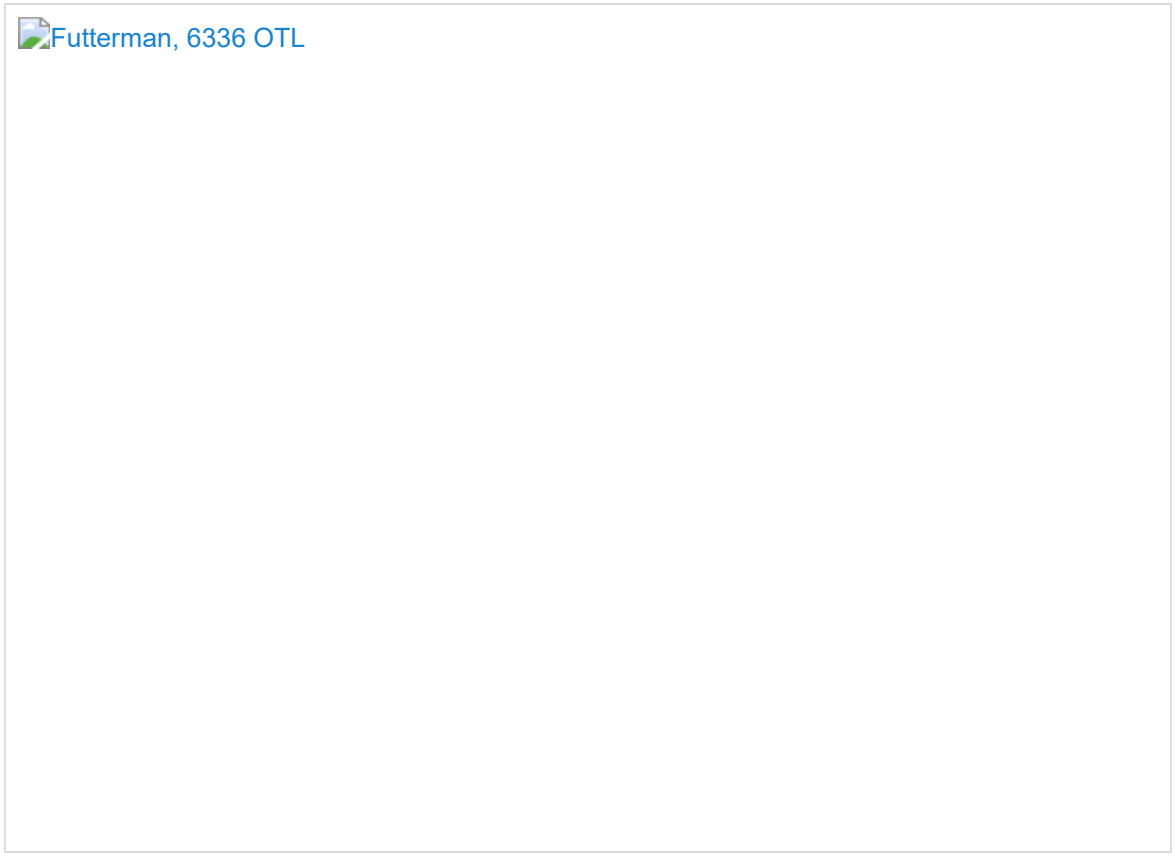
2) The best solution for Push Pull seems to be the Circlotron.. At the risks of frying your speaker – but that comes with any OTL, that does not swop the transformer to a large capacitor/electrolytic.

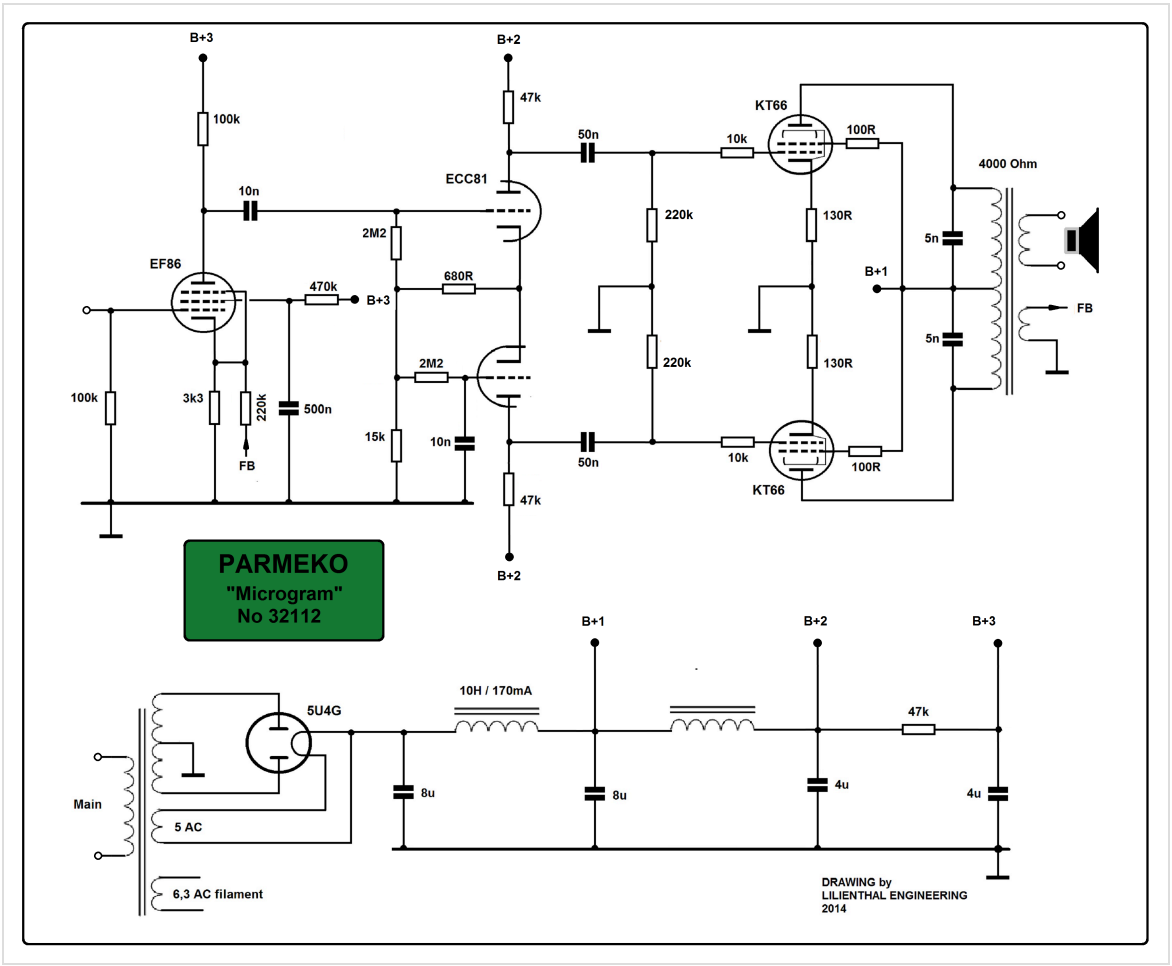
3) The obvious candidates for OTL operation are cathode followers, but do not ignore the potentials in genuine *anode/plate followers*, despite that these are very difficult to calculate. Perhaps the best solution are inverted power grid applications.(See **Stephie Bench**)

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 ri 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.


Futterman, 6336 OTL



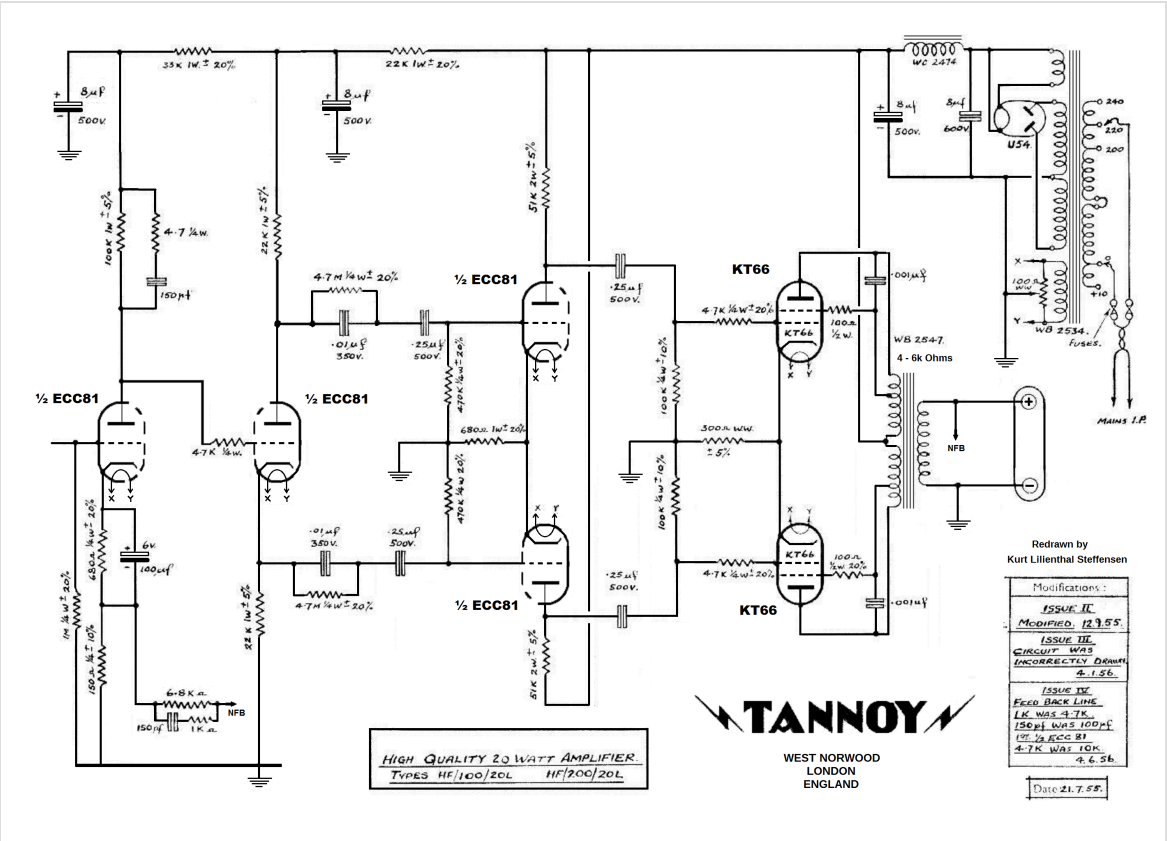
Parmeko 32112, KT66 PP, 1954-56

This British made PA amplifier is a beauty and school example of good build quality. In the schematic above I have stripped the amplifier of the entire preamplifier section and all garniture. This is what is left: The Mullard 5-20 circuit that most British manufacturers made during the 1950's and 60's. That is a little sad, as it is such a good looking amplifier. Well – nothing is ever perfect. At least Parmeco used an ECC81 driver instead of the lazy ECC83 that Mullard suggested. An easy modification for lower gain would be to triode couple the EF86 valve. It might also be worth to fiddle a little with the feedback resistor and possible to decrease the fb ? Note the use of two smoothing chokes. The smoothing capacitors are quite small and it would be no problem to double these with modern capacitors. The separate fb winding insures the amplifier against instability in case of capacitive loading.



Parmeko was a manufacture of transformers founded in 1927 as “Partridge and Mee”. Parmeco are *still* in business today and *still* makes transformers and other electromagnetic components. In 1935 the company split in to two and changed the name to Parmeco. The other part of the former company would also continue to make transformers known as “Partridge”…….!!

Parmeco made some beautiful rack amplifiers for cinema during the 1930’s, unfortunately I have not yet been able to track any schematics for these. Here are some pix though:https://www.google.dk/search?q=parmeco+amplifiers&rlz=1C1LENP_enDK543DK544&source=lnms&tbm=isch&sa=X&ei=-h_VVMPzEaT6ywOgwIK4Dg&ved=0CAgQ_AUoAQ&biw=1366&bih=612#imgdii=_

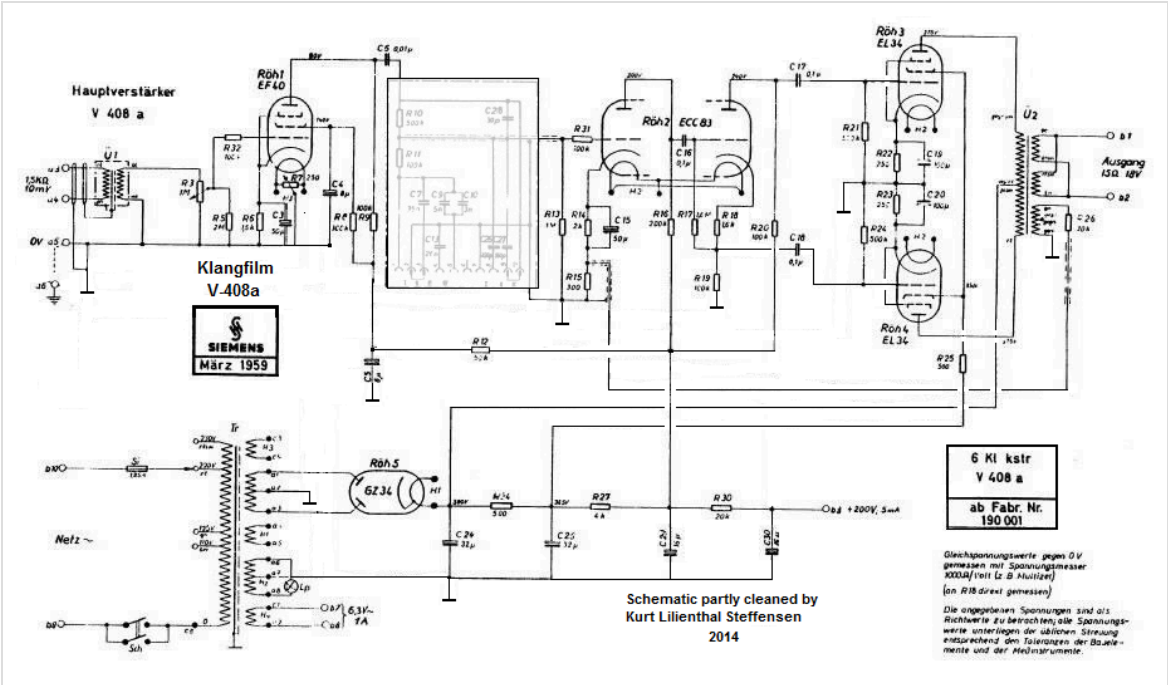


(Suggested by yours truly)

Tannoy HF/100/20L , KT66 , 1955

It is interesting that while most American HiFi companies based their designs upon the Williamson circuit, most British HiFi companies stock to the well known Mullard design. Parmeco 32112, LEAK and Radford are typical versions of the Mullard application note. The Tannoy here is an exception to that rule and indeed a very well designed one. Tannoy drives the KT66's gently at about 4-450V at the plates and they only demands some 20 Watts from the pair.

Looks good to me…..



Klangfilm kvl-408a, EL34, 1955 (Suggested by Al Marcy)

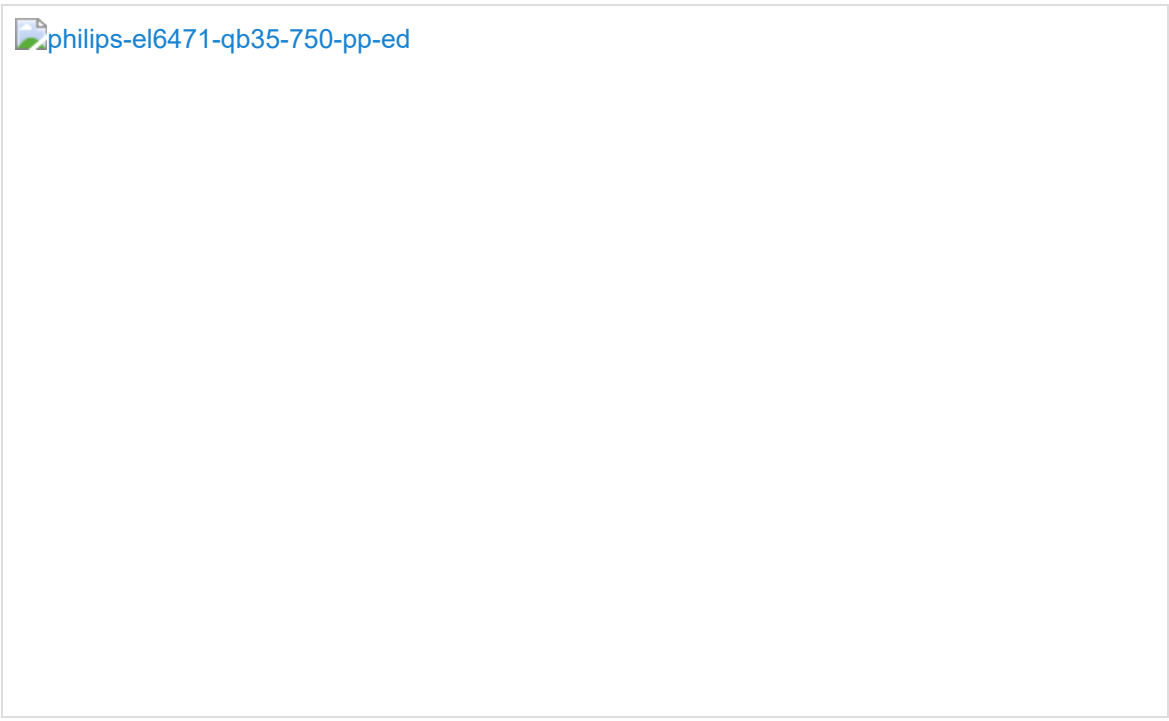
Boy – yes, we need some Klangfilm here. (Klang means “quality/merits of sound” in German and Danish) I regret the poor quality of the schematic, but it was the best I could find. I have cleaned the typical mess of wires, that German designers seemed to love back then.(Every damn piece of wire would be drawn at the diagram) I can not read the values of the components, but the design comes through well enough, I think. Klangfilm made a lot of fancy designs. Many of the pro Klangfilm EL34 gear was high Voltage class B, up to 800 Volts ! Mercy…

They even used the outstanding EL156’s and the weird RL12P35’s.(Caps and plate Voltage at the socket shield !)
Siemens, Klangfilm, AEg, Telefunken was the German pendent to US Western Electric and the British GEC, Marconi Osram.
In Denmark we had such companies as Ortofon, Bruel & Kjær, B&o, BoFa, Electro Mechano, MP Pedersen, Oxytron, Peerless, Vifa,
Amplidan, J. Schou, Jensen, Radiometer and a few others….Collected they may pass as the Danish Western Electric…Huh.?…
No.?
Right then, back to business…..If you happen to have such 408a in your possession you better mod that amp to something like – say..a Williamson design. ECC83 as phase splitter as well as driver..? Nah, I don’t think so.
How about a 12AU7 or 12AY7 as input and concertino, then 12AU7, 6CG7, 5687, 12BH7 or similar as driver…. GAH PLIIING.! And you are in Röhren himmel…….You might consider to bias the 34’s with some genuine German Volts for an active class A design. Plenty of free windings at the main trannie. Siemens made good quality iron, all worth the effort. This Klangfilm one might very well end up as your top amp.

