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Lilienthal Engineering

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

100 amplifiers – part 4 , 1959 – 82

This compendium is often updated or edited I have LOADS of more articles cooking. I need PICTURES , though. If you happen to own one of the amplifiers analyzed here, please shoot a few pix and mail them to me. It will all be accredited in your name. Comments – of ANY kind – are welcome too. If you like – you can even write a vignette yourself about an amplifier you think is worth a few words. Email me at : 100amplifiers at gmail.com .

Part 4 of “100 Amplifiers to lift your hat”.



1959 was a happy year. Stereo – the old dream of three dimensional sound, was introduced to the market in 1958 and by the following year 1959, STEREO was a commercial fact. Yours truly was born – indeed a happy year, I’d say. The 50’s and 60’s was marked by the new political economical thinking, that began at the end of the 1800’s, the Glass Steagall act and Roosevelt’s “New deal” from the 1930’s, (interrupted by the WW2), the WW2 aftermath gave birth to the Brettonwood agreement and the human rights. Minimum wage was a fact , hence people had money to purchase goods and production was profitable. During the 1950’s and up in the 60’s the western world prospered and poverty was held to the lowest rate ever. The theories of Keynes’s ruled – Stereo, colors, new music and love made the 60’s.

STEREO

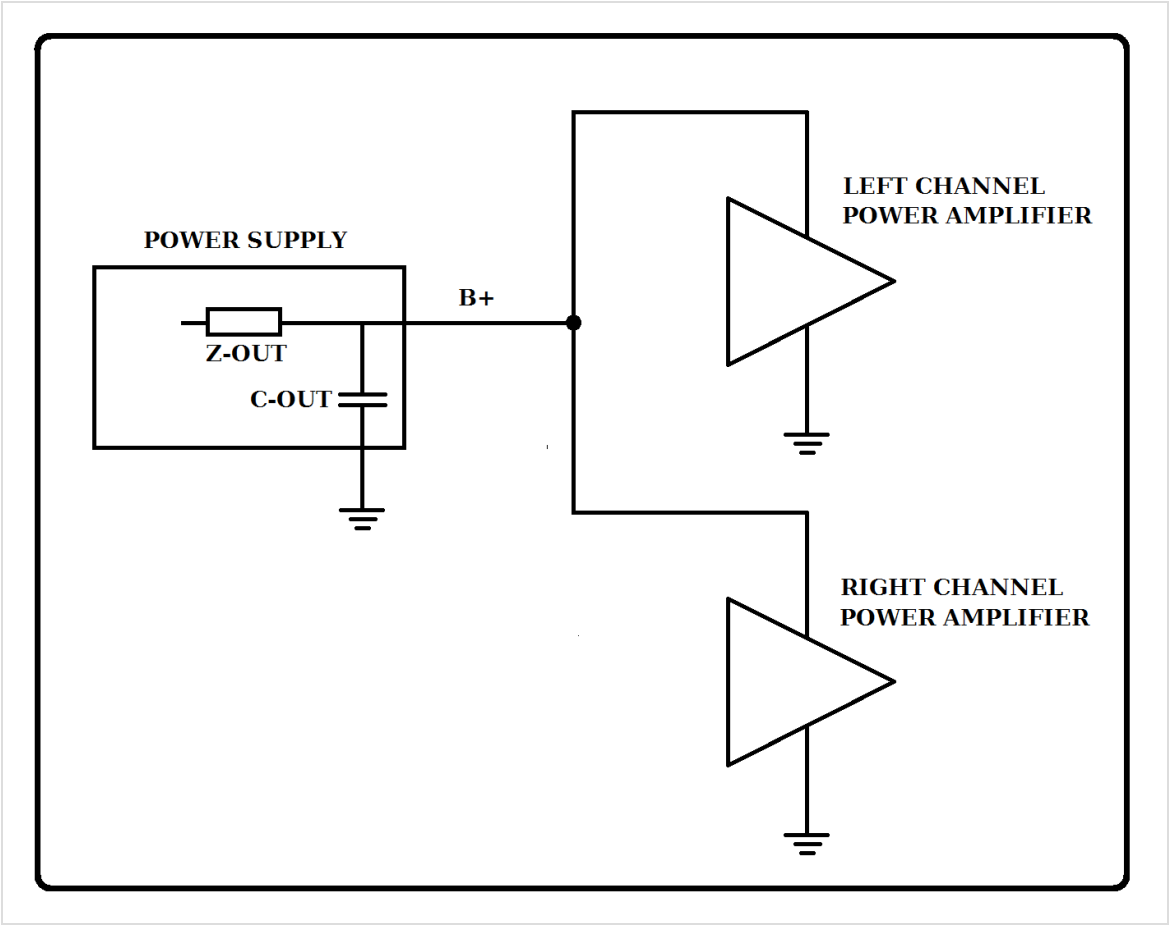
Stereo is probably the most significant *technology* introduced in the audio world, in my opinion. It allows the reproduction of sound to provide the *perspective* that our perception system is designed to use when collecting data and information about the world around us, created by movements in the air molecules. This spells music to us bottleheads.

In the 1950's the quality of the mono groove peaked, due to a number of improvements on the cutting side as well as the reproduction side. Using the same single groove and a single mechanical needle to create and dig out the two channels of the recent low noise vinyl, was not a simple task to solve.

The "Full Frequency" range of about 30Hz to 16kHz, a dynamic range of just about 50-60 dB's and a channel separation of some 20 dB's possible with stereo vinyl is not impressive specifications . But it sure works and the best vinyls, played with the best possible Pick Ups and accordingly suited amplifiers, not least the challenge of the RIAA network, is still to this day a very impressive experience. That said I love the best digital sources, just as much and I like the ease in use and the lack of noise from these formats. Magnetic tape and high resolution digital sources outperforms vinyl in my ears.

anyway – the power amplifiers and speakers do not care if we play mono, stereo or even 11.1 surround. I will not here go deeper into the merits of the Pick Up amplifiers/step up or RIAA sections. I might take that up in another article, But it IS an issue that the *power supply* needs to feed two power amplifiers, instead of one. Stereo may come at a price. Let's have a look.

POWER SUPPLY UNITS



Above is shown a Power Supply Unit that feeds two power amplifiers. All PSU's have an internal resistance. Now, this resistance differs at different the frequencies, it is not a pure Ohmic resistance. Such AC resistance or complex resistance is referred to as *impedance*. It is illustrated above as the "Z-out resistor". The C-out capacitor illustrates the smoothing electrolytics , as well as the "variable" capacitance, related to the current drawn and frequencies in matter. In a passive PSU the Z-out is the collected impedance of all series and parallel parts in the PSU. These are in short:

– The copper resistance and regulation of the main transformer.

– The impedance/regulation of the rectifier. (Very low for solid state diodes, medium low for gas rectifiers , high to "very high" for vacuum tube rectifiers)

– The copper resistance of the smoothing choke or chokes – if any such is used.

– The resistance of voltage series drop resistors.

– The size (in Farad) and merits of the electrolytic capacitors used.

– The typology of the PSU.(I will get back to that)

Now, let's say that the PSU we use have an "inner" impedance of 100Ω. (This is actually a rather low value for a passive PSU of high voltage as used in valve audio amplifiers)

Lets also say that the idle current of the two power amplifiers is 100mA each = 2 x 100mA in total. The loss (or regulation) of the PSU is then 100Ω x 200mA = 20 Volt. Say that the B+ voltage, before any load is attached, is 400V, then after applying one channel, the B+ falls to: 400V – (100mA x 100Ω) = 390V. Applying both channels: 400V – (200mA x 100Ω) = 380V.

Hence, the regulation is 20V , no load to full idle current load or simply 5%. This is actually a low value, most of the PSU's of vintage amplifiers in this compendium will exhibit a regulation of 10-20% and a little handful, less than 5%. It is close to impossible to calculate the exact impedance of the entire PSU in advance. Too many variables are involved. But it is simple to measure and compute afterwards. All we need to do is to measure the B+ voltage with no load, then measure the same with full load. (No signals applied) We then divide the ΔVolt with the actual current drawn from the load. In the example discussed it would be 20V/200mA = 100Ω. The regulation is then 5%, full load to no load. Be aware that the regulation of main transformers is often expressed "no load to 50% of full load", this provides better specifications, but is only "half the truth".

The regulation – or losses – reduce the possible full output power (= dynamic distortion) , but worse – it introduces multiple sorts of distortion as well. I will not get into all of these here, as it would need to be an entire book of its own, but I will explain the most significant ones in a rather simple manner.

Vera Lynn.

Now, we will stick to the example established above. We have the PSU with a z-out of 100Ω and we have applied two medium power amplifiers, each drawing 100mA DC with no signal applied. We are listening to Pink Floyd "The Wall" , perhaps the CD in order to achieve a little higher dynamic range.

Does anybody here remember Vera Lynn? Remember how she said that
"We would meet again".. Some sunny day?

Uh – sounds like a threat of a new war to me…..Anyway , at the end of this piece, the orchestra sets in at a rather loud level. Let's analyse that from the perspective of the amplifier.

The piece is in stereo, which means that in general the two channels are playing different signals, although the main parts are more or less in common.(100% common = mono)

The loud orchestral passage, may cause that one channel draws a peak of say 50mA (or much more) , we then have: 100Ω x 50mA = 5 Volts further of loss. This means that the B+ , that was down to 380V, due to the idle current from the two channels, is further down by 5 volts = 375V. This affects the dynamic peak of the power amplifier playing that signal pulse by the effect of the -5 Volts. In other words , we do not get the full dynamic pulse as supposed to. Now, these – 5 Volts on the B+ *affects the other channel too*, despite it did not pass that particular pulse through its system. The 5 Volts *modulates* the signals of the other channel. In fact the loss passes through the entire system via the chain of the current. How exactly such modulations affect the signals, depends upon several factors, not least the size of the resistors and capacitors. To put it another

way , we loose isolation between the two channels (something that is related to channel separation) , but also between the *individual* stages. The collected distortion are rather complex, not least with relation to the phase and does not necessarily show up in a traditional sinewave test, even less so if the channels are tested on an individual basis.

As you can tell from this, the best possible power supplies should have a z-out of zero Ohm over the entire freq range. In practice we can do with less and much depends upon how clever the entire amplifier has been designed. If you are capable of hearing “the sound” of main cables or the effect of an isolating main transformer/filter ahead of your system, it is NOT because you have good ears, it is because the amplifier is poorly designed. The isolation, regulation and rejection is poor.

Recovery

It is common to use too large smoothing capacitors, as well as too large coupling/signal capacitors. This makes a lot of sense with regards to energy reserves in the PSU and low freq roll of in the signal path. But large capacitors prolongs the recovery time, although in a rather different manner for the purpose of two mentioned . As you can imagine, when drawing the 50mA peak pulse in the example before, we drained the capacitor reservoir for the current needed to fill this entire pulse. No energy comes free. This same capacitor now needs a refill, but it can not refill as fast as it can deliver. This is because it only refills during the peaks of the rectified AC , and then actually only during the short times in which the rectified voltage is *higher* that the remaining voltage at the capacitor. The voltage difference may be 5-20 Volts to begin with and then gradually it turns into balance. Remember that the z-out is 100Ω , hence the maximum possible current to refill is the voltage difference through these 100 Ohms and the size of the capacitor in Farads. Time is another factor, ripples during such passages yet one and further musical signals while this is all going on is yet another factor. In EU we have 100 times per second to do the refill, in US they have 120 times, due to the main AC freq.

It belongs to the picture, that perfectly balanced class A amplifiers, in theory draws a constant current during any passage, but even class A amplifiers are affected by the phenomenons discussed. I usually allow my amplifiers to enter the class AB area, in order to improve the dynamic capability, hence I need to address this problem.

Now, this was indeed the short tour through the current factory, but I think you get the picture.

Choke is good friend of mine.

As I have pointed out a good power supply has low regulation, due to low z-out/inner impedance. A PSU of high regulation is said to be soft and a well regulated one is stiff. The best possible PSU is the *regulated* type. This means an active PSU, by means of a dedicated error amplifier and a series or shunt regulated element. – Or both for that matter.

Why – you may ask – why do we not see well regulated amplifiers at least in the high end marked. ? Well, to defend myself from such a hostile question, I do regulate my high end amplifiers. But the

reason why the majority does not it simple. First of all – it is very difficult to design good regulated power supplies. It is equally difficult to design regulated PSU's as it is to design the amplifiers it self. This is because the regulated supply must *exactly* mirror the amplifier, from lowest possible signal to full power and maximal possible worst case peak and at the same time cover at least the same freq range as the amplifier. We are NOT allowed to let the phase shift to much as the error amplifier must be able to follow the signals handled by the amplifier only in opposite phase, being a mirror. The signals exposed to the error amplifier, are not necessarily the same as the music signals, but they are of course closely related to these.

The second reason is that a regulated power supply adds to cost, weight and foot print.

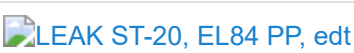
Few audio designers are used to design regulated PSU's, they do often rely upon the traditional passive types. This may be part of the explanation.

The second best possible power supply is the **choke input** also known as LC. See the article about choke input in part 2.

The third best PSU type is the CLC type. Capacitor input (C) , choke (L) and capacitor out (C) . Chokes acts to a high degree as constant current devices, hence reducing a lot of the mentioned problems.

The poor solution is direct capacitor , but oddly enough this may also be one of the best solutions…….!

Consider an endless capacitor tank (will take forever to charge) or at least so large, that even a worst case signal drawn would not mean a loss of more than a few hundred millivolts. Such IS possible, but apart from being extremely expensive and very large (Difficult to charge) it is a potential handgranate in your living room. I pass on such extreme, safety in my home triumphs HiFi……



LEAK , ST-20 , EL84 PP, 1958

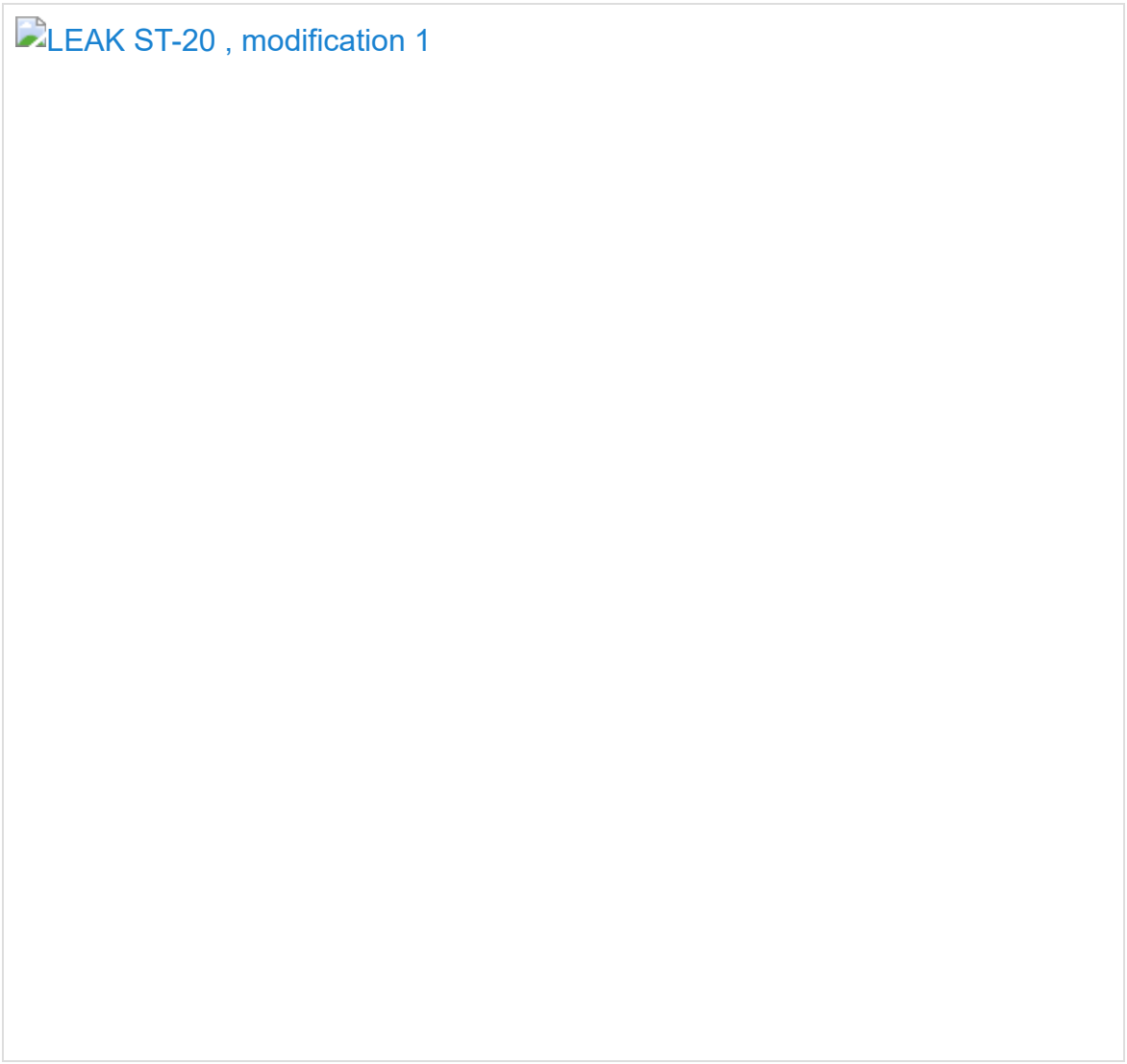
The LEAK ST-20 was introduced in 1958 and soon became one of the most popular amplifiers for domestic use in England. The similarity to the "TL-12 point one" from 1948 is striking. The ST-20 sounds good as it is in its basic form, but this favorite design of Harold Leak is not really one of my favorite designs – I am here being polite. The thing that saves the circuit from fatal flaw is the generous use of feedback – it measures fine when exposed to sinewaves. The input as well as the long tail phase inverter/driver are handled by ECC83's. This is actually the

Achilles heal of the entire design. Harold wanted a lot of gain in order to apply a lot of feedback. This would be perfectly alright if these high gain stages were good to begin with. But it is not so in this case or any other of the LEAK designs for that matter. The first stage ECC83 amplifier is rather mediocre, not much headroom (1,5 V bias) and due to the high ri and plate load resistor , the HF roll off is low. In other words we are dealing with a “slow and lazy”, yet sensitive and relatively noisy input stage. The longtail circuit, that serves as phase splitter and driver, provides further gain. The extreme high values of grid resistors are necessary in order to secure a reasonable adequate freq range as the z-out of the ECC83’s are high as well.

I am not a fan of the principle of designing amplifiers with poor freq range and relatively high distortion in order to “win it back” by means of feedback. It is my experience that good amplifiers to begin with, partly needs less feedback and partly makes better advantage of eventual feedback.

The EL84’s needs some 8-10 V RMS in order to drive them to the full output. In case of an input signal of 1 V RMS (Not an unreasonable estimate in our days) , we are talking about a modest gain of 8-10.

Why not use that fact to our benefit ?



Modification of the LEAK ST-20.

Above I have changed the ECC83's to ECC82's, the gain is still about 12 in the first stage and 10 in the long tail inverter – giving a total gain of 120. This will allow quite a lot of feedback, should you wish. You may remove the 50u electrolytic at the cathode of the input, this will improve the linearity and headroom, at the price of a little gain of which we have plenty. You can implement all the modifications I have suggested or you can pick what you like.

Try these simple and easy modifications, just to get an idea about how much potential your old ST20, actually possesses. The capacitors between the stages in the original design are way too large. The 250nF that couples the long tail to the output stage results in an fn of about 0,5 Hz. This leads to excessive amplification of subsonic signals as well as capacitor blocking in case of transients. 5 to 10nF is plenty here. Same goes for the 100nF that couples the first stage to the

paraphase. Change this one to a value between 1-5nF. This has the further advantage that capacitors of such small values are the best we can make. A glass or silvered mica will outperform even the best and most expensive “audio grade” capacitor by quite a margin.

If you swap the ECC83’s in the long tail circuit to ECC82 as shown above, you may as well replace the EL84’s grid resistors from 1M to some 220k. This will increase the stability and life of the EL84’s. In this case you will need a capacitor between the paraphase and the EL84’s of about 47-100nF.

If you swap the first stage ECC83 to ECC82, you will need to change the 47k resistor in the power supply to some 4k7 or whatever you have between 3-10k.

It is certainly worth to experiment a little with the value of the 12k feedback resistor.

This should get you started. Happy modding

I will get back to the possible modifications of this amplifier in more detail later. There is still thousands of ST-20’s in use today and the transformers are of good quality, well worth a little effort in the quest for best possible sound quality.

PS. Thanks a lot to David Barnett for pointing out a silly error in my topology terms, earlier on. It is now corrected.(I accidently called the long tail a paraphase – what a silly bummer)


ALtec Lansing, 345A , EL34 Williamson abbr. m. pix , , ed vers 3

ALTEC LANSING , STEREO 345A, EL34 PP, 1959

The 345A is a wonderful simple, but efficient design. Pentode coupled 6AU6 at the input and a 6C4 split load phase inverter, driving the EL34's. Nothing more, nothing less. This is what I call an abbreviated Williamson. Can you believe just how widespread the Williamson design came to be…. I will guess that about 70% of all amplifiers designed in the 1950s and 1960's were variations over the Williamson theme.

The 345-A has a feature that allows it to be bridged for twice the output. I have not drawn the switch used intended for that.

I was rather puzzled by the feedback circuit and as I wrote earlier on, I suspected there was an error in the copy of the schematic that I had. This turned out to be true. Thanks a lot to Chris Burwood for spotting this and helping me here. The error is now corrected.

Chris spotted another error , though. I had drawn the 68p capacitor from plate to cathode on both EL34's. Actually it is only mounted on the upper tube. Chris also asks what it is good for ? (He is probably asking because he is a gentleman being polite and not wanting to embarrass me more than necessary, now that he has spotted two errors – actually there was three.) Well, it shunts the EL34 at high frequencies, cancelling HF/oscillations, probably to do with the feedback scheme and the OPT. The freq is equal to 1 / 6,28 x ri EL34. I have no characteristics that covers the actual set up voltages, but I would guess that the ri is about 25-30k Ohms. This equals to a roll off starting at some 90-100kHz. Why is it only placed at one power tube, Chris wants to know. I suspect this has to do with a resonance at that freq on that particular winding side. At least that makes sense, right ? It is more common to add such a filter from plate to grid, plate to ground or over the particular winding. They all leads to Rome and I have no particular favourite here. Chris omitted that capacitor and I do not think this will do any harm. A freq sweep from about 60kHz to 140kHz will reveal if any oscillation or high resonance peak takes place.

Keep them comments coming, please.

The 0,24 Ohms – that I have blurred out, only needs to be there in case of bridging the amplifier in to a mono amp of twice the power. I do not suppose this is a feature that any one would want today. Simply omit it.

Anyway – there is not much more to add here. The bias network is simple, but also a little silly. The bias voltage adjustment is supposed to set the current of all the four output tubes, but there is no means of measuring this, neither is it possible to adjust the balance. I would suggest to insert a 10 Ohm resistor in each cathode leg of the EL34's and split the negative bias voltage in to four individual adjustment circuits. Connect the four EL34 grid resistors of 220k to the four individual potentiometers, as shown. Any value of that potentiometer from about 2k to 5k will do.

The output transformer only allows 8 , 16 and 32 Ohms speakers to be used. (This was a decision made , due to the bridged power output solution.) This is a little sad, as it is otherwise a pretty much flawless design. Should you want to build a copy of this handsome amplifier, an output

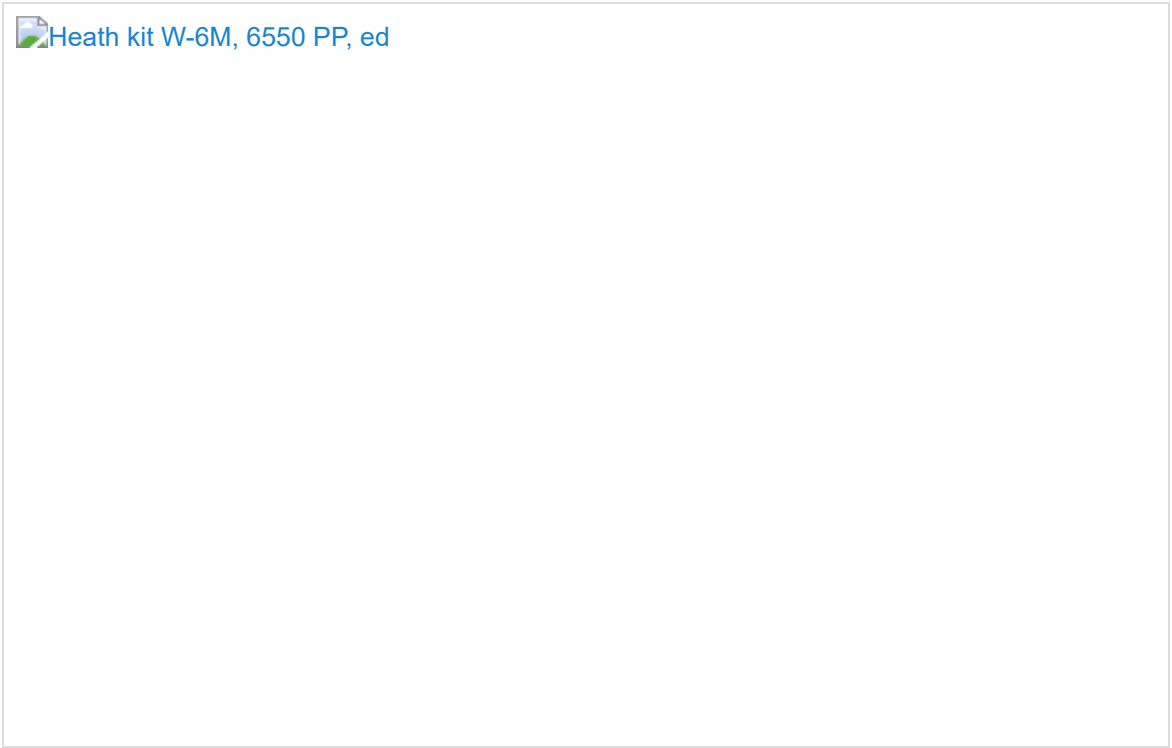
transformer of some 3,5 to 5k Ohms of primary impedance will be needed. The exact value is not important , as it changes accordingly with the actual bias Voltage and not least the impedance of the speaker. A 5k Ohm load, will allow triode coupling.

It is possible to triode connect the 6AU6 RF Pentode. Just be certain that the plate voltage ends closely to +90V +/- 10%. Adjust the plate and cathode resistor to manage this. At about +90V and about 3mA, the bias would be around 1,8 V according to the 6AU6 datasheets. 1,8V/3mA = 600R. A 620 Ohms ½ Watt resistor will do fine. 250V – 90V = 160V / 3mA = 53,3k Ohms. A plate resistor of 47k or 56k 1 Watt will do. This modification will increase the gain and you might want to adjust the 1k feedback resistor.

As the input impedance of the 6C4 splitload phasesplitter is extremely high in the direct coupled mode, there is a benefit possible in dumping the cathode decoupling capacitor. The low ri provided by this capacitor is of no advantage here and the high gain isn't necessary with modern signal sources. The non decoupled cathode will provide degeneration (local FB) and linearise the input stage, whether this is in pentode or triode mode. All in all, less noise and distortion of this stage.

6AU6 = EF94 = CV2524 = 6136 = 7543 and the Russian "6P2″.

A very nice STEREO amplifier.



