The Wayback Machine - https://web.archive.org/web/20190326181315/http://lilienthalengineering.com:80/100-amp…

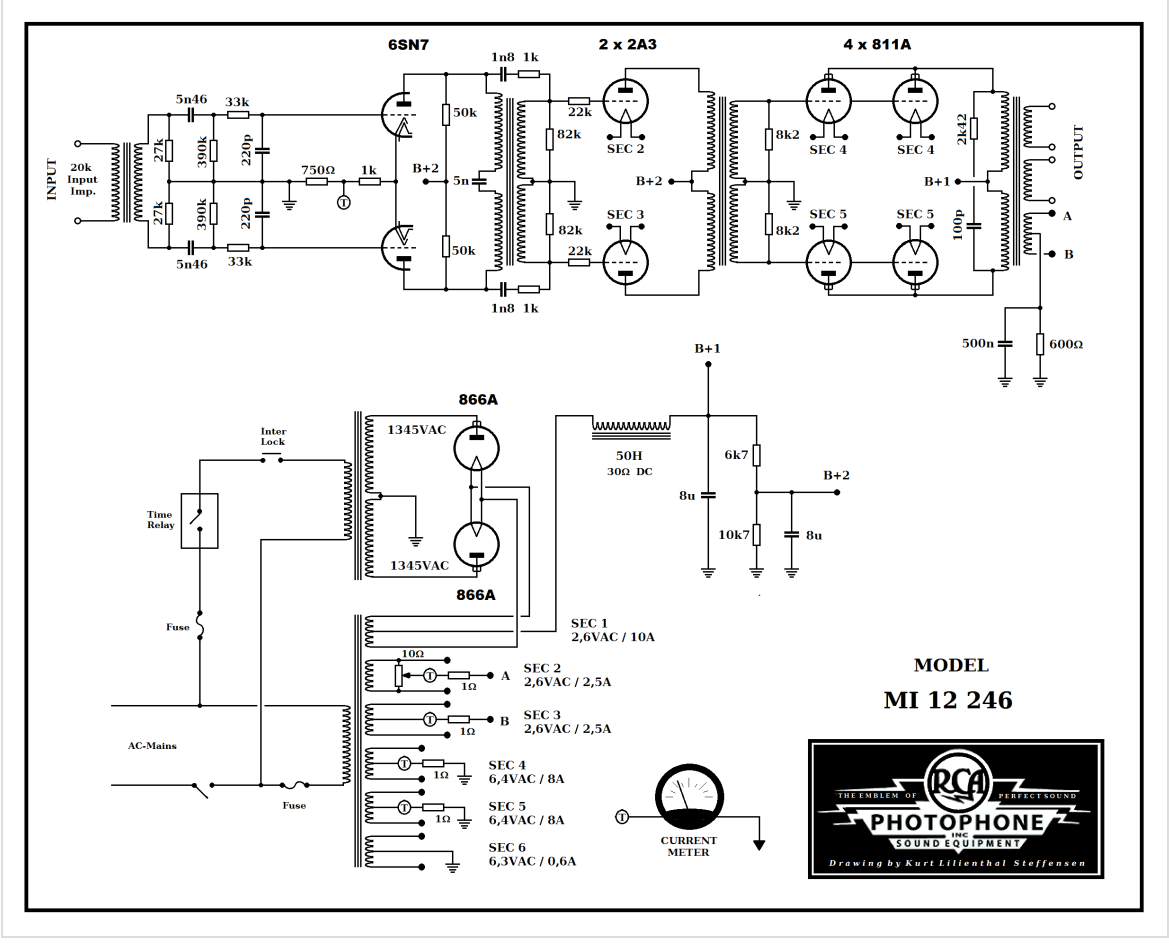
Lilienthal Engineering

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

100 Amplifiers, part 2 , 1945 – 54

This compendium is often updated with new information or otherwise edited as my spare time allows. Please, send your comments to: 100amplifiers at gmail.com

---



RCA , MI 12 246 , 811A PPP , 1941-50

Beautiful beautiful beautiful……

Input step up transformer – resistor voltage divider phase inverter (VERY simple) – 6SN7GT medium mu triodes – interstage – 2A3 power triodes – interstage – 811A power triodes – output transformer. Nothing more, nothing less.