It really looks wonderful. Here is a link to some pictures:

http://www.tube-classics.de/TC/Klangfilm/EurodynAmps/KLV408/KLV408.htm

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PHILIPS , EL6471 , QB3.5/750 PP , 1955

In the 1950's and 60's , Philips in Holland produced a number of pro-use amplifiers, spanning from 2-4 channel pre-amplifiers to small, medium, high , super high and extremely high power amplifiers. This group of amplifiers was referred to as the EL6400 series. The Power Amplifiers of the EL6400 series were all class B service at anode voltages close to max ratings.

EL6471 is a typical example of such amplifier. It is a class B power amplifier rated at 1000 Watts and it runs at about 3200 Volts. The weight of this monster is 155 kg.

Despite all of this, the EL6471 was only a micro dwarf from the EL6400 series. The largest power amplifier in this exotic family, was a 200kW giant mammute monster. (See the chapter "Extreme High Power Amplifiers" for more about these amps)

The EL6471 is a simple and very efficient circuit. It is all balanced (Differential) even the feedback loop.

The input signal is taken to the input transformer, The input transformer may be connected as a SE input or balanced input. The ratio is 1:2 with a centre tap for phase splitting. This means that the full signal is maintained to each grid of the E80CC. In other words if a 100mV RMS input signal is applied to the entire windings of the input transformer it will transform this to 200mV RMS at the secondary winding. But as this is centre tapped and hence split into two winding of opposite phase it provides 100mV RMS to each E80CC grid.

The E80CC is coupled as two ”independent” voltage amplifiers consisting of individual cathode resistors. The cathode resistors has not been decoupled, hence local feedback is established. Local fb is usually a good thing, from a sonic point of view as it improves the linearity. It comes, however, at the price of higher internal impedance of the device and lower gain. In this case it is a good deal, and after all, we cant decouple the cathode resistor entirely as we want the overall feedback to be connected here.

E80CC is a very good triode and it is an excellent choice here. I am not quite sure, though, that the value of the cathode resistor is an optimal choice. I would have preferred a higher value, I guess. (In practice I ”dial in” the value in by means of a spectrum analyser and later on ”tune” it in with the following stage applied)

As a matter of fact I am quite confused about how the E80CC is actually configured. There is at least two errors in the manual and they conflict in what ever manner I try to calculate the correct values. This could be the value of cathode and or plate resistors or the voltages referred in the manual with regards to anode, cathode or PSU. It is simply not possible to detect the specific errors in the manual. (And the text is in Dutch of which I am not too good)

Anyway – the stage works properly as made , but most likely leaves a little room for improvement , not least with regards to headroom. (Bias)

The input of the input transformer is shorted via relay 2 during heat up. (60 S)

The output signal from the E80CC is taken through a parallel RC combination to the grids of the two E80L’s. The RC combination: 330k //150n, acts as a complex impedance, that in practice performs as a High Pass filter. The E80L’s are therefor DC coupled to the output of the E80CC triodes via the 330k resistor.

One can argue pro or con about this solution. The disadvantage in this case being the relative large phase difference due to the RC coupling. There is actually nothing harmful from the phase difference in itself, but it produces some issues when incorporated in a global feedback loop. Apart from the possibility of a regular AC coupling via a signal capacitor, (would be established simply by removing the 330k resistor) , it is possible to provide a DC coupling either by elevating the E80L’s or by providing a negative voltage source (PSU) for the E80CC input amplifier. See Fig. 1

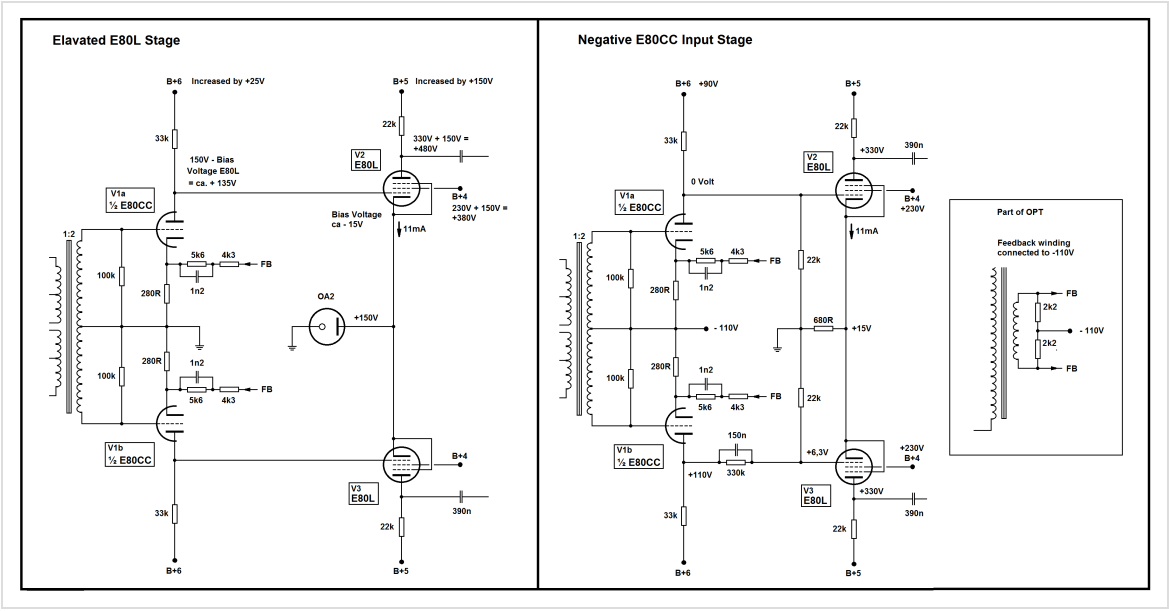


Fig. 1 , Suggested DC couplings

The advantage of a pure DC coupling is that no phase difference over the audio range will be established. This will allow more fb and/or better stability.

I guess I would have taken the easy way out and designed a regular AC coupled stage one to two.

The two E80L's has a cathode to anode voltage of about 315 V. The voltage for the screen grids is not fixed, but they share a common resistor 330k , thereby to a certain degree cancels the other vice produced voltage differences.

The output signal from the E80L's is taken to a triode coupled EL34 pair. The cathodes of the EL34's is connected to a negative PSU. The grid resistor network is connected as voltage dividers between ground and the negative supply. By means of the 50k potentiometer it is possible to adjust the bias of the EL34's individually and hence bias the output tetrodes QB3.5/750 directly from the cathodes of the EL34's. The anode to cathode Voltage of the EL34 is about 390 Volts.

The negative cathode voltage of the EL34's bias and drives the output valves directly.

The reason for this arrangement is to provide adequate power to drive the grids of the power tetrodes in to the positive grid area , as is necessary for class B service.

It is a very simple and flawless solution. Provided that we accept class B as a legitimate solution.

This brings us to the final stage. The power output is handled by a pair of QB3.5/750 tetrodes.

This is a HF transmitting valve, intended for class C or B service. It can handle up 4000 Volts at the anode and 500 Volts at sg2. A max of 250 Watts anode dissipation and a further 35 Watts of sg2 dissipation. The Thoriated Tungsten filament needs 5 Volts and 14,1 Amperes to heat it up. That is 70,5 Watts only to heat is. It can withstand up to 350 C at the bulb, this means that we need to

circulate air in order to cool it down. The EL6471 amplifiers handles this by means of an integrated fan.

Now – the plate voltage is around 3000 Volts and I suppose that the sg2 is is fed by around 320 Volts. Hereby I am guessing that the idle current for each valve is around 20mA.(50mA ?)

The load provided by the output transformer should be something in the ballpark of 14kOhms.

The grid stopper applied to the QB3.5/750's is only 100 Ohms. This is due to the need for current peaks in the positive region of the grid voltage. The 47 Ohms resistors at the screen grid acts as current limiters.

The 150n capacitors at the two secondary windings of the OPT is there to prevent oscillation.

The separate FB winding stabilise the amplifier in case of reactive loads – which are quite reasonable to expect. The feedback to the cathodes of the E80CC is freq dependent due to the parallel combination of 1n2 capacitors over the 5k6 resistors.

There is a meter in this amplifier. This is not the usual gimmick thing. In an amplifier like this it is mandatory in my opinion. We simply need to be able to check and adjust the current through the output stage, in particular as it is DC coupled to the driver stage. The meter measures the idle current over particular strategically placed resistors in the cathode path of the valves. I have not drawn these resistors in the schematic, but I have incorporated them in the shown resistors and marked their place by red dots.

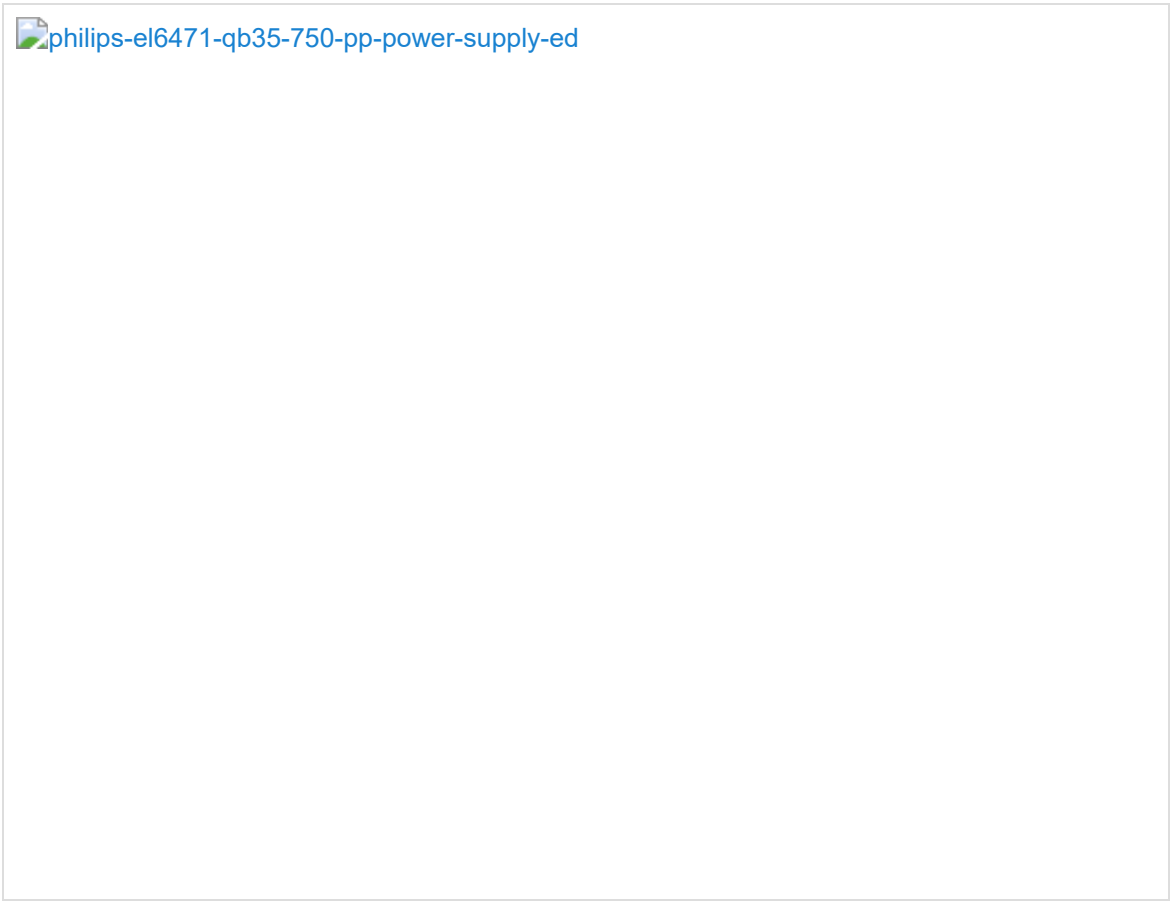
I would personally have used two such for the E80L stage – one for each individual cathode. But Philip's felt they could do with a single common resistor, don't ask me why.

The gain of the the individual stages is as follows. The gain of the input transfer is two, but as this is split in to two , it equals 1 . The gain of the E80CC stage is about 12 times. The gain of the second voltage amplifier made of two E80L's is 105 times. The gain of the EL34 cathode followers is 0,94 times, being a cathode follower. This means that the total gain from input to the grids of the power valves is 12 x 105 x 0,94 = approximately 1200 times.

Now that is indeed a lot , almost 62dB's. The input sensitivity for full output power is claimed to be 1,65 VRMS in the manual. But that conflicts – a lot – with my calculations. Perhaps it should have read 0,165 VRMS ? That would make sense.

The voltages I have indicated in the schematic is of course , as always +/- 10%

There is no hard data on the bandwidth and distortion of this 150-160 kg monster amplifier. But it is actually not an 100% class B amp. TB Triodes …..



EL6471 Power Supply.

The power supply is a story of its own.

Apart from 10 heater filament windings , there is four individual rectifier circuits made from two power main transformers and three smoothing chokes.

The power consumption of the heaters alone is:
2 x 5VAC/28,2A = 141 Watts for the two QB3,5/750
2 x 6,3VAC/ 3A = 18,9 Watts for the two EL34's
1 x 6,3VAC/2,1A = 13,2 Watts for the E80CC and the two E80L's
1 x 4VAC/5A = 20 Watts for the two DCG1/250's
4 x 2,5VAC/28,8A = 72 Watts for the six DCG4/1000G's

A total of **265 Watts**.

The +320V supply that delivers current for the two EL34's and the screen grids of the power valves is made of two single anode mercury vapour rectifier valves called DCG1/250.

DCG1/250 is relatively small, height is some 100mm/4 Inch. It is equipped with an EU 4 pin socket. But don't get fooled by the look. A pair of these outperforms any regular vacuum rectifier, whether it is a 5R5G , 5U4G, GZ34, 274B etc. The loss is low and it will withstand a Peak inverse of 3000 Volts and a peak current of 1,2A.

This supply is a choke input. The choke is placed in the ground side, hence less isolation is needed.

Usually it is necessary to pre heat a mercury valve. The datasheets for DCG1/250 recommends at least 15 Seconds, but in this PSU there is no pre heating. The reason that Philips can get away with this, is that so little current is drawn from the two EL34's and they need to heat up as well. On top of that the sg2 grids of the power valves is delayed via relay 1 for 60 Seconds.

The negative voltage power supply is straight forward. It refers the cathodes of the EL34's to a negative voltage of about -240V , hence providing the app. -70 Volts to bias the power output valves.

This power supply is also responsible for the current that heats the bi-metal in V16: 4102-01. This is a heater controlled relay that acts as a delay and activates the Relay 1.

The +580 V power supply is a common type as well. The smoothing choke insures low ripple and the rectifier silicon diode bridge insures better regulation than a regular electron valve rectifier.

It handles the currents for the two voltage amplifier stages. This total current is less than 40mA , making it an easy drive

Now, the most exciting part of the massive EL6471 power supply is the three phase driven DCG4/1000's bridge rectification. The fact that we are using a three phase source increases the ripple freq to a factor of 6 , compared to times 2 for a one phase rectifier bridge. Now , the smoothing factor increases as well, by a suare factor per double freq !

This means that it is a lot easier to achieve less ripple and the stress factor to the rectifiers as well as a potential choke decreases by the same factor. But as with any improvement in electronics, this always comes at a price. Here it is higher distortion in the current pulses. Philips solved that by using a choke input, which totally eliminates the problem. The choke is again placed in the ground side in order to avoid high voltage potential differences from the entire choke system (windings , core and enclosure if such is used)

Lets have a closer look at these impressive mercury rectifiers.

The DCG4/1000 has a max rating of 10.000 Volts peak inverse at continuous 250mA current and still allows a 1 A peak. At lower voltages such as 2kV peak inv. , continuous current is 500mA and a 2A peak. The nature of these mercury gas valves is a little tricky. After transportation it has to rest in its upright position for at least an hour. 24 hours is recommended. Another thing is that we can not just turn it on. It has to warm up and allow the mercury to vaporise inside the bulb. For this particular rectifier a min. heat up time is 30 S. In this particular circuit Philips allows it to warm up for an entire minute. The family of DCG4/1000 and similar valves is pretty large. 866 , 3B28 , PA5021 , just to mention a few. The end letter DCG4/1000G , indicates the socket used. In this case it is a Medium 4-pin. ED indicates Edison socket and B4 is the EU 4 pin type. The common use for these relatively large mercury rectifiers were industrial use – often three phase applications.

A cool feature of mercury rectifiers is the purple neon glow.

See here: https://www.youtube.com/watch?v=btSg2SX3lUs

The predecessor to the EL6471 was the EL6470 from 1953. It was pretty similar and used the same QB3,5/750 output tetrodes. It only had four DCG4/1000 and was rated for an output of 750 Watts.

A mkII version of the EL6471 from 1955 was already made the following year. The DCG4/1000 rectifiers was replaced by silicon diodes. Two in series for each DCG4/1000. The OPT was modified and a few other minor modifications was performed.

This model was referred to as EL6471S.

There is actually a neat little feature buried in this EL6471S that I feel is worth our attention.