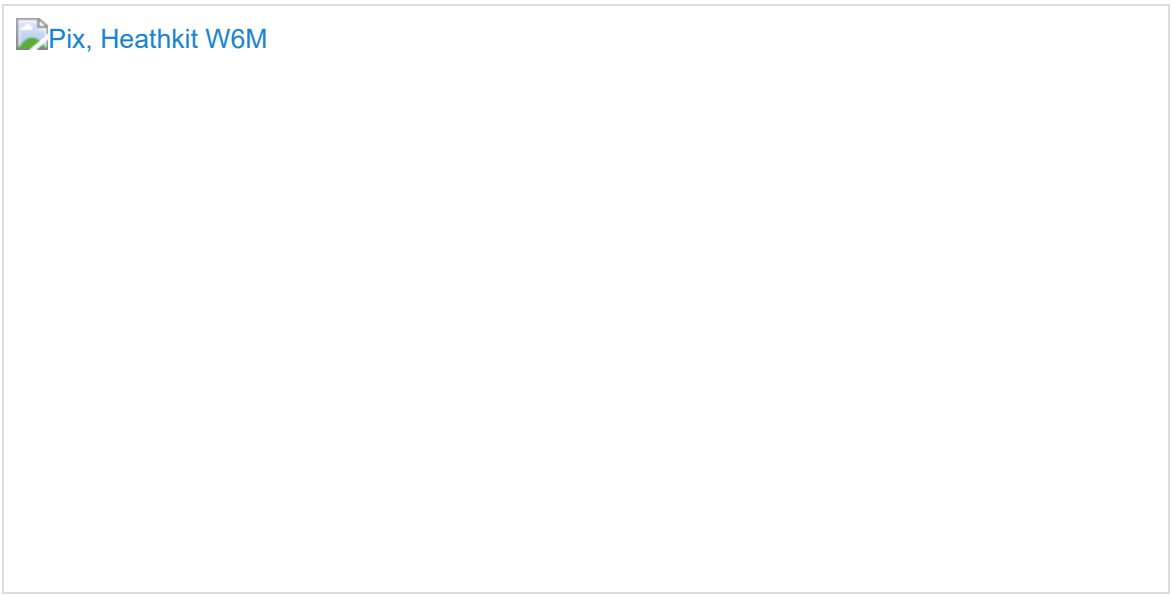
Heathkit W-6M-70, 6550 PP, 1958
Heathkit made a number of Williamson designs.This one called "Improved Williamson" is a 6550/KT88 power with 12BH7 cathode driver and low loss Solid State rectifiers.
I sincerely believe that Heathkit must have a place in this company. Whom has not at some point

been in contact with a Heathkit product ? My first oscilloscope was a Heathkit. Heath company's first kit was an aeroplane !
I will go deeper into the story of Heath when I find the time.

Their amplifiers might not be top of the hat, but most of them were actually quite good and often the iron was some of the best they were able to produce at the time. With a little modifcare – your Heath may become top hat….(There is several other Heath schematics in my Williamson article series, yet to be published)

Anyway, the W-6M is indeed an improved Williamson. I am normally not happy with 12AX7 drivers, but here Heathkit straps it with a 12BH7 cathode follower, which means that the disadvantages of the 12AX7 are restrained. The bias of the cathode follower also sets the bias for the 6550's. I would suggest a 10 Ohm resistor in each cathode leg of these in order to measure the current and ad a tiny bit of local feedback, I am also very happy with the damping control. (Current feedback)

Wonderful engineering. This is by all means a "hats off" amplifier.



Heathkit W-6M , photo :community.klipsch.com

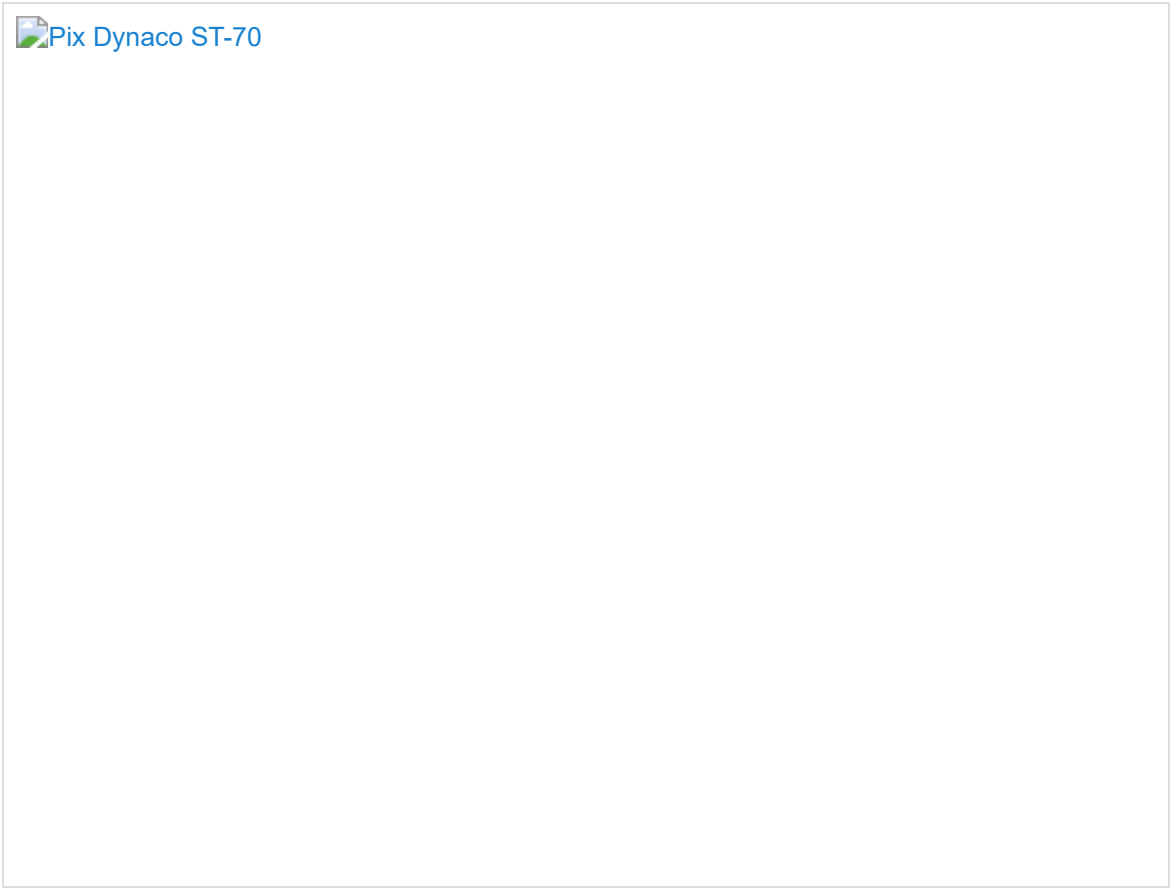


DYNACO ST-70, EL34 PP, 1959 (DYNAKIT ST-70)

I am afraid that I dont have much good to say about this amplifier. It is bound to be here, though, as it is the most common tube amplifier in the world. The main transformers and the smoothing choke in the ST-70 are quite underrated, even more so when they were exported to the 50Hz mains supplied Europe. It is a deep mystery to me that the staff of “Absolute Sound” elected the ST-70 as one of the top 10 amplifiers of all times ! It is most certainly the best selling tube kit ever –

more than 300.000 pieces were made according to Dynaco themselves. It was a quite affordable KIT and easy to build, but in my ears they do not sound good. The sound is harsh, rigid and grainy. It modulates the signal in a weird way and distorts the transients.

But fear not, brave men and women. They are relatively easy to modify. You do, however, need to dump the entire small signal section and the low quality PCB that came with it. I would suggest that you replace the board with a metal plate of same size and install – say a Williamson made of 4 twin triodes – or a paraphase circuit needing only two such tubes. In order to lift a little of the burden to the underrated power transformer, it is advisable dump the tube rectifier and replace it with two solid state diodes. If at all possible, do also install a larger power transformer and a proper smoothing choke. Elsewhere on this site I will later show two possible circuits based on the ST-70 hardware.

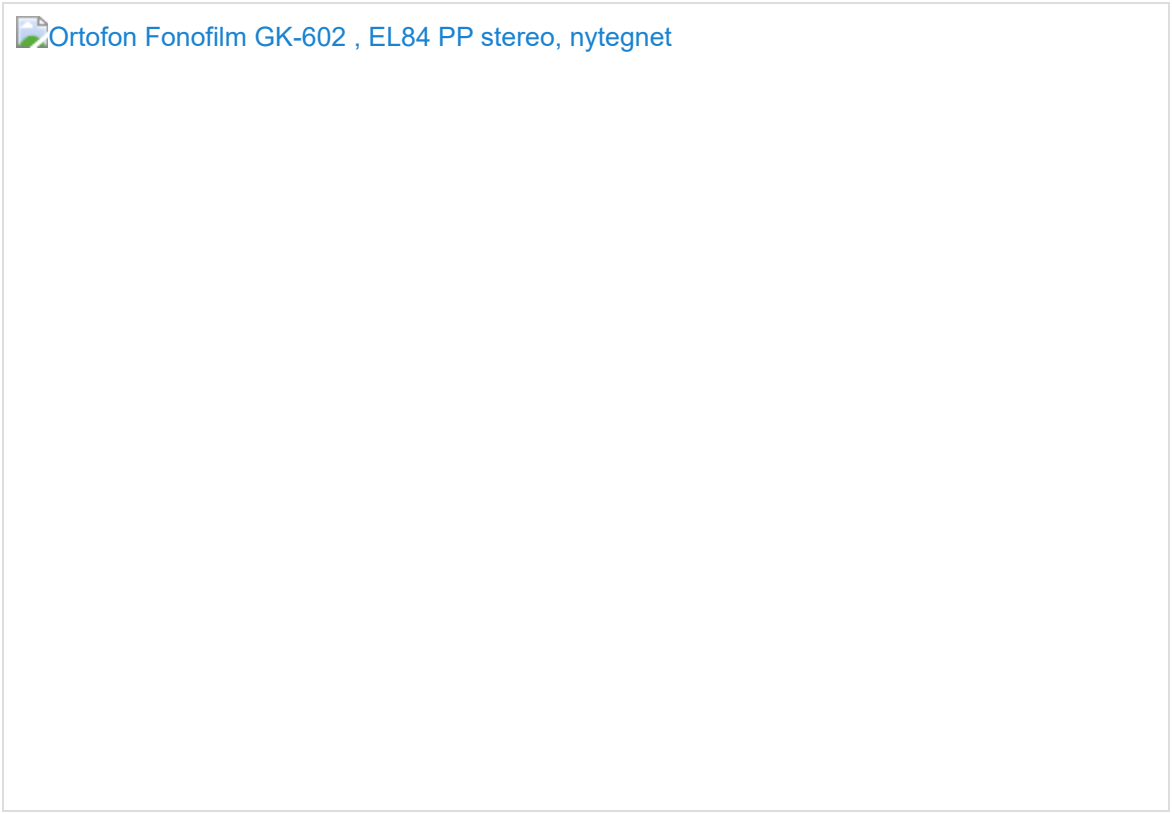


Dynaco ST-70. (DynaKit) , 1959 , authors collection. (Photo by K. Lilienthal St.)

It looks good, I think. But the exposed high Voltage at the PCB is a threat to all living beings.

It is indeed worth to visit the site of Patrick Turner in Australia. Lots of high class info and stuff. He even sells transformers. Here is a link to the Dynaco modifications as suggested by Mr. P.
Turner: http://www.turneraudio.com.au/dynacost70mods.htm

Mr. Turner and I share the critical thoughts about this design and he and I came up with very similar ideas on how to improve this classic. This is probably why I think his homepage is well worth to recommend. I guess this is pretty much the same in the way we always seems to feel that a person that laughs at our jokes , is an individual with a well developed humoristic mind or that a person that listens to the same music as we do, is a person of good musical taste.



ORTOFON , FONOFILM , GK602 , EL84 PP , Stereo , 1960

Stereo monitor amplifier made for sound studio, broadcast and similar pro-use. The GK602 is an abbreviated Williamson. The basic engineering is good, simplistic and efficient.

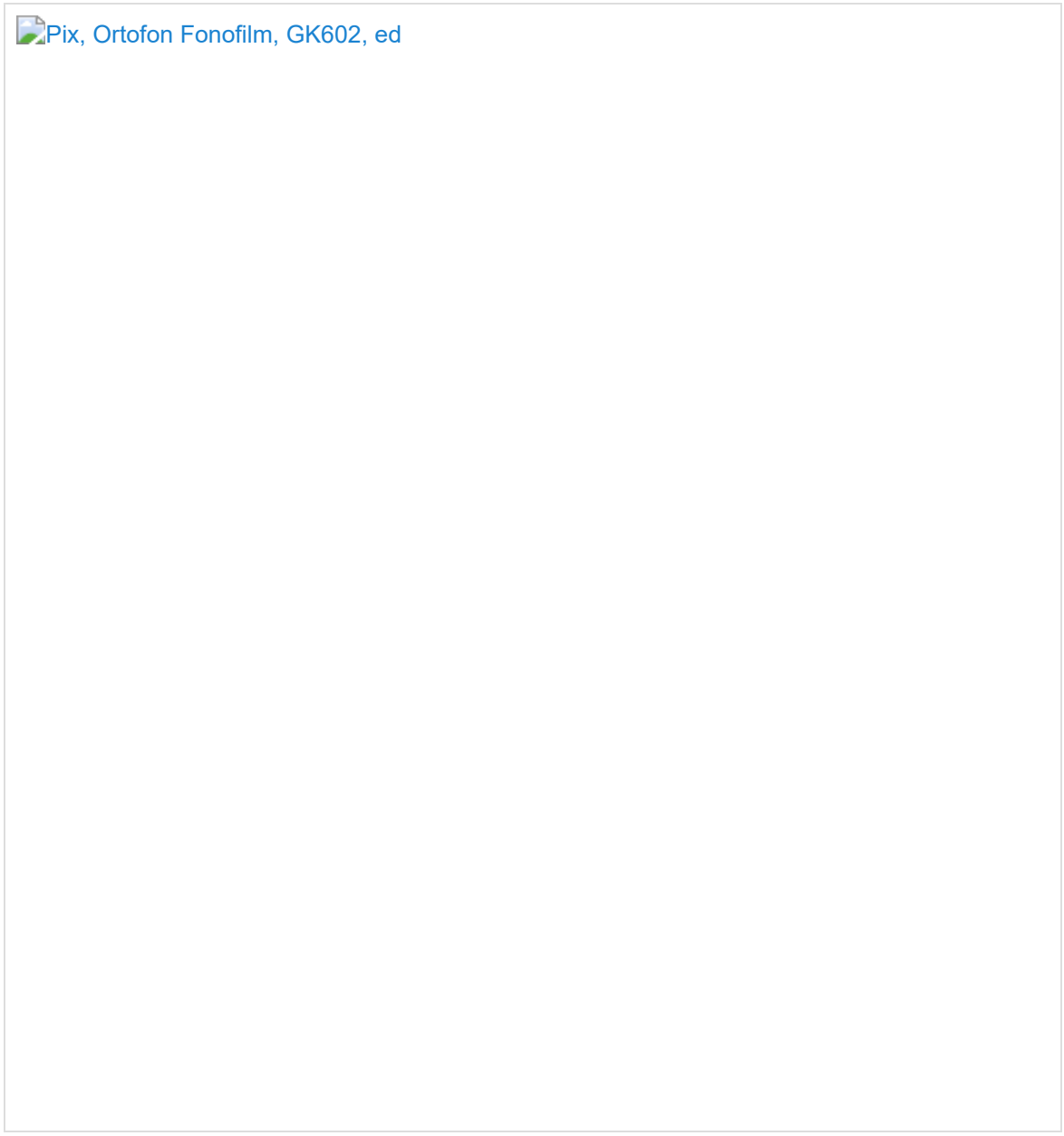
The input transformer is a good idea – in particular for pro-use, due to the galvanic isolation that prevents hum loops.The input level arrangement, however, is rather foolish. The high impedance of the various resistors, including the 200k potentiometer are sources for noise pick up, resistor noise and not least acts as an unwanted HF cancelling filter. The remedy is simple, remove the 200k

resistor and pot, do also remove the 500k and the 100n capacitor as well. Connect the center tap of the 50k control to the grid via the 27k grid stopper. This grid stopper isn't really necessary either. I would most likely prefer to refigure the input pentode, but that is difficult without having the amp in the flesh live, due to the DC coupling. But the 100n capacitors from the split load triode to the grids of the EL84 are on the high side. (Or low seen from a freq pov : app. 3Hz) Reduce these to 10 – 22n. It is hardly worth to reduce the grid resistors, as this will load the phase inverter harder and reduce HF response as well.

But you might consider to couple the sg2 of the EL84's to the apparent Ultra Linear taps. The little wonder pentode EL84 sounds terrific in pentode mode and not that much will actually be gained from the UL mode. Anyway it is often a good idea to use current limiting resistors of 270 to 470 Ohms for the sg2 at EL84.

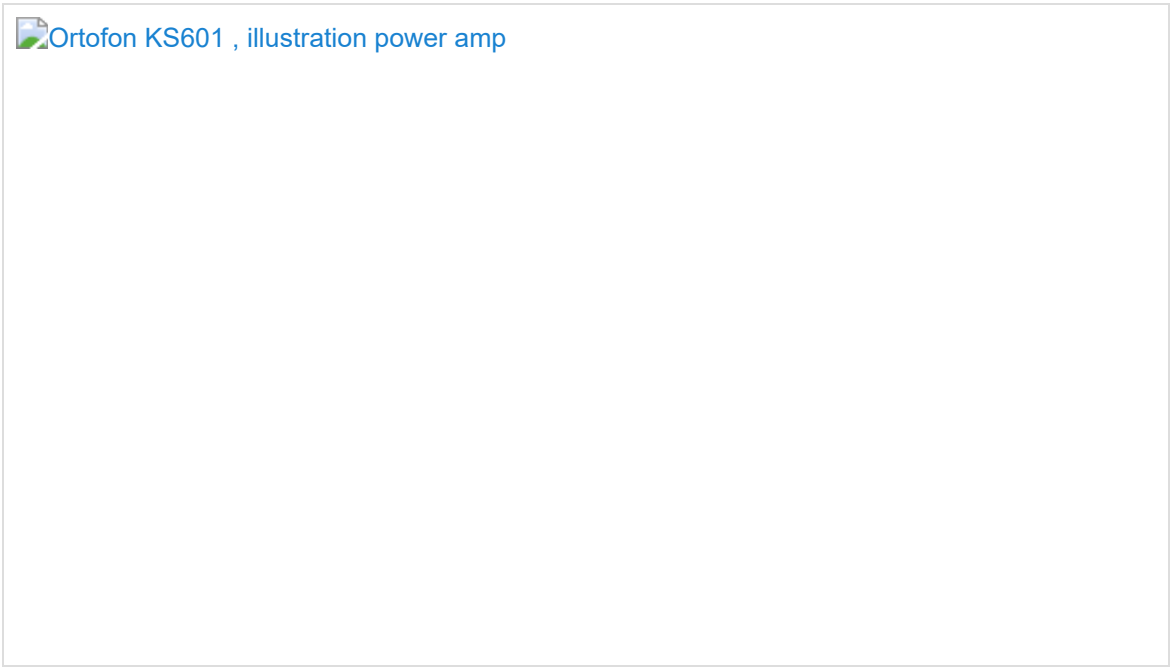
There is a nice little feature about this Ortofon amplifier. In test position, one side of the 6,3VAC heater winding is connected to the grids of the EL84's. This is a neat little help, when adjusting the balance. (AC and DC) Adjust for lowest possible signal (Will be the AC main freq, 50HZ in Europe and 60Hz in USA) It does not provide any help with regards to the DC balance. This may be quite a deal different from the AC balance, due to variation within the EL84's. A matched pair will improve the conditions here.

You may wish to disconnect the electrolytic that is common to the cathodes of the EL84's. It sometimes improve the sonics, but as it is very case sensitive, it is impossible to predict the result. Trial and error here – as so often, when we deals with the science of AUDIO.



Ortofon GK-602.

The output stage of the GK602 is similar to the output stage in the famous KS601. Let’s compare the two.



ORTOFON, KS601 , 6973 PP , 1960

While writing the vignette on the Ortofon GK602 above, I remembered that the KS601 was of a similar design. That puzzled me a little, as I like the GK602 circuit, apart from the mentioned, but I never liked the sound of the KS601. I didn't remember any details about the KS601 circuit, but *they had* to be different somehow. Let me tell you that it was "appallingly good fun" to dig up that KS601 schematic again.

Good things first: Ortofon decreased the signal capacitors C6 , C7 to 47n. They also decreased the grid resistors R10, R11 to 470k. But in order to keep up the bad work, they introduced 220k as grid stoppers ! (R12 and R13) Then – probably in order to gain a little of the lost high freq, they decided to decouple these by 18p , C8 and C9…..hmm…..

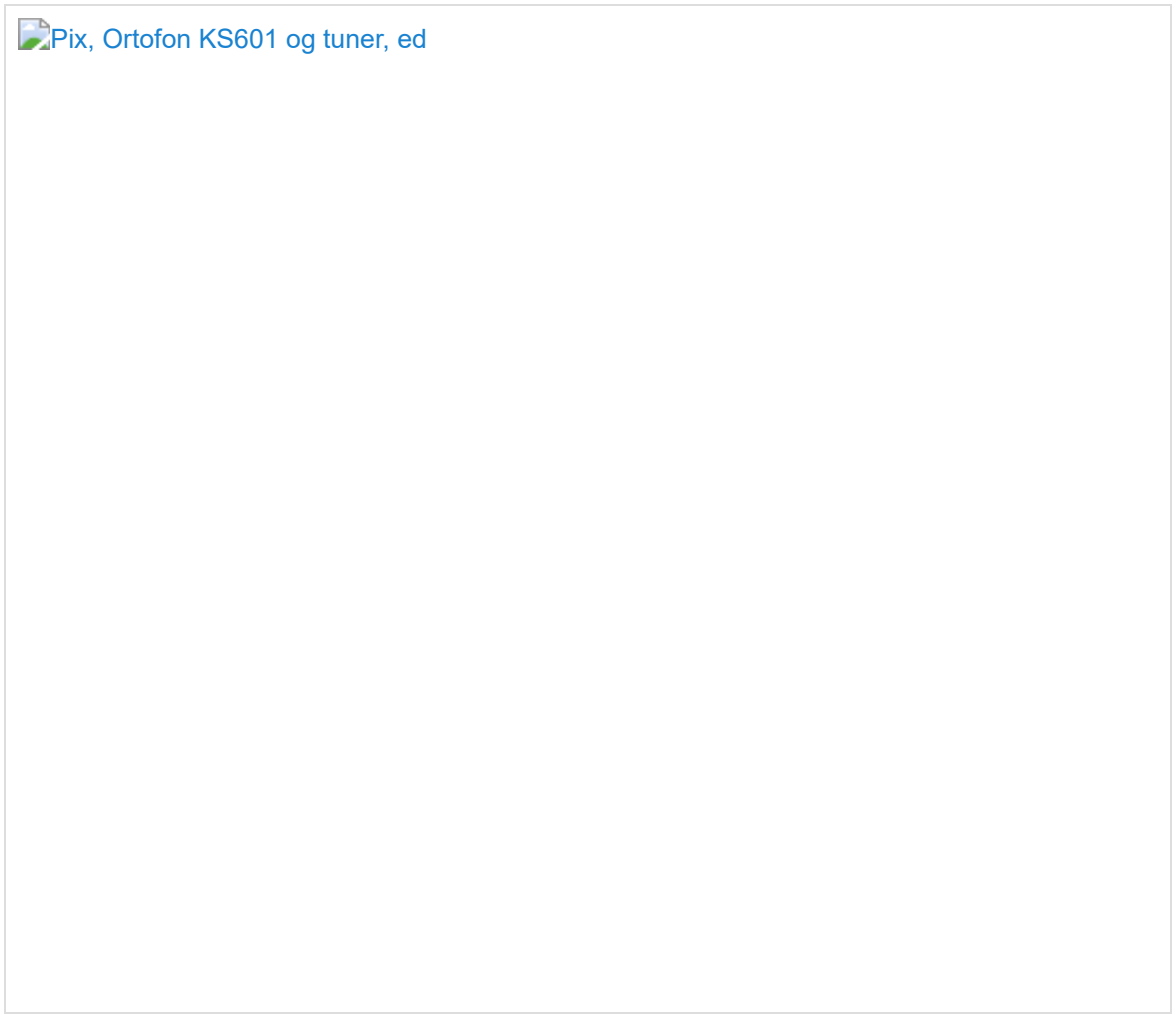
The copy I have got of the KS601 stereo integrated amplifier is rather poor and a little messy. First I noted the change to 6973 of which I have no opinion as it is one of the few I have never experimented with myself. Then I realised the differences mentioned above. But then I spotted the R7 resistor of 100k. Hmm…didn't like that much. It provides DC feedback and positive signal feedback……Then I spotted the C5 (10n) – amazingly…This is also positive feedback. And then my eye glanced at C4….! (10p) ..hmm..another feedback loop….Can you believe that..? On top of all that we have the regular fb , via R14//C10….. What a mess….

I suddenly understood why I did not like the KS601 sound. This is a perfect example about *what not to do*.. It is a crying shame…I really like the odd look of the KS601 and I love the Ortofon Pick Up's. There is not much more to say about this amplifier – the pre amplifier part is just as poor engineered. I am sorry to say so, Ortofon.

If you wish to improve the sound of your KS601, disconnect the following components: C4, C5 and R7. (You may have to adjust the plate and cathode resistors to values like the ones in GK602)

Do also remove the crazy high grid stoppers and accompanying capacitors. (R12 , R13, C8, C9)
This will drastically improve the sonic quality of this amplifier.

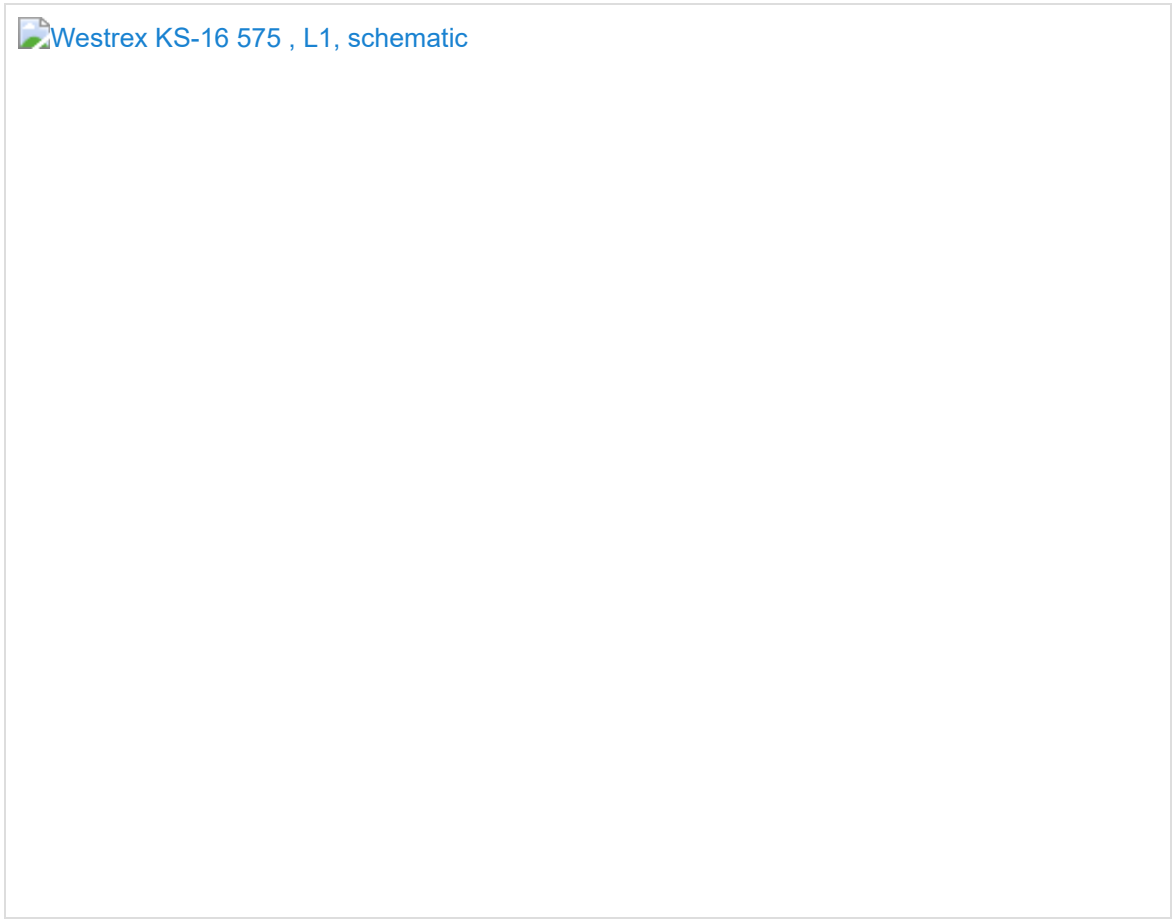
I do understand why it is tempting to make use of positive feedback, It looks stunning at the oscilloscope, using sine waves as signal. The amplitude simply jumps up and as long as we avoid direct oscillation, the sine pattern looks amazingly good. Keep in mind that the positive fb signal, follows the original with a similar pattern, only shifted a little forwards in phase. It does NOT destroy the pattern of the sine, but it does so with complex signals, in particular when more than one fb loop is involved. We are in this KS601 talking about four such loops within loops.