Power supply is: Gas rectifiers 866A (similar to 3B28) – swinging choke – two capacitors – two resistors. Nothing more, nothing less.

How can you not like this amplifier.

Despite the minimal consumption of parts, this is a very expensive amplifier to build. The mammut swinging choke alone (50H and 30 Ohms copper resistance !) will cost and weigh as much as the average supermarket HiFi system. The main B+ power transformers is huge and expensive as well. Output: 2690 VAC ct. ! The filament transformer is an absolute minimum 140 Watts ding.(I would design for twice that) Then you have the huge output transformer…….Then three audio signal transformers….and finally the tubes and other components. Metal work, finish, labour and a fancy current meter…

Stereo ? ….Times two……

Expect a *component costs* at a minimum of $6000,- for a stereo set (2015 prices) – then consider how much it would cost at the consumers market…I would not even consider to build this thing for a customer of less than US$ 30.000,- . No wonder we do not see many of these animals around anymore.

Let’s have a closer look at this ambitious project.

MI12 246 was obviously meant for pro use. The design is pretty straight forward, but compromises are kept to a minimum. The input impedance is 20kΩ, which – in my opinion, is perfect even for modern use. I consider pre amplifiers or line sources that can not handle 20kΩ as bad engineering.

Due to the inductive loading of the transformers, all stages provide maximum gain and lowest possible distortion. I can not calculate the actual overall gain as I do not know the actual transfer ratio of the transformers, but we do know from experience that it is high in these vintage constructions. Quite a lot higher than necessary for modern use. Do note the clever use of feedback via the 2A3’s through the output transformer. This is actually bridge feedback in the double sense ! It is bridged due to the balanced approach, but it is also bridged in the sense of current and voltage. This equals to power feedback. I thought I was the only one on this planet to use power feedback. There is nothing new under the sun.

The filters at the input removes unwanted lows and highs. Keep in mind that this was a PA amplifier, even capable of driving mono groove cutting systems. The filter at the first interstage, primary to secondary, is either cancelling or transferring high frequencies. (I can't tell as I do not know that actual phase of the windings). Instead of using two capacitors from the plates of the 6SN7 to avoid DC current, the primary winding is split and only one capacitor will do the job. Simple and elegant. The filter at the output stage compensates the merits of the OPT. It would not be necessary using high quality modern alloys, materials and know how.

The "T" marks indicates test points to monitor the idle current.

The slightly higher filament voltages given, is due to the quality of the copper wires, soldering and main cables back then. It was not unusual to specify the filament transformers such, in particular for pro or military use. The "Interlock" switch is meant to save the life of service personnel, should the lid/door accidently be opened while the amplifier is on. It was given by law – still is…..

My only objection to this monster amplifier, is the class B output stage. It is hard to complain about it, as this was a high power amplifier designed for daily abusive use. Could be a day at the races or repeatedly running "Gone with the wind".

The 811A is a zero grid bias transmitting triode. This means that it can't run in class A. The amplification factor is – now hold on – 160 !!! A pair of such will output some 200 Watt's in class B. The Mi12 246 uses four such, hence about 400 scary triode Watts. The primary impedance of the actual OPT will be some 5-8k Ohms. The size will depend upon the lowest specified power frequency. But even at 30Hz , as it probably is , the size and weight is monstrous.

It would be possible to convert to 812A's. This is a similar triode, gain factor of 29, it would still need to run in class B, but at least for low range would be class A. This modification would mean that you would have to use either active bias of some 40 Volts or one common or two individual cathode auto bias resistors. I am sure this will improve the quality at the modest cost of some gain. It would also be possible to use DA41 or DA42 triodes, although you would need to add a little voltage in series with the 6,4 winding of each output side. The DA's use 7,5 Volt heaters.