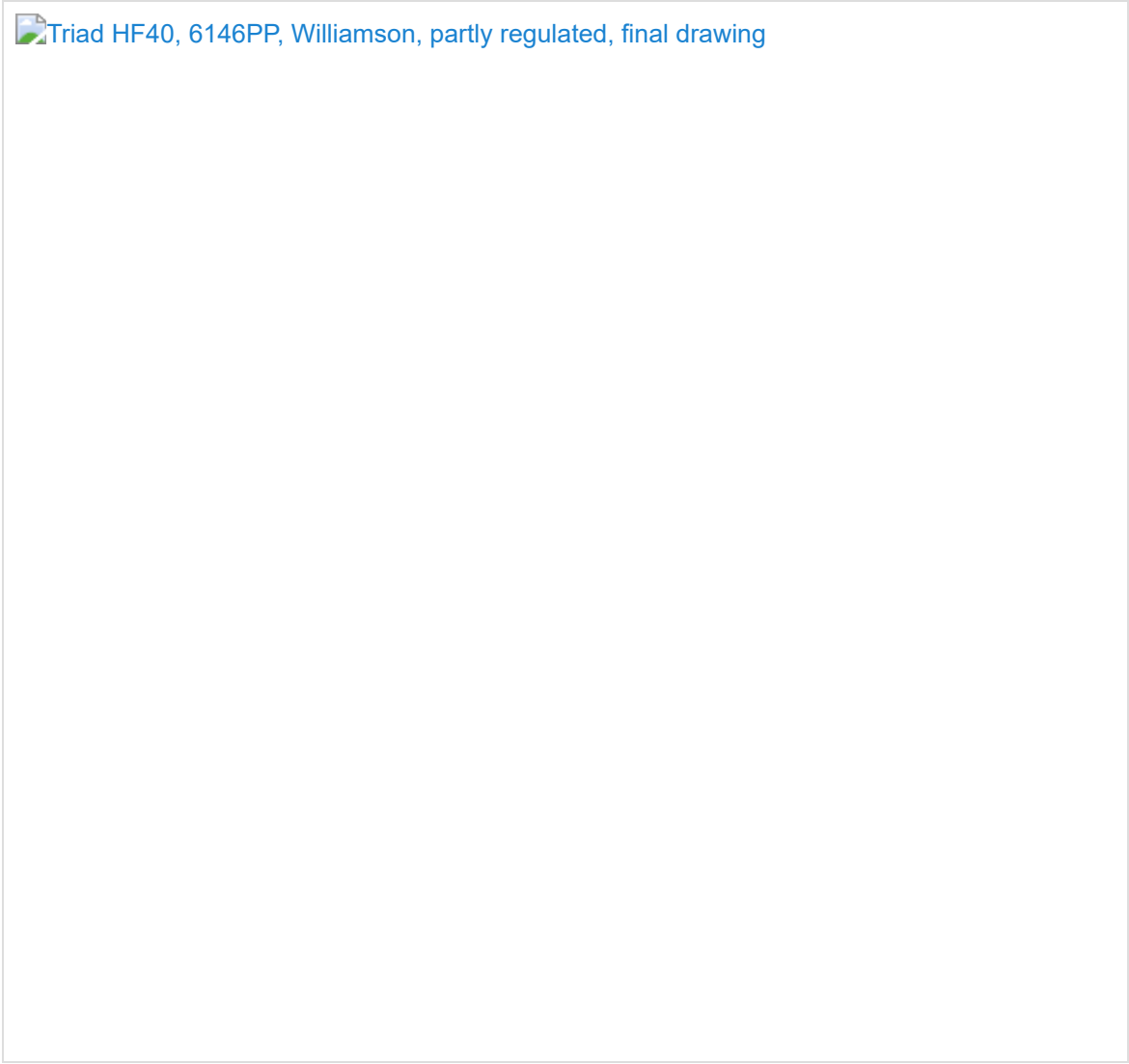
Fig.2 , part of EL6472

Note that this little network of four capacitors and two resistors is connected to the very same B+5. This does not make any sense, right ? The capacitors blocks any DC, so why did Philips even bother to implement these components ?

Well , it is actually a common mode pulse noise or oscillation canceller. If the voltage at the B+5 changes slightly, say due to a transient of some HF oscillations , these signals is transferred to both outputs of the E80L and grids of the EL34s. These are the same. It is quite elegant, right ?

Apart from this little feature, the diodes and the OPT, only a few minor changes was made in the EL6471S model.

Yet a later and larger version of 2kW called EL6472 was released in 1956. The basic circuit is the same, but the input valves is E80F , then two EL34's and yet two EL34's as cathode followers to drive a pair of the even larger QB5/1750. Six DCG4/1000 and a three phase transformer, just like little brother and a further 100kg.



(Suggested by yours truly)
TRIAD kits HF-40, 6146 PP, 1955.

All though this is a Williamson inspired design and the *physical* layout of the kit was stupid (much too small and tight) , it is indeed an unusual and very well designed amplifier.

The 6S4 single triode was intended for deflection amplifiers in TV sets. But fear not, it is one heck of an audio amplifier too. The mu is relatively low:16-17 , but that is used as an advantage in the HF40. The headroom is plenty, despite the low plate voltage in the WIlliamson alike input made of

triode 1 and 2. The 6S4 handles a plate dissipation up to 8-9 Watt's with ease and only a fraction of this is dissipated here. Despite the mentioned low voltage, which is common for 99% of all Williamson designs, the input sensitivity of the Triad HF40 meets modern line level standards. This is indeed a rare thing for amplifiers made before 1975 or so. I only seem to remember that the Kiebert designs had such high input headroom. The 6S4-A versions had a warm up time controlled heater.

The 6146 is not the regular audio beam power output tube, but it is in fact an improved version of the 807, which again was the HF version of 6L6 . The 6146 is intended for HF use, thus the plate cap in order to reduce inner parasitic capacitance. 6146 was officially made in four versions: 6146, 6146A, 6146B and 6146W. All of these fits very well into audio amplifiers and they can take a lot more beating than the trusty ol' 6L6's. The only drawback is the use of a plate cap. I find that these are often unreliable, despite the larger contact area (!?) and I do not like that lethal voltages are easily accessible outside the amplifier cabinet.

As mentioned I consider the HF40 to be a well designed amplifier, but there is a few weird flaws as well.

The signal path in the HF40 is the usual Williamson theme, except that the input triode is ***not*** DC-coupled to the concertino/split load phase splitter. The benefit of AC coupling between these two stages in that it is possible to use higher plate voltage for these two triodes, hence improving the linearity, thus reducing distortion. Unfortunately, for reasons we might never understand,Triad missed this opportunity. The plate voltage is much lower than necessary here, when we take into account that plenty of "free" voltage is present and that the AC coupling by means of the 500n capacitor allows us to use any plate voltage we desire for these two williamson triodes.(Input and phase splitter) My guess is that Triad headed for the usual DC coupled design to begin with. The evidence is that *it is indeed there*. If we remove the 500n capacitor, the grid resistor 470k and the cathode resistor 1k5, we have a full working DC coupled Williamson. This can not be a coincident. I suspect that when applying the +180V from the regulator to both of these triode plates and the screen grids of the output tubes, as well, they experienced low freq oscillation – also known as "motorboating" , and from there they chose the easy way out. There is a way out of this and I will get back to that.

The 6S4 driver following the phasesplitter is of rather conventional construction. The common cathode insures that it is maintained as a balanced/differential amplifier. Nothing wrong with that, but this one would benefit a lot from a higher plate voltage as well. The plate to cathode voltage is about 190V and the current per triode about 6mA, hence a bias of 10 Volts. This is actually a proper bias voltage seen in the light of the low gain from the input stage.(Less than 8) A more linear operation area of the 6S4 would be with some 250V plate to cathode and a current of some 10 to 25mA per triode. It is likely safe to dial in a bias point as low as 8V, due to the low input gain, but a little trial and error would settle the optimum spot.

The outputstage runs in pentode mode, as the beam electrode is fixed to +180V. Although the 6146 is not a genuine pentode, neither is is a tetrode. It is perfectly alright to refer to it as a pentode or beam pentode to be more precise. The bias for the output tubes is developed from a

halfwave rectified voltage that it fed to the OA3 voltage regulator tube via a current limiting resistor of 5k/5W.

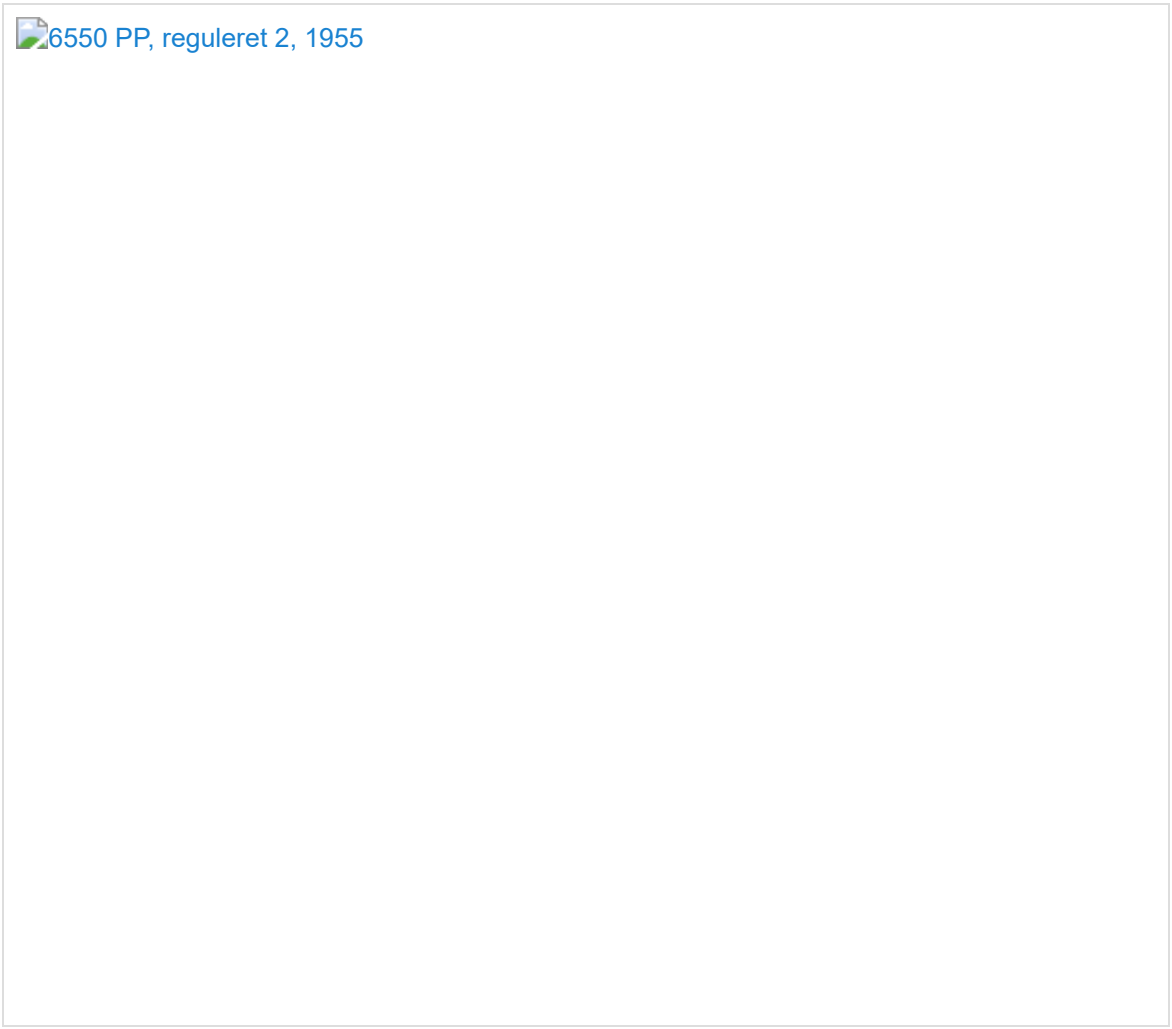
10Ω

This chapter is in the process of writing..

Partly Voltage regulated by means of an OA3, 6SJ7 and 6L6G. Two 5R4GY rectifiers and two smoothing chokes. Four 6S4 triodes and of course – TRIAD quality transformers and chokes.

Excellent kit and a design superior to most – certainly a lot better than the Dynaco kit's.
Should be said, though, that an almost identical circuit by Sarser and Sprinkle appeared in Audio magazine 3 years prior to this kit.


6550PP , reguleret, 40w, 60w, 1955

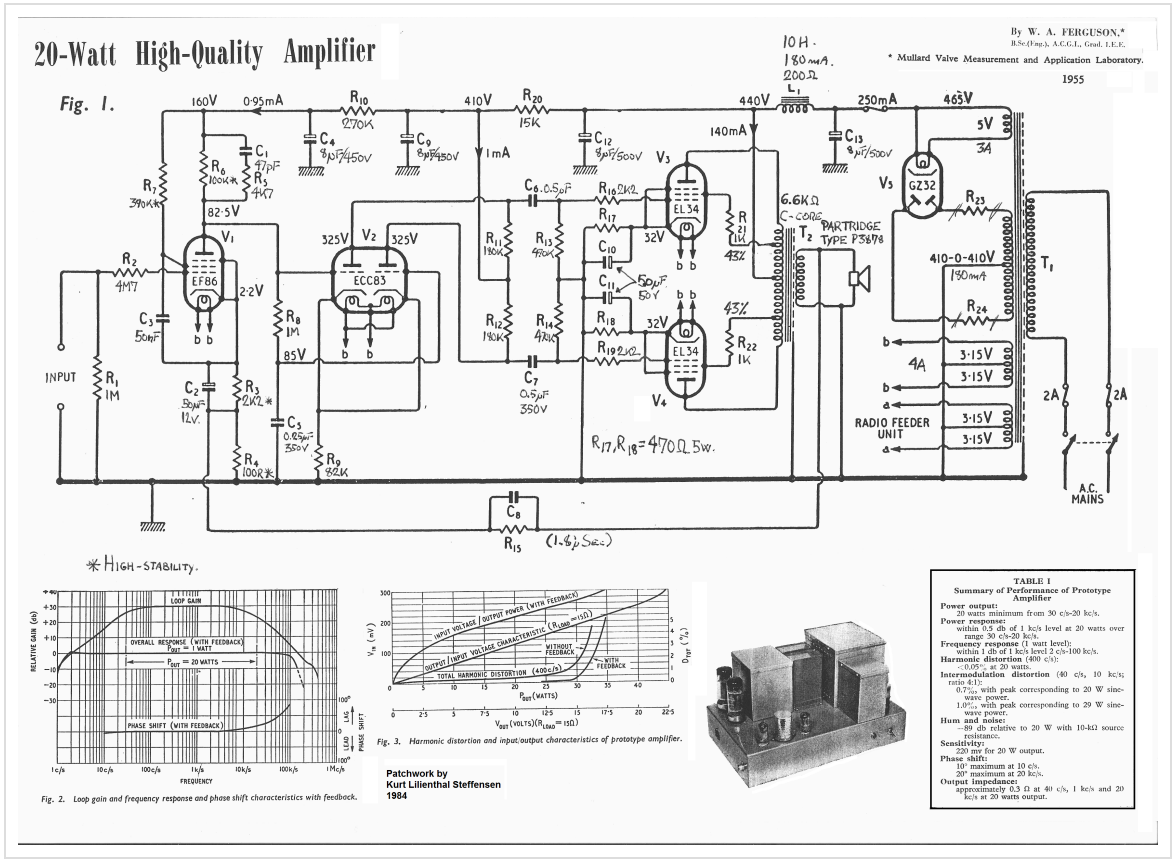


?? , 6550, 1955.
These circuits (possible by Kiebert) is a genuine adventure into good audio engineering.
Both of these amplifiers are improved and regulated Williamson designs. I can't seem to remember from where I got these schematics, but it might have been from a 1955 "Audio" magazine.

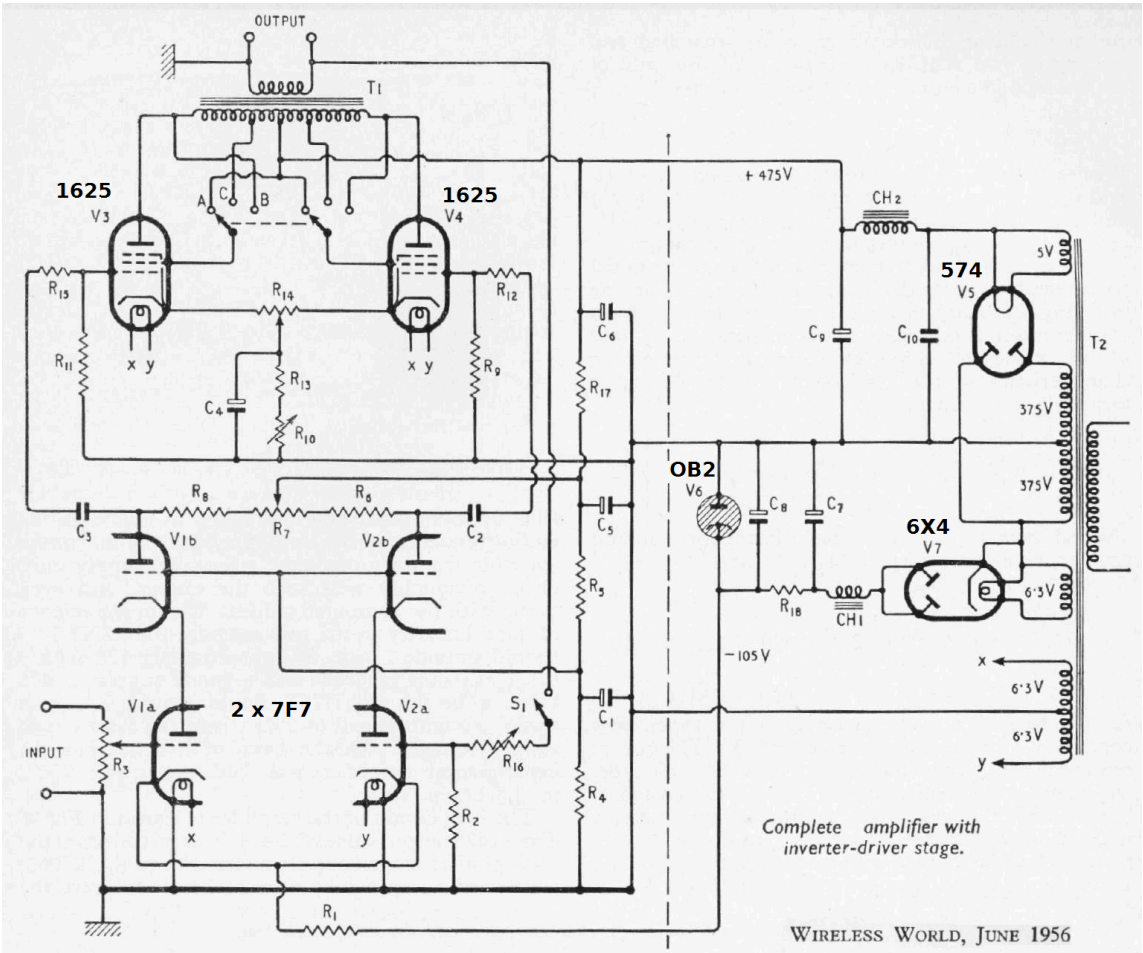
I will go much deeper into these circuits in my "Williamson" article , that will be published on these site later on. It is first class electronic design and I throw my hat to the ground out of pure admiration…..

The Mullard, GEC, RCA, Philips and other 1950's app notes, Audio, Wireless World and many other magazines are an endless source of good schematics and knowledge about audio amplifiers and similar electronics. Much too much to be published here.
Amongst these we find the proto designs for many later famous amplifiers. Marantz 8B, Radford and Dynaco just to mention a few of whom based some of their amplifiers on a particular well known Mullard design. **"Mullard 520", "Mullard 5-20"** or simply **"Mullard 20 Watt high Quality Amplifier"** as Mullard called it themselves. It was designed by W.A. Ferguson. I know that I have often criticized this amplifier, but to be honest it is not really the design itself that flaws – it is the way Ferguson strapped the EF86 pentode and used the ECC83 as a longtail phase splitter as well

as the driver. ECC83 is indeed a poor driver due to the high internal impedance. 180.000 Ohms of plate resistance on top of that, as Ferguson suggest, does not do a lot of good here. But swop it to 5687, 12BH7 (or 6CG7 as Marantz did) triode strap that EF86 – back off the amount of feedback and you actually have yourself a rather decent “20 Watt high quality amplifier” anno 2015. High quality C-core output transformers, that goes without saying.