ORTOFON KS601 (at top) and the accompanying tuner.

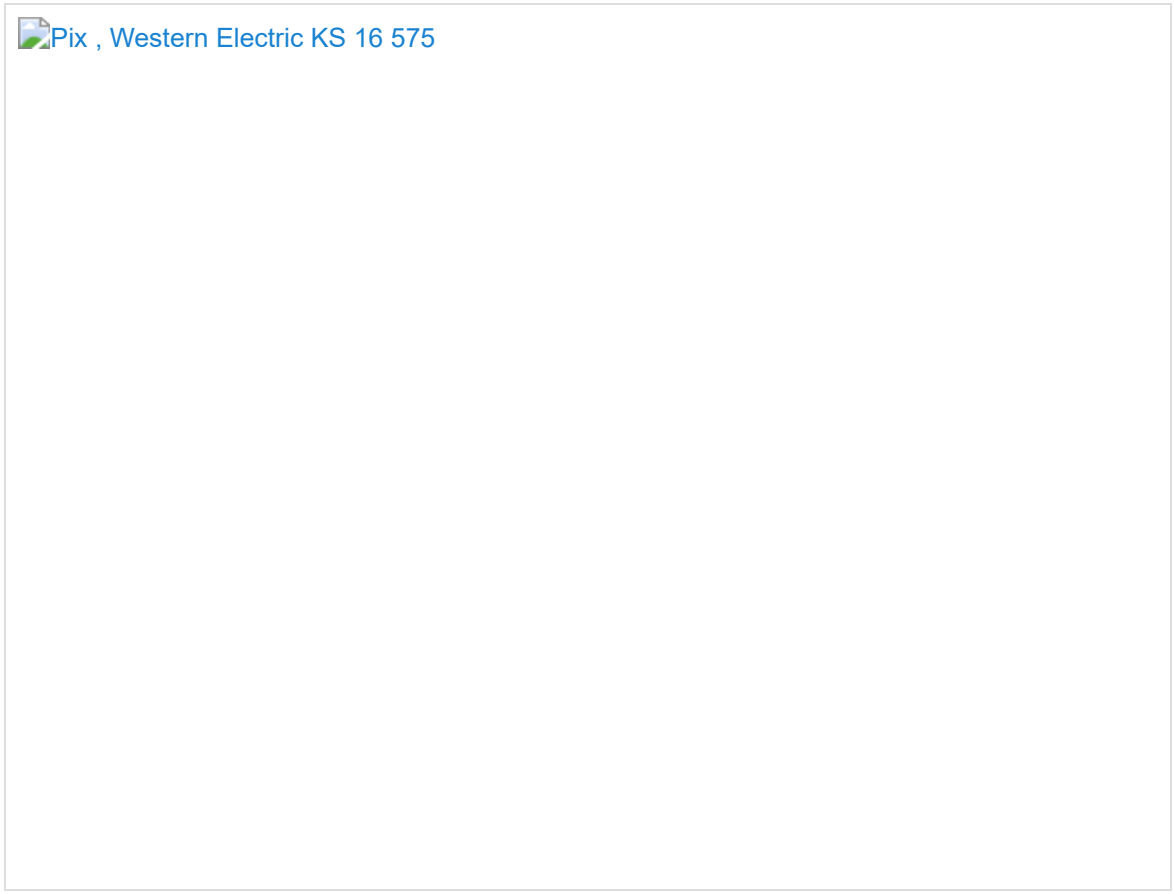
Don't you just love that look….. :-)

From the 1950's to up in the 1960's , Western electric had many amplifiers build on contract. McIntosh made at least three different models – all based upon the famous Mcintosh typology. Dukane made a very interesting high power 6550 PPP.



Western Electric (Westrex) , KS-16 575, 6L6 PP, 1958

Made by Mcintosh. Very similar to MC225.



Western Electric KS-16 575

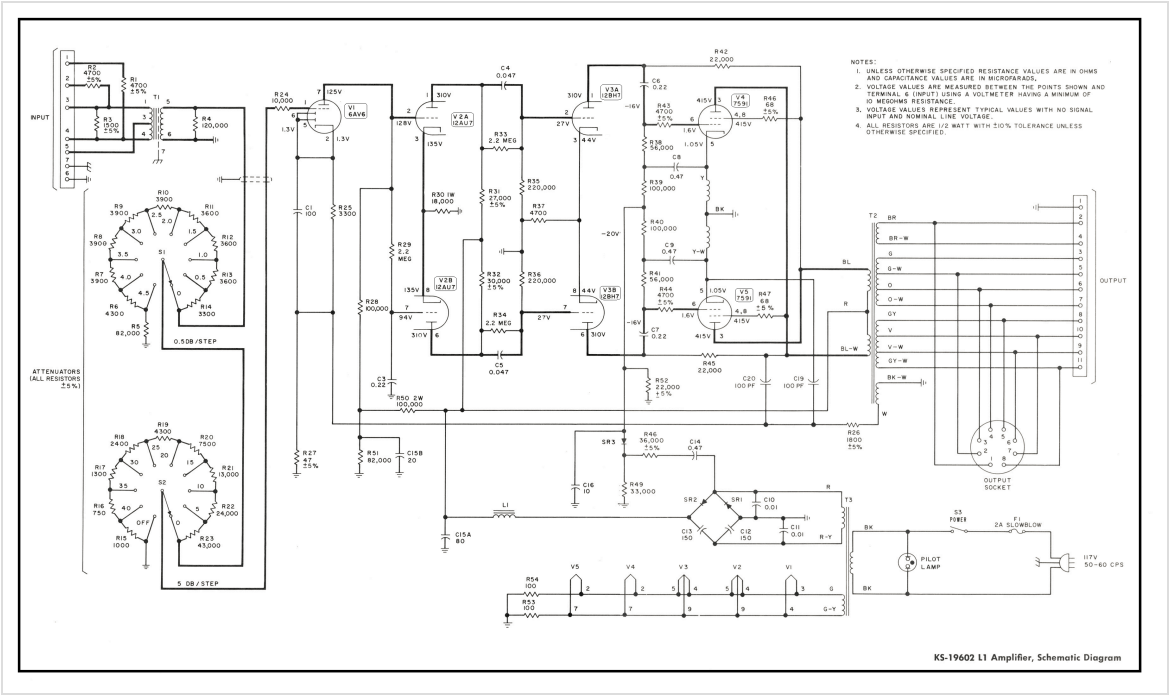


Western Electric , KS16 622, 6L6GC or 7027A PP , 1961 (Currently no Schematic)



Western Electric KS16610 , 6550 PPP, (Currently no schematic)

Made by Dukane.

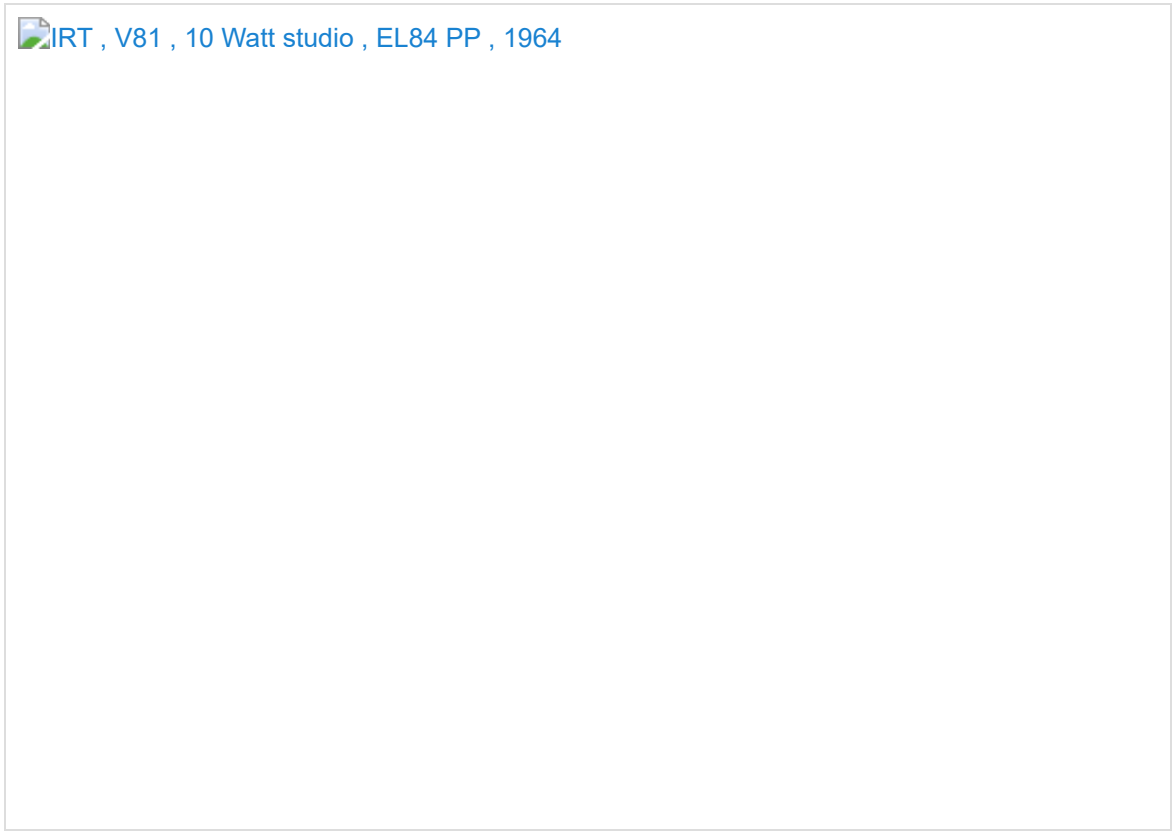


Western Electric (Westrex) , KS-19 602 , 7591A PP , 1963

Made by Mcintosh. Typical Mac design.



Western Electric, KS-19 602



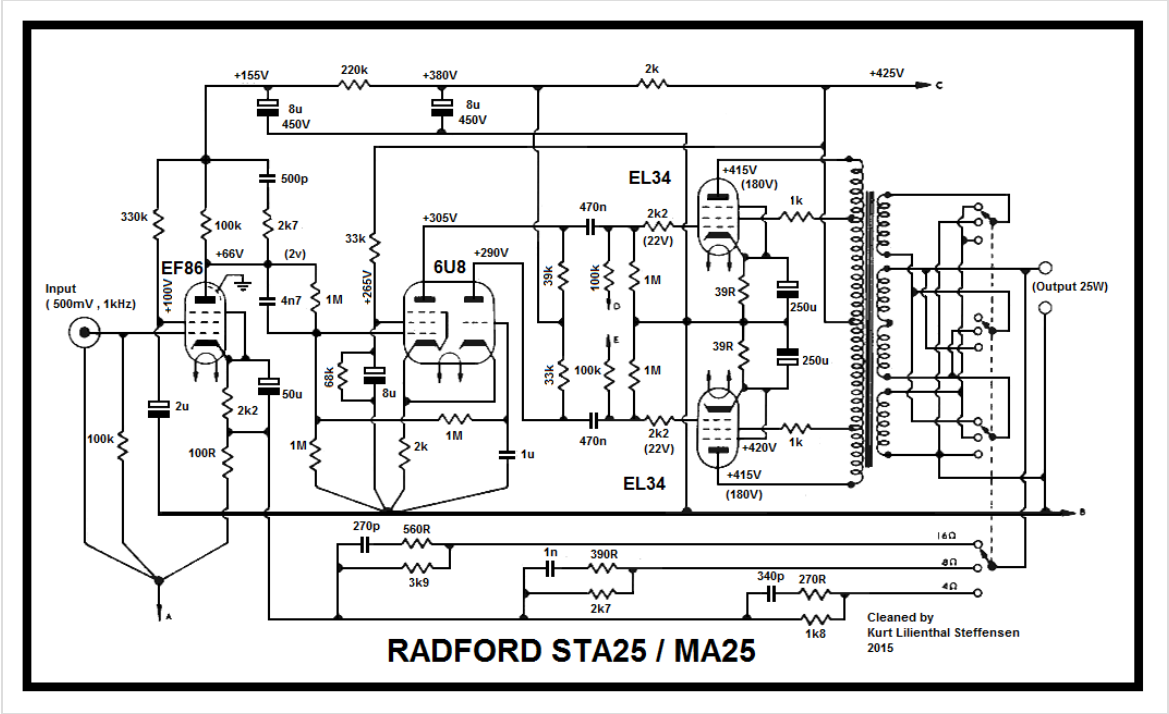
IRT , V81 , EL84PP , 1964

Very interesting amplifier designed for pro-use in broadcast and sound recording studio. I usually complain about using input transformers and not letting them do the phase inverting. I assume that the reason why it is so in this amp, is due to the simplification of the level control and tone correction. Anyway – the E88CC is a cathode loaded phase splitter. The DC voltage on the grids are fixed to 80V via the voltage divider of 120k and 51k. The plate resistors differs by some 10% in order to achieve balance. Further balance is provided by the 5654 driver that is supposed to be adjusted slightly out of symmetry for proper balance. Note that the driver is choke loaded. This reduce distortion and ensures highest possible voltage swing. I am not happy with the positive feedback from the plates of the E84L's , but gain was traditionally attractive in the old school.

There is something funny going on in the power supply here. What is that transistor doing at the ground plane ? My first thought was that it was a bias loop , but I failed to spot the outtake. Then I realised that it actually regulates the whole gadang. He he….cool. We are so used to find the series regulating element at the + side, that we hardly recognize the same thing when it is placed at the opposite side. It is not a highly regulated PSU , the series element also acts as the error amplifier and it is not capable to respond to the audio signals drawn by the amplifier. It is kind of a "slow" acting current limiting circuit´, but it will work properly as long as the amplifier works in class A. A modern Darlington transistor would possibly do better.

This is good old school and a good representative of continental broadcast/studio audio engineering of the 1950's and 1960's. Similar circuits were used in Denmark and sweden back

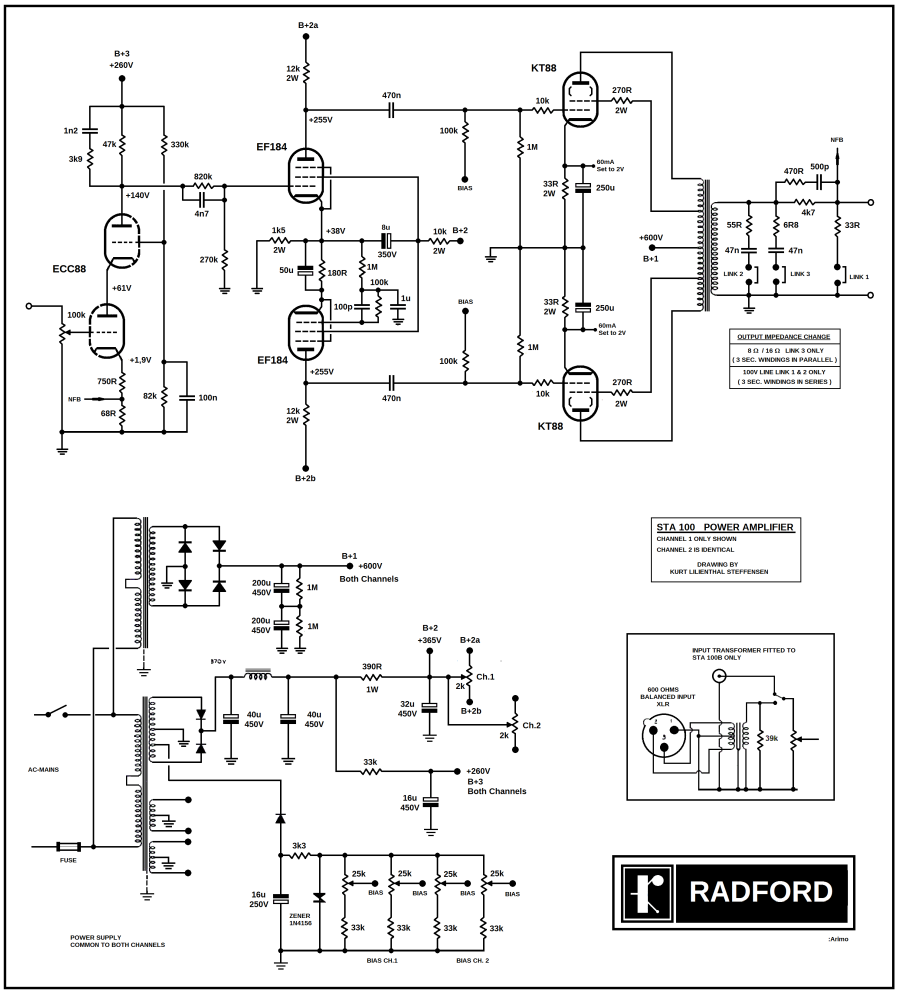
then.



Radford STA25 , EL34 PP, Stereo , ca 1966

The Radford series are wonderful candidates for serious “modding”. All of them are potential high class amplifiers, due to the good iron used. The Mullard circuit is the limiting factor here. I would have liked to walk you through a serious modification of one of these cool Radfords, but I do no longer own a Radford and I cant remember in great detail what I use to do with them “back in the good ol’ days”. If I chance to fetch a Radford at a reasonable price, I will follow up on this vignette with an in depth modification article.

The Radford’s are wonderful amplifiers – as said the weak point being the Mullard circuit. Having said that, the Radford’s and the Marantz are by far the best Mullard circuits known to me. It is in particular interesting to study the STA-100, as it is a very clever and elegant variation over the Mullard theme. Radford made their best known amplifier, series III, in the mid 1960’s, as well as a few speakers and a low distortion audio oscillator.It was possible to purchase an according pre-amplifier, known as SC-22, that could be connected directly to the power supply of the power amplifiers. I have owned this as well as several of the Radford power amplifiers. The SC-22 pre-amplifier newer spoke to me. It is noisy and rather harsh. The power amplifiers, MA-15 , MA-25 and the STEREO versions STA-15 and STA 25 are all the same design except for the power supplies. I enjoyed the good merits of these , exceptional midrange, but I found the bass somewhat weak and the top was to hard/white for my taste. It was possible to improve these designs and I had a lot of fun doing so. I did it so often, however, that I have forgotten exactly what I use to do. Let’s have a look at the best of the Radfords – the STA-100. (I have never heard a STA-60)



RADFORD STA-100, KT88 PP , ca 1967

I like this design a lot. Radford really nailed the potential merits of the Mullard circuit here and steared well aside from the weaknesses of the same. The input is a cascode ECC88. This is actually a radio frequency amplifier and it will handle audio frequencies with ease.The cascode is DC coupled to the phase inverter, via the voltage divider of 820k and 270k ohms. This means that the voltage at the grid of the EF184 is: 140V/820k+270k=1090k=0,13mAx270k= 34,7V. The bias of the EF184 is then 38V – 34,7V = 3,3V. Not particularly high for a second stage. The 4n7 capacitor decouples the 820k resistor, hence maintains the gain, although at the cost of the phase shift from this capacitor. You may ask then, what is the purpose of the DC coupling ? Frankly – I dont know. The advantage of avoiding a capacitor would be a little higher feedback, but this is lost due to this little capacitor. It may be a good idea to remove this cap. It will reduce the gain, which is always a silly thing to do at the input, but in this case it will improve the headroom of the following stage and it make it possible to add a little more feedback. The upper triode of the ECC88 cascode is reduced with regards to high frequencies by means of the filter of 1n2 + 3k9, across the plate resistor. As I have no data of the output transformer it is impossible to say if this may be avoided, with the modification suggested. Trial and error is the solution here.

The phase inverter is made of two fast TV-horizontal small power pentodes EF184, capable of a very high voltage swing. This will drive the KT88's to kingdom come – if needed. I have once adjusted a STA-100 into class AB2 (or maybe it was class B – memory does not always serve me well no more) and I seem to remember that it was possible to draw a peak of several hundreds of Watts from this machine.

The output stage is conventional, although the KT88's are driven hard. (The Original Gold Lion's could take it) It should be noted, though, that a small degree of auto bias is provided by the cathode resistors, that is also used to monitor and adjust the bias current. One thing, however, is quite unusual. The output transformer is equipped with three secondary windings of equal size. In case of a 100V line load. (some 70 to 120 Ohms) , the OPT should be strapped with these three windings in series. Otherwise these are to be strapped in parallel, handling any load from about 4 Ohms to 20 Ohms. Now, this is unusual and quite a unique feature of the STA-100. (We normally have several taps in order to match to the load , say 4 , 8 and 16 Ohms) Radford gets away with this, because of a high amount of feedback, which is possible due to the cascode input and the controlled phase shift during the entire amplifier. Excellent engineering. Let's have a closer look at how the STA100 , behaves into different loads.

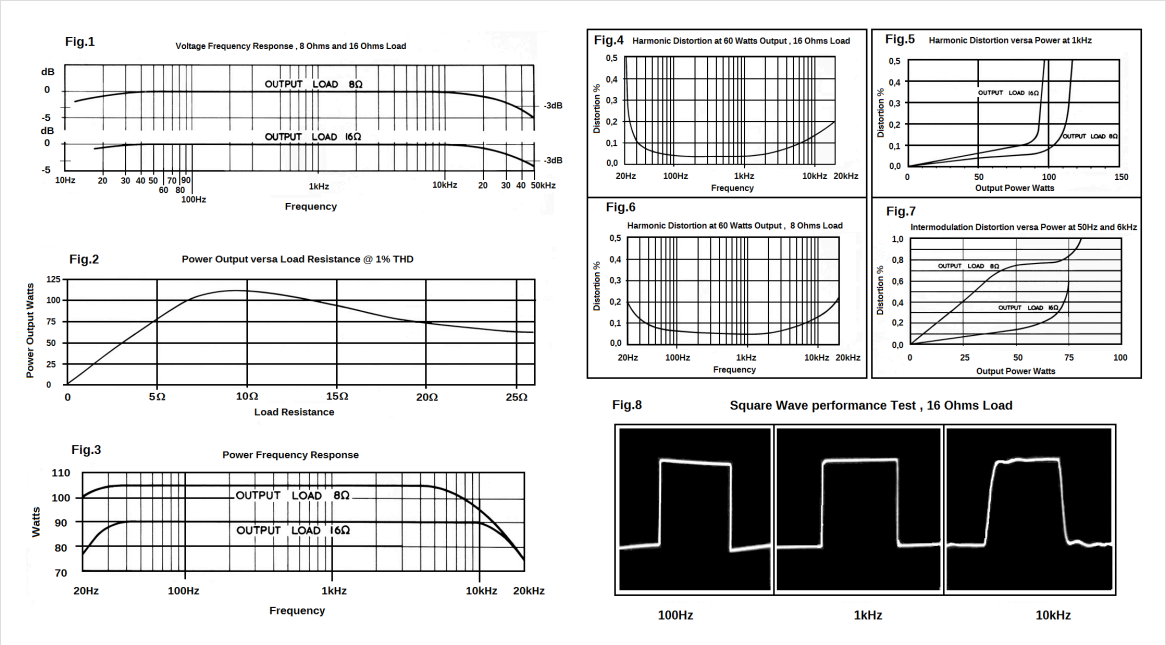


Fig.1 shows clearly what happens when we apply a higher or lower load to the *same* output of a valve amplifier. We move the center frequency. This means that a higher load moves the entire freq range upwards and vice versa. The radford handles this beautifully, the differences are marginal. The 16Ω load has a -3dB fall at 40kHz and the 8Ω load is close, only a few kHz below. In the low end we can see the small difference, but neither of these are audible.

Fig.2 shows the power into various loads , all held at 1% THD in order to compare bananas with *bananas.* We can tell that the optimum *power transfer* load is at about 8 to 12 Ω. But the amplifier handles loads from 4Ω and way up above 25Ω , without delivering less that 60 Watts. Note that it still provides some 25 Watts into 2 Ω. Quite impressive.

Fig.3 confirms the observations in Fig.1. STA100 delivers more than 100 Watts from 20Hz to about 8kHz into a load of 8Ω. A little less into 16Ω , the freq range is moved a little upwards.

Fig.4 and Fig.6 , shows the harmonic distortion from 20Hz to 20kHz at 60 Watts. Here we can tell that the subsonic distortion increase abrupt below some 25Hz into a load of 16Ω. The same would be seen at 8Ω below some 12-16 Hz, had we tested that low.

Fig.5, the distortion at 1kHz is considerably higher at 16Ω and it sky rockets above some 90 Watts (clipping) . The distortion into 8Ω allows some 110 Watts, before clipping.

Fig.7 , surprisingly the intermodulation distortion is considerable higher at 8Ω. I am not sure why it is so.

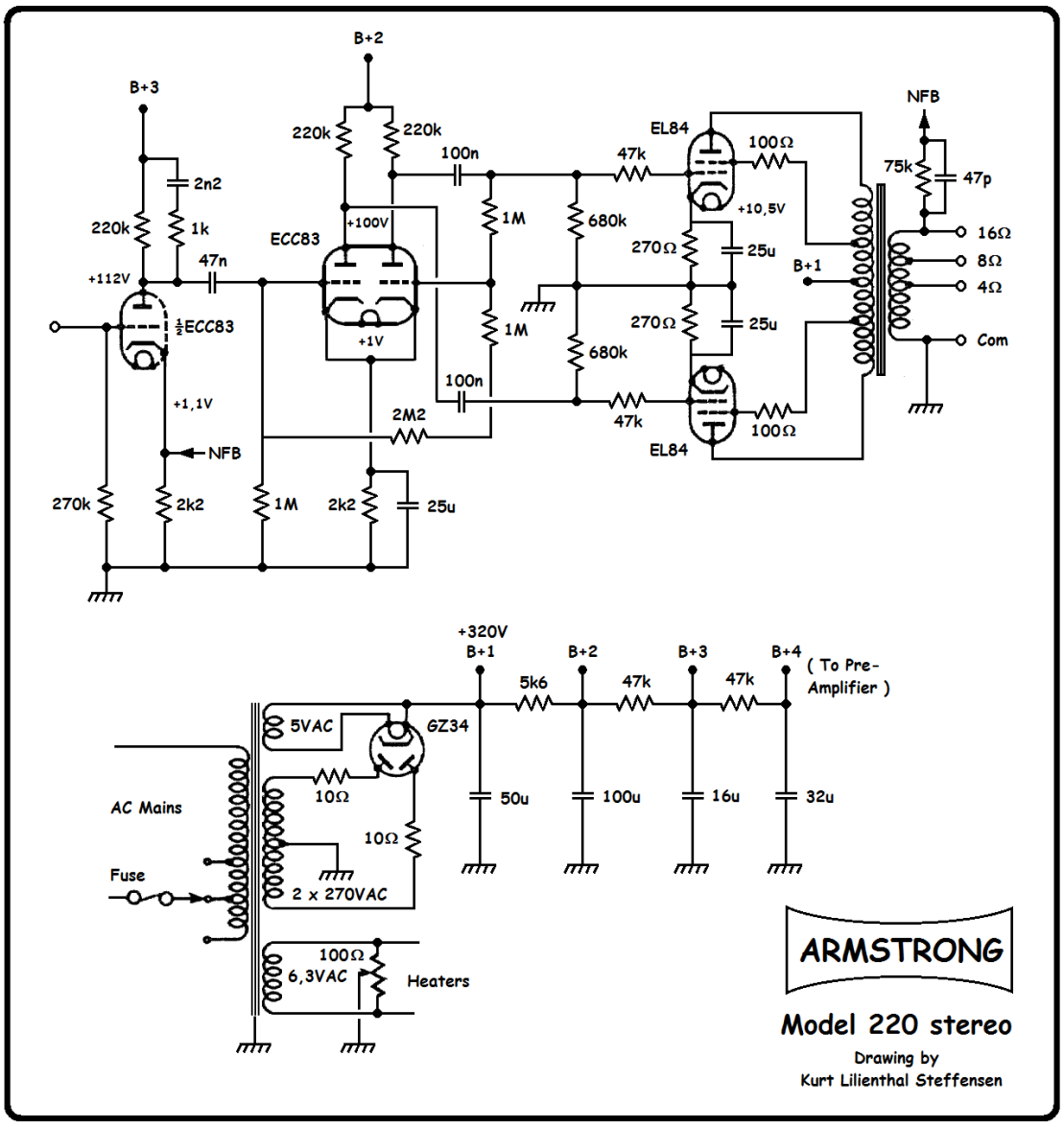
Fig.8 , gives a good idea about the phase shift and pulse response. This is excellent perfomance.