It IS actually possible to modify this beast to a PAIR of 211's or 845's, class AB, or – if the main transformer can handle it – pure class A. Again you need to add some volts or use a separate filament transformer of 2 x 10VAC and – of course – swap the sockets to Jumbo. Cathode resistors or active bias. A pair of 211's or 845's will immediately accept the primary load.

The time delay relay is vital, as the gas rectifier needs to warm up, before the AC voltage is applied.

I shall say this only once……A high voltage amplifier such as this is an expert task. Deadly voltages are present all over in such a construction. You have to be a trained professional to deal with such an animal. The possible lethal pitfalls are way too many to list. The same goes for repairment, service or modification. Do not go into such design as this, unless you are an experienced pro. Even then – think twice, my friend.

Hats off to RCA……



Williamson (Cocking and the WW team) , KT66 PP, 1947

– this is the most copied audio circuit of all times and most certainly one of the best circuits ever made for audio.
Perhaps a copy itself of Mitchell's
circuits @ 1945 according to **Jean Hiraga** ? (I need to look further into that)

The Williamson design was the culmination in a series of articles brought in WW under the name "The quality amplifier". This series of articles began in 1924, lead by W.T. Cocking.
David Theodore Nelson Williamson was employed by MO-valve, England and later by Ferranti , Scotland until 1960. The Williamson amplifier was never patented or commercially produced by Williamson , but appeared as an article in the Wireless World
magazine in 1947. Williamson was, at the time when the amplifier was designed, employed by MO-valve the maker of KT66, B65 and 53KU and this could very well explain the generosity. According to sources MO-valve had an intern paper with the Williamson design as early as 1944.

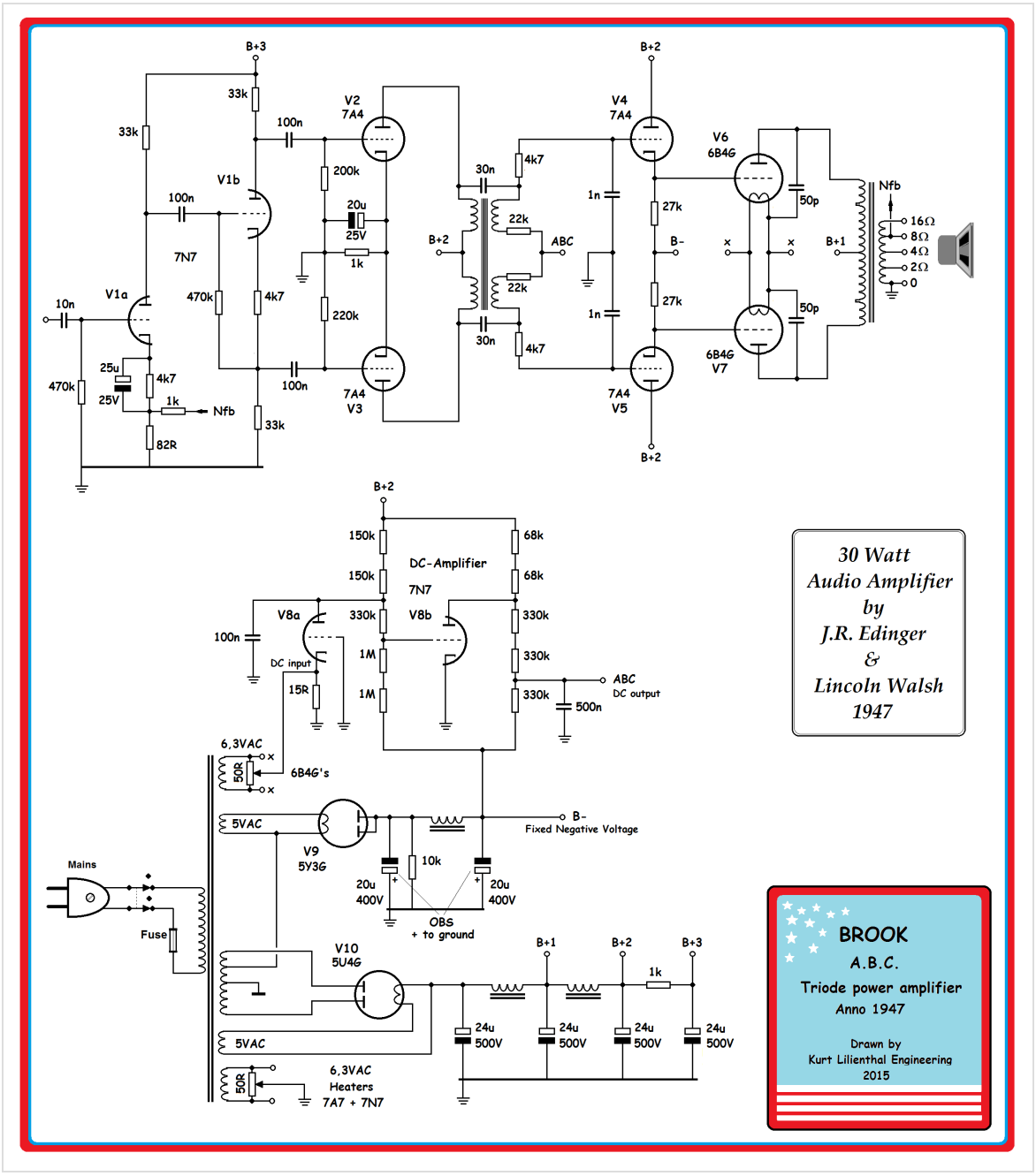
Looking at Cocking's design a few years earlier it is almost impossible to imagine why it should be such a landmark to imply a thing as simple as a preamplifier before the cathodyne/concertino/split load phase splitter. After all, what we need to make a good PP amplifier would be: Output stage, driver, phase splitter and a pre amplifier. Williamson did just that. The first stage pre amplifier are DC coupled to the cathodyne phase splitter that feeds the driver with an almost perfect signal of opposite phase. By means of a good and well designed OPT and the relatively simple design, it is possible to apply a great deal of global feedback and these are the main causes for the good performance and characteristics of the Williamson design.