Mullard 5-20, EL34 PP, 1955



LIST OF PARTS

C_1, C_7	20μf, 450V electolytic	R_9, R_{11}	400kΩ, ¼ watt
C_2, C_3	0.1μf, 600V	R_{10}	200Ω rheostat, 10 watt (Output bias adjustment)
C_4	120μf, 150V electolytic	R_{12}, R_{15}	1kΩ, ¼ watt
C_5, C_6	40μf, 450V ,,	R_{13}	100Ω, 5 watt
C_8	40μf, 350V ,,	R_{14}	100Ω pot., 5 watt (Output cathode balance adjustment)
C_9	40μF, 450V ,,	R_{16}	1MΩ pot. (Feedback adjustment)
C_{10}	10μf, 600V	R_{17}	4.7kΩ, ¼ watt
Ch_1	5H, 300 ohm, 40mA choke	R_{18}	15kΩ, 10 watt
Ch_2	10H, 90 ohm, 200mA choke	S1	S.P.S.T. switch (Feedback disconnect)
R_1	50kΩ, 1 watt	T1	Output transformer—(See text)
R_2	68kΩ, ¼ watt	T2	Power transformer 375-0-375V, 200mA, heater as required
R_3	500kΩ (volume control)	V1, V2, 7 F7; V3, V4, 1625; V5, 574; V6, OB2; V7, 6X4.	
R_4	47kΩ, ½ watt } Cascode 2nd grid voltage		
R_5	100kΩ, 1 watt } divider		
R_6, R_8	220kΩ, 1 watt } Cascode load and balance		
R_7	50kΩ pot., ¼ watt } adjustment		

Hedge Cascode power amp. 1625 PP, 1956

The 1950's was an intriguing period from the point of view of innovation in audio. I think it is safe to say that during that time the technology of audio kind of matured and many circuits got refined. It was also a period of which engineers and manufactures dared to apply circuits that needed adjustment by the domestic users – in particular during the first half of the 1950's. Circuits such as adjustable damping and AC balance comes to mind. Another issue that describes this fascinating period was far better passive components. C-core transformers was invented providing output transformers that surpassed the old shell types by several octaves. Better reliable resistors and capacitors and so on. Still yet , had the engineers of those days been able to use modern passive components as of today, they would have partied all day long.

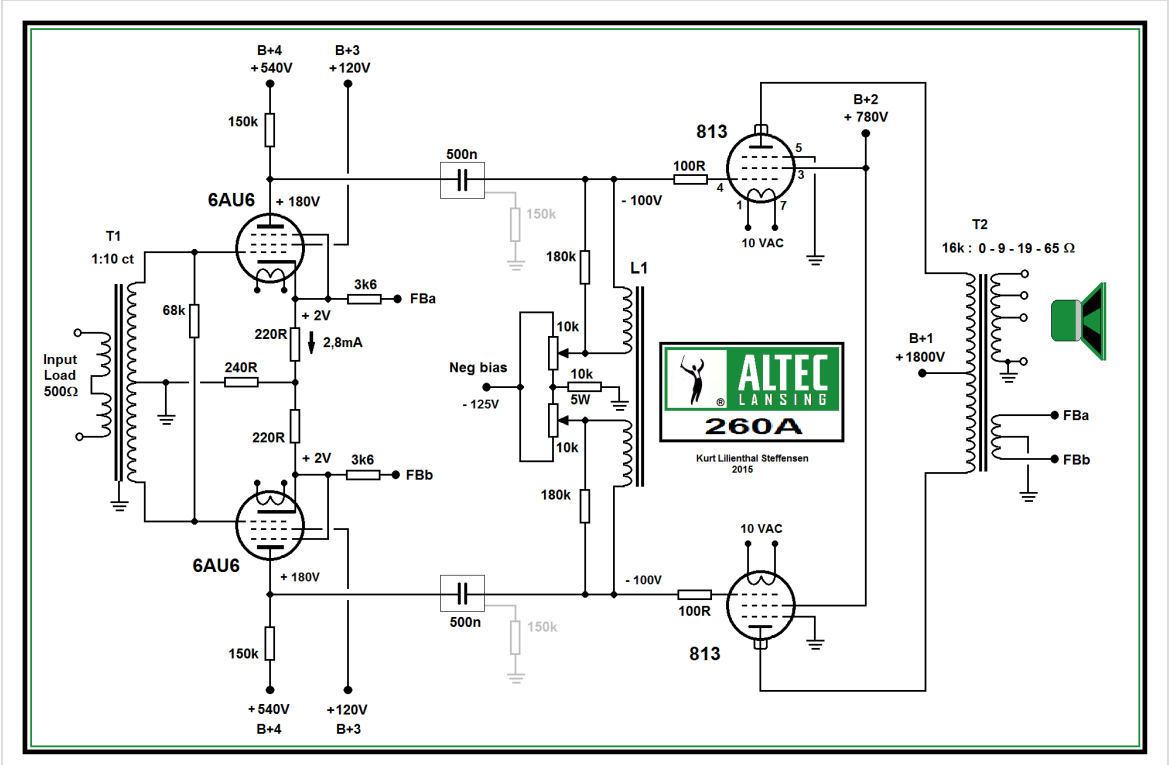
The above cascode long tail phase splitter amplifier and driver is a typical example of the skills and imagination carried out by the audio engineers of the 1950's. It was designed by L.B. Hedge and appeared in Wireless World , June 1950. There is nothing new in this circuit, but it is nevertheless interesting and great care would have been needed to tame the 7F7/6SL7 in that application. Apart from that valve nothing is component critical. The output valve may be any of the KT66/6L6/807 family – and this is a very large family indeed. Same goes for the rectifiers, just about any such will plug in here – even solid state. A thing that was impossible to obtain back then was good and large electrolytes. Hence it is not unusual to find paper/oil and metalized paper capacitors, the major compromise here being the relative small capacitance related to these. Good capacitors, potentiometers and transformers were extremely expensive in those good ol' days.

This is definitely a circuit worth for experiments. Any OPT suitable for 6L6G/KT66 will do.

Fisher 55A , EL34/6550 PP, 1954-55

This was the last amplifier in Fisher's 50 series. The circuit is similar to 50A and 50AZ , but the the pre amp section and the feedback scheme is very different.

Read vignette and schematic at Fisher 50A in part 1.



Suggested by Bill Perkins:

Altec 260A, 813 PP, (1956)

Now, we are talking…Look at this at this thing…1,2V RMS at the input terminals and you will have some 260 freaky ALTEC Watts to feed your speaker !
(Take that , you 205D SE purist 🙂

This is really a “look and learn” thing. Stunningly simple for a high watt tube amp. Heck it would be even for a 10 Watt’er.

Iron input phase splitter (way to go) , 6AU6 PP choke load drive (Balanced to you geeks) and 813’s output. The input transformer is a 1:10 step up. The manual states the input load as a 500 – 600 Ohms. Note the 68k Ohms load resistor that is connected between the input grids of the two 6AU6’s. This insures a stable load to the transformer, hence the input and provides a smooth roll-off. It also tend to reduce any odd difference between the two grids, thus reduce distortion.

The driver choke could be just about any interstage with a midpoint (center tapped) and the secondary may be left unused or if possible split into two and incorporated at the primary in order to make an autotransformer. The output transformer is difficult to find. It should be a 12-16k Ohms primary and whatever output you prefer. If it has 0-4-8-16 Ohms taps, you can make the grounded midpoint from the 4 Ohm tap and use the 0 and 16 taps as the feedback to the 6AU6 cathodes. A little twisting with the 3k6 feedback resistor may be necessary.

You may wonder how they manage to drive them mighty 813’s from a pair of dwarfy 6AU6’s ? The answer is simple. 813’s needs very little drive power (Read: no grid current and high amplification) in order to deliver. You hardly need to tickle it at the grid and it gives away all it got. That’s how I like women as well.

altec-lansing-260a-power-supply-ed-vers-2

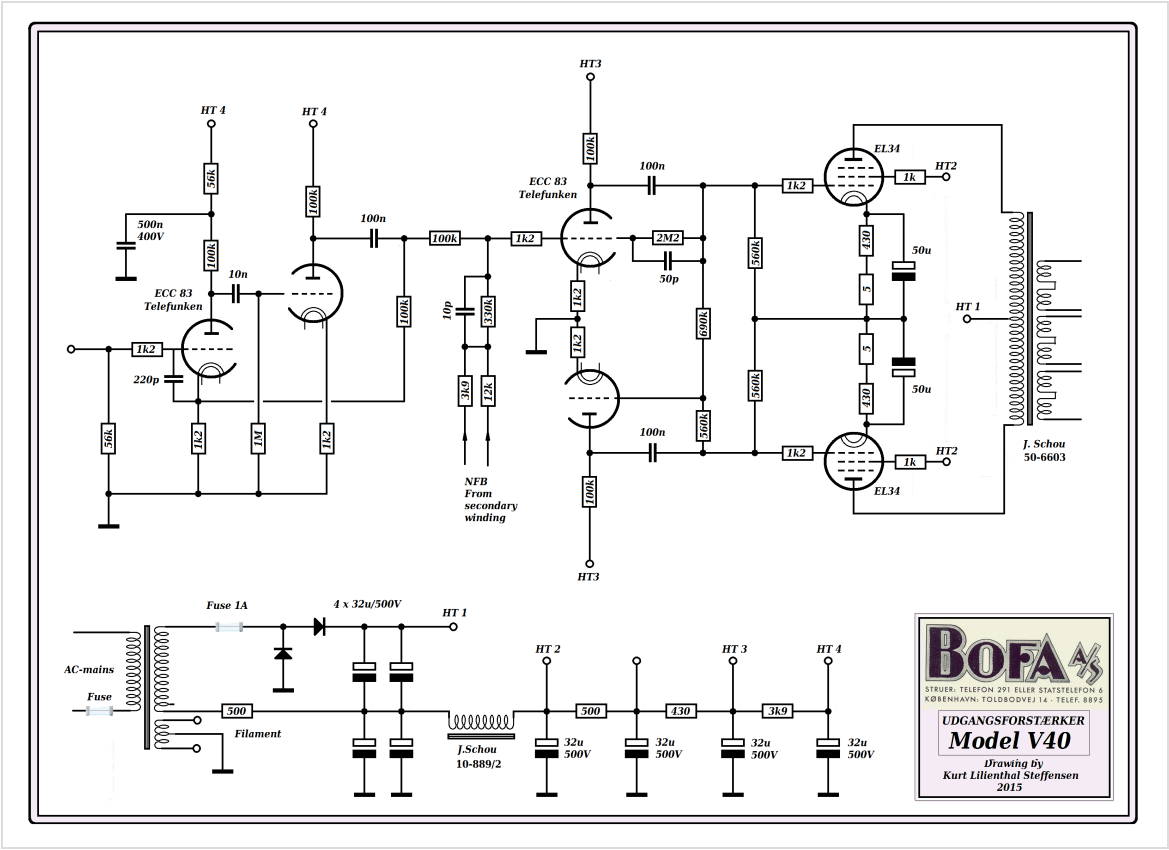
2 x 3B28 and a 5R4 rectifier…He he…I like..

Well – here comes the downside..Weight 186 lbs….1800 plate Volts and 780V sg 2…! I use a little less Voltage in my Williamson 813 PP design (to be found in the Williamson articles), and you might find some of the little tricks I use advantous if you wanna go into high Voltage transmitting tube audio.

A note of concern. I would not recommend playing with these transmitting tube designs unless you are 110% familiar with advanced high Voltage tube technology. No tube is worth sacrificing your health or life.



Good pick.



BoFa V40 , EL34 PP , 1957

BoFa is a division under Bang & Olufsen, Denmark. BoFa produced amplifiers, loudspeakers and projectors for cinema and similar public address use. BoFa is still active in the cinema business.The first audio amplifier for cinema made by BoFa was introduced in 1928-29. This may come as a surprise to many, but Denmark (Petersen and Poulsen) and Germany was pioneering sound for movies very early on . So was Alan Blumlein, England – he researched in developing a stereo sound system for cinema between 1931-39. He was interrupted in this work as he was drafted to develop RADAR during the war.(Sadly he got killed during this task)

The first two stages in the V40 is a cascade of the two high gain sections of ECC83. The cascade are tamed by a pretty high amount of feedback, that is possible as only two capacitors are present in the short feedback loop. I think we can say that BoFa wears both belt and suspenders in the way that besides the grid stopper of 1k2 , they added a capacitor of 22p to the input of the ECC83. These two methods serves to limit the high frequency and prevent oscillation and disturbance from radio and other HF signals. A high gain triode such as ECC83 presents a rather high input capacitance. A total of 190 – 220 pF at the input of a ECC83 is rather common, depending upon type of socket, build of tube and component lay out. The input capacitance of a triode being the parallel combination of the grid to anode and grid to cathode capacitance. The grid to cathode capacitance is Amplified by the tube – this phenomena is called the “Miller effect”.
Cin = Cgk + Cga (1 + A)

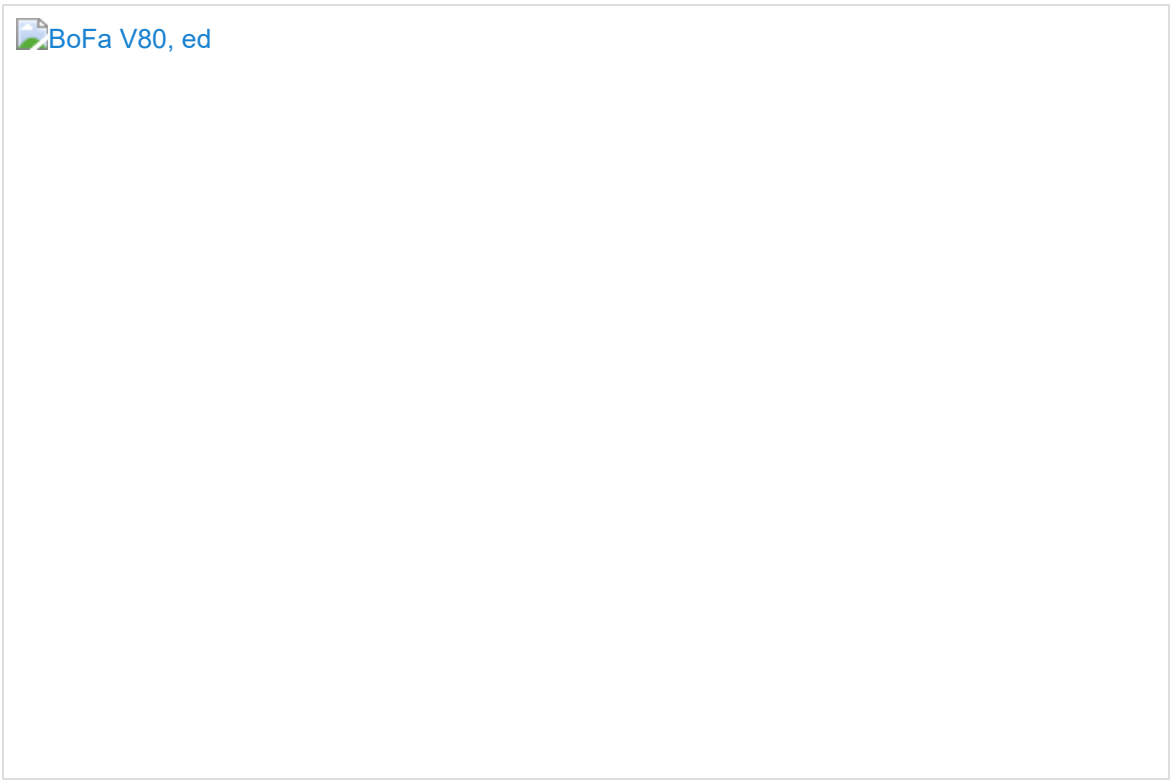
The distortion is quite low, due to the relative high amount of feedback set by the ratio of the 100k and 1k2. The small 10n signal capacitor insures a roll-off at about 15Hz/-3dB , due to the high 1M

grid resistor at the second stage. (1 / 2π x 10n x 1M+ ri//Ra)

The next ECC83 handles the phase splitting and drives the two EL34's, as well as providing further gain. The phase inverter is not quite the usual paraphase in the sense that the cathode resistors are *not* decoupled (Bypassed by capacitors). This provides local feedback to the paraphase, the advantage of this is better linearity, which equals to lower distortion. Audio Research made a similar arrangement in some of their late 1970's amplifiers.

The parallel combination of the 2M2 and 50p from plate to grid is yet another HF cancellation !

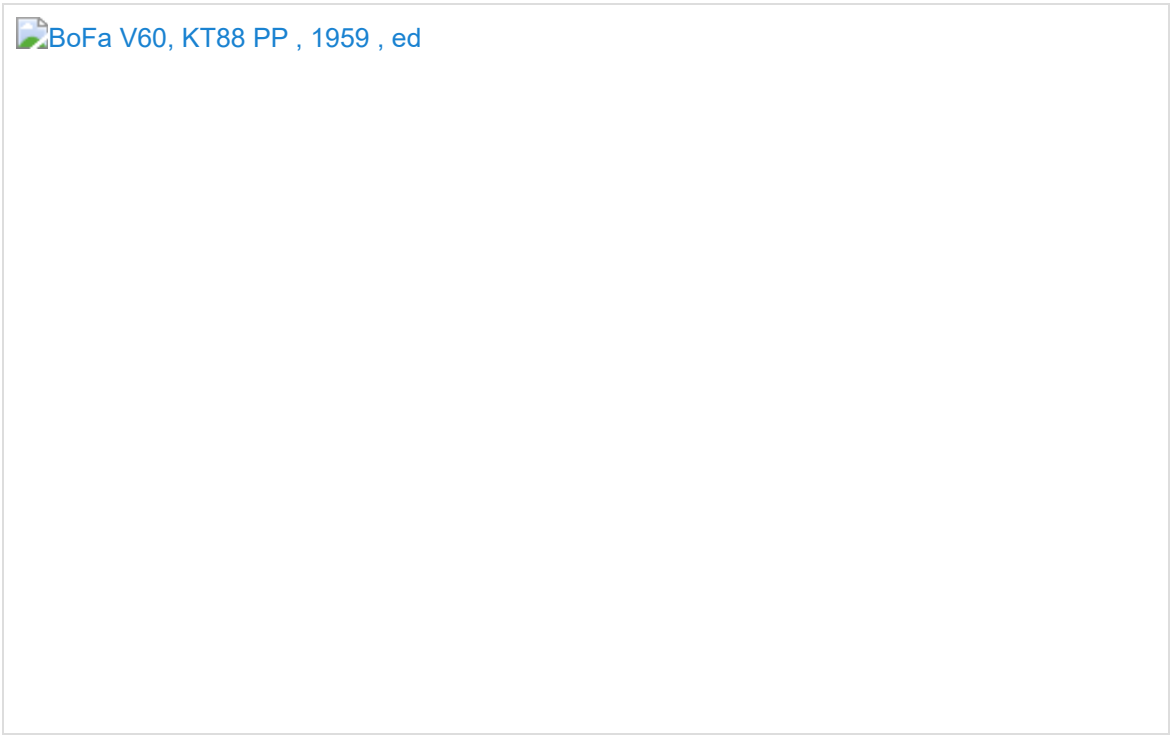
The output stage is straight from the book. The EL34's are pentode coupled for high efficiency , grid stoppers of 1k2 and current (+ HF !) limiting 1k at sg2. It is in fact a good idea to use high value screen grid "stopper" , in particular when using beam tetrodes/pentodes, as this will prevent signal dependent oscillations, that often takes place if wideband output transformers are used. Most screen grid resistors are of values such as 100 to 220Ω , but it is often of great benefit to increase these to values between 470Ω and 1kΩ.