Summa summarum.

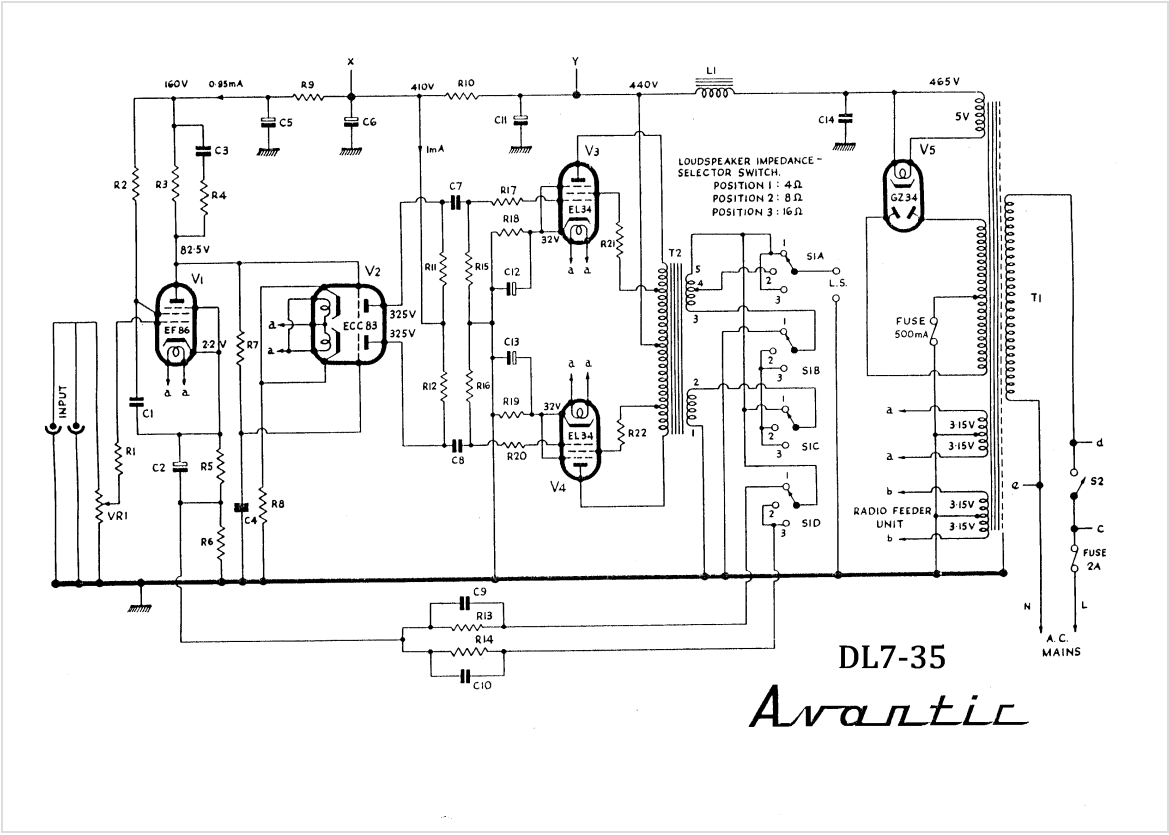
STA-100 sounds very good indeed and it measures equally well. Hats off to RADFORD…..

Finally a word of warning.

The power stage of the STA-100 is only possible with the original old Gold Lion/MO/G.E.C. KT88's. Despite that the application notes of these, stated a max. grid resistance of 250k Ohm, it was possible to load these with 1M. I will not recommend this practice with modern KT88's. not even with NOS , US made 6550's. This is in particular important, when the valves are driven with a plate voltage as high as 600 volts and 60mA of idle current. (= 36 Watt's plate dissipation) In case of installation with new production KT88's, change the grid resistor to 250k Ohms or less. (A little sad seen from the EF184's) Do also insert at least 470 Ohms/3-5 Watts resistors at sg2. Possible 1k Ohms in order to avoid any nasty HF oscillations.

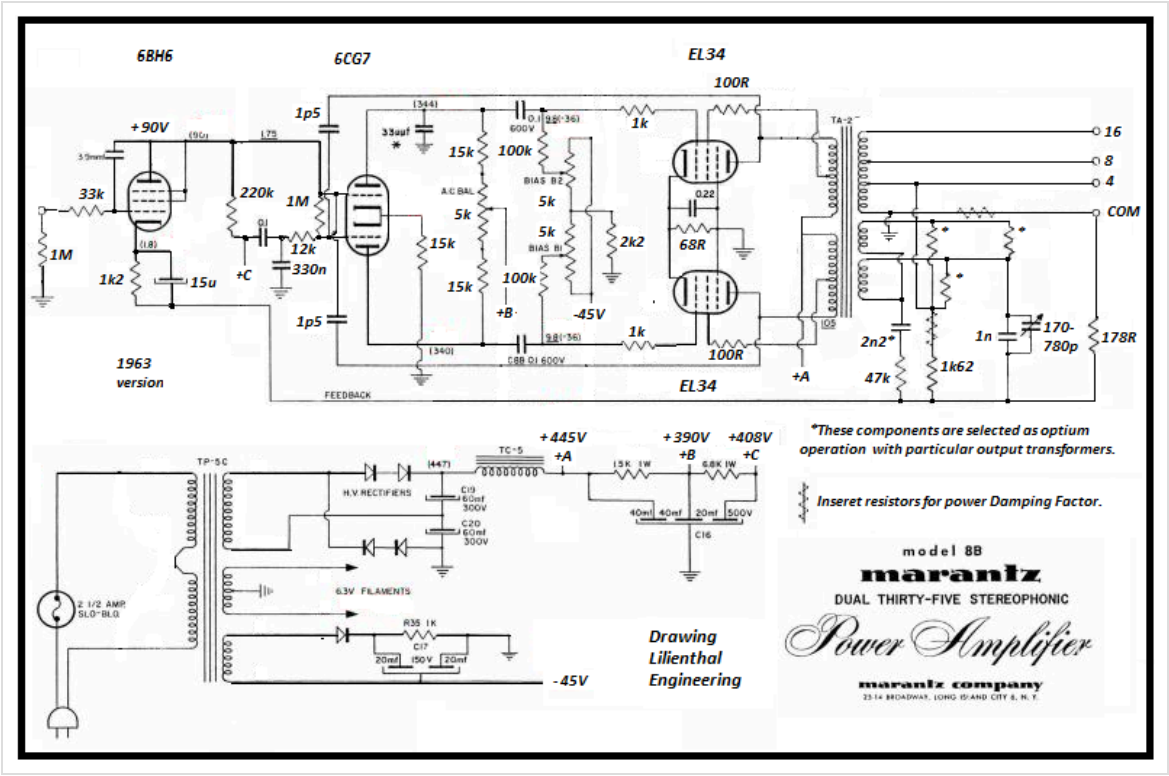


Armstrong Model 220 (and A20) , EL84 PP



AVANTIC , DL 7-35, EL84 PP, (By Beam Echo)

The Armstrong and Avantic above are further examples of the “Mullard wave” that swept England in the 1960’s. There is not a single original thought to be found in these amplifiers, they are indeed straight copies from the Mullard catalog.



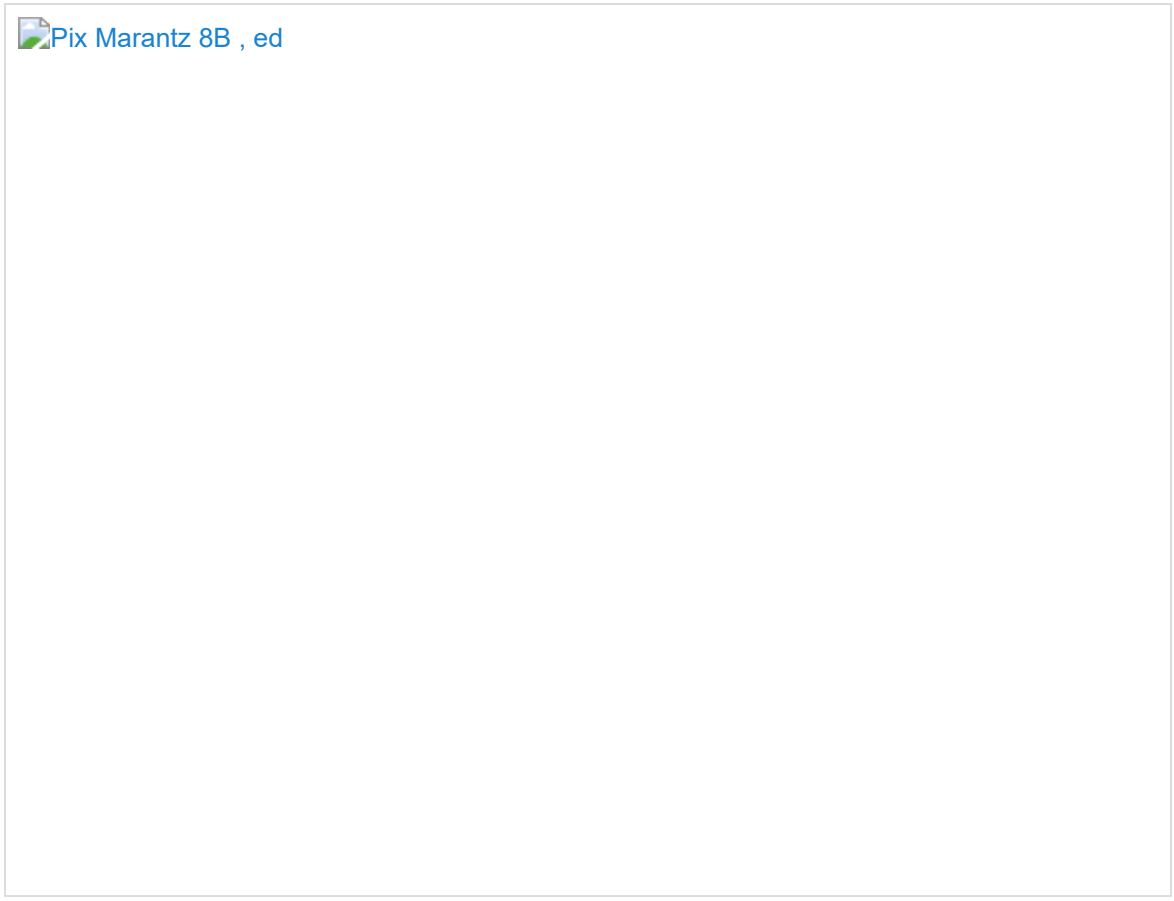
Marantz 8B, 6CA7/EL34 PP, 1961-62

Two versions was made of the famous 8B, one with a paralleled 12AX7 input and another with a 6BH6 pentode.

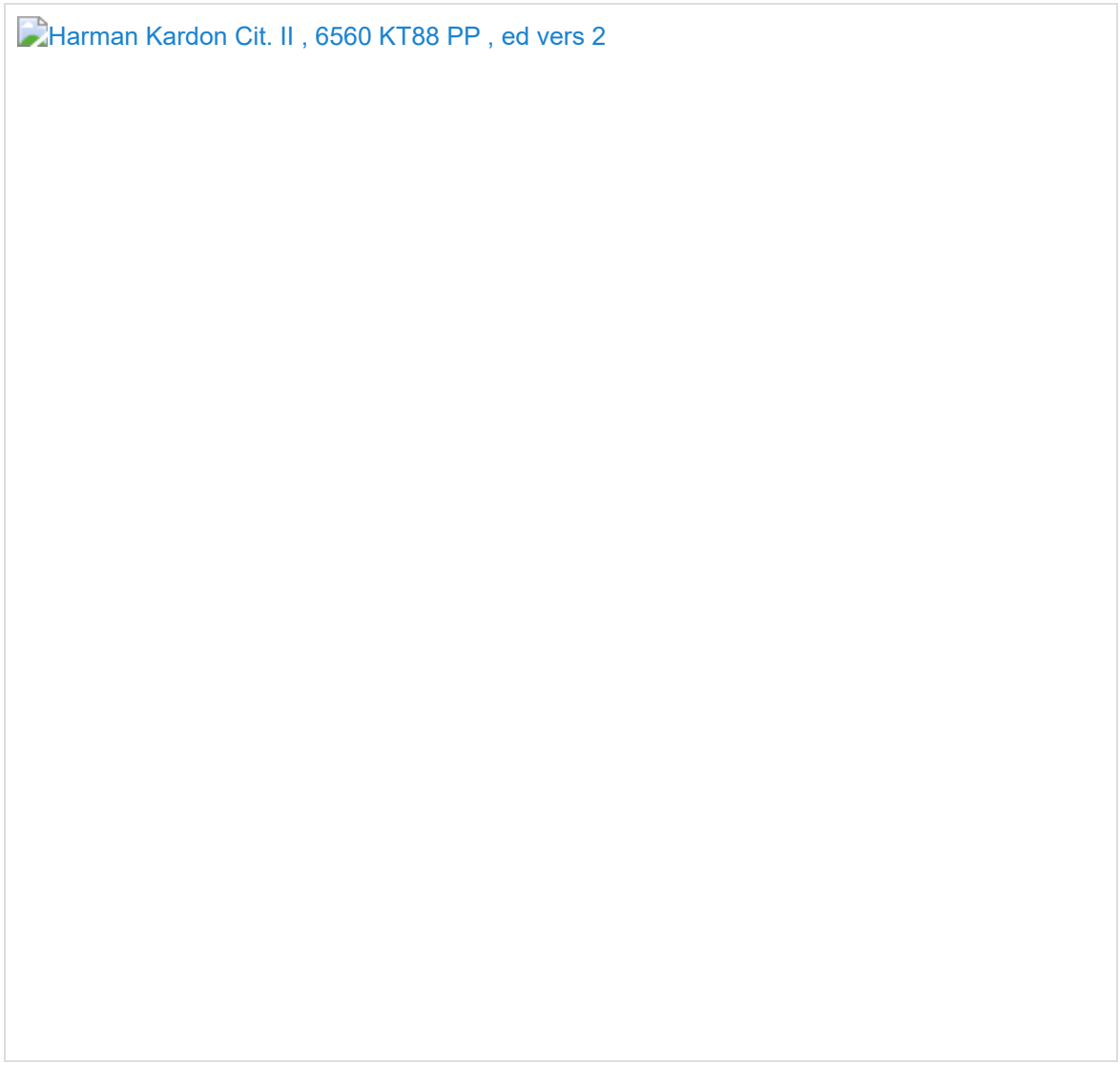
Some prefers it converted in to Williamson design. (Easy to do) It is similar to the Mullard “20 Watt Quality amplifier” aka 520 that was published a year or two previous to the Marantz 8B. The Marantz was however a better design, not least due to the 6CG7 driver. (Mullard used an ECC83) . A few years later Dynaco came up with an “improved Mullard 30 Watt” , using the better driver circuit from Marantz.

The models 2,5 and 8 are almost identical circuits.

Cool looking classic……Good sounding classic.



Marantz 8B

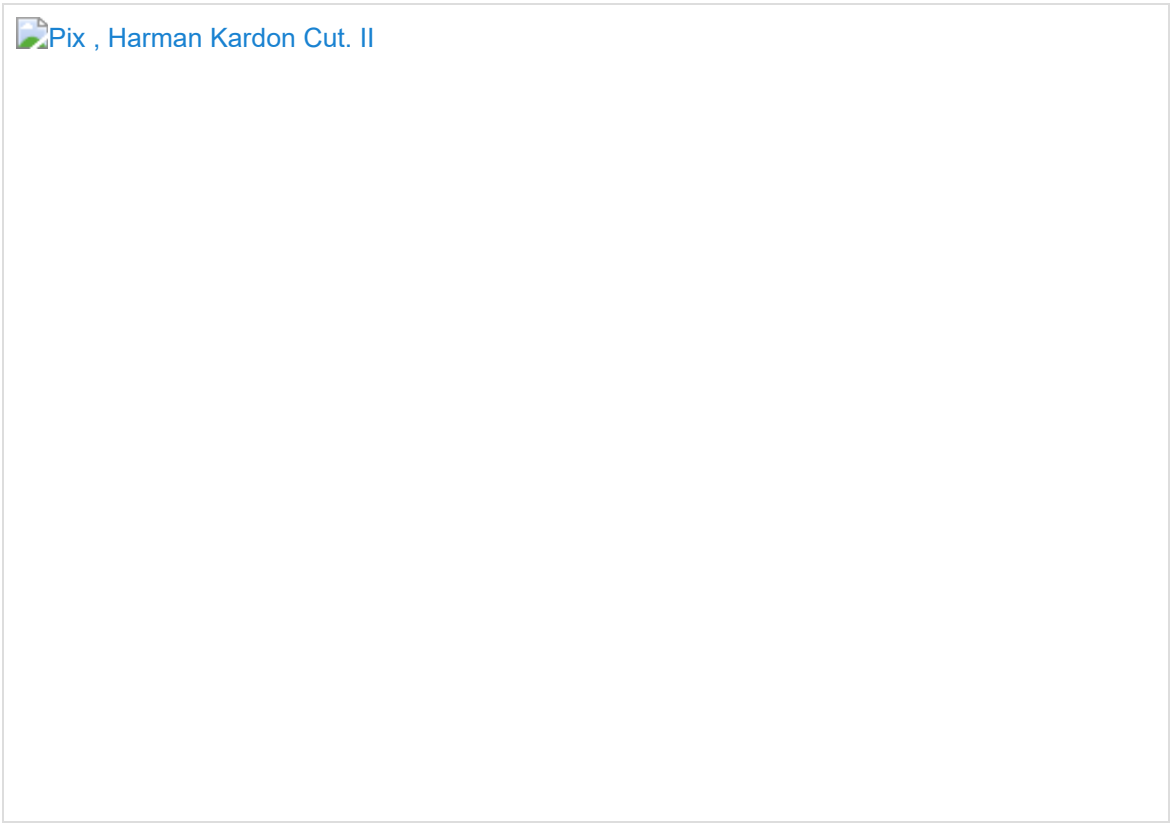


Suggested by JC Morrison and myself:
Harman Kardon Citation II, 6550 PP, Stereo , 1959

Heavy and..hmm…heavy…..At the schematic above I have removed the meter and its associated network and I only show one channel. The three 12BY7's are actually small power pentodes, but it is a good idea to use them as Voltage amplifiers as the sensitivity they offer is high. Granted they would sound better strapped as triodes – but that may be a matter of taste and preferences, I guess. There is a lot of mixed feedback in this Citation II. Mixed fb never sound good in my experience, but in this Cit.II the causes for the fb made this way is mainly due to the phase-splitter. I don't mind the Schmidt or long tail phase splitters.They can be pretty good. If balance in these is of main concern then there is principally two ways of dealing with that. Compensated by passive components or compensated by means of balanced feedback. We can tell from the circuit as well as the matched resistors, that the Harman Kardon engineers was indeed worried about the unbalance. HK uses both methods and further creates a fb loop within the global fb loop. Single point fb , however, is a compromise as the Schmidt/long tail phase splitter is a balanced/differential circuit. Single point fb feeds both phases at the same amplitude back to one phase input, thus introducing an unpleasant complex distortion. HK solved the puzzle by feeding the signals back from both of the primary sides of the output transformer to the opposite phase inputs at the phase-

splitter. Now, that would be perfectly alright, had they not decided to use global fb as well. Having a fb loop within a fb loop is good if we wants to make a sinewave generator, but it is not good for complex signals such as music. Add to that the sg2 feedback via the so called “ultra linear” coupling, the fb to sg2 at the input pentode as well as the local cathode fb here and we have a chaotic mess of 5 fb points in total. There is also a total of *seven filters* in that simple circuit, due to the complex fb scheme. A good way to deal with that phase splitter and fb is the way Klangfilm did in their V502 model. (To be found elsewhere on this site)

H K could also have grounded the 4 Ohms tap and returned the signals from the 0 and 16 Ohms taps and that way included the secondary in the fb.



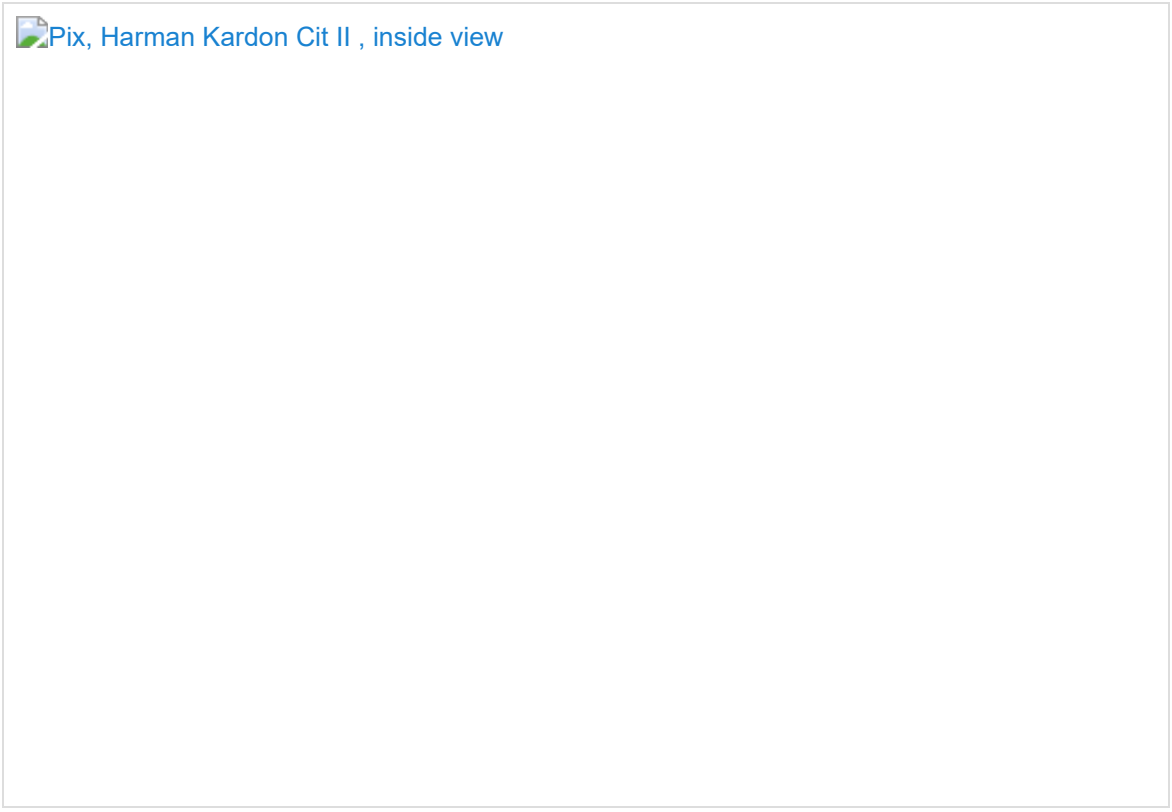
Citation II.

I modified one of these beasts some 25 years ago.
I can’t remember exactly what I did to it, but it was a struggle because I wanted an SRPP input stage and to keep the schmidt phase-splitter somehow.
Stupid of me….I should have converted it into a Williamson or triode input ferro phase splitter and possibly kept the driver.
Citation II was designed by Stewart Hegeman. Outstanding crazy good OPT made by Freed, New York.
If you have one of these and want to modify it, it is very well worth the effort due to the high quality of the Freed transformers. I would suggest one of these alternatives:

1) Triode couple all 12BY7’s and disconnect the global fb from the secondary side to the input 12BY7. It is a matter of taste and need for gain if you would choose to decouple the input cathode

resistor – but at least you should try it. Cut the number of fb loops and discard as many of the filter compensations as possible. A little experimentation is needed. It is always a good idea to make a start from open loop state. (All fb loops off)

2) Simply convert the whole mess to a Williamson design. There is no need to swop the 12BY7 drivers – simply triode strap these. Change the input to a twin triode a la Kiebert and you are there. Add as little fb as possible – noise and hum may be an issue here. Further reduction of ripple noise may be provided by a small choke (10-20mA , 5-20H) replacing the 4k7 PSU resistor.



Inside view of the Harman KArdon, Citation II

David Bogen came to America as a young Russian immigrant in the early 1900's. His first company manufactured souvenir copies of the statue of liberty. Bogen was rather dedicated to the new radio technology and formed a retail company dealing with the audio aspects of this new technique. Western Electric dominated the marked in this area at the time and refused to sell to Bogen and other so called third parties. In order to get by this limitation Bogen established a manufacturing company and began the production of audio amplifiers in 1932. Needless to say that he did well. The Bogen company was at a later stage acquired by Lear Siegler , hence the name.