The amplifier often appeared in US magazines based on 807's as output valves, likely because of the vast supply of post war surplus 807's. Some two years later a slightly better version was published in Wireless World.
The circuit is a masterpiece in simplicity and audio engineering. It was not a perfect design though, nothing is, – improvements are possible. I go into this in depth in my article "Hunting the ultimate Williamson". To this day, however, the Williamson design topology is one of the best for high quality audio.

The Williamson amplifier became a legend and an icon and it is very well deserved..

Hats full off and down to the ground, Gents….We owe a lot to Williamson, Cocking and the team at the Wireless World magazine.

Update: I have recently come by further exciting info about Williamson and his famous amplifier. Turns out it is older than we use to know and that it was originally made with PX25 triodes. More to come about this later.



Brook, A.B.C. , Triode Amplifier, 6B4G PP , 1947.

It took a while for me to find a good schematic, then another while to draw it into something possible to read, but here it is – in all its pride and joy. It was designed by J.R. Edinger and Lincoln Walsh. You might not believe it , but this amplifier is yet another **Williamson** circuit.

V1 is a 7N7 twin triode and represents the recognizable part of the Williamson. V1a acts as the voltage amplifier and V1b is the phase splitter. The 33kΩ working resistors makes it a fast version at the cost of a little gain. V1a is not DC coupled to the phase inverter, as is otherwise usual, but this allows us to use a higher voltage, hence reducing distortion. The extra capacitor, reduce the possible amount of feedback.

The input to the amplifier is restricted with regards to low freq and DC blocked by means of the 10n capacitor at the input terminal. This is actually a good idea as frequencie below some 30Hz is gradually doing more harm than good in a audio system. I would, however, much rather deal with that by means of the capacitor between the input Voltage amplifier and the split load phase inverter.This is indeed a better place to limit the sub frequencies. A capacitor of 10n or perhaps even lower would do fine here.