BoFa V80 , EL34 PPP , 1957

The V80 is pretty much the same as V40. There is less feedback at the input cascade and the grid to cathode capacitor is omitted.

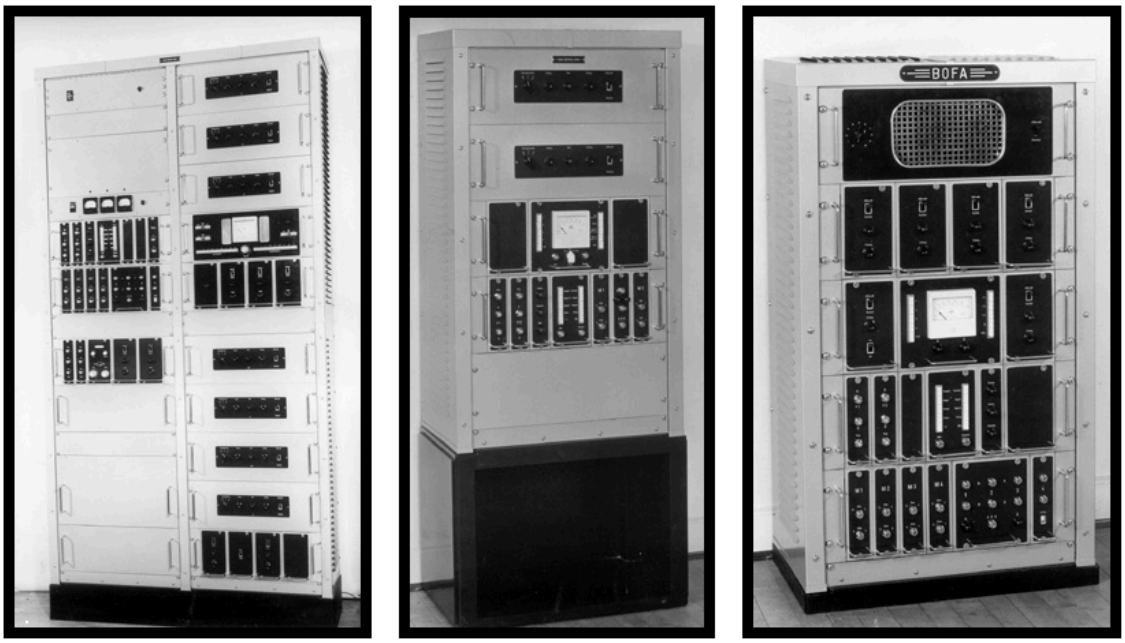
The feedback scheme is the same for all the three amplifiers. The negative feedback is not global and neither does the two feedback loops interfere with one another. That is good. The V40 and V80 has 3 outputs, one of them being a 100 V "Line". A switch is used to select the load impedance and this switch sets the used feedback resistors as well.



BoFa V60 , KT88 PP , 1959

The V60 was one of the last valve amplifiers from BoFa. The V-series from the 1950's included a small EL84 PP called V15 and a high power version model V120. (The valves used in this, is unknown at the time of writing) .

Most vintage schematics from B&O insisted on Beyschlag resistors and Telefunken tubes. I pretty much learned the same thing in the 1980's. Jørgen Schou was the primary supplier of transformers to B&O, this guarantees the quality of the iron and makes it worth to modify these beautiful amplifiers. All three amplifiers in this vignette was supplied with a EM84 magic eye for signal monitoring. The 5 Ω resistor at the cathodes of the power tubes, was used for measuring/monitor purpose.



BoFA cinema sound systems. (Left and middle: 1950’s , right: 1940’s)

PYE HF25 , pixs

Pictures by **Andre Hanekom**, whom also owns the amplifiers. Wonderful indeed. Absolutely as British as English tea, bacon and scrambled eggs. Typical 1950’s carbon resistors by G.E.C.



PYE HF-25, KT66 PP, 1957-58

(Suggested by **Andre Hanekom** , Hanekom Blue Angel Cartridges)

The PYE HF-25 is pretty much a clone of the famous LEAK circuit: input Voltage amplifier coupled to long tail phase split driver. But this PYE has a few significant twists about it. First it is noted that the input twin triodes is coupled in parallel.This slightly reduces noise, but more importantly cuts the output resistance in half, thereby increasing the upper roll-off. The long tail circuit is conventional and so is the output stage. But this amplifier is equipped with current feedback via the 0.27Ω resistor placed in the current loop of the loudspeaker. This was a common practice in the USA in the early 1950's, but it is the first time I have seen it in a commercial British amplifier. But there is more, it is provided with a regular Voltage feedback loop as well. This actually equals to

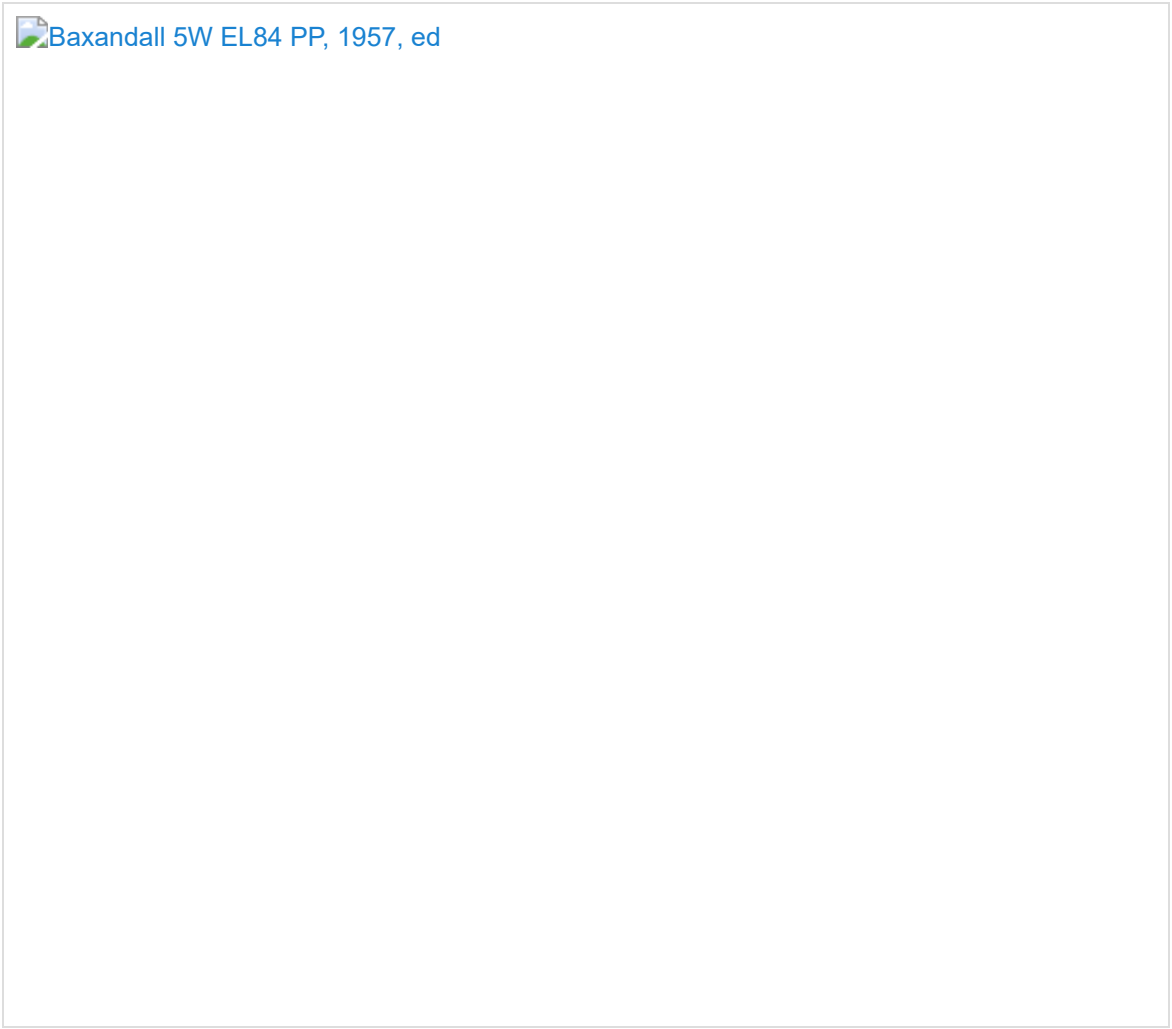
power feedback , a very rarely used feedback method.(One I supported in my articles about “power distortion” and current drive in the 1990’s)

The feedback scheme suggests the appropriate components for approximately 26 dB’s of total feedback.

I would suggest to *increase* the transfer capacitors between the stages in order to avoid capacitor degeneration.

PYE was an old company established in England in the late 1800’s !

Quite a nice and respectable amplifier. Probable better than the LEAK’s……..



Baxandall 5W amplifier, EL84PP, 1957

This amplifier is a splendid exploration into minimalistic design. It was published in WW as an “inexpensive high quality amplifier”. These were buzzwords at the time – we keep forgetting just

how expensive parts were back then. Baxandall even ran it in class A in order to “remove some stress from the output transformer”. A very different approach from nowadays.

The circuit is an abbreviated Williamson and much care had been implied in order to optimize the amplifier with as few components as possible. It is still a very good bid on a low cost high quality amplifier.

Yes – it IS the very Baxandall behind the tone controls we know as “Baxandalls”.

A GREAT little small design.

Now, that we have the EL84 at hand, let’s talk a little about this magical miniature valve. In my experience EL84 is one of the most satisfying power pentodes to work with, in that it is so easy to entice it to do its best. It range from a charming musical sound to a convincing High Fidelity reproduction without much effort and even vibrant high end – if care is exercised. It is impossible to get a bad result from a pair of EL84’s – if only a modest point of common sense is observed in the design process. It even sounds fabulous good in guitar amplifiers. (Think of the VOX guitar amplifiers of the 1960’s) Whether we choose to strap it as a triode, in Ultra Linear mode or the most stringent pentode – it responds very well indeed. It is one of the few valves, I can live with in class B – although I prefer it to run in A or AB. We can load a pair of EL84’s with just about anything from 5kΩ to 12kΩ and it still sounds good. It is a very tolerant pentode – almost as versatile as a triode.

The EL84 was made by Marconi as N709 and the mill. type was CV2975. A few special quality versions was made:E84L, EL84F , 7189, 7189A and 7320.

The US version 6BQ5 and 6BQ5B are not quite as good as the European Pentode versions. The Russian equivalent version is 6P14P and a higher rating type is 6P14P-EV. I believe that 6P15 is a close equivalent too.

There is not many near equivalents to EL84, but there is a few. XL84 is a 8V heater version and LL84 is a 10V version. (US : 8BQ5 and 10BQ5 , respectively)

The later ECL86 was in fact an EL84 and half an ECC83 in the same envelope. Certainly that meant that the max. plate ratings of the EL84 had to go down and the stray capacitances up.

EL84 was designed by Philips/Mullard and introduced in 1953. The predecessor was EL41 a Rimlock socket, power pentode. A good one actually…….

A word of warning.

UL84, PL84/10CW5, EL86/6CW5 are often mentioned in relation with EL84. But this is indeed a bad mistake. These are VERY different pentodes, not even close to EL84. I believe that the mistake originates from the exception to the practice of the European type number codes. Usually the first letter in this code refers to the Heater voltage , the second to the number of electrodes,

first digit refers to socket type . (C = small signal triode, L = power pentode, 8 = noval socket and so on.) ECC85 : E = 6,3V , C = triode , C = triode , 8 = Noval socket , 5 is meant to distinct from others. Thus an ECC85 is the same as an UCC85, except for heater voltage. E = 6,3V , U = 100mA for series heater string applications. The weird exception to this rule is EL84/XL84/LL84 – PL84/UL84

Read here for a full explanation of the European valve designation practice: https://en.wikipedia.org/wiki/Mullard%E2%80%93Philips_tube_designation

PL84, UL84 and EL86 is the same power pentode, except for heater ratings. But as mentioned they are NOT equivalents to EL84. In fact they will all “melt down” and possibly destroy more in this process, if you substitute EL84 with one of these. PL84/UL84/EL86 are LOW voltage and low ri pentodes. The Max screen grid 2 ratings are *way lower* than the ratings for an EL84. Do not confuse these valves with EL84. The PL84 (my favorite) is more difficult to use than EL84, but it is actually possible to achieve an even better performance. Just do not design with an EL84 in mind. Great care and consideration must be used for the best results, when working with PL84’s. The primary impedance of the output transformers needs to be only 25 to 50% of that suitable for an EL84. This means potential better transformers and certainly one of the reasons why it is *possible* to achieve better results from an PL84/UL84/EL86. The B+ voltage must be 250V or less. A voltage of 170 to 200 is a common practice. An optimal use of the PL84, UL84 and EL86 family is the Circlotron circuit. Telefunken PL84’s are possible the best horses in that race. If you can not locate a genuine Telefunken PL84 at a reasonable price (They seem to go for 2A3 alike prices these days) , the Mullards are a close second. Have to be said though, that they are all good. UL84’s are cheap and you might consider to heat them with a DC supply in order to avoid any hum products. The Philips EL86 OTL application is not recommended in my opinion.The two pentodes does not work in unity in that circuit.



Circlotron example with the PL84 family. A pair of PL84 in a conventional Push Pull will easily put out some 15-20 Watt's into a load of about 3000 Ohms. Obviously a quartet twice as much into 1500 Ohms. Now, a quartet of PL84's coupled in a Circlotron circuit will do the same, but the demand for voltage swing at the grid is quite a deal higher, due to the cathode loaded output in a Circlotron like the one shown here. The amplifier above is capable of driving loads as low as 200

Ohms and it will still be suitable up to some 1200 Ohms. The ideal load will in theory be around 400 Ohms. As it is quite difficult to obtain loudspeaker of such high impedance – except for headphones – it will be much better to substitute the two 100uF capacitors at the output with a genuine output transformer. In fact only one capacitor is needed, provided it is an bi-polar one. If only a pair of PL84's are to be used the OPT needs to be twice the value mentioned.

I do not like the halfwave rectifier much – I would immediately swop the PY82's to solid state bridge's. This will provide better regulation as well. The AC voltage for each side of the PSU could be anything from about 120V to 180V. (120mA or more is adequate) You may need to adjust the cathode resistor to fit the actual voltage.

The cross coupled input phase splitter is a matter of choice. Any phase inverter will do, but it is of advantage that it is a balanced type: paraphase, longtail or cathode inverter, due to the feedback scheme. It is a LOT of fun to play with PL84 as well as the Circlotron – not to mention the cross coupled phase inverter. But be aware that the circuit is delicate and needs plenty of care. On the other hand – if well made, you are certain to have a small amplifier of very high sonic quality.

Hats off to EL84 and its remote cousin PL84. Excellent pentodes for audio.



MUZAK Corp. , PB-128A , 6L6G PP

It is difficult to date this rare Muzak PB-128A, but late 1950's to early 1960's is a qualified estimate. The interesting feature in this abbreviated Williamson, is the use of 6V6 as phase inverter. The low ri of this triode coupled 6V6 and the low load resistors of 10k Ohm, insures very fast pulse response and high HF roll off. As it DC coupled via the plate of the 6SJ7, the input impedance is extremely high, thus the same merits are insured for the 6SJ7 input amplifier. The 1uF coupling

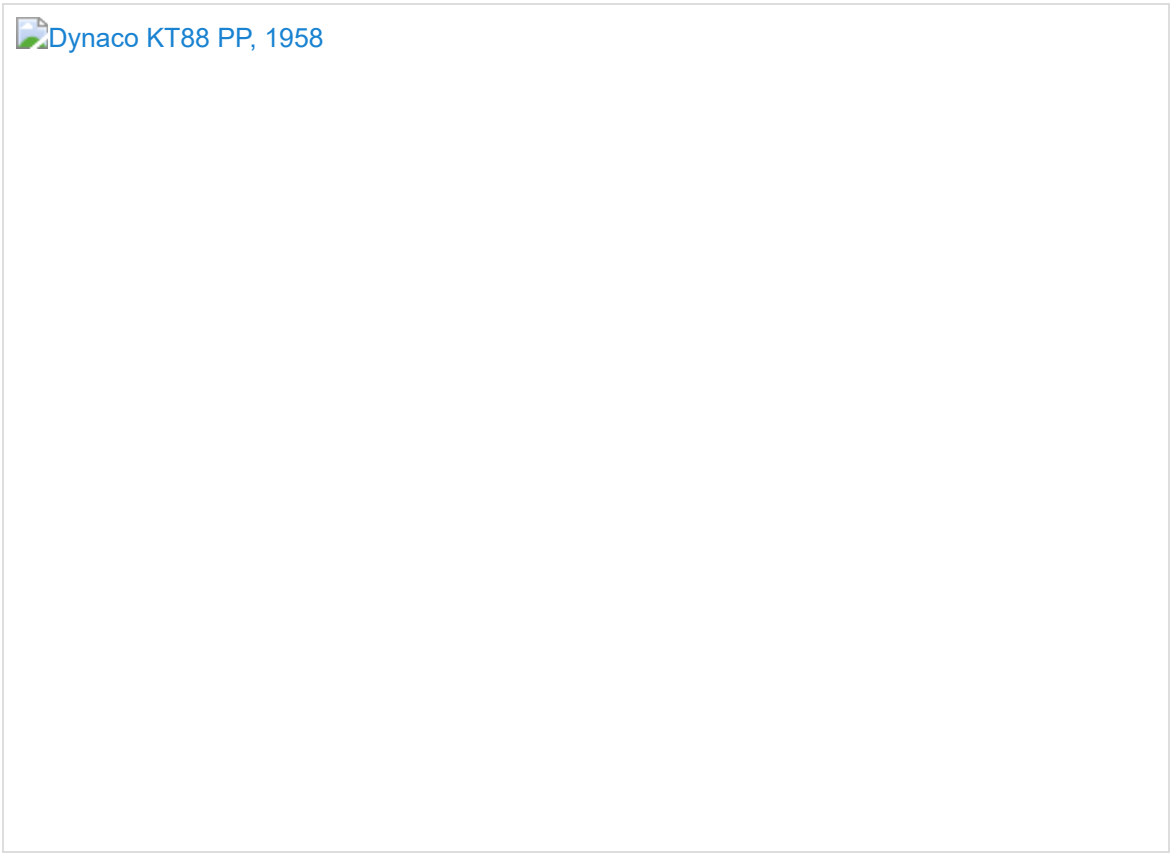
capacitors, on the other hand are on the high end. The LF roll off , is around 1,5 Hz and this is most certainly too low. This lead to DC recovery constants that will mess around in the high midrange and upwards. The 6V6 split load runs at about 8mA idle current, which helps, but not enough. I would swop to some 100n or so.