More to come about the Bogen amplifiers



Bogen, MO30 6L6G PP and Bogen, MO60 7027A PP



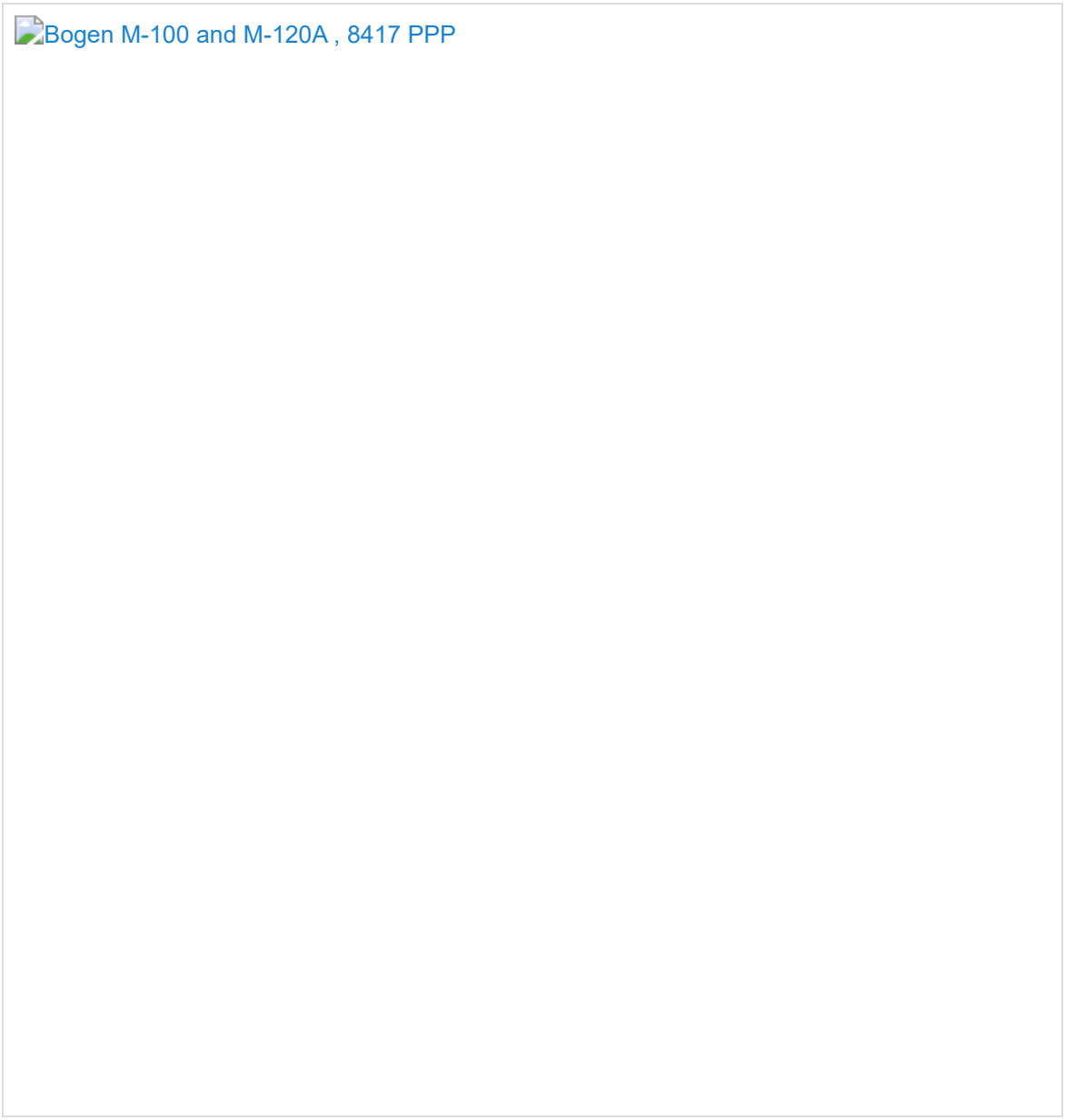
Bogen MO-100 , 6550 PP

David Bogen produced a series of PA-amplifiers from the late 1950's to the early 1960's.The 3 models above are all based upon the same basic circuit. The input stage 6C4/EC90 is a tough little 7 pin miniature medium-mu triode.(6C4W and 6100 for demanding environments with regards to shock and long life) This is an excellent choice as it insures a good head room, low distortion and high HF roll off (= low phase shift). Bogen does run the 6C4 very gentle indeed, both with regards to plate voltage and cathode current. It is likely to last longer this way, but he is not getting the best out of this little darling. Far from actually. More amazingly though is the choice of tube in the phase splitter driver stage. 12AX7/ECC83 really isn't the best driver. It is very difficult to understand why it has been so common to use this tube as a driver. It does allow more feedback due to higher gain, but nothing is won by this approach as the distortion, pulse and HF response is equally worse when the grids of the power tubes is driven by the high output impedance. Add to this the low headroom at the input , due to the low bias voltage on the 12AX7. Almost any other twin triode is much better suited for this task. A 12AT7 or 6CG7 would improve the sonic quality quite a lot and less feedback would be needed. Certainly the damping factor is theoretically higher due to the higher amount of feedback, when using 12AX7, but in practice this has no significance. Partly due to the copper resistance of the voice coil, but also because of the copper resistance of the output winding of the output transformer. It is very easy to modify these amplifiers with a better driver, so lets not dwell at this common weakness. We see the same poor design on contemporary amplifiers from time to time.

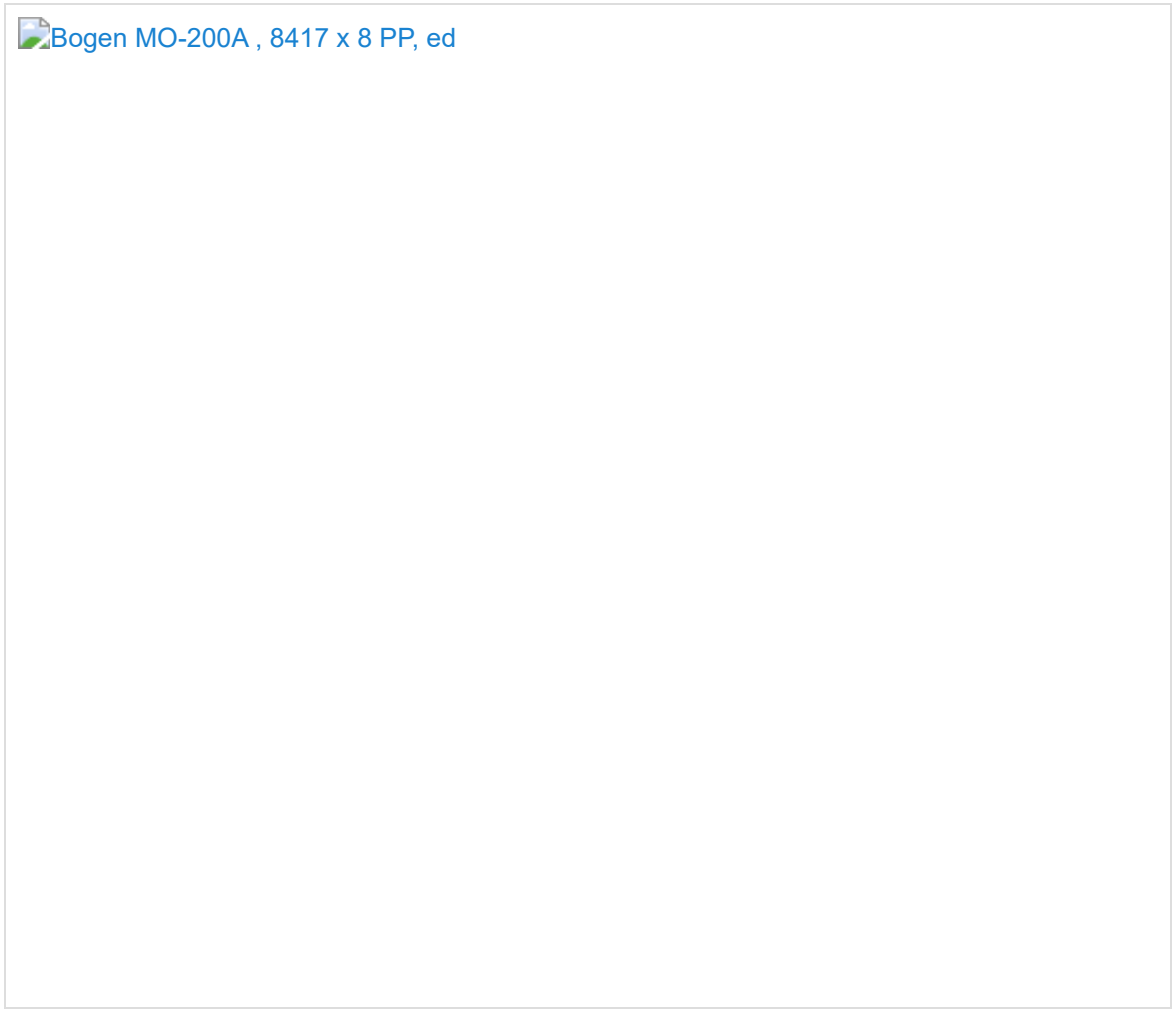
Apart from this, I think the Bogen series is good and decent amplifiers. Note that the bias network is low impedance as supposed. Only drawback here is that it is made in such way that it is possible

to adjust the bias into the region of destruction. A simple extra resistor towards ground will prevent this. It may be a better idea to split the 10k bias pot in to a 5k pot and a 5k6 resisor to ground.

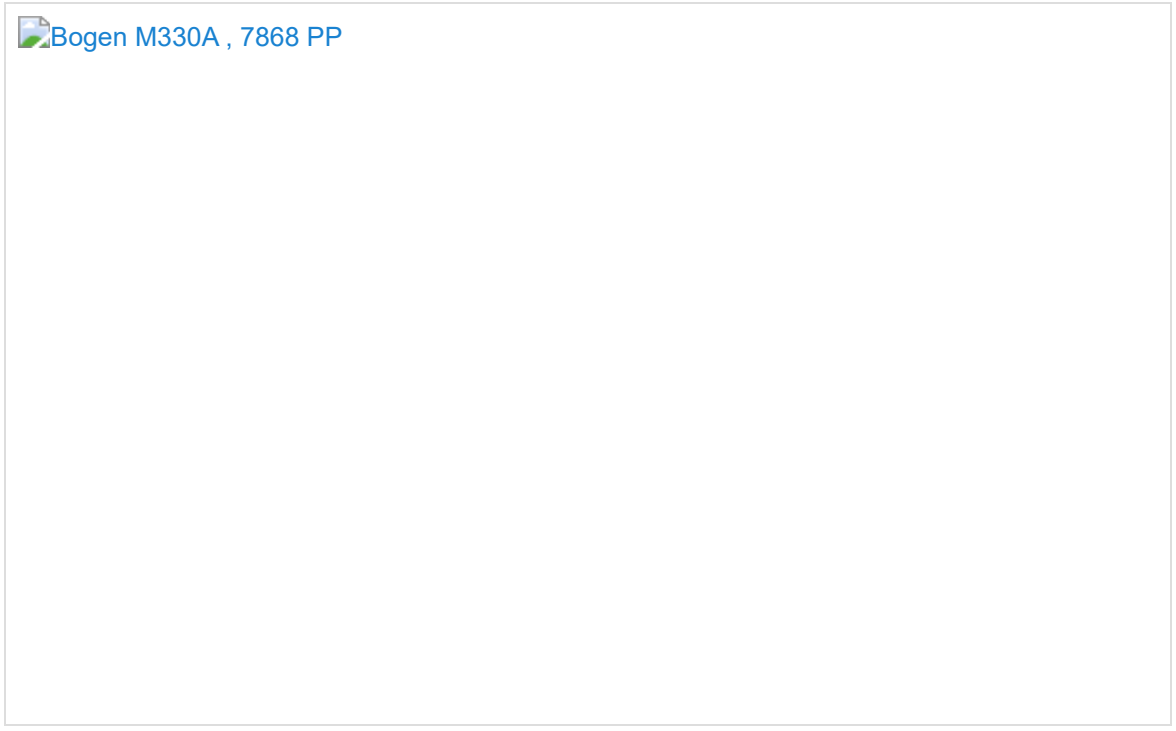
The 10R cathode resistors is a good practice. I would leave it in circuit at all times.
If we use a small 1/4 Watt it will act as a “fuse” too.



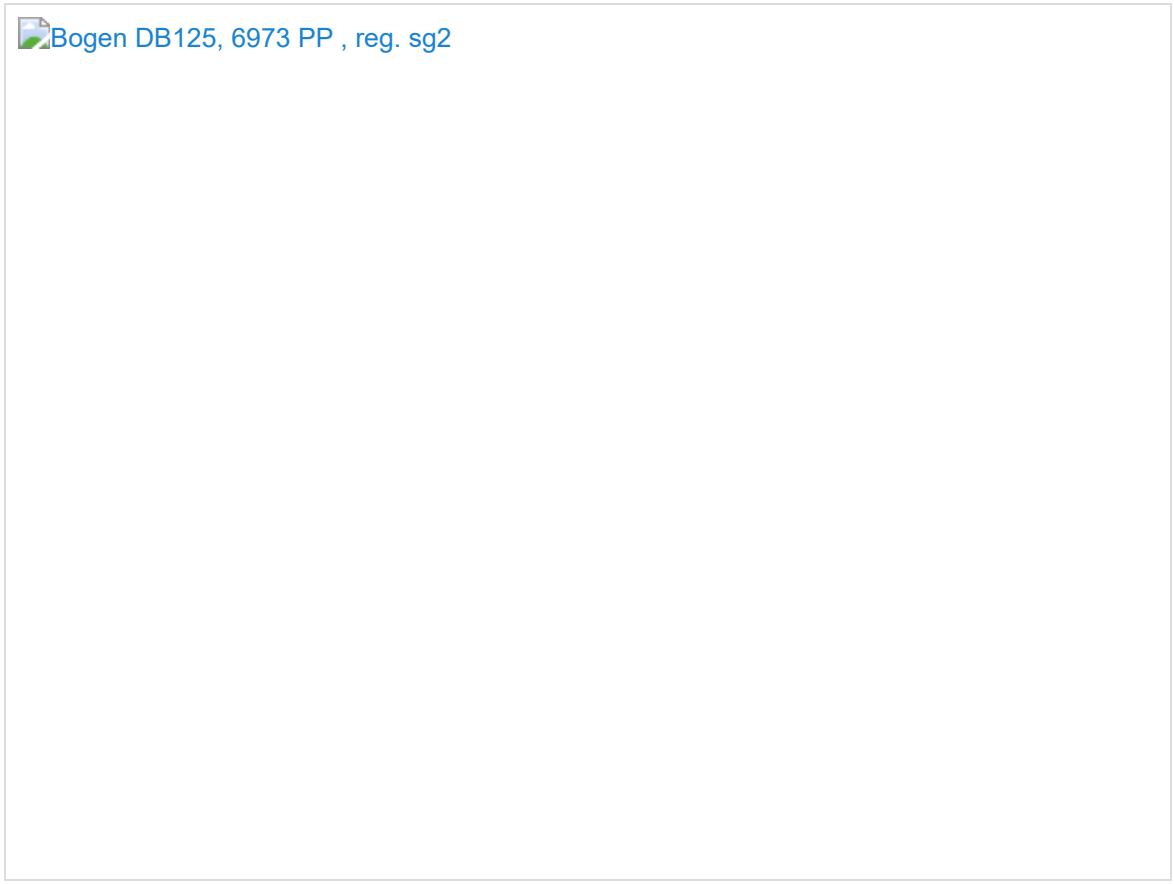
Bogen M100 & M120 , 8417 PPP , 1958-60



Bogen MO200A , 8417 PPP , 1962



Bogen M330A 7868 PP

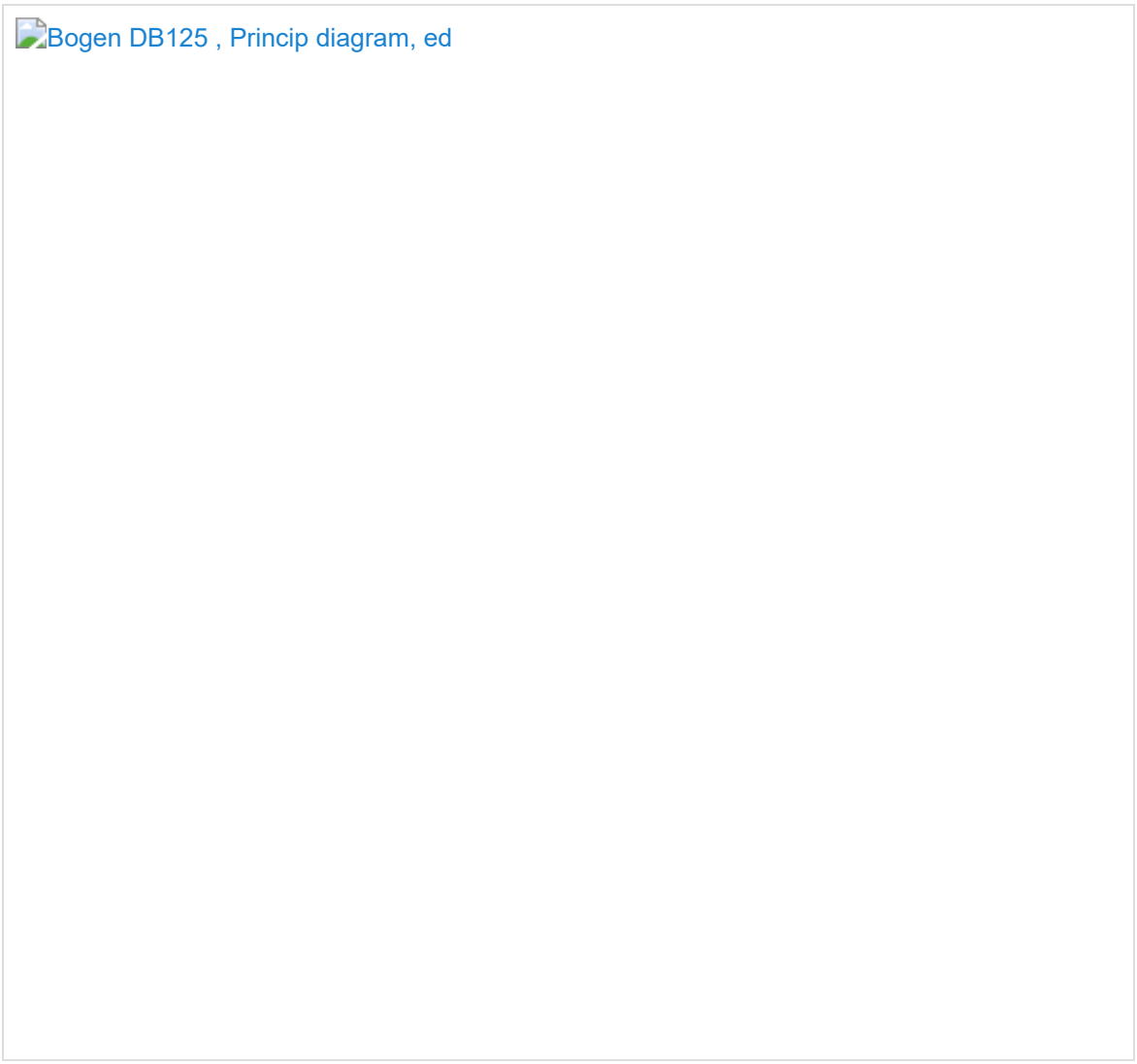


BOGEN DB125, 6973 PP.

This in an interesting amplifier in many aspects and I wanted to analyse it a little closer.
The preamplifier section is not worth to analyse in details and neither is this compendium about preamplifiers. In short I will only mention that the RIAA section is made with a feedback filter. This is a perfectly acceptable way to do it, but only if it is done with DC feedback. Otherwise we will experience a dramatic gain of subsonic signals that is certain to push the amp, and possible following sections way out of the established working points. This is exactly what happens here. A passive RIAA filter would do much better. The following voltage amplifier is a cathode follower. This is a good way to insure that the tone filters is well defined, due to the low output impedance. But for reasons I cant seem to comprehend the CF stage is followed by the volume control and all these merits are lost. Either way in my ears the only good CF's *from a sonic POV* is the ones with a CCS in the cathode.
Lets move to the power amplifier.

I found the schematic difficult to understand, mainly due to the way it is drawn. Some of the suspect issues may be due to errors in the schematic or simply poor engineering. As I have no DB125 in my position, I have either ignored these or taken them as a fact. For instance I do not know what is meant by the two components that are marked with a cross.(C28 and R53) As they dont mean anything for the understanding of the circuit I have removed them in the schematic below. I have also removed the circuit used to switch in another set of loudspeakers.The 4 Ohms winding , marked in blue is only engaged when two sets of speakers is connected.

This means that if you have a 4 Ohms speaker, you will have to pretend that two sets are connected and set the speaker selector switch to AB.



BOGEN DB125 , Principle working schematic

DB125 is yet another Williamson inspired circuit. The input amplifier is DC coupled to the split load phase inverter and this is what defines it as a Williamson, It does not matter if such is AC or DC coupled and a dedicated driver doesn't need to be involved to make it the circuit we refers to as a Williamson. This is an abbreviated Williamson.

The 6973 output stage is running an idle current of about 10mA per pentode (According to Sams Photo facts schematic) This makes it a thing between class AB and B. I would expect more than 30 Watt out. The plate and sg2 voltages exceeds the max. ratings, specified by RCA. We will not dwell at that. 6973 is a tough little power tube, developed for audio in the last half of the 1950's by RCA .

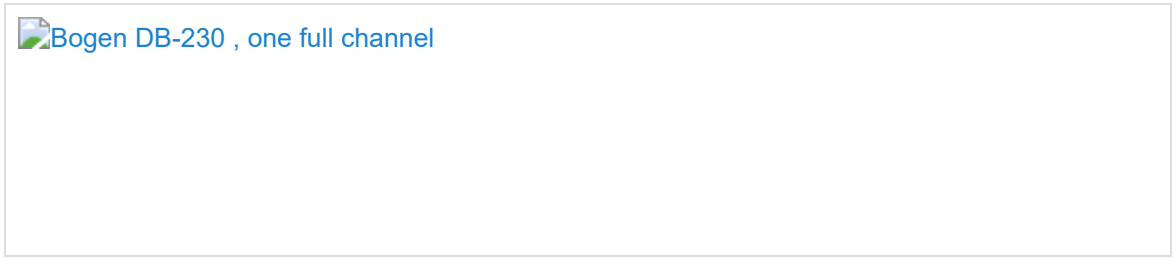
The interesting aspects of this amplifier are the second stage feedback from the split load , the current feedback and the 6CM7 voltage regulator.

The pentode part of 6U8 runs at a low 0,5mA. The RC filter over the plate resistor dampens HF.



Bogen, DB-260 6DW5GT PP , Stereo , early 1960’s.

(Text in the editing process)





Bogen DB-260.



STC , 250W , 828 PP, ?

This STC made in England is candy to us fans of regulated/stabilised power supplies. It is a genuine Williamson design, but “faster” ECC82’s are chosen over the older octal versions – I will get back to this. Look at all that regulation and pay attention to the regulated direct coupled driver. Excellent engineering. The 828 beam power output tubes are regulated with an overwhelming 750 Volts at the

sg2's and by means of a swinging choke input and yet another smoothing choke feeding some scary 1750 Volts to the plates. Respect, gentlemen – it is not often – if ever – we have seen a regulated high Voltage, high power amplifier. 4 rectifiers, 4 chokes, 5 Voltage reference/regulators and one fully regulated PSU in a single mono amp !

Do also note the relay that couples in the high Voltages and activates the indicator lamp, telling us that the amplifier is now ready to roll.

Unfortunately there is a fly in the ointment. This amplifier is of such a good design that it is heartbreaking to note the *unbelievable low Vo*ltage that is applied to plate of the input and phase splitter. The ECC82 is a reasonably good substitute for the older 6SN7 twin triode (6J5/L63 single triode) , but it is not as linear as its older predecessor – in particularly not at low Voltages. This leads to relatively high second harmonic products. Now – that may be perfectly all right when the two triodes are coupled in push pull due to the cancellation of such amplifiers. The driver stage is such a push pull design. But it is sloppy cooking when single end triodes are coupled with too low Voltage. And it is a double fault when available high Voltage is present in rich. I would also question the high values of the plate resistors in the driver stage, but this is a compromise due to the relative high Voltage swing needed. Anyway – both of these things can be dealt with. It is easy to steal some voltage from the 750V supply – I would also recommend to use 6CG7 for the first two stages, rather than ECC82. The push pull/balanced driver does not produce much second harmonics and an ECC82 may be fine from this point of view. But I would rather go for a higher headroom and a more linear driver such as 5687, 12BH7, ECC 90 or similar. Maybe even a choke loaded application ?

Unfortunately I have little info about this rare amplifier. I would guess it was made between 1951 and 1964 , as the ECC82 was introduced in 1951.

I would certainly lift my hat to this 250 Watt class AB circuit.



Rogers Senior mkIII, ca 1959

As the model name indicates this was the third generation in this Senior series from the British Rogers. Only two stages, all signal conditioning is carried out by the cascode'd Schmidt phase splitter. Quite nice. Apart from this the design is conventional, so lets concentrate on that Schmidt cascode and the unusual feedback scheme.

The Schmidt phase splitter is a differential amplifier, but one side of it is partly "driven" by the feedback from the OPT. Actually it is split to the grid and the cathode ! There is further fb from the plates of the upper ECC83 to the grids of the lower ECC83. As there is no capacitor here it also acts as DC fb , maintaining the DC balance of the system. Finally the 4k7 resistor from the midpoint of the upper plates feds fb to the grid of one part of the balanced amplifier. That is an

awful lot of feedback and though it lowers the 2′ and 3′ harmonics, hence THD, it creates a large portion of high harmonics. I like the simple schematic, but in my experience such fb themes rarely , if ever, sounds too good.

Still, I like that amp and imagines that it use to play a lot of early Beatles.



Rogers , Cadet mk III , Stereo , 1962

The Rogers “Cadet” series was introduced in 1958 and was the affordable alternative to the Senior models. Despite the simple circuit and economic consumption of components the Cadet is a rather good design. It is an abbreviated Williamson – a circuit which provides excellent sonic qualities, when properly engineered. The split load phase splitter ensures two very uniform signals of opposite phase.

The ECL86 is a triode and power pentode in the same envelope. The triode is nothing but the familiar ECC83 and the power pentode is quite similar to EL84 – although not an exact copy.

I am sure that this amplifier sounds fine as it is, but there is lots of room for improvement. I am not particularly happy about the choice of the high mu, high ri triode (“ECC83″) as split load and driver. But there is not much we can do about it, considering that the valves contains both these ½ ECC83’s. But we can do quite a lot about it anyway. The power valves are very easy to drive – the necessary Voltage swing in order to drive them to the full – say 10 Watt’s – is about 9 V RMS. This means that we have a lot of gain to swap with.

The first triode – that is responsible for all gain to the power valves is starving. The current drawn through it is about 0,5 mA. And the bias is as low as 0,65 Volt. This does not leave space for much headroom. I would suggest that the plate resistor of 220k at this first stage are changed to some 82-100k or even lower.

The split resistors of 47k in the following stage, could be swapped to some 33k. As both triodes now draws more current and we still wish to maintain a high Voltage over these, change the 5k6 resistor in the power supply to about 2k2. These two minor “interventions” will increase linearity and improve the transient response and HF roll off in both stages.

The values of the transfer capacitors between the stages are way to high. This ruins the pulse response, due to capacitor blocking and it allows bass signals to interfere with the upper signals. The fn of the first stage is about 5Hz, due to the 22n cap.. Changing that 22n cap to 4n7 will do good. The phase splitter connects to the power valves by means of 100n capacitors. This is an equally low sub freq. I would change it to 22n. You can change only these capacitors and other vice leave the amplifier as is it and you will still hear a considerable improvement.

If you apply all the modifications I have suggested, it way also be worth to play a little with the feedback network. The 6k8 may be reduced some 50% or increased up to 2-300%. Lower values increases the fb and vice versa. The capacitors 680p may possible be removed – this goes for the 400p shunting the grid resistor of 1M at the phase splitter , as well. But as I do not have any specifications of the output transformer and no Cadet mkII nearby, I cant provide more info here. If you do not have access to a signal generator and oscilloscope , you may prefer to leave the caps as they are.

Happy Cadet soldering.



Suggested by JC Morrison:

Acro Sound 20/20, EL84 PP, Stereo , 1960

Yup – this is a neat little thing. Stage one:amplifier and phase splitter, stage two: output. Simple, efficient and similar to a lot of designs from the time.Rogers “Cambridge”, Madison 360, Dynaco, B&O just to mention a few. Sometimes this arrangement was made by one of the triode/power pentodes in same envelope.

This Acro, however, is direct coupled. The cathode return of the EL84’s to the input is not signal feedback, it is DC feedback in order to prevent runaway and improve DC balance. Nice, really nice……But…….All the good things with this amplifier is also the bad ones. It is difficult to decide where to begin and where to end.

There is no direct signal capacitors within the feedback loop, which means that as much feedback as the OPT allows. may be applied. The lack of signal capacitors also means that there is no lower freq limit, other than that made by the induction of the OPT. However – first of all , there is a clear limit to how much fb, we can apply, as it is taken from the gain of the 12AX7 multiplied with the gain of the EL84. Clearly Acrosound realised this, thus the 1M Ohm plate resistors of the 12AX7, in order to provide as much gain as possible. So much for the immediate theory. In practice the electrolytics at the cathodes of the EL84's and 12AX7 equals to signal capacitors from a phase point of view. These electrolytic capacitors *are indeed in the signal path*. This means that the advantage of avoiding the signal capacitors are almost gone.