The third stage V2, V3, V4 and V5 – is the driver. It is made of a balanced set of 7A4 triodes, transformer coupled to the 7A4 cathode followers. Although it may look as two or three stages, it actually only counts as one stage. The output from the V4,V5 cathode follower is DC coupled to the input of the 6B4G's. This means that the *cathode follower* sets the bias for the 6B4G's. This is important to understand as this feature is part of the Automatic Bias Control., The bias at the input grids of the cathode follower is controlled by the output of the DC amplifier. The DC voltage at the cathodes of the cathode follower, simply decides the current through the 6B4G's.

The 6B4G power triodes are practically grounded. The parallel function of the 500 Ohm heater/cathode potentiometer is 125 Ohm,. This resistance is in series with the 15 Ohm current sense resistor, making a total of 125 + 15 = 140 Ohms – for both tubes, The bias voltage needed to control the 6B4G's, must be negative with reference to the cathodes of the 6B4G's (-40 to – 60V or so) , which means that the cathodes of the *cathode follower* must returned to a negative voltage via the 27k cathode resistors.

The two input grids of the cathode follower is common from a DC voltage point of view. This means that the DC voltage supplied to the grids of the cathode follower via the center tap of the secondary of the interstage transformer, sets the bias for both the cathode follower and the power output stage.

The output stage is a pair of direct heated 6B4G triodes. 6B4G is an *exact* equivalent to 2A3, 5930 and 6A3, apart from socket and/or heater voltage. It is also possible to use indirectly heated triodes such as 6B5G or R-120, as these are both otherwise very similar to 6B4G. This would mean that the cathodes should be connected directly to the 15 Ohms current resistor.

This interstage circuit is not the only unusual factor about this amplifier. It is equipped with a rather clever Automatic Bias Control , hence the short name: "ABC". The ABC circuit was invented and patented by Lincoln Walsh, some years previous to this amplifier.

The ABC circuit is handled by V8, yet another 7N7 twin triode. This circuit may be considered as an error amplifier in the sense that it "corrects" the bias for the output tubes. In this case it means that it provides a gradually shift of the output stage, from class A into class B. As the input signal increases the current through the two output tubes, the voltage over the current sense resistor increases as well. This DC potential is amplified by the error sensing circuit made of V8. V8 is in other words strapped as a simple *DC amplifier*. The output of this amplifier , marked ABC, controls the bias for the cathode follower, hence the bias for the output tubes. The audio signal is decoupled from the amplifier at about 5Hz, due to the input capacitor and yet decoupled once more at the output.

There is several issues we would need to address in order for such a servo controlled bias network to work properly. I has to stay away from the audio signals to prevent it from introducing distortion in the form of “false” signals blended into the original signal. In order to remove the audio signals from the error amplifier, we need to make a LF pass filter – it is here made as a parallel filter by the 10n at the input and 500n at the output of the DC amplifier. Such filter, as used in this amp, may be said to contain an attack time as well as a release time. How do we make a proper compromise, between these three different demands by means of a single capacitor or to be specific , two such in series with the signal.

The circuit in this amplifier, does not provide any corrections with regards to AC and DC balance. There is to some degree a balance adjustment possible with the 500Ohm heater potentiometer at the 6B4G’s. But this is common to these tubes and the AC from the 6,3V heater winding is blended in here in a rather random manner. I have no idea about how well, this circuit actually works. In a way Alan Blumlein made a similar circuit in the 1930’s, although extremely simple using only two resistors. This circuit, does not shift between class A and B, but it automatically adjust the bias as well.

I will one day, build this amplifier and compare it to Blumlein’s circuit and the auto bias circuit made by my good friend Guido Tent and Menno Vanderveen, Netherland.
: www.tentlabs.com/Components/Tubeamp/page24/page24.html

7N7 is equivalent to 6SN7, except for the Lock-in socket used in the 7 series. The Lock-in socket is electrically superior to the Octal socket, due to lower capacitance and socket losses, but in practice it is a little troublesome to use. The 7A4 is equivalent to 6J5, except for the Lock-in socket. (6SN7 is a twin version of 6J5) Should be mentioned though, that the 7N4 uses an improved electrode structure in order to increase the HF response, hence – at least in theory, it is slightly better than 6J5’s and 6SN7’s.

The Brook Automatic Bias amplifier is a unique and