The separate feedback winding improves stability in case of capacitive loading. It is also possible to adjust the amount of feedback by means of the 250k potentiometer. This is also a good thing, as it gives a little help in matching the loudspeaker to the amplifier.

Finally it is good to see that the input capacitor of the power supply is small, followed by a smoothing choke and only then a large electrolytic capacitor. This prolongs the life of the rectifier, as well as reduce the ripple currents. The bleeder resistor of 13k Ohms, reduce the Voltage to fit the first two stages and the screen grids of the 6L6 output. This method actually improves the isolation, although at the price of a little higher ripple currents and power consumption. The resistor draws some 26mA.

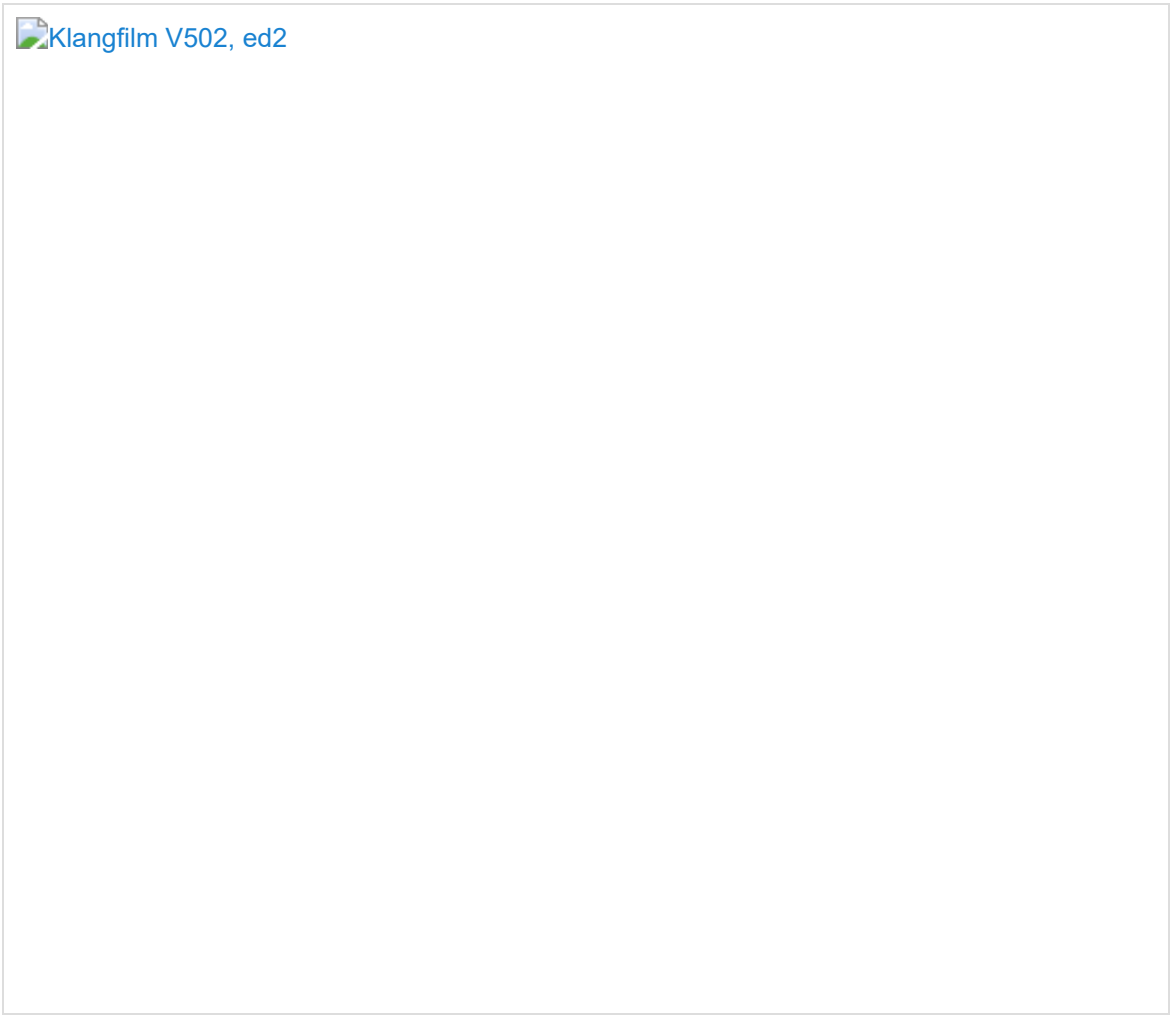
I am not sure that a serious manufacturer of High Fidelity these days, would dare to use a company name like this. I am sure that even the rectifier is bored with muzak. The Muzak Corp. was related to Langevin, which in turn was related to Western Electric – and so on.. We always seem to get back to the Bell Lab. somehow, dont we…..

All in all a very nice amplifier, with little need for improvements.



Dynaco kits, 1955 to 1968.

Well known classics and good OPT iron.
These Dynaco circuits by Hafler and Laurent were almost one to one copies of Williamson, Mullard and GEC designs, but in my opinion the Dynaco copies are generally not very good engineering.



(Suggested by yours truly)

Siemens Klangfilm V502, EL34 PP, 1956

This is a very high quality amplifier made by the Klangfilm department of Siemens, Germany. Klangfilm dates back to the 1920's and was once owned by the AEG company that also held Telefunken. I have several valves marked "KLANGFILM" , but I am not sure if these were indeed produced by Klangfilm. Might as well had been AEG, Siemens or Telefunken. Anyway Klangfilm produced professional amplifiers and similar gear for PA-service and broadcast. Cinema and theatre was their main market.

The V502 is a master stroke. The EL34's are driven quite conservatively in class AB service with some 370 Volts at the anodes and a gentle bias of about 46mA. This equals a plate dissipation of approximately 16 Watt's + 2,7 Watts at the sg2, all in all about half of which EL34 accepts. A pair of original Telefunken 34's lasts a very long time in this rack mountable amplifier. It is clearly made for long and stable service. The ECC40's are configured for similar low current and Voltage. No PSU electrolytics to dry out here, they are all MP (Metallized Paper). These and paper in oil capacitors were rather common at the time. The on/off switch are made of a regular twin switch, but here connected in parallel for double reliability. Better safe than sorry.

In the schematic I have left out the tone controls in the pre-amplifier and the networks feeding the in build meter for user service adjustments. The preamplifier is way too sensitive for modern domestic use. If you own one or two of these amps, and you happen to be a dedicated vinyl fan, I would suggest to convert the pre-amplifier section in to a RIAA amp. The input transformer is of usual good Siemens quality and it will provide you with a sweet and delicate sound quality. The build quality is the usual Siemens, Klangfilm, Telefunken. This means *high* with care for the detail. It looks pretty darn good, I only regret that Siemens/Klangfilm never potted their transformers. (Neither did Telefunken or Philips) Sometimes a shield of mu-metal was strapped around the winding side, which is quite an efficient solution, although it does not look as good.

Right, lets talk about the power amplifier. The OPT only has two secondary windings, one is fixed for 12-16 Ohms speakers, the other is a balanced feedback winding that we will discuss later in more detail. I like the idea of a single speaker output winding as it avoids the usual leakage losses in unused windings (0-4-8-16), sadly this one is dedicated to 15 Ohms speakers only. The EI core laminates is of high quality CRGOSS, however the copper DC resistance is on the high side. 260 Ohms per half primary winding. It might have been on purpose to provide an extra safety margin in case of runaway of the 34's. On the other hand it was not unusual that the copper resistance was quite high in the output transformers of former times. But too high copper resistance adds to distortion and negative dynamic regulation – Losses – and should be avoided if possible.

The advantage of a separate feedback windings is that it does not force the amplifier into instability in case of capacitive loading from crossovers, cables and such. Here the winding is further balanced to provide balanced fb to the balanced driver – this is the only proper way to apply fb to a balanced stage. No global fb used in this amplifier !

The input stage is balanced as well and splitting the signal in form of the well known long tail. But these Klangfilm guys does not rely upon the best that may be achieved by a grounded common tail, they used a negative Voltage in order to implement a high resistance. This is almost as good as a modern CCS Fet/transistor. The remaining unbalance are not "recovered" by means of fb, but simply by the elegant and simple resistor network at the plates. Thus the DC balanced are maintained and the output differs in magnitude by outputs taken at various points. Excellent and simple solutions to a number of problems in one stroke. Many contemporary designers would favour by studying this old circuit.

The driver and pre-röhre is the trusty old ECC40. This excellent twin triode are quite similar to E80CC, but equipped with a rim-lock base.

The Klangfilm V502 is admirable good audio engineering. Hats off guys….

Ortofon Fonofilm GK571 , EL84 PP , 1957, renset

ORTOFON , FONOFILM , GK571 , EL84 PP, 1957

This is a pretty neat design. Not much to complain about here. The Ortofon GK571 was meant for pro use and it shows. A genuine attenuator of custom made resistors was dead expensive in 1957. (Still is , by the way)

The input pentode is a special quality type E80F supplied with gold pins. It is triode strapped and coupled directly to the input of another special quality twin triode E88CC. The E88CC is designed as a cathode coupled phase inverter. The plate resistors are low, which insures good HF and pulse response. The extra plate resistor is added in order to equalize the amplitude of the two opposite phase signals.

The output stage is coupled in Ultra Linear mode, although triode strapping was possible. P3 the 50Ω trim pot , allows balance to be adjusted, to some content. The user are supposed to use matched pairs of EL84, thus pressing S1 that couples the grids of the power valves to one side of the 6,3VAC winding. Then simply adjust to lowest possible audible “hum” – and you are there.

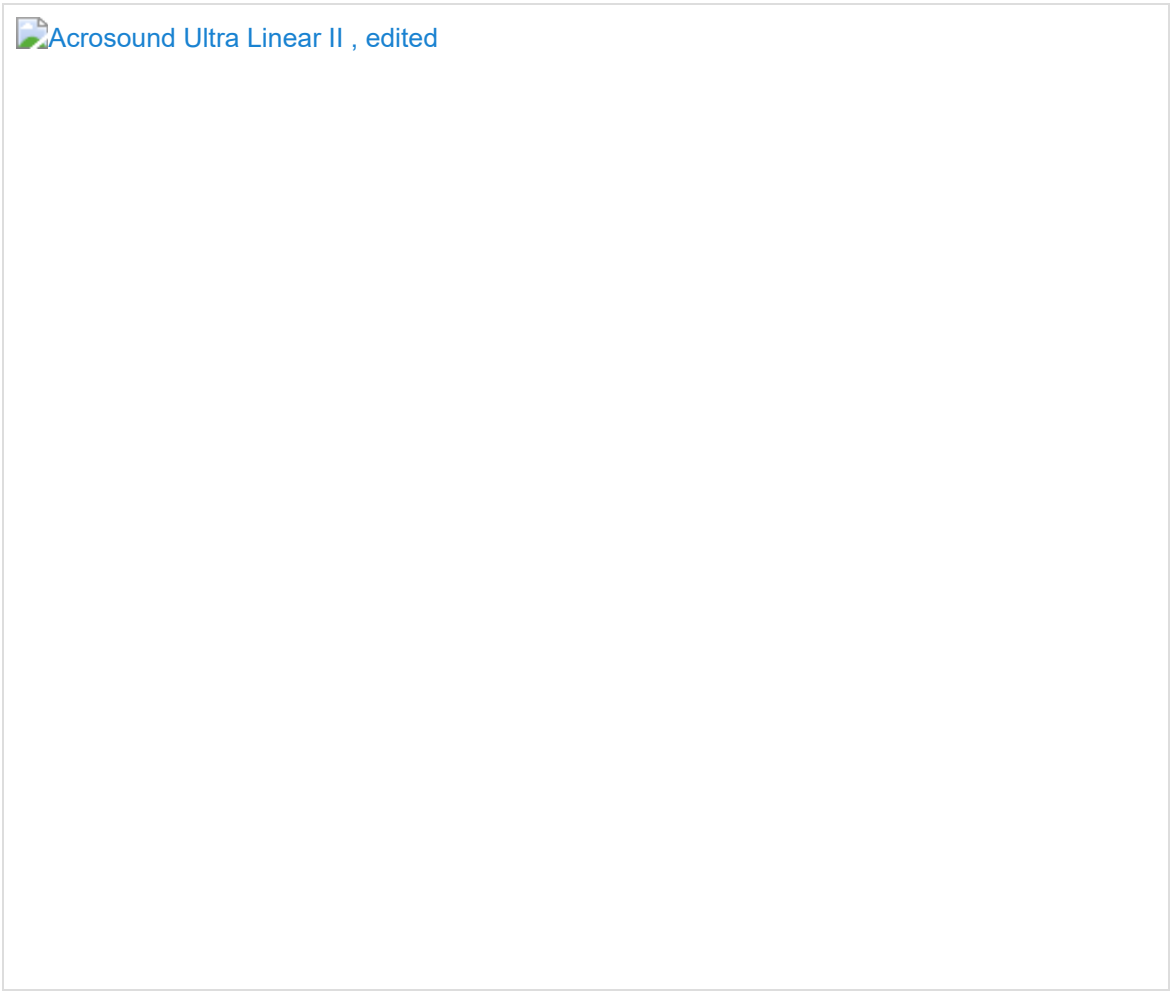
The signal capacitors from the ECC88 to the grids of the EL84’s is too large. This means a long recovery time, hence some nasties at the high end of the freq. I recommend a shift to some 22 – 33n.

As much as I adore the input attenuator, as much do I worry about the complex resistor network. This means losses at high frequencies. Ortofon has to a degree met this by the decoupling of the 200k resistor with C1. (Factory adjusted) But I would rather dump the whole thing and do with a single high quality pot or att. of some 30 to 50kΩ.

The input transformer comes in very handy for pro use – in particular in the 1950’s. But we do not need that much gain for domestic use. It is probably advisable to remove it, although also a little sad. It was an expensive device back then….Still is….

All in all a very good engineered amplifier.

Hats off to Ortofon, not least because of their inventions with regards to cutting systems and Pick Up’s. _____



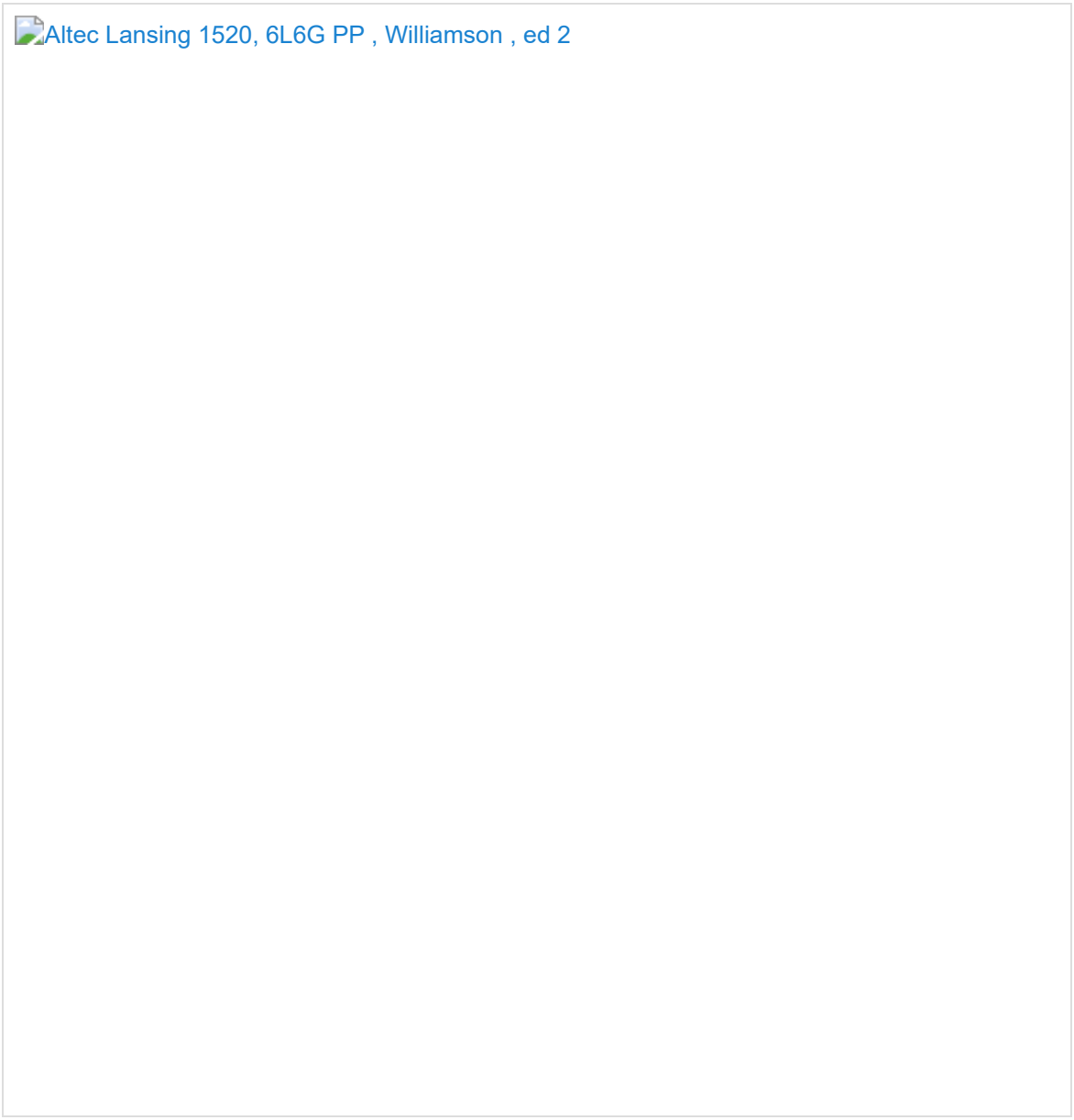
(Suggested by JC Morrison:)

AcroSound UL-II, 1954-58 ?

The AcroSound company was founded by Hafler and Keroes. Apart from their good transformers, the company produced some really nice amplifiers.