The cruel paradox about feedback is that the poorer the amplifier is to begin with, the more does it need feedback, but the less can it benefit from fb. And the better the amplifier is to begin with, the better can it benefit from fb, but the less does it need it.

The extremely large plate resistors at the 12AX7, makes this twin triode even slower and more lazy than it is already from birth. Not only that, but such extreme high resistance, reduce the plate voltage to such a point of which the 12AX7, is almost turned off. Most certainly in the worst possible place with regards to linearity. This means that Acro starts up with a high distortion and low bandwidth (HF) input stage, that badly needs a great deal of fb, but cant benefit much from it. It merely becomes an average audio amplifier with a middle of the road distortion. It might sound fine, but it is most certainly possible to do better. Much better

A quick and almost free modification is to remove the cathode circuit of the EL84's from the 12AX7 and insert a signal capacitor between the 12AX7 and EL84's. This also makes it possible to remove the input capacitor, that is there only to block the DC voltage from the elevated grid/cathode arrangement of the 12AX7 from doing any harm to the input sources. Turn the 12AX7 into a regular longtail inverter. Could also be a paraphase or a split load, using the other triode as the input amplifier. (Read more in the chapter about phase inverters) It goes without saying, I assume, that the plate resistors of the 12AX7, should be decreased to a more moderate value. I would say 47k or so. In fact I would go for a 5751, 6072 or similar medium/high triode. We may even drop the decoupling of the cathodes, as we do not need much gain to drive a pair of EL84's.

Right, back to the actual circuit. Now, the copy I have of the schematic is difficult to read. That is why I have placed the values of the fb components in brackets. The best I could read from the copy with regards to the AC output voltage from the main transformer is 175VAC. This can not be right as it would equal to 450-500Volts DC, depending upon the regulation of the transformer and the DC resistance of the smoothing choke. A qualified guestimate would be that Acro designed for about 320 to 350 Volts DC. Maybe less. I am a little confused, though, with regards to the large cathode resistors as shown in the original circuit. These are marked 1k Ohms, which I think is an error. Anyway – with about 310 to 320 V available, the cathode resistors for the EL84, should be around 270 to 330 Ohms per cathode. Half that if you want a common cathode resistor.

Lots of space for improvements in that old Acro sound.

B&O, Grand Prix 609-610, ECL86PP, ed

Suggested by yours truly:

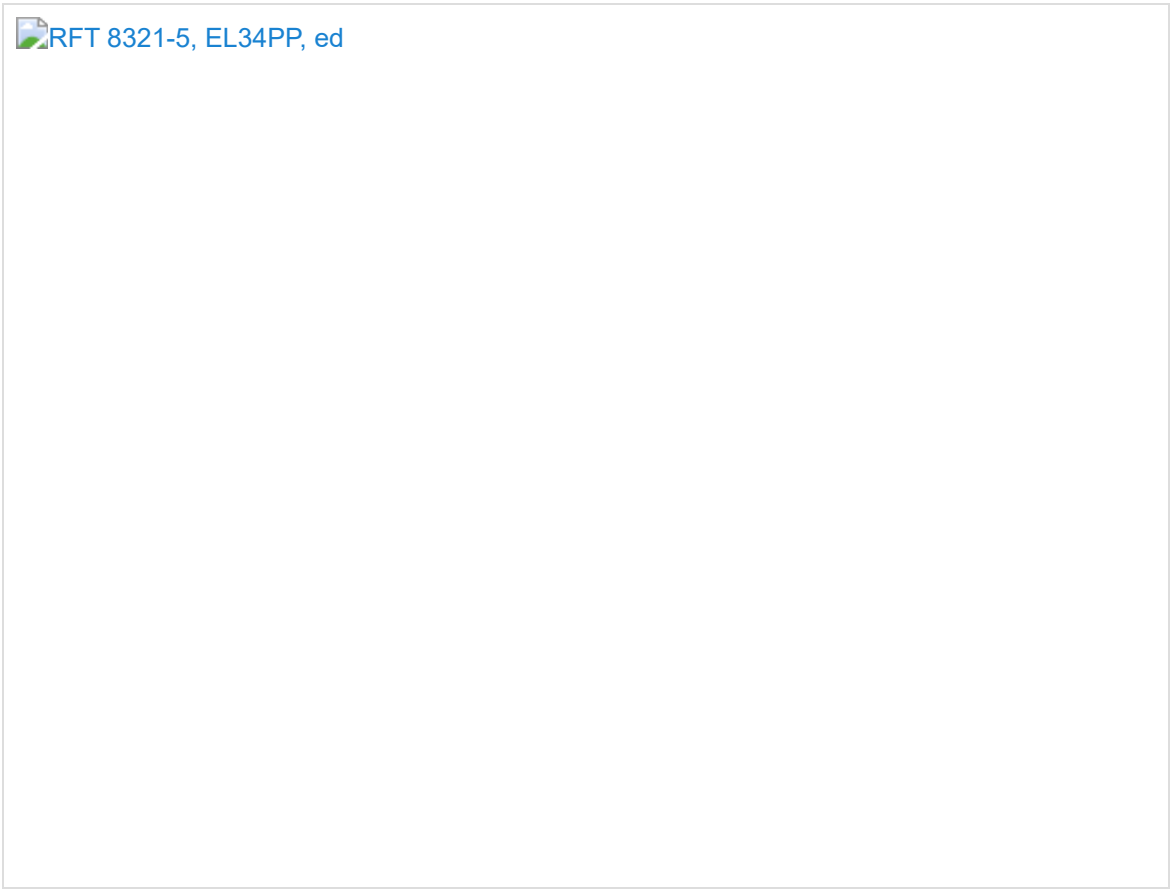
B&O, Grand Prix 609/610 Stereo, 1962

It is nothing special from an engineering point of view. Tiny J. Schou OPT. But it sounds SO darling good and I use to amuse myself by playing this along with friends new fancy top gear Mark Levinson, Audio Research etc., and pretty often this “Bang and Nil” would beat the hyped gear to shame. B&O began their Grand Prix series around 1938-40 and dosen models were made. In 1959 they made a nice PL84 Single End stereo version. I use to have both of them and used them frequently as demo’s. B&O had a separate PSU , placed away from the tuner and amplifiers.



Above is a full diagram of the 1959 stereo version. B&O used to supply very extensive service manuals, showing oscilloscope patterns and values for every single point around the whole mess. Every single damn component were described down to suppliers stock number. Telefunken valves and Beyschlag resistors were there prefered ones. Take a look at the full schematic above and gaze. Below is a “cut out” schematic of the Single End PL84 amplifier. It won’t blast Led Zeppelin at concert levels, but it sure sounds very sweet and musical and there is lots of room for joyful modifications.





Suggested by yours truly:
RFT 8321.5 , EL34 PP, DDR, 1958-64 ?

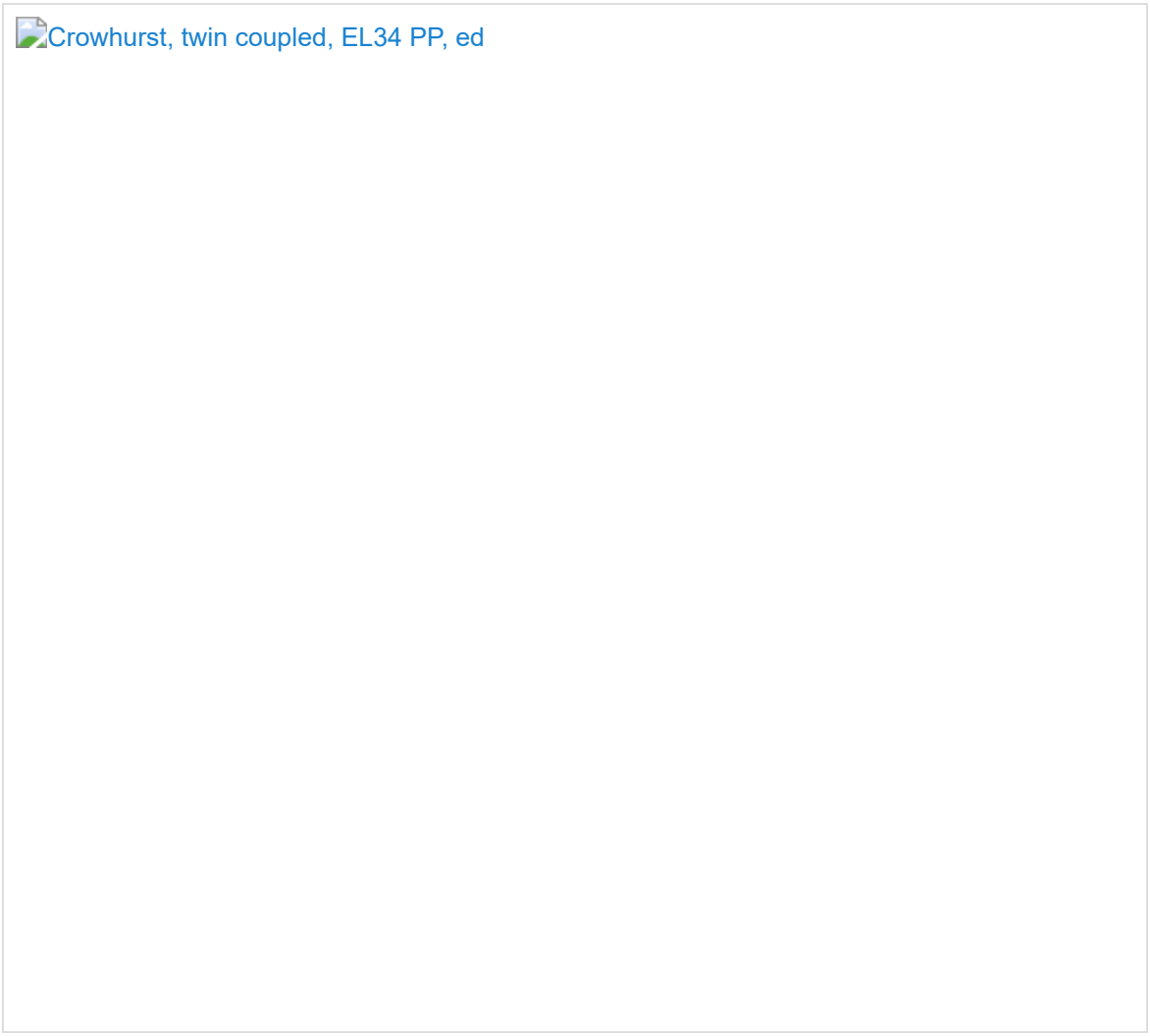
Nice to see an amplifier that are neither Williamson nor Mullard design. This is a two stage ECC83 with a tone stack in between. Then an ECC82 paraphase phase splitter and driver. Then good genuine pentode class A output handled by trusty old EL34. Pretty nice and it sounds good. EYY13 is not your common rectifier, but it is quite similar to GZ34.*

** Update: I have received a mail from Gunnar in Germany pointing out that "EYY13 is not the same as GZ34". Thank you very much for your kind interest and for making this point, Gunnar. I realise that the EYY13 is not a regular animal – that is what I mean when I claim that it is not a common rectifier. Allow be to elaborate. The EYY13 has two diode gaps that are completely isolated. There is two plates, two cathodes and two heaters. It therefore also needs two isolated windings in order to work as two separate diodes.. I guess that the purpose of this arrangement is to have a rectifying device capable of doing such jobs as Voltage doublers and similar. In the RFT amplifier, however, the two filaments of the EYY13 are coupled in parallel and it is used in the conventional manner. In the circuit it works just like a GZ34 and the specifications are pretty similar. EYY13 is capable of a somewhat higher current, compared to GZ34 and the inner resistance is somewhat lower. The series resistor of 50Ω, however, cancels this latter difference, thus it is almost exactly identical to the performance of the GZ34. EYY13 needs 6,3VAC and is equipped with a German steel socket – GZ34 is a 5VAC heater type and it is mounted in an common Octal socket. I believe this covers difference between the two rectifiers and I would like to add that EYY13 is indeed a remarkable vacuum rectifier.*

This 8321-5 is the only commercial amplifier I have ever had that made my old Tannoy Gold's series sing DEEP powerful bass notes. **But before you head out and buy one of these amplifiers, you should *be aware that it only has ONE output*, which is meant for high load speakers**.If you do not have any 20-30 Ohm speakers and don't know how to modify the output transformer, the amplifier is pretty much worthless. I modified the secondary winding arrangement and a few other things – and – gaziinka – there it was. Sadly, I did not have this mono block set in use for very long. To make a long a long story short, an accident damaged one of the amps and I put them to stock for later repair…It is still such late. (Should you happen to have one of these amps, in spare, I would be happy to buy the OPT or the entire amplifier)

I will definately get back to this design, because by pure luck I got something very special from this amplifier. In time I will upload the information about the modifications here.

RFT was the East German pendant to Telefunken/Siemens/Klangfilm and Philips and they made a lot of good stuff worth to explore.

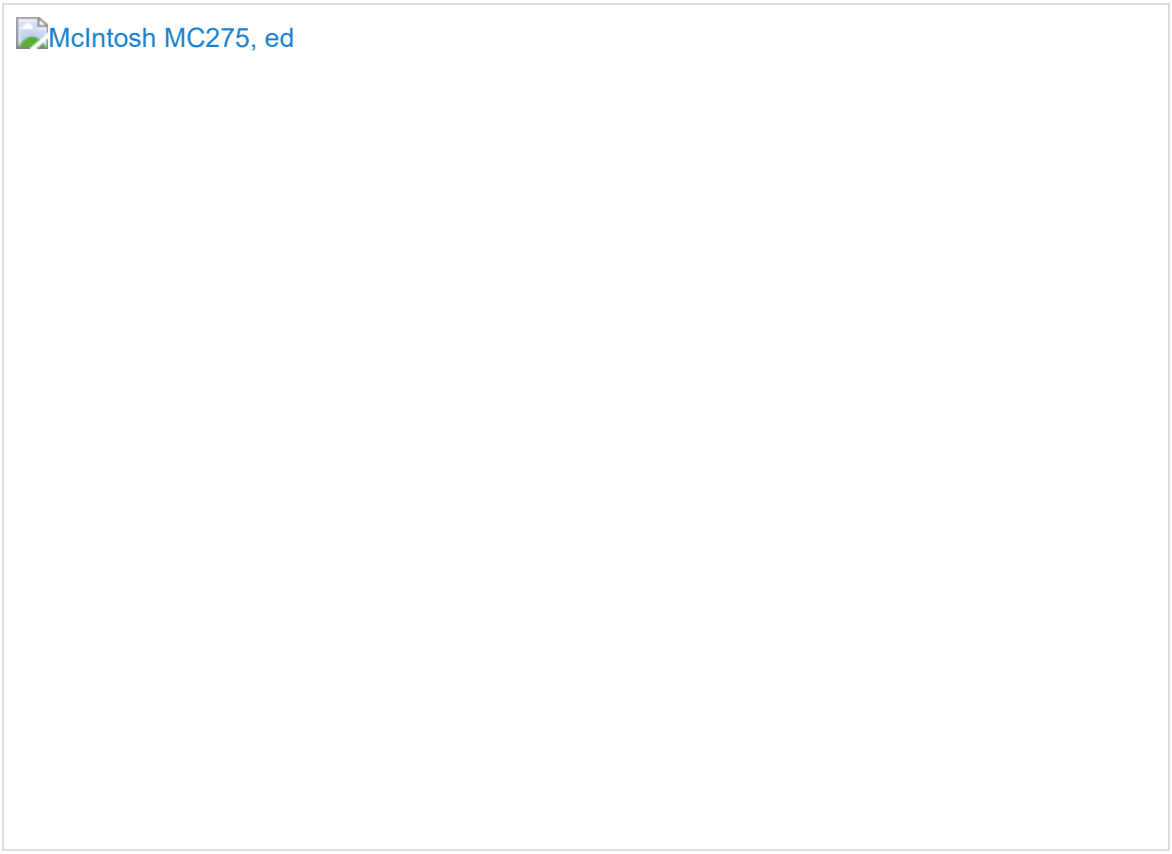


Crowhurst, twin-coupled, EL34PP, 1960

Norman Crowhurst, London was a personal hero of mine. He wrote a number of excellent articles about audio transformers in “Audio/JAES” , Wireless World” and many other such magazines during the 1950’s and 1960’s. He was an outstanding authority on that object as well as a fine engineer into audio electronics. This particular amplifier was the last design (to my my knowledge) in a series of articles from 1957 to 1960 about the so called “Twin-coupled” amplifier. As I understand it, it was a kind of “poor mans take on the McIntosh unity transformer”. What Crowhurst did was to twin couple two identical transformer in the manner shown, thus managing results similar to McIntosh. I am not quite sure how good the idea is – I suspect that differences between the transformers involved may affect the results. But keep in mind that an original McIntosh transformer was very expensive back then and McIntosh had the rights for the patent. Today McIntosh patens has been free for several years, but as it is so difficult to wind, I know of no commercial attempt to copy that old transformer. Tim de Paravicini made his version of the unity transformer for his EAR series of amplifiers and Papworth had a similar design for some of their amplifiers. If demand is high enough, I will make a version available to the DIY community and for OEM orders, but so far the need for such design has been negligible.

Anyway – this Crowhurst amplifier is a darn good Williamson design, whether you want a cathode or plate loaded EL34 Push Pull. For a conventional plate loaded amp, you will need an 4-6 k Ohms, 40-50 Watts OPT and for a cathode loaded some 1-2 k Ohms about 30-40 Watts should do the trick. This circuit will actually drive a cathode coupled output stage.

Hats of to Norman Crowhurst.





McIntosh MC275, KT88/6550 PP,Stereo , 1962

This amp might be McIntosh's own milestone.
A classic status well deserved. I have only heard it briefly many years ago, but I seem to remember it sounded a little weird, slightly cold and "white".?
I love the the design as well as the outlook. I remember a guy using it for bass guitar. He loved it too….
Grateful Dead could not get enough McIntosh power. Woodstock festival was powered by Mac's….



Binson, PO601/200, 4xEL34 PP, PA-Amplifier, 1967

Most of the professional PA power amplifiers made at the continental Europe from the 1950's up to the early 1970's were equipped with EL34's. The Binson here is a typical example. Binson was an Italian company producing PA and orchester gear. They were quite popular here in Denmark. I picked this one because it is a typical and beautiful Williamson design, but in particular I quite like that all stages including the sg2's are regulated – albeit not the best possible regulator. A smoothing choke would make wonders. I have fainted the pre/tone reg. amplifiers and kept the modification for higher sensitivity.It is also good to see a PA design without a single ECC82/12AX7 in the signal path. Do also note the EM84 "magic eye" power indicator. You can readily use this design for a high quality HiFi amplifier. One pair of EL34's would need an OPT load of some 5000 Ohms, 50 Watts.

Quite nice.



McIntosh MC3500/MI-350, 8 x 6LQ6 PP, 1968

I have never heard or seen any of these wild amplifiers in real life and I doubt the sonic qualities will fit the delicate domestic red wine environments of most audiophiles. But it was an amplifier

meant for the pro marked, PA and industrial purposes.
It is a grand tour in audio design, and the drama from 350 Watts of sheer tube power should silent most critics. 500 Watts for a few minutes – if you dare. I would guess that peaks are possible up to 2-3 times that.
Most high power tube amplifiers (if not all ?) are high Voltage and usually class B. This Mac use only 470 Volts and in runs the tubes in class AB ! 50mA per output tube adds up to a total of 400mA at idle taken from the output stage.
The more I look at this circuit the more fascinated I become. It is indeed a masterpiece. The output transformer are incorporated into the entire amplifier in a manner that was never seen before and has never been seen again.
The output tubes are plate, sg2 and cathode loaded. The cathode load also acts as local feedback, thus the need of excessive Voltage swing to drive them. The screen grids (sg2) shares the +180V winding. The driver stage are made up of two twin triodes working in a balanced mode: a gain section 6DJ8 and a cathode follower 6BL7GT with very low z-out capable of supplying lots of currents to the grids of the output tubes, when these are driven into the positive bias area. These two sections is incorporated with the OPT as well by means of two separate windings. Do also note that the plate supply to the 6DJ8 driver are connected to the plates of the output tubes, which means positive feedback. The reason of this is to keep the Voltage swing going as the two cathode feedback windings of 6BL7GT and the output tubes demands a very high Voltage due to the cathode degeneration.(No gain)
Further feedback are applied to the phase splitter. All in all the feedback amounts to some 38dB. Positive feedback and feedback loops within a fb-loop never improves the sonic quality in my experience, despite the better THD figures. But it would otherwise be very difficult to drive the output stage if the full power are accommodated.

The power supply are very simple for such a monstrous amplifier and I am sure it would gain a little from larger electrolytics as well as yet another choke or two to smooth the power.

I am kind of puzzled about the cathode follower input. I simply can not see any reason why it should to be there.
The phase splitter stage represent a large 1M ohms load and it is very easy to drive.

I am impressed with the design and the specifications clearly shows that Mcintosh knew what they were doing.
The amplifier was designed by Mile Nestorovic and launched in 1968. The evidence of the master stroke are not least that we here 50 years later still discuss and admire the design. Mcintosh made many amplifiers for industrial and lab use and the MC3500 was a commercial version of the MI350 industrial amplifier.

As a young man I dreamed of owning a pair of these monsters. I spotted it in a Maplin catalog from England. Apparently they could not sell it at the price asked back then, and in the late 1970’s I was offered the pair from Maplin stock at a very favourable price due to my continuous inquiry.
I cant remember the price anymore, but it was well below half of the asking price.
Should have bought them and directed to Ebay nowadays..

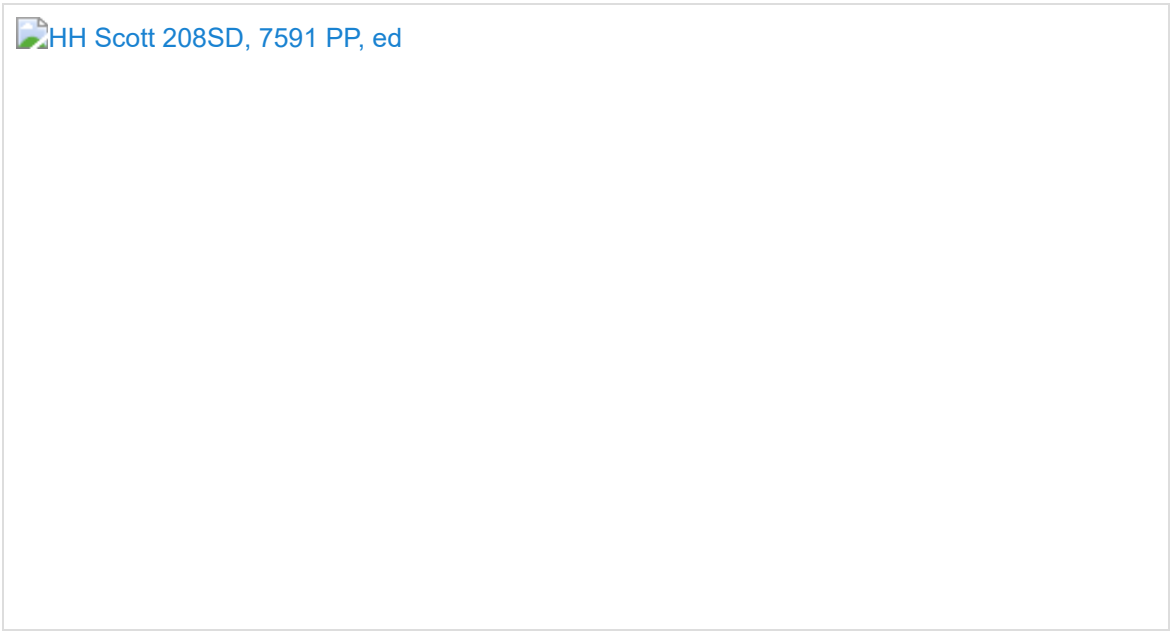
A milestone not least because it was one of the first monster amps in HiFi – despite it was targeted at the pro business.
(Well, it was small compared to some of the early Westerns….. ;-)

Sheerwood S-5000II, 7868PP

Sherwood S-5000 II, 7868PP. Stereo , ?

Simple abbreviated Williamson design. Although this is one of Sherwood's top model stereo amplifiers it is a rather typical Sherwood design. Well – it is indeed a typical 1960's design and could have been made just about every where in the world. The 7868 power pentode was a late development made exclusive for audio high fidelity applications. It was never used much, despite the high quality as transistors took over the hifi market in this period. The production of the 7868 ceased a few years after it was introduced.

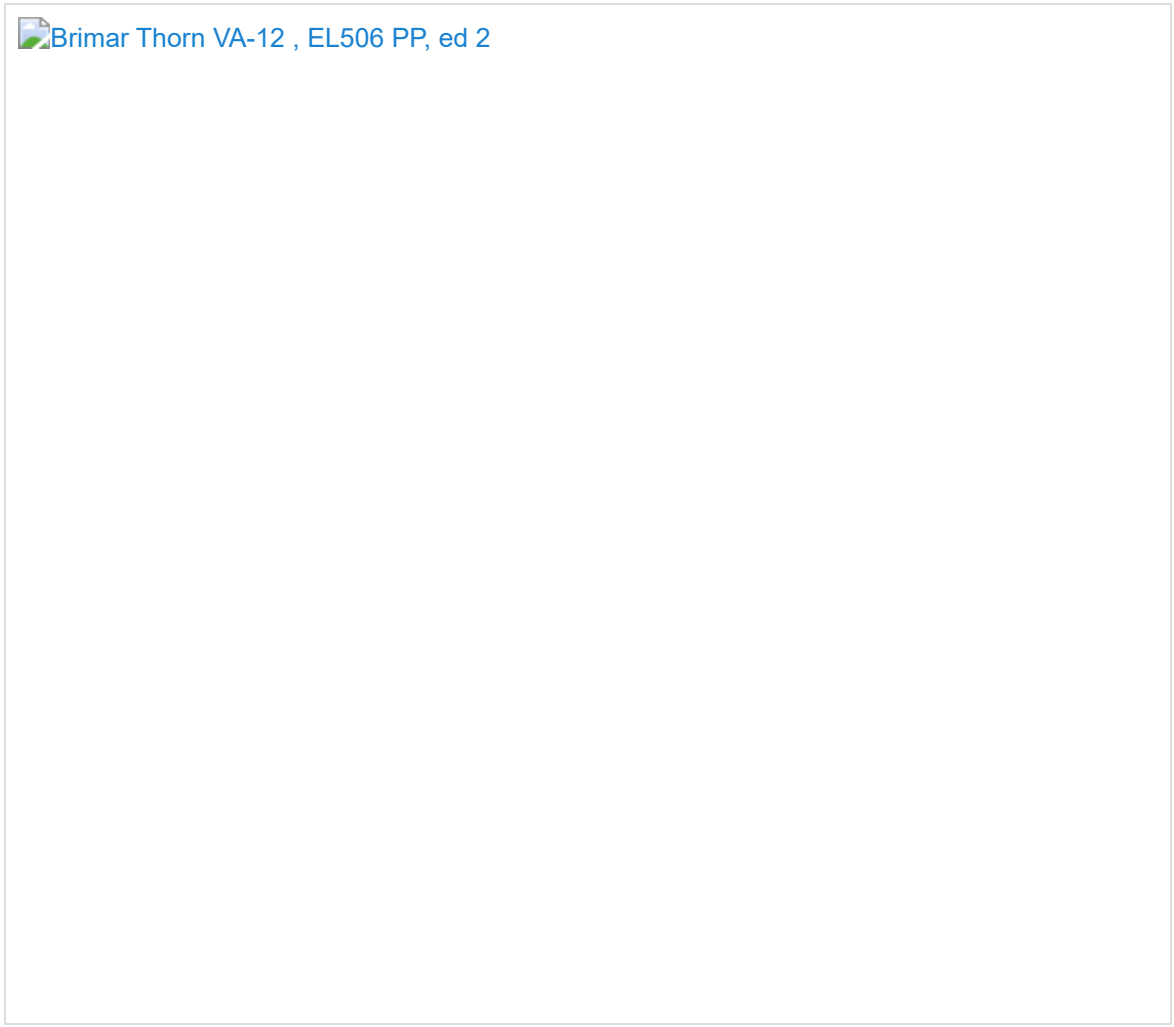
I have no idea what Sherwood means by the stated "80 Watt amplifier" – perhaps 2 times the peak power ? I would estimate this amplifier to be a 25-30 Watt's class AB animal – as there is no way that an 12AX7 are capable of driving the 7868's into class B, even less so as a concertino phase splitter.



HH Scott, 208 Stereo, 7591 PP, 1964

Joe Roberts suggest that I add some of Scott's PP amplifier design's in general.
Yes, the ones I know of are fine audio engineering. Nothing special, but decent and rational designs. HH Scott was founded by Herman Hosman Scott in 1946. HH Scott company are best known for their splendid vacuum tube stereo receivers made from the late 1950's to the closing of the company in 1966. All the Scott's stereo receivers I have seen uses the Mullard 520 circuit with split load/concertino phase splitters as drivers. Often 12AX7's or 6U8's. This is not an optimal application from a audiophile pov, but it is an economic solution and Scott was heading for the main mid priced market. It should't be too difficult to modify the Scott's into a long tail phase split driver or perhaps a Williamson design. I am told that the transformers are pretty good, which should justify an throughout modification. The schematic are a typical example of Scott's stereo power amplifier – only one channel is shown.

Stereo logo's 2



Brimar – Thorn VA-12 . EL506 PP, 1967

This is an unusual amplifier in more than one way. When I first saw it on the original Brimar schematics , I took it for a Williamson circuit. But on closer examination, I realised that it is far from such a device. The VA-12 must be one of the absolute last valve amplifiers designed by members of the original and knowledged valve technology generation. That alone makes it special – but there is more.

The ECC807 input valve is an improved low noise high mu twin triode. It holds a record high mu of 150 for a triode type of the old school. Only planar triodes are otherwise capable of such figures. The output pentode EL506 is a late development as well, probably mid 1960's. Both of these valves are Brimar , Thorn AEI brain childs. It is no secret that I usually prefer modern materials and I really like the last generations of valves and tubes. It is sad that the technology got obsolete at the very peak of its performance. We can only dream about , what wonders that would had been created, had it lasted just a few decades more. Compare it to what has happened with resistors, capacitors, transformer alloys, solid state and such. These has all dramatically improved during the 1980s and 1990's.

Anyway – back to the VA-12. The first thing you should notice is that the first three stages are Direct Coupled. This will allow higher NFB, hence reduction of distortion. Usually such a three

stage DC coupling is also a way to ask for problems. But the guys at Brimar, however, came up with a pretty elegant solution here. The line I have marked in blue is a DC feedback loop. This will hold the circuit stable, despite changes in voltage supply, but it will not balance the circuit. Imbalance is bound to be introduced due to difference in the individually triodes as well as changes caused by time and aging. Brimar came up with yet another elegant solution here. The ECC83 phase splitter driver is a “cathode driven type”. This means that the grid of the lower triode of the ECC83 are tied to ground via the 100nF capacitor and driven by the cathode input. The capacitor cancels all audio signals and the grid is practically grounded. However – and here comes the trick – the Voltage divider made of the 1M5 resistor coupled to +318V and the 300k resistor coupled to the cathode of the second triode insures DC stability and bias, despite the drift of the triodes in the entire DC loop. (All valves drifts) This is a simple, efficient and tremendous solution. The zener diode at the first triode serves as the DC reference. Good quality zener diodes was a relative new thing in 1967 and it is a clever use of such diode. It may be improved further by use of an “isolated” constant current source, like below.



Constant current source modification.

The CCS modification shown here, goes for all such similar schematics. The best Zener diodes are those around 5V to 7V. (A LED or more in series could also do the job, as they are often very stable at the Voltage gap. The red ones are the best in this regard.) Look up the datasheet of the

particular Zener you intend to use, then find the optimal current. You then detract the current from the valve itself and let the CCS do the rest. Constant current sources can be made in many ways. Two bipolar transistors, one FET or any hybrid in between. Look them up. I would suggest to remove the 100uF electrolytic from the Zener and replace it with a smaller value real capacitor. Say 100nF to 2uF.

Right…Back to the amplifier……

The plate filter at the first triode and the decoupling capacitors over the in between stage voltage dividers, improves the phase relations. All in all, these little tricks allows some 36 to 40dB's of feedback. This is a very high amount in a valve amplifier.

The output stage is straightforward textbook design. The 10k grid stopper is a good idea and I wonder if a screen grid stopper would not be a good thing too. It usually is – in particular with high gain power pentodes/tetrodes. As said, EL506 is an excellent pentode and not much can be seriously improved here.(Of Course we can swap the EL506 to any other pentode or even a triode, provided that we adjust the Voltage and OPT accordingly)

The VA-12 is indeed a wonderful design and this is also why I consider the choice of the ECC807 and ECC83 to be a sad bummer.

As mentioned ECC807 is an extremely high mu triode – u150. The cascade coupling of these twin triodes insures a very high overall gain. It is possible to achieve figures in the range of 6000-10.000 times. Now – this is a whole lotta gain.Such high gain only makes sense if we a able to through it away or feedback. Unfortunately such high gain circuits introduce a lot of phase shift and this limits the possible amount of feedback. (If we want to cover the entire audioband – and we do) In the VA-12 they came up with a rather poor solution for this problem. They simply dumped much of the gain into the blue air. The Voltage dividers made of the resistors of 2M7 and 820k between triode one and two and the resistor 1M5 and 820k between the second triode and the ECC83 phase splitter, eats up most of the gain. The high gain stages, increases the Miller effect by the amount of gain in each triode. This is why the voltage dividers are decoupled by capacitors. Do you get it ? The high gain coupled ECC807 introduces the illness and the Voltage dividers and the caps are trying to heal it. A rather weird solution. The gain that is left amounts to some 380-400 times and after feedback the sensitivity is 130mV for full output. The distortion on the other hand has not been reduced to more that 0,1% , simply because the distortion introduced to begin with in the circuit used is unbelievably high.

A much better and simpler solution is to use medium mu triodes in the first place. That way we can dump the Voltage dividers and caps – maintain low noise and dial in the sweet spot for a set of medium mu triodes. This will drastically reduce the distortion in these two stages and we maintain the potential for a high amount of feedback.

The ECC83 phase splitter is not a particularly good driver. The high z-out from the ECC83 reduce the HF merits and fast pulse response. Here a medium twin triode will do much better too. The

gain of the ECC83 phase splitter is not much more than 25 times – we would not mind sacrifice some of that for lower distortion and wider freq band.

Despite all this, the VA-12 is a well engineered circuit. The DC feedback theme is a brilliant and neat little trick. The ECC807 was the last generation of the ECC83 breed and as much as I admire this little wonder triode it is of no good in this circuit. The EL506 is a similar little gem. It is a close equivalent to 7868 and could be considered as a mix between an EL84 and EL34. The socket is the Magnoval type and this is why most DIY avoids this valve.

This amplifier may very well be the last amplifier made by the old school and it concludes the era of valve and tube amplifiers in very much the same way as it began. Just like Langmuir's first amplifier it is a brilliant design – with a flaw. Excellent in its basic, yet easy to improve.

Hats of to the last "original" valve amplifier…..

The end of an era 1916 – 1966.

50 years of sweet analoge and glowing technology. From the late 1960's to the late 1980's all the former manufacturers of valves/tubes in the western world shut down. A tremendous lot of unwritten knowledge was lost. At the peak of this technology more than a million employees was involved with the production of tubes. Tens of thousands of engineers, chemists and metallurgy experts retired or had to resort to other jobs. The collected knowledge of an entire technology was in large lost forever.

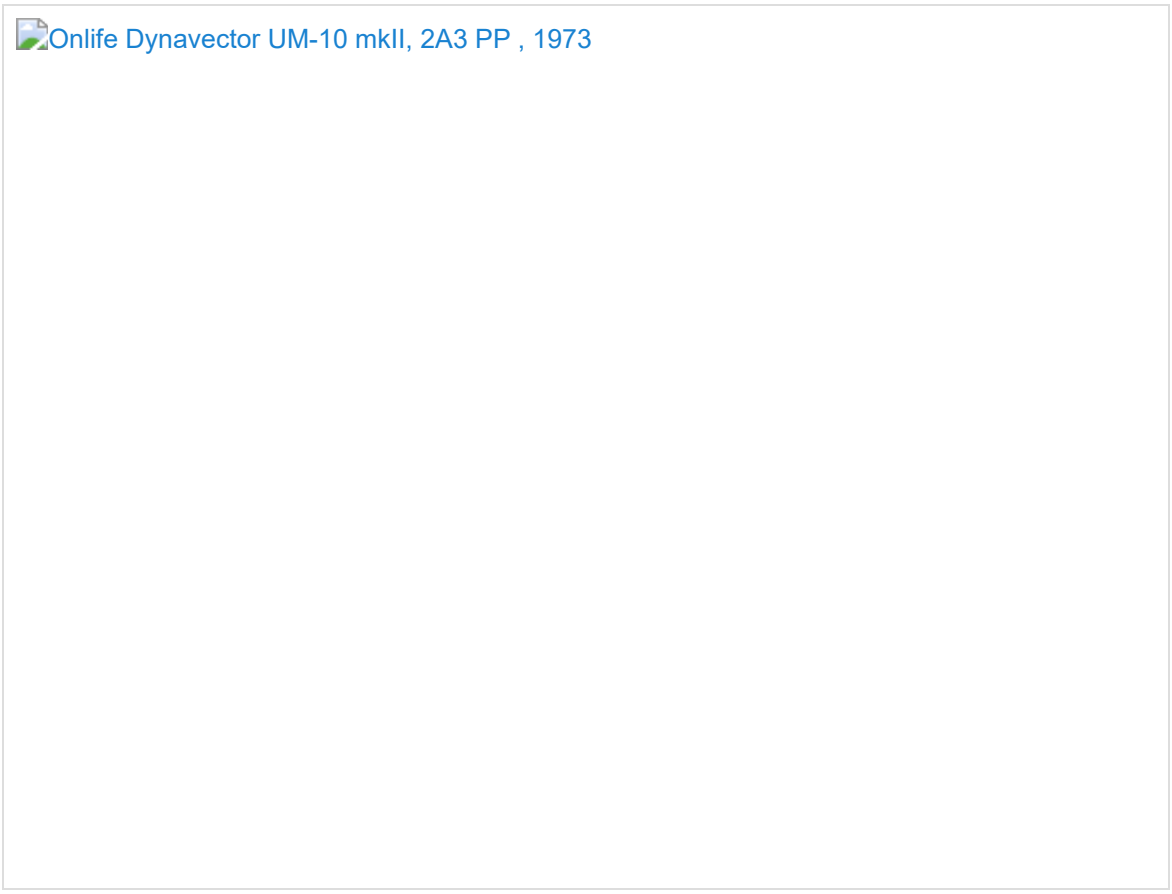
The sources of NOS tubes are bound to dry out within the next 10-20 years.Fortunately new production of tubes continues to improve – not linearly , mostly by two steps ahead and one step back, but it is getting better it seems. I love tube/valve amplifiers and I will keep using and producing them or the rest of my life. The magical reproduction from a well designed tube amplifier is second to none in my ears.

Thank you for reading. The final chapter in this compendium, will deal with "modern" valve amplifiers.

Hats off to an era of imagination, great talent, knowledge and craftsmanship.

The retro wave of tube technology.

The "back to tube era" began in Japan in the late 1960's and gradually spread to Europe during the late 1970's and finally to USA in the late 1980's. In the 1990's the interest in triodes, SE amplifier's and the socalled NOS (New Old Stock) tubes took new heights and the demand of tubes for audio gave rise to new productions of tubes.



Onlife UM-10 mkII, 2A3 PP, Stereo , 1973

I had the good fortune of having one of these amplifiers in my possession many years ago when I was still a young man.The painstakingly handdrawn and now damaged schematic is yours truly grabbing the opportunity to learn about a new circuit. (Does not seems as if my schematic drawing technique has developed much since) This Onlife thing sounded fantastic, despite the unusually short part list of components. – or perhaps exactly because of that. ;-)

I quite like that some japanese audio companies had the nerve to produce amplifiers based on the technology of the past. They did not measure well, but they sure sounded much better than the transistor amplifiers of the 1960′ and 70’s. In my ears good valve amplifiers still outperforms even the best and most expensive transistor amplifiers.

I salute Onlife and Dynavector – made in Japan.

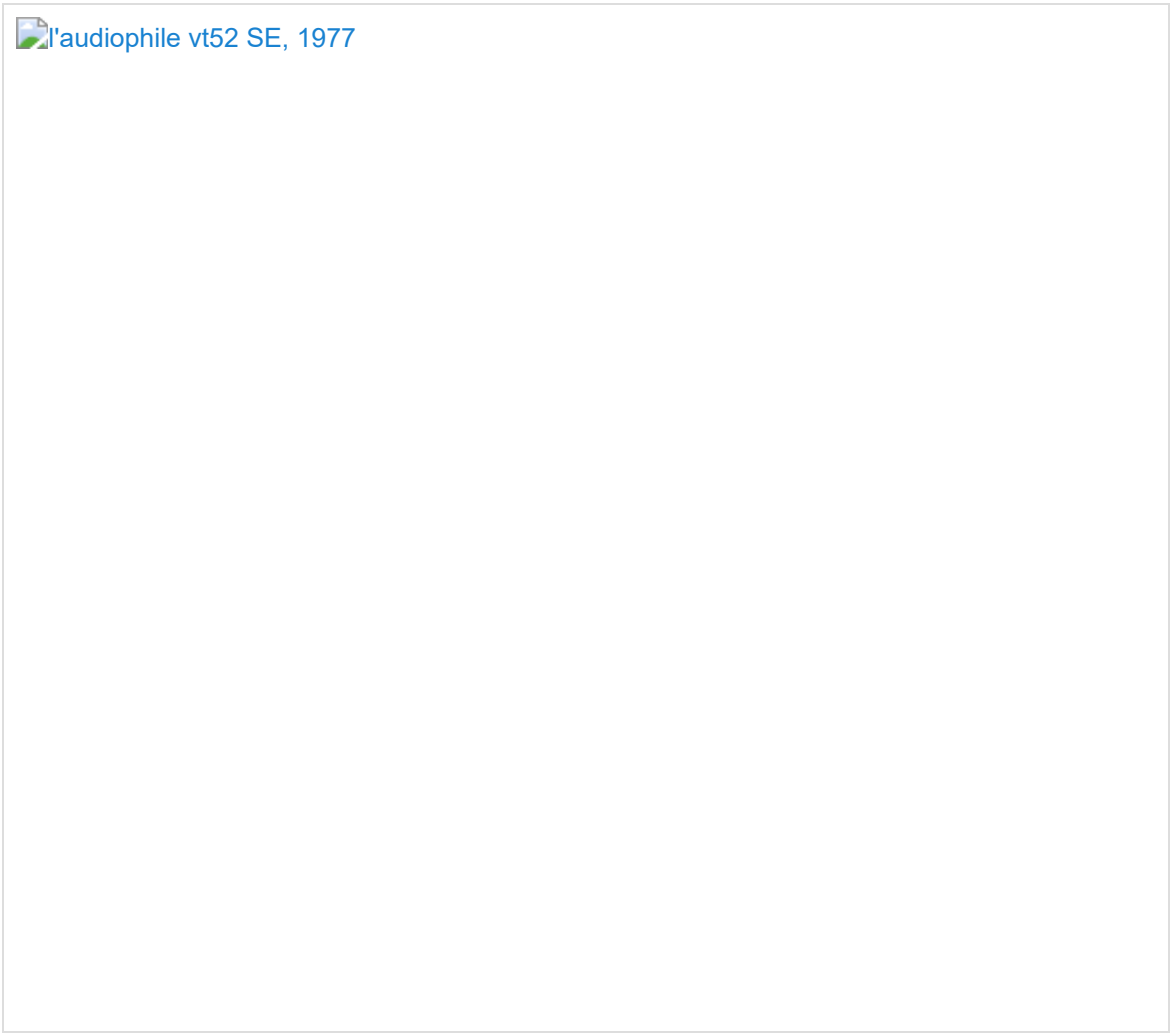


Dr. Asano, PX25 SE, 1971

It is impossible to say by whom or where the retrowave of tube amplifiers began. All the major commercial HiFi companies shifted to transistors during the 1960's and most of them never looked back. In Europe some pro-audio/PA amplifiers were still based on tubes and the entire pro-music branch was never capable of shifting to solid state guitar amps. But most certainly the retrowave of triodes in particular Single End triodes took of in Japan. Such notorious names like Dr.Asano picked up the old glass envelopes in the late 1960's. From Japan it spread to French – possible due to the French/Japanese audiophile Jean Hiraga , then Scandinavia, England, Germany, Italy and so on. And in the late 1980's early 1990's it slowly began to appear with the high power fixated USA audiophiles.

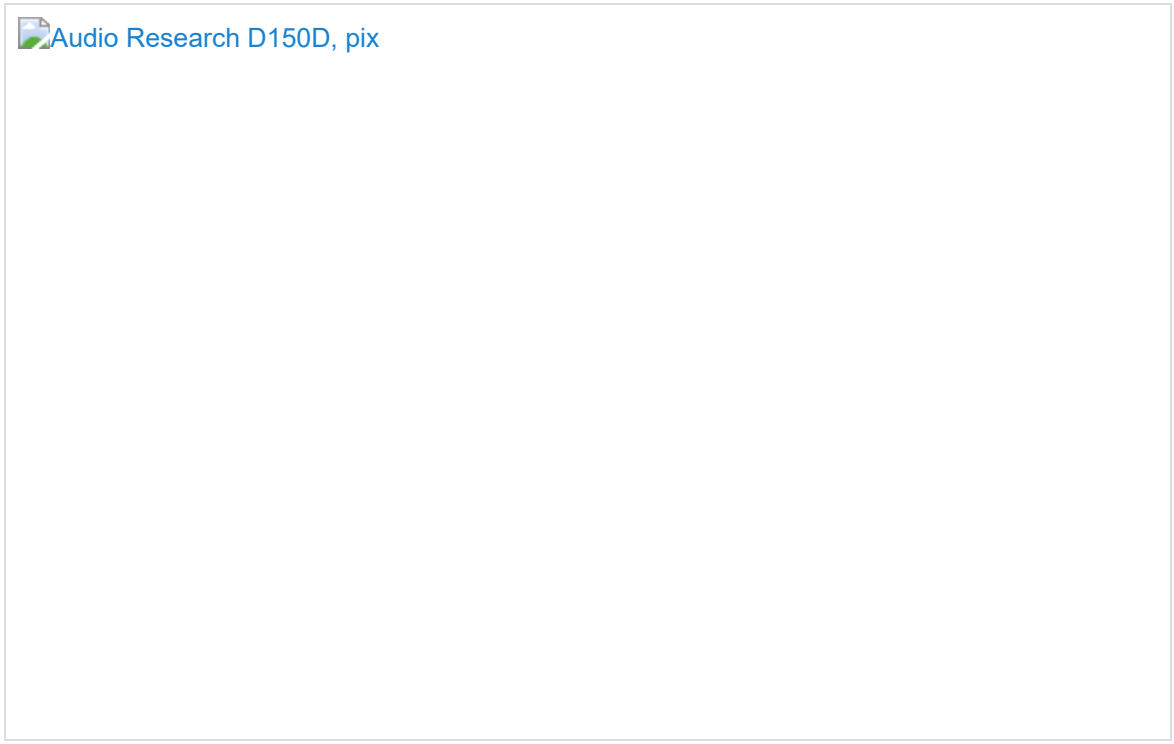
The PX25 amplifier above by Dr.Asano is nothing new at all. Actually it is a textbook example of the amplifier technology from the 1930's. But ironically this fact *is the news*.

The Japanese audio magazine "Stereo Gallery" published a number of designs by Dr. Asano from late 1960's and upwards. Dr. Asano had a small workshop from which he sold tube amplifier KIT's to the japanese DIY's community as well as fully assembled units. According to JC Morrison, USA/Sweden it was in fact Dr.Asano that designed the Ongaku amplifier as well as many other later well know icons.

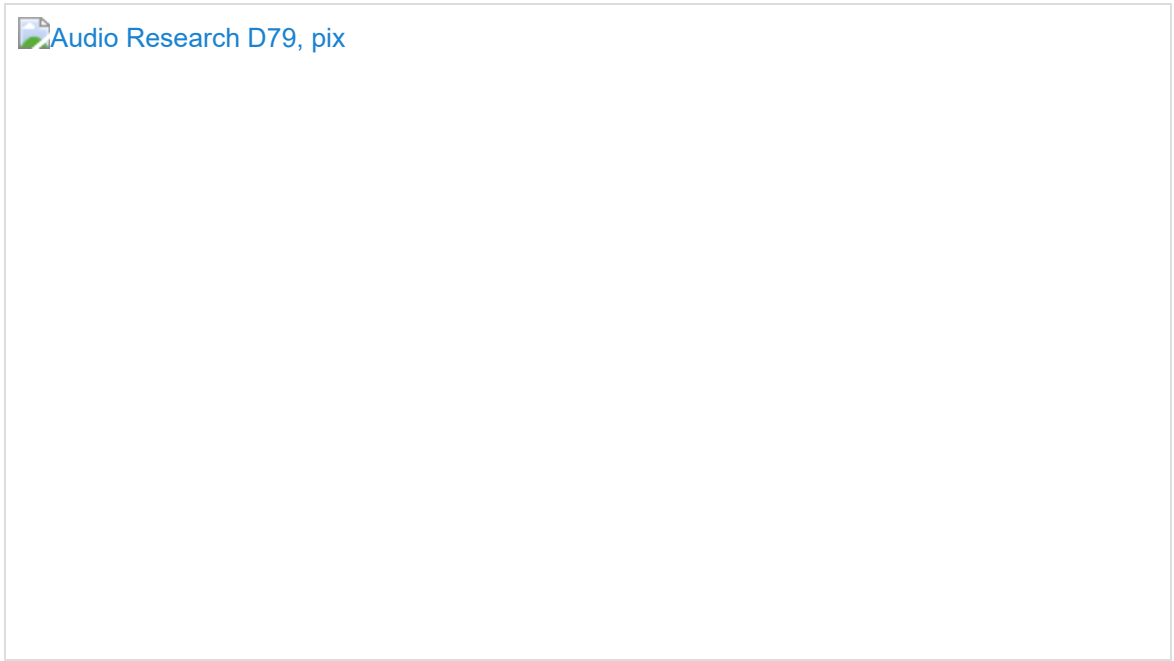


l'Audiophile , Loftin White version, VT52 SE, 1977

This amplifier was published in the french magazine l'Audiophile, 1977 and in the book of Jean Hiraga , mid 1980's. It is a typical example of the components gastronomie we practiced back then. – Still do to some content, I might add. Me and a good friend (Ulrik) got to the point of which we considered these special and hard to get components as sacred reliquary. Silvered Mica capacitors, ITT pm-mkII (It had to be the light brown one) , mill. specified tantalum electrolytics , silvered if possible, tantalum resistors, non inductive 2% resistors (Mill. specified – that goes without saying) , Beyschlag carbon film, green Resista metal oxides, Allen Bradley composition, custom made Jensen flash electrolytics and oil/paper and so on. It was a blast.

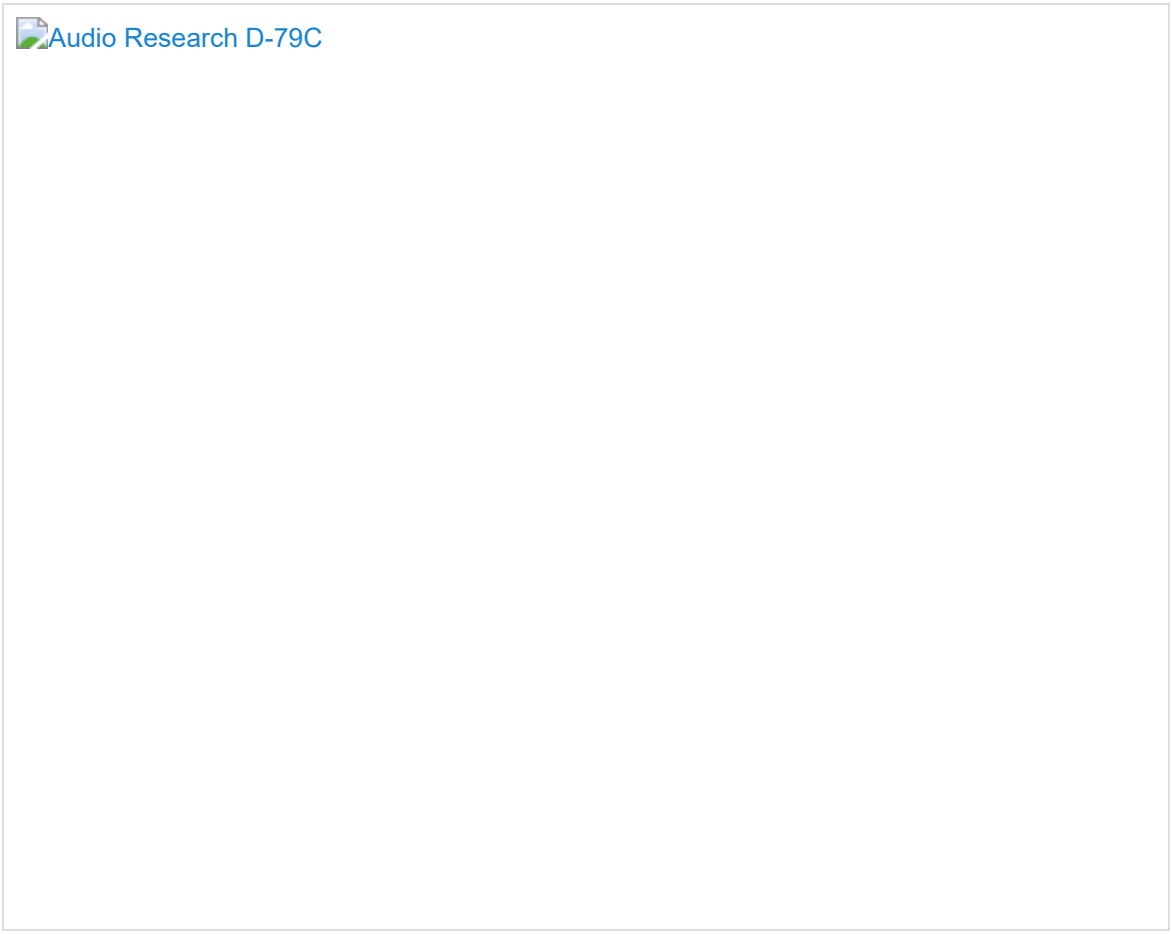


Suggested by Bill Perkins:
Audio Research D150, 6550 PP, Stereo, 1975
This monster amp looks absolutely stunning…..I have always admired that lab look of this and the Electro Research's.
Boy – you really love them big amps, Bill.
Great looking classic.



I would also like to suggest the **Audio Research D79, 6560 PP**. – sure looks fantastic.


Audio Research D79's



Like many other designers of vacuum tube amplifiers I have a mixed relation with the Audio Research tube design.