The UL-2 is an all balanced/differential construction. It allows adjustable “power damping” in the form of Voltage and current feedback. This was a feature that was rather common in the 1950’s, but sadly it passed out – possible to due with the difficulties of adjustment by the common user. This amplifier is most likely the best designed by Acrosound.

Excellent design.



(Suggested by Bill Perkins:)

Altec 1520,6L6GC PP , ca 1955

Improved WIlliamson. Thanks a lot to “Ho” , for providing me with a schematic possible to read. I have now edited the schematic and filled in the values of the components as well as the DC voltages.

Trannie input 12AY7, 6SN7, 6SN7 cathode driver to 6L6GC out….

Nice – really nice…It differs from the traditional Williamson in that the power tubes are driven by a cathode follower and that it uses active bias. The 12AY7 is a good choice for the input tube. I also like that all stages are properly isolated from one another by means of individual Voltage dropping resistors/electrolytics. But I am not too happy about the low voltage presented to the two triode parts of the 12AY7. (60 Volts and 108 Volts, respectively) I would try to tap the Voltage to the Williamson input stages (Both of the 12AY7 triodes) directly from B+1 via a 10k resistor and 22uF or so. Care should be taken to find the proper bias point for the second triode. But some further 70 Volts or so, to both of these triodes will provide wonders. I would also decrease the input plate resistor and go for a higher bias point at the input triode. Higher bias here is more headroom. I

think it is possible to double the bias to about 2V , due to an increase of the plate voltage to about 130V and a plate current close to 2mA. All in all this will also place the two triodes in a more linear area of the plate characteristics, which spells lower distortion.

The 5nF coupling capacitor is a little too low for modern high quality full freq HiFi. (fn about 32Hz) I would go for 12 to 22n. (Too large capacitors affects the pulse and HF merits, due to the DC recovery)

Do also note that the PSU is a choke input type. This demands a choke capable of handling the excessive AC Voltages, but provides considerable better regulation and lower ripples than a regular CLC. Do notice that at turn on, the PSU capacitors will be exposed to the full AC voltage peak from the main B+ windings and therefore has to be rated to be able to handle that. I would use modern 350 VDC high quality electrolytics in series and add a bleeder resistor of 220 to 330k/1W over each.

The overall gain high for modern use, though. I suggest to remove the input transformer and add 10 Ohms/1W resistors at the cathodes of the 6L6's in order to be able to measure the bias. I always use such resistors and strongly recommend this as a common practice. Apart from providing a neat measuring point, such resistance slightly improves the linearity due to cathode regeneration and further adds some protection against runaway.

My guess is that the 6L6's are ran at about 350 Volts, sg2 270V and that they sought for high power. That means that OPT is about 6-7k Ohm and the current per 6L6 is 44mA + 2-3mA sg2. (I was very close here – it has now been confirmed by means of the good schematic I was kindly offered by one of the readers) Should you chose to spoil yourself rotten – go for a pair of KT66's.

There is a few things I would like to add here, now that I have a second run at this schematic. The bias arrangement does not provide any DC or AC balance. I think I would prefer a balancing potentiometer at the cathodes of the 6SN7 cathode follower or alternatively two individual bias adjustments for each grid. The other thing I would like to address is the 100kΩ bias adjustment potmeter. By placing the pot as the sole voltage divider, responsible for the bias voltage it is possible to accidently turn the whole thing into self destruction – further it is quite difficult to find the proper point as the pot cover a very wide range: 0V to -135V. The simple and efficient solution is to add one or two resistors, like this:



Fig1 , shows the two extra resistors. Strictly speaking only R1 is necessary, but R2 will allow ease and precision of adjustment. The smaller the voltage span the potentiometer needs to cover the better are we capable of adjusting it. On the other hand we need to make certain that the regulation will cover the usual spread amongst 6SN7's.

Lets do some "backwards" engineering. The voltage across the 6SN7 (plate to cathode) is 360V. See Fig.2

The current drawn can be calculated via the informations in Fig.2 – we find it is just about 4,8mA. We could call this 5mA, as the variation of regular tubes is more than +/- 10%. Anyway – by looking at the plate characteristics for 6SN7, we find that at 360 Volts and 4,8mA, the bias is about -16V. See Fig.3.

If we covers an area of about -10V to -22V , we are on the safe side – by quite a margin. Now, the entire voltage from ground = 0V to the negative side of the electrolytic capacitor is 135V. To make it easy on ourselves let's say we make the voltage divider of the three resistors, R1, R2 and the potentiometer to a total of 135kΩ. That means we draw 1mA through the resistors from the 135 Volts to ground. If we make R1 into a 10k, we insure that we can never adjust below -10V. If we then make the potentiometer into 22k, we can adjust from -10V to -22V. This means that R2 must be 135k minus 10k and minus 22k = 102k. We do not need any precision here (We adjust for the precision needed) , this means that any standard resistor value is perfectly alright. The potentiometer could be anything from about 18 to 27k. R2 could be 100k. Another little tip – the lower the resistance of the bias network the better the stability. But as we make them lower, they draw more current, hence increasing ripple. If we cut the total values into half of the above, we would end at 67,5k and we would draw a total of 2mA. (135 Volt/2mA = 67,5kΩ) This would cut the values of the resistors in to half nearest standard values: R1 = 4k7 , Pot = 10k , R2 = 47k. We would still be on the good side. The 22uF electrolytic could be swapped into 47uF. (150 VDC)

The final note I would like to make is that I personally never use half wave rectifiers. I would prefer a bridge any day in order to improve regulation and allow a higher electrolytic, possible even a CRC filter. (Capacitor – resistor – capacitor)

I really love the Altec amps, in fact I prefer them to Western Electric's. But that is just this viking speaking.



Altec Lansing 1570B, 811-A PP, 1958

This is yet another adorable power amplifier from the labs of Altec. It is a Williamson design (again !) with an exclusive choke loaded driver. The 811-A's runs in class B, which means that not only does they need a reasonable high Voltage swing it is also necessary that they are driven from a low impedance current capable source. Hence the choke load.

The rest of the amplifier is pretty conventional, although of good and intelligent engineering. It is clearly made for high power and continuous use. The Voltage for the driver amplifier is taken from a separate winding, using a Voltage doubler. The 600R resistor in the current loop provides the negative bias of -30V, by means of the grounding technique.

The total gain of the amplifier is about 72 db. This sounds like a lot, but it has to be seen in the light of the output of close to 200 W. The input sensitivity fits a modern signal source very well.: 1.0 volt rms for the rated output Power Output of 175 watts at less than 5% THD from 65 Hz to 20,000 kHz. At 165 watts the THD is less than 3%. from 70 Hz to 10,000 kHz. At "low" levels the

frequency response is 10 Hz to 50 kHz ± 1.0 db, according to the specifications. It came with an optional input transformer.

The output Impedance is declared to be less than 10% of the nominal load impedance. Noise Level: Output noise -25 dbm: 77 db below rated output.

As far as I can tell this Altec had no fuse. Instead it is equipped with a thermal bimetal circuit breaker. This has the advantage that in case of overheating the 5 Ohm resistor would be in series with the power transformer and the amplifier would keep on playing, although at lower level. It was mounted with an interlock switch as well, in case someone would try to tamper with it with the power on.

Dimensions of the green monster: 10 1/2″ H, 19″ W, 13 1/2″ D . Weight: 59 lbs

The Williamson input stage is DC-coupled, which often means a relative low plate Voltage for first tube. This goes for the 1570 as well. The plate resistor of 330k makes that lazy 12AX7 more sleepy than it has to be. It would make good sense from a sonic point of view to change it to 5751, 6972 or 12AY7. The 330k should be divided, so that only some 47-100k loads the input. Remember to insure that the phase splitter (second stage) , are strapped to fit the plate Voltage for bias !

The 6SN7 makes a fine differential amplifier, but you may consider to strap it with a long tail or CCS at the cathodes. You might also consider to change the 100k plate resistors to a more reasonable 47k or so, for a higher roll off. (Better pulse response)

The driver is fine as it is, no need to change anything here. Just about any small power pentode/tetrode/triode will do the job as long as the correct bias is taken care of. 6W6G is a fine little power tube, 6V6G, 6Y6G, 6K6GT, 6F5GT, 5881 or 5932 would be fine here as well.

Due to the nature of the 811 and the circuit as such is is not possible to adjust this amplifier into AB – not even AB2. The 811’s are biased at 0 Volts and thats it.

I do not know how much current the power transformer may deliver at continuous service (I have no 1570 at hand), but it looks like it might be capable of some 150-200mA ? If so it is possible to modify it for a pair of 211’s in class AB. Now THAT would make this amplifier a true monster with regards to sound as well. You would need an additional transformer to deliver 10 VAC at some 7 Amperes (or two of 3,5 A) As there is no easy way to obtain a negative bias for the 211’s a common cathode resistor would be needed. You might also consider a pair of 211H’s (Plate caps). These are not quite the same as 211, but might be an even better solution in this circuit. In both cases adjust the bias for class AB2, that will ease the continuous current demand and still allow some 20-40 W class A. By using a separater transformer for the 211 filament, we will lift some 50 Watts of burden off the shoulders of the mains transformer. I think it is a plausible modification.

The 1570 PSU is a nice choke loaded breed, which insures good regulation. It strikes me however as a little weird that Altec chose to use a bridge of four 5R4’s for an amplifier in class B service.

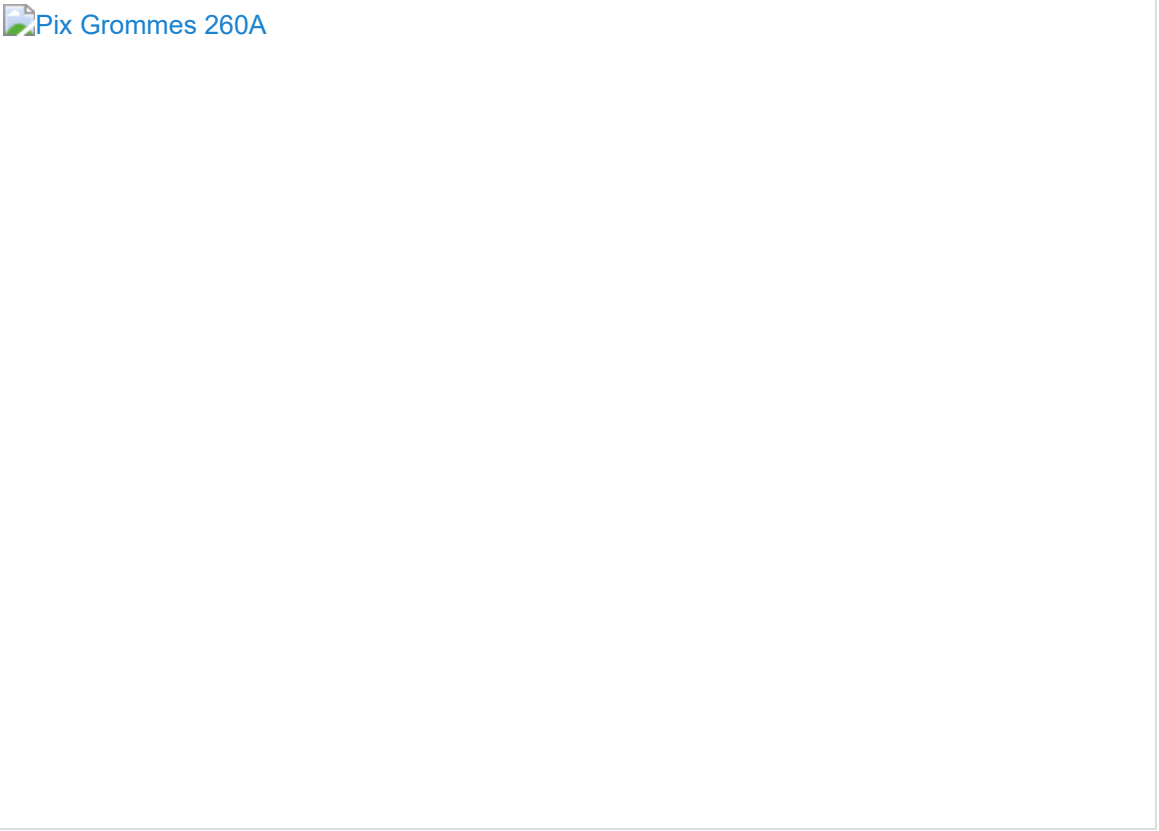
The Voltage drop over these are quite dramatic, in particular for a class B amplifier. This *will* compress the signal. That might not be a bad thing for many public address applications, but it will modulate the signal as well and that is never good. The small 6uF paper in oil capacitor wont be of much help here.

The plate to plate copper resistance of the OPT is quite low – only 96 Ohms. This is in particular low considering the relative high impedance of 6400 Ohms. Nice job, Peerless.

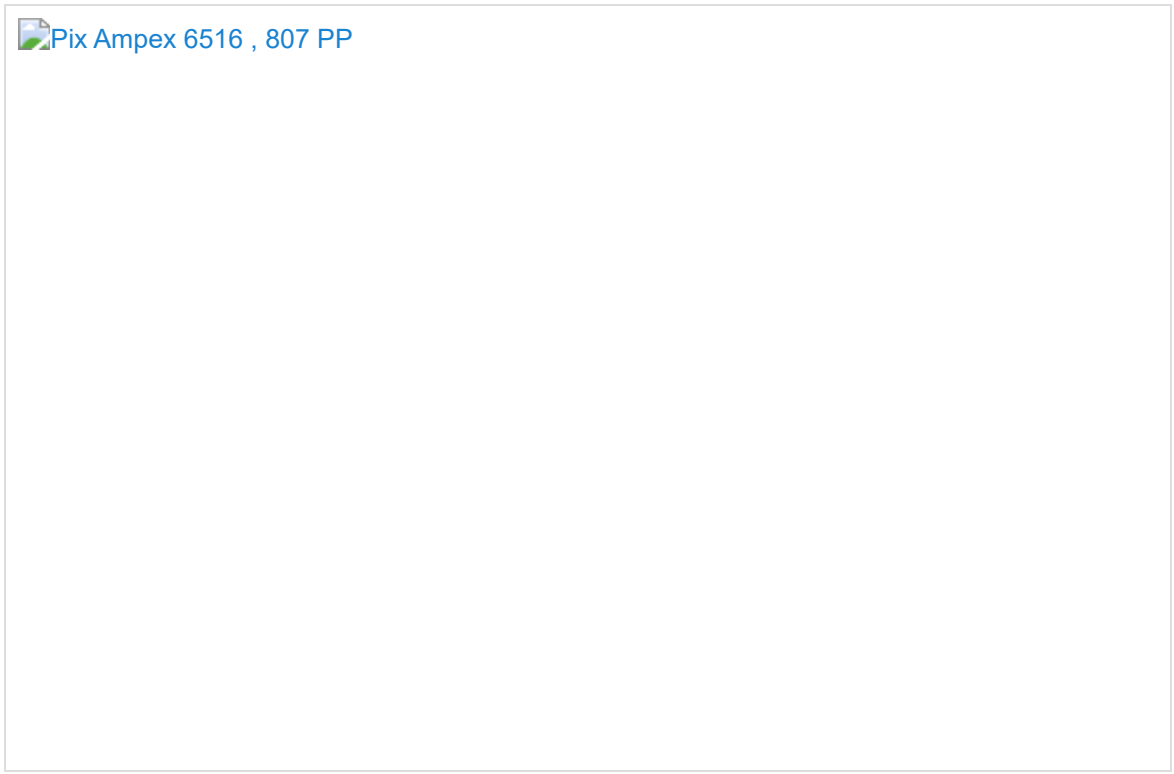
Hats off to the engineers from Altec Lansing.



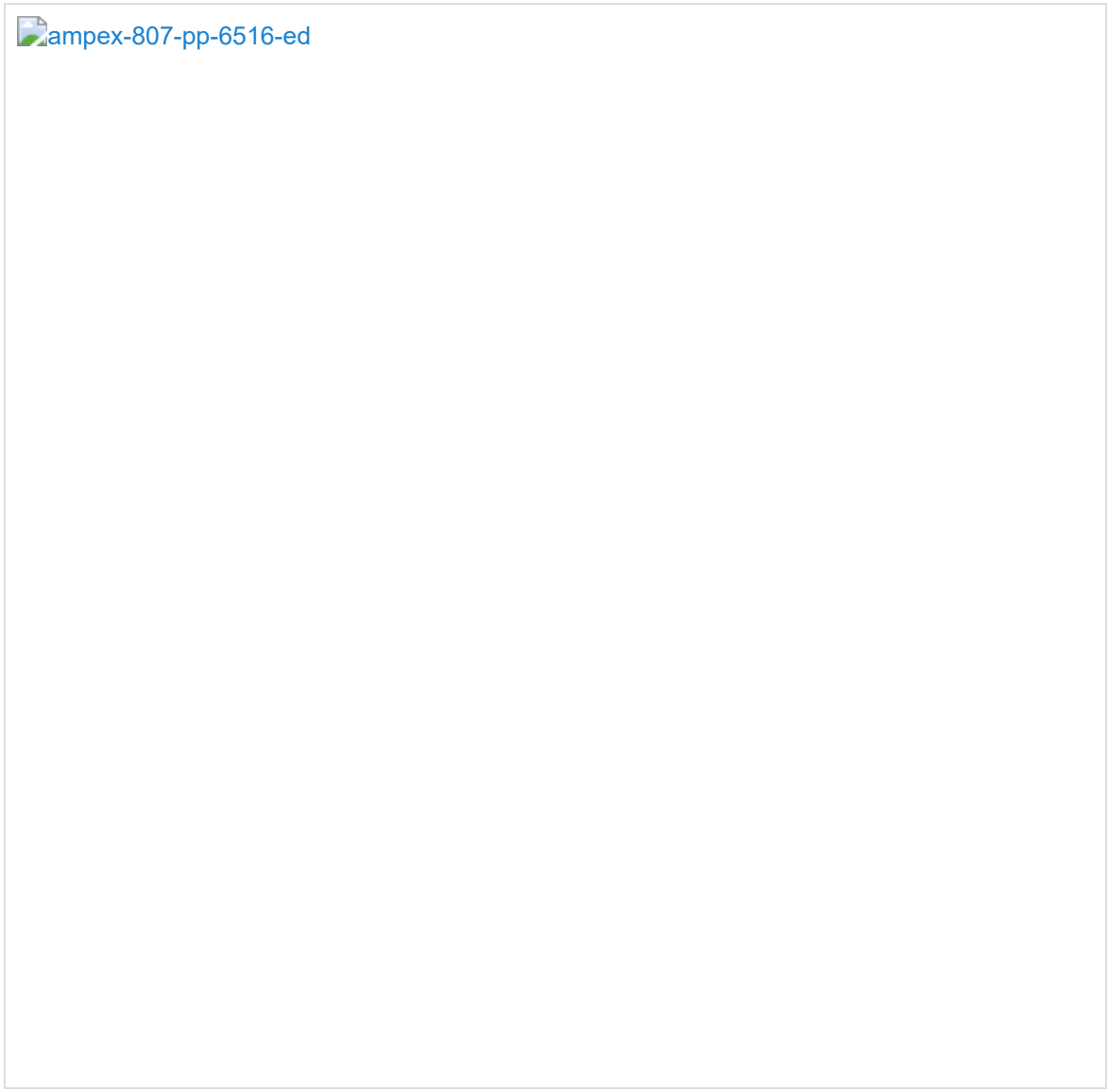
Suggested by yours truly:
Grommes 260A, KT88 PP, 1958
12AU7 cascode, 12BH7 driver phase splitter, OB2 regulated bias, 6L6GB regulated sg2 and two paralleled 5U5G's. Variable feedback damping. Stunning good engineering.
I like most of the 1950's Grommes designs, that I have seen. There is always a funny and original detail or two to be found in these amplifiers.
Grommes was established in 1946 and are apparently still in business as "Grommes Precision" producing solid state devices for the pro market. A reissue of the 260A amplifier was announced around 2004, but I don't know if it was successful ?