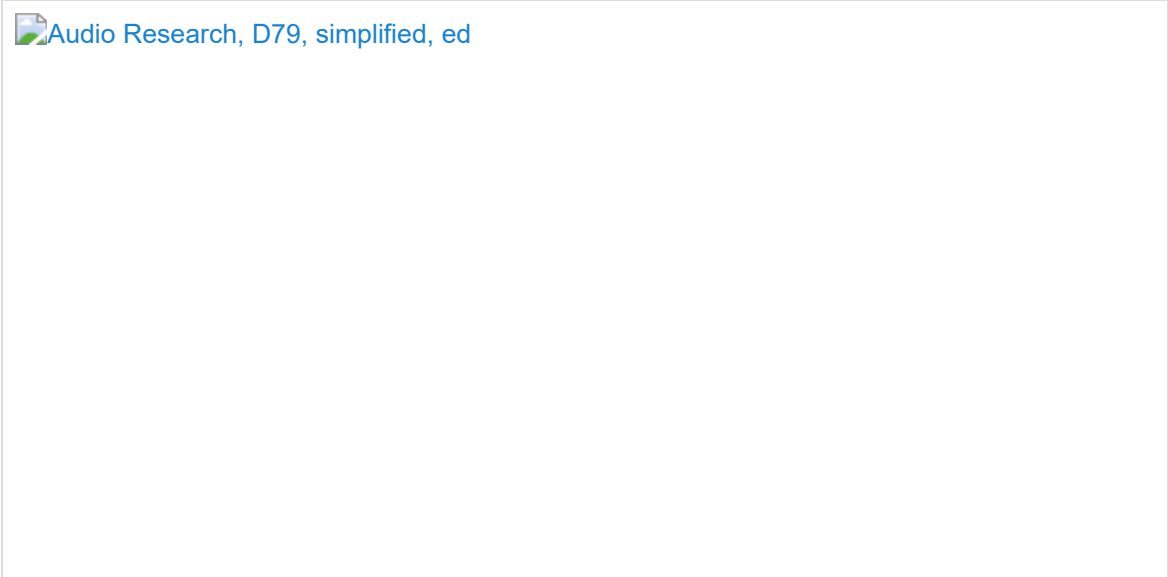
I have serviced, repaired and modified countless AR amplifiers. When modifying these tube amplifiers I mostly *removed* components and otherwise just simplified. Regrettably the tube and hybrid amplifiers designed by William Johnson are grossly over engineered in my opinion. They are indeed a mix of brilliant equilibristic solutions and an eccentric tendency to overcomplicate. Johnson would be wearing both braces and belts in the form of multiple compensations networks, double or triple use of passive components. These were often (mill. surplus ?) 1% resistors of such funny values like 301k, 205R, 4k99 , 49k9.

Johnsson obviously had an issue with phase splitters. Maybe he got allergic to the concertino phase splitter due to the poor way Dynaco used it in the Dynakits he modified back in the 1950's and 60's.

William Z. Johnson founded Audio Research in 1970. Previous to this date he had a workshop dealing with repair and such. In the late 1960's he made his first amplifier designs, using Dynakits as the basic parts. The first A.R. amplifier "Dual 100" launched in 1970 was equipped with Dynaco transformers. I know little of this amplifier, but the next product from Johnsson, introduced in 1972 was the "Dual 51". Johnsson stock to that design for the rest of his life. Just like Futterman and McIntosh he kept working back and forth on that circuit. All A.R. amplifiers are variations over that

theme. The Dual 51 was modified 12 times during the first 15 months of its life – that is almost a new variation per month.

Allow me to back up some of my opinions with some objective facts. The D79 series is a typical Audio Research design. Whilst the basic circuit remains the same in the D79 series, the difference between each ”generation” is relative large. In the first D79 model Johnson uses 12 triodes to do the preamplification, phase splitting and signal conditioning. In the B model he had simplified that to half as many triodes. The C model, picks up the thread from the first model, only here Johnson uses op-amp’s to do the job. I have chosen the most simple of these models as an example of my observations. Let’s have a closer look at the B model.



Above is the **Audio Research D-79B** schematic. I have not left out a single component, this is indeed the naked amplifier. The meter circuit are not drawn and Johnsson often decoupled his capacitors with small caps in values of a few picoFarads, these are not drawn either. The amplifier consist of something as unusual as three and a *half* stage ! The “half” stage are marked with yellow. We will get back to that later, as it is usually best to analyze an amplifier circuit from the output and backwards.

The secondary of the output transformer is grounded at the 4 Ohms tap and this serves two purposes:
1) Balanced loading of the 6550 cathodes.
2) Balanced feedback to the E83CC differential amplifier.

The 6CG7/6FQ7 driver is a modern noval version of the 6SN7. The 10k potentiometer in the plate network allows us to adjust the AC signal balance. The driver is DC coupled from the ECC83 of which balanced feedback is applied to the cathodes.The cathode potentiometers of 20k, allow adjustment of the bias for these two stages. The output and these two stages are all balanced. (Bridged or differential – whatever you prefer to call it)

This part of the amplifier is indeed wonderful and intelligent design against mainstream. Most similar circuits uses single end global feedback taken from one of the “positive” taps at the output windings.

I produced a series of KT88 mono blocks in the 1990’s and when I finally ran out of the good G.E.C./MO-valve Gold Lion KT88’s and had to switch to the US made 6550, I learned from experiments that the US 6550’s sounds best and lasts longest at about 450 Volts. I am certain that Johnson knew that too, but he decided to go for a 100 Watt design, hence the 600 Volts. You might question the 600 Volts applied to the 6CG7 drive (max ratings 300 V) , but Johnson really needed a lot of Voltage swing in order to drive that plate/cathode loaded output stage. A 12BH7 and/or step-up trannie would probably be a better solution. Talking about high Voltage – I do not like the idea of a potentiometer with 600 Volts at the center tap, I would rather place it at the cathodes or entirely avoid it. Anyway – these are subjective opinions of mine – and this is a William Johnson design – shut up, my self.

The thing about the AR design that really puzzles me is the phase inverter. For reasons I shall unfortunately never comprehend, Johnson chose to most weird solution for the phase splitting that I have ever seen. He took one part of the input signal directly to the diff. ECC83 stage, but the other part he directed to the utmost incomprehensible obscure detour in the history of audio. In order to achieve a signal of the opposite phase he passed the signal through an ECC83 triode of high amplification. Obviously as this would degrade the high freq response, he added a 6DJ8 cathode follower of high input impedance and low output impedance to deliver the signal for the next stage. In order to reduce the gain for the whole mesh to 1 as it should be, Johnson decided to establish direct feedback from the cathode follower output to the grid of the ECC83. Yet another capacitor to isolate the DC potentials. Can you believe that ?

I have tried my best to come up with just the tiniest little reason for this circuit, but I cant find any. Heck, if it sounded better than a “regular” phase splitter – or even just as good , I would accept it. But it does not – neither is it cheaper, easier or anything else – it is just plain wrong. Johnson adds a little noise, some distortion and a slight phase shift to half the signal for no good reason at all – nothing is gained by this solution.

There many better ways of doing it – in fact the best solutions are right at hand. Let me show you……



Fig.1 Here I have deleted one triode and some other components (Not least the extra capacitor). Apart from that it is the EXACT same amplifier as before. But we now have two symmetrical signals of opposite phase. In other words a “real” phase splitter. This one is the Concertino, Cathodyne or split load phase splitter. Yes, it goes by many names. The cathodyne or a transformer are some of the best phase splitters we know of – if made properly – that is. Just about any triode can do the cathodyne job. The precision of the phase splitting are determined by the match of the plate and cathode resistance. 1% resistors are fine. 22-47k will fit most triodes. Just remember to add the auto bias resistor to the plate resistance or deduct it from the lower resistor and you are there – simple as that. It is a common myth that the cathodyne are asymmetric or that the Z-out is different between the two half. It is not so – the plate output is in parallel with the plate resistor and the series string of the tube and cathode resistor. The cathode output is in parallel with the cathode resistor and the series string of the tube and the plate resistor, hence they are equal – except at very high frequencies.



Fig 2 indicates a Schmidt or long tail phase splitter. This one is also almost present in advance with only a few minor allocations of the resistor network. I would suggest that R1 and R2 are replaced by a simple FET constant current source. The negative Voltage are already present. This applies to the circuit in fig1 as well. Grounding of the grid circuit – if possible, depending upon which method chosen – may delete C1. A floating paraphase phase splitter is possible as well, with just as little effort (Not shown), but these are not really good in HiFi amplifiers. Feedback may be applied to any of the two stages – even to the grid circuits if one prefers such a radical solution.



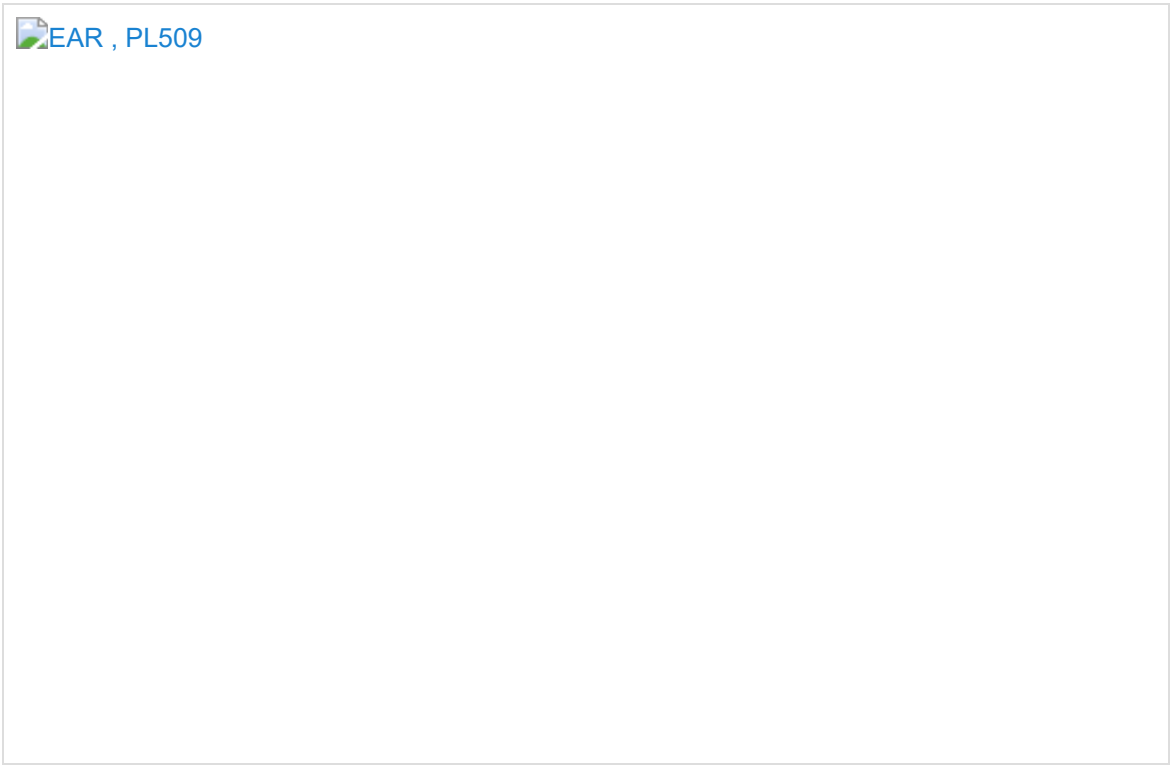
Fig 3 . This is just to show that without any feedback or very little to the cathodes of the diff. stage – a shorter signal path is possible. We may run into difficulties in driving the output to the full in lack of gain/Voltage swing.



Further gain would be accomplished by adding a common input stage as shown in **Fig 4** – and then without realising it , we have made a Williamson amplifier..he he…. I can understand why Johnson did NOT wanted to bring such quaint design to the show , when he reintroduced tube amplifiers in America.

I would loved to have met Johnson and discussed his intriguing and weird design. There is so much unused potential in the Audio Research amplifiers – it would have been a unique privilege to be allowed to design an AR amplifier, based on the basically splendid ideas of Johnson. Sadly this will never happen as Johnson passed away recently – 2011. Well, it would never had happen anyway – but it is good to have dreams ;-)

Rest in peace, Mr. Johnson – I am sure you are at the *high end* up there.



Esoteric Audio Research PL509, PL509PP, 1976

This was the first *real* valve amplifier I had. – Well, I had an ex-jukebox EL84 PP as a kid and several guitar amplifiers, but this amp was an ear opener to me in the late 1970's. I got it from Tommy Horning (Horning Hybrid), who got it from Peter Qvortrup (Audio Note, UK) back then when he was still living in Denmark. At that time, I use to have Luxman and similar "semi high end" solid state gear (I was a great fan of Luxman) and it was a revelation to hear this unusual amplifier. It sounded dramatically better than any of the Luxman, Denon, Technics, Marantz etc. I have had previous to that day. I cant remember if it was when I had my huge JBL system or if I had swapped to the Magneplanar MG-IIB's at the time, but I loved these PL509 mono blocks.

The PL509 power pentode was made for television line deflections. It is a very tough valve capable of pretty high current if needed.(I seem to remember 1,4A peaks and even more when "pushed")

As much as I love hand drawn schematics, as difficult they are sometimes to read. I missed a few important details while analysing the circuit in this schematic, hence decided to clean it up and draw a new one. Hopefully this is a bit easier to read.



The circuit of the amplifier is quite similar to McIntosh's unity coupling and to a contend Walker's balanced QUAD's, but wears the indisputable signs of Tim de Paravicini from that period.

I am still writing and editing the analyse of this amplifier- more to come.

The PL509 amps are good amplifiers – but they do need a little care and modification in order to bring the best out of them.

It was designed by **Tim de Paravicini** and I suspect that the the old original hand drawn schematic are by Tim's pen. I would like to use this opportunity to celebrate Tim de Paravicini. When I first saw the Michaelson Austin circuit I immediately recognized the similarity to the EAR circuits. At the time I knew nothing about Tim, but I realised that there had to be a definite thread between these

two amplifiers. I learned many years later that Tim de Paravicini has engineered several amplifiers for Michalson and Austin, Luxman and many more. I seem to like the TVA's a little better from the point of view of simplicity. But all that Tim de Paravicini touches seems to come out as high quality audio items.

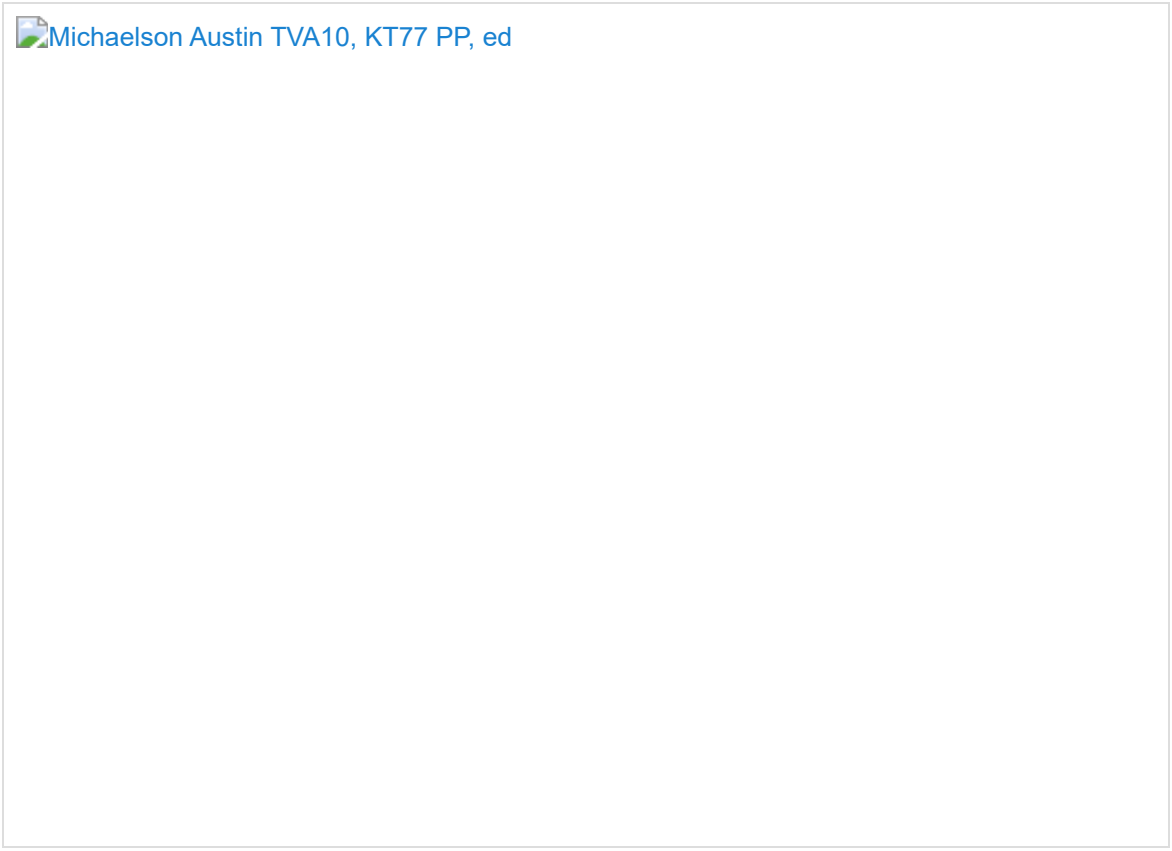


BEARD P100 mkII, KT88 PP, 1970's ?

The circuits I have come by from Beard shows a remarkable familiarity with the signature of Tim de Paravicini. I do not know if the P100 was indeed engineered by Tim or if it was just inspired by Tim's work.
I had one of these in the workshop for repair several years ago (1994 or so). I modified it and it sounded like a dream. I can't remember anymore how it sounded before the modification, possible

because it was dead (I don't think I did much modification to it), but I kept it in my lab as long as the customer allowed me to do, simply because it sounded SO good. I wonder if it was equipped with Partridge OPT's ?

I seem to remember that the customer came back some weeks after collect and gave me a bottle of good red wine. I guess he agreed with me and that is always nice.
Update: I have found the notes of my BEARD modifications. I will upload these later on.



Michaelson Austin, TVA-100, EL34PP, Stereo ,

This design are very close to Tim de Paravicini's EAR circuit above and it is easy to spot Tim's "trademark". I once had one of these and I was quite happy with it, although the bias network needed a modification rather badly.

PAPWORTH, M200, 4xEL34PP

The Papworth's are very close clones of Tim's circuits. I will upload the schematic and some mod's I once did, not least a dedicated regulated PSU for this amp, as soon as I find my papers and notes. Stay tuned…….



Bill Perkins:

Audio Research D250; many 6550 PP, Stereo , 1983

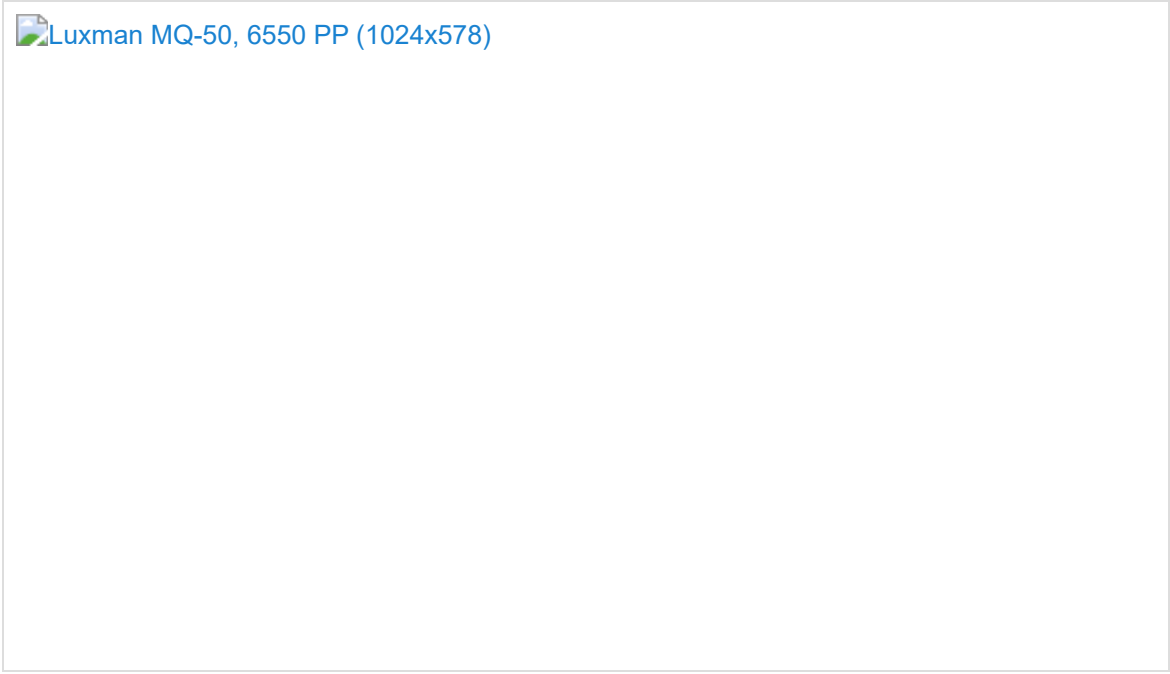
Massive monstrous tube stock machine…..Is it like 20 piecessss of 6550's….?

May be bridged to half a kilo Watt….. (= you need a better speaker…or ears..)

Not my barrel of tea….

I cant remember if I have had any of these in my workshop…Audio Research'ers were regular patients in my tube hospital. Boy – I ended up almost fearing them….Heavy monsters, lots of PCB mounting and solid state and op-amp for regulators, relays etc. Not at all easy to repair. Modern AR's are not particularly good engineering in my book. (post 1980 or so).. I have modifies SO many AR's in my time…All I did was to REMOVE parts and rearrange into proper engineering….They always sounding and measured better after a serious overhaul.

But this D250 is a serious HEAVY one and needs to be on this list.



Luxman MQ-50, 6550 PP, Stereo , 1983

I think it is quite appropriate to end this vignette series with a Japanese amplifier. The MQ-50 is one of Luxman's better tube power amplifiers. The input is a differential ECC82/12AU7 amplifier performing phase splitting as well as gain. A negative supply insured high impedance at the cathodes which improves the balance. A Constant Current Source would have been even better. The global feedback is taken from a separate winding at the OPT and this restores the balance. Note, the funny little error at the schematic indicating +487V at this winding. Of course there is no Voltage potential here.

once had one and although I modified it quite a lot it was actually good – even straight from the shelves. The Luxman iron is good, albeit tiny…. When studying this design I smell Tim de Paravicini. I do not know if it is indeed a design from his hands, but it sure looks a lot like his favorite circuit and I know that Tim worked for Luxman around this period. The building quality was not bad at all, but certainly not very rational either. The parallel of three resistors to form a 25k6 resistor is "over-engineering" and reminds me a of Audio Research. A single 27k resistor would do perfectly here – valves are not 1% items, neither are they that case dependent. I do remember lots of small silly PCB's inside these Luxman's many of them seemed more time consuming to solder on to, than simply wiring the stuff. But there you go. The size of the Lux' iron was always on the low side, but I really liked the look of them.Luxman made a lot of tube amplifiers, most of them rather mediocre. I have serviced many of them the worst one being a 50CA10 – so called triode. Boy – what a piece of ..eh..not good….But it looked good.

I have also owned a CL32 and CL34 pre-amplifier. These were no good either, but – they looked good. Luxman on the other hand made a lot of real good transistor amplifiers and as said – they all looked good. (I still have one of them)

Luxman started as a transformer manufacturer and it is ironic that they entered the HiFi market with an OTL amplifier – at least according to rumour. Anyway – I like Luxman and this MQ-50 is a rather decent tube amplifier. And it LOOKS good . Period.

I simply HAVE to mention **C.G. McProud**. He made several interesting amplifier designs and wrote a good deal of interesting articles and books.
But first of all – C.G. McProud founded the Audio Engineering Society. (Magazine Audio, later AES)
I can not think of any one person of whom had such a huge impact on audio.
Hats of to McProud. (What are the C G ? Carvin Gregory ?)

I will leave the solid state amplifiers to another, Joe.

Quotations from the Sound Practice Joe's that helped me making this list:

J.C. Morrison : "Acro 20/20 and the Brook 12A… two amazing PP amps better than any old SE in my book. The Acro UL2 is also worth a mention, mainly because it is the basic amp audio research, Conrad Johnsson, in fact all modern UL pp EL-34 and 6550 amps are based on, and rarely equaled. Even the Citation II, which is Harmon Kardon's copy of the Acro amp, is really good… some "high end" companies just bought old Citation II's for the power and output iron. rebuilt them as their own. Copied from Keroes..and for solid state, you can't leave out the ML-2 (john curl's 20 watt SS amp). Even today that is a badass amp. and the TNT-100 from Acoustat… one of the best early SS amps."

Guido Tent: "For the "no valves inside" section: Hypex n-Core"

Bill Perkins: "Favorite amps at my house are the Altec 260As, modified; the Altec 1520s, also modified; the original Audio Research D150(?), which was their first seriously large amp; and the subsequent D250. I liked the ARCs for their tremendous low-end performance and their spectacular 3D Imaging. Alos, and unlike most, I quite liked the ARC D100 — their first foray into s/s — BUT not until completely rewired with the old, round Cobra wiring was shit for literal decades, and pretty much trashed the sound of much of what they made.

Francis Stephanik:"count me in with my hard to beat Sid Smith's amps
(1947) RADIO CRAFTSMEN RC-2,PP 6V6. Sweet,musical,simple! And musical, RADIO CRAFTSMEN model 500,KT66, (1950)best OPT's by far……test selected by US NAVY. Time before Marantz.

While we're at it listening, right now pair of David Bogen's PX-15,PP6L6, (1951) premier flagship amps.
They are my top picks.

Have
fun,

Francis St.

Joe Roberts:
Once I started writing a book on this topic, finished vignettes of 10-15 amps, then lost it all in a Mac crash, along with a half-edited issue of SP.

I'd add: 1926 Daven RC amplifier, That ugly brown RCA 245 PP amp from 30s consoles….forget the model # EH Scott PP amps–the first home hi-end audio , Hallicrafters HT-5/BC-614 speech amplifier WE Beachmaster, Early McIntosh unity coupled 15 W, 30W, etc
Altec 1420A, Peerless A-100A ,Fisher 50A. Western Electric covers most of the primordial specimens of tube topologies.

Many of the most important designs were not products but published DIY circuits, including tube manual circuits and transformer catalog amps (UTC, Thordardson).

Al Marcy aka "Happy Ears" :
I started this insane hobby, ~twenty years ago, when I bought two Fisher amps from a TV repair shop, in Phx. X-202-B and X-202-C. Both were way better than my Sony receivers… but, the bias circuits both had problems I did not know how to fix. I got tired of buying new 7591 tubes. I decided to learn to fix tube amps. I figured I would build a few to get the idea… my first 6BM8 SE blew away the Fisher's. We all learn what we learn, even if it is not what we intended to learn.

Products are business transactions. Homebrew Audio is another transaction, entirely. Western Electric built great tubes and amps and speakers and made tons of bux providing early movie theaters with technology, on lease, and trained the operators and everything. They did business the old fashioned way… very well.

WW2 introduced "systems".

We are living with the consequences. (We may each puke when whenever we need to puke, dig?)

There are still some great artifacts laying around.Some folks renovate old cars. That is fun, but, it was even cooler to customize cars, back when…

"Different strokes for different folks…and so on and so on and skoobie doobie doobie…"

Happy Ears!

This ends the compendia of 100 amplifiers to lift your hat – but I am continuously editing and adding new stuff. I might follow up with a series of recent designs, but contemporary designers has

a silly habit of considering their schematics as “top secret” secret secrets. I do not know why, as anyone who wish may draw the circuit directly from the amplifier in a matter of hours. Modern companies claims copyright of their designs to such a degree that they seem to want the schematics to remain invisible ? They do not seem to understand that schematics in public are one of the best possible advertisement they could ever wish for. Peter Qvortrup of Audio Note, understood this very early on and he took care that lots of Audio Note schematics were publicly available . He is still in business, while many of the secret companies has indeed turned very secret. (Read: closed) The same service friendly and sympathetic approach are conducted by Audio Research, Fender; McIntosh and Marshall. Schematics are available from the homepages of these companies at no cost for the users. A copy made by an DIY of *any* amplifier from these companies is an ambassadeur of the product and it will promote the sale from these companies. It really is as simple as that. Personally I prefer to recommend products of which the relevant schematics are easily obtainable.