Grommes 260-A , Photo courtesy: www.soundup.ru



AMPEX 6516

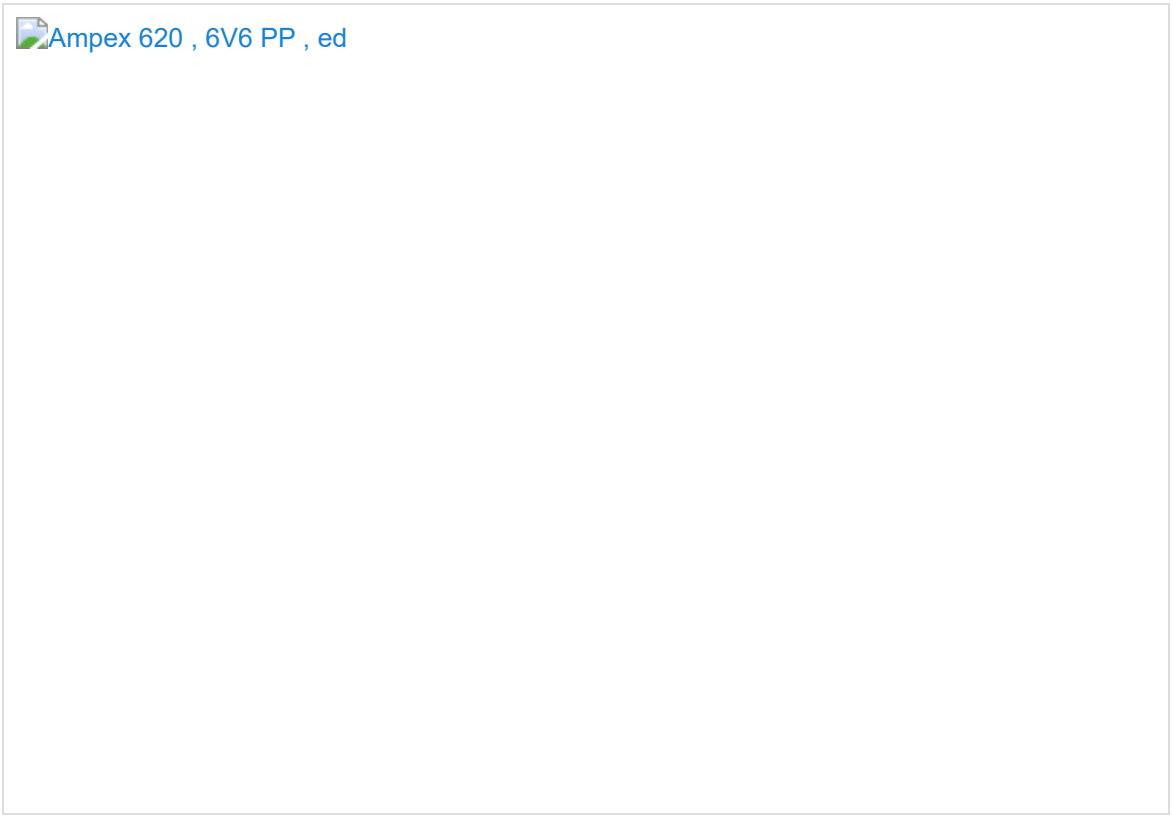


AMPEX 6516 , 807 PP.

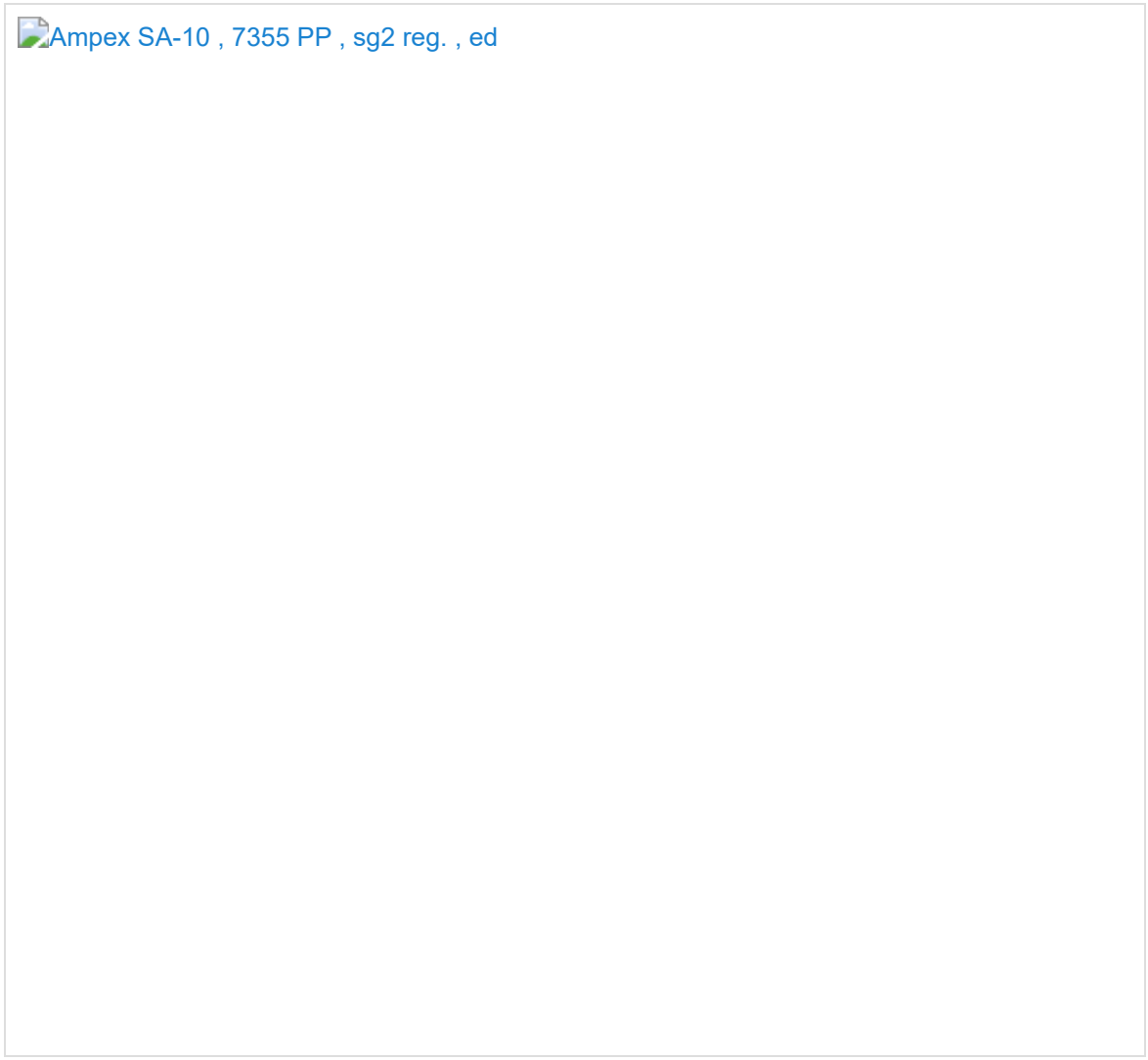
Early (Perhaps the first) Ampex monitor amplifier, ca. 1952. Ampex was founded a while after WW2, probably 1950, as a manufacturer of reel to reel tape recording and player machines. (The company was the joined forces of Russian Alex

Germany was miles ahead of every one else with regards to high quality audio magnetic tape machines.

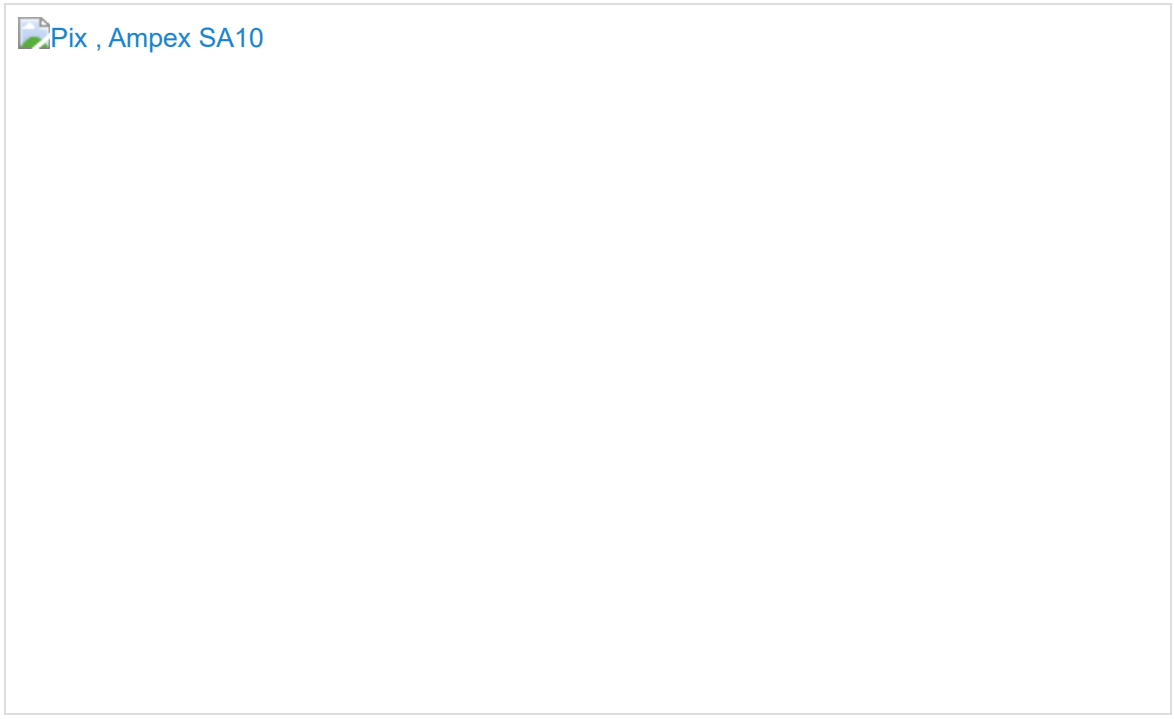
Analysis will follow at a later time.



AMPEX 620 , 6V6 PP, ca 1954



AMPEX, SA-10 , 7355 PP, ca 1960



AMPEX, SA-10 , pictures found at the internet.



AMPEX 6973 PP, (1958-62 ?)



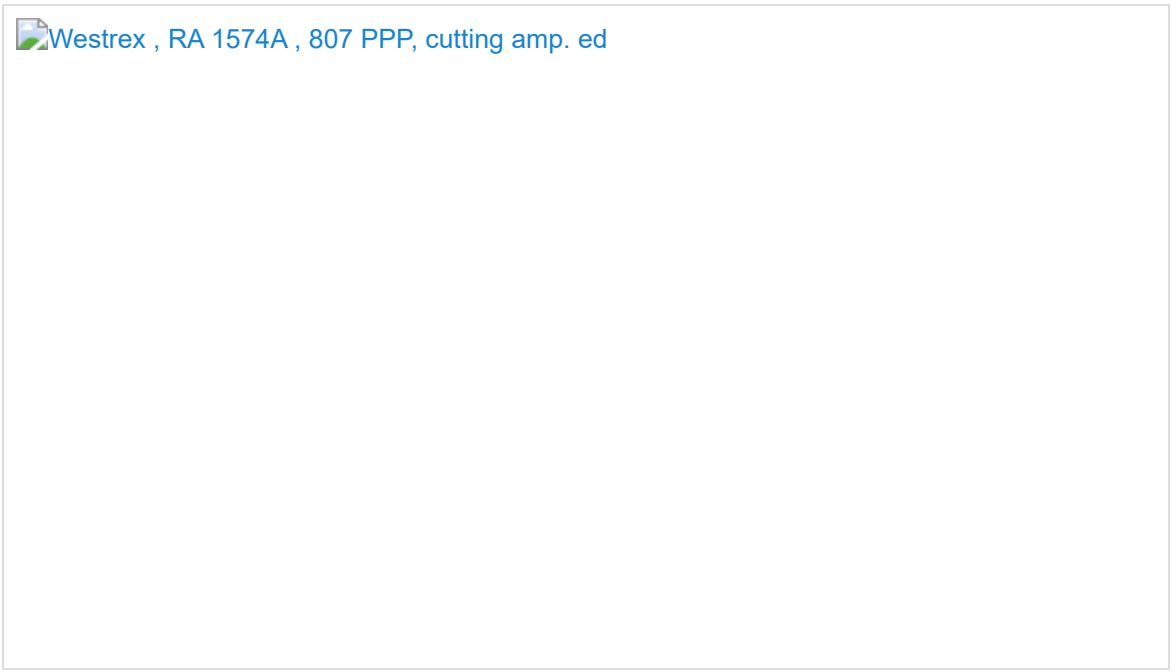
AMPEX , EL34 PP , Custom Series Model 30 Watt Amp , 1959

I will get back to these wonderful Ampex designs.

DISC CUTTING AMPLIFIERS.

Shortly after WW2 in 1946, Fonofilm Industri A/S (Ortofon) developed a new cutting system that raised the freq range of disc recording from some 5-6kHz to 14-16kHz. The system was adapted by RCA and several other major companies. A few years later Fonofilm/Ortofon developed the moving coil Pick Up. It was introduced worldwide in 1952 and many license agreements was issued. The relative recent development of high quality magnetic tape recorders and magnetic tape in Germany made it possible to control the recording process. During the 1950's new high quality cutting systems (Neumann, Ortofon, Westrex, Scully, Decca,) and not least a generation of new cutting amplifiers, all in all created for the first time the possibility for high quality domestic reproduction of music. (Presto, Rek-A-Cut and similar companies never reached any significant sonic quality to the best of my knowledge)

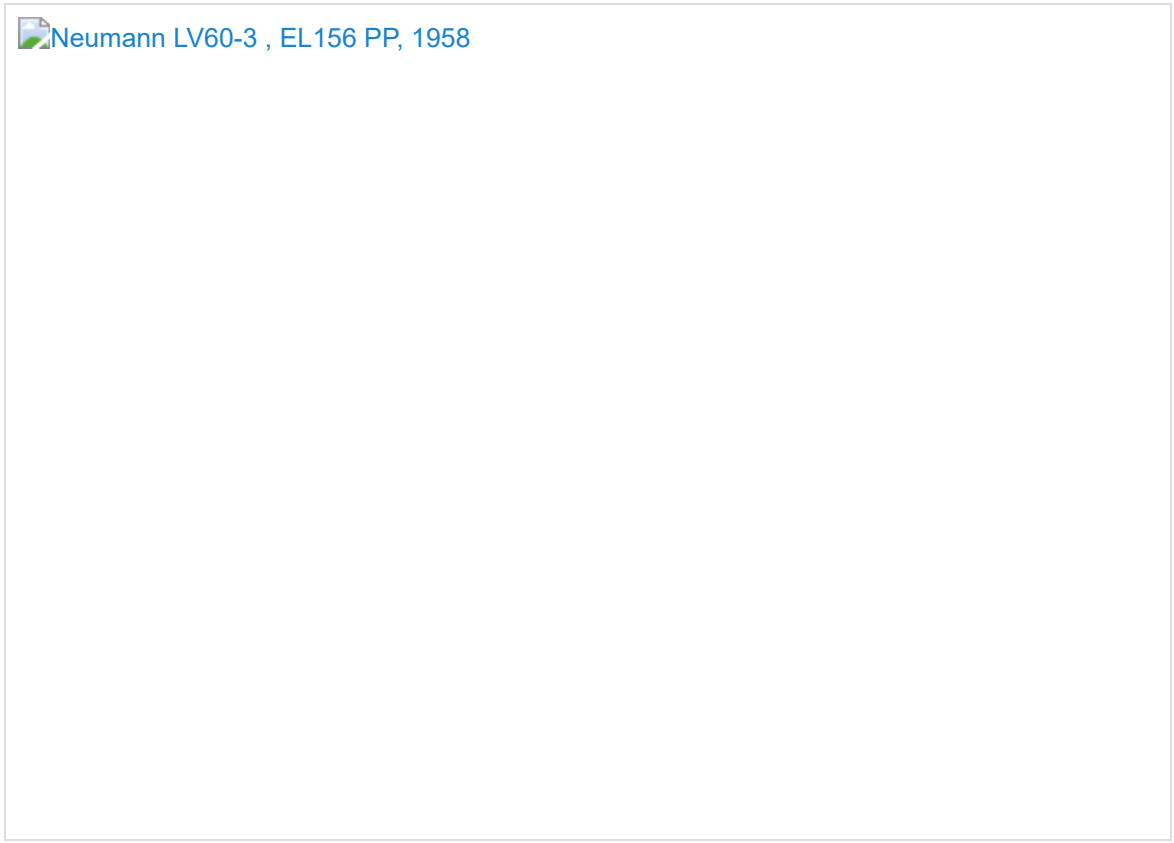
I will at a later stage list some disc cutting amplifiers made by Gotham Audio, Fairchild, Fonofilm Ortofon, Neumann, Telefunken and RCA.



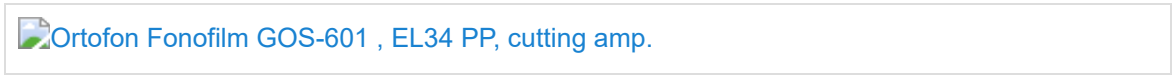
WESTREX, RA-1574A , 807 PPP, Cutting Amp. , 1956



GOTHAM , PFB-150-WA , 6973 PP, disc cutting amplifier



Neumann , LV-60, Disc Cutting Amplifier , EL156 PP, 1958



ORTOFON FONOFILM , STEREO CUTTING AMPLIFIER , EL34 PP , 1960

Only one channel shown , without power supply. The amplifier are supplied with 950V DC, 400VDC, 300VDC, heater voltage and -84V for bias.

End of part 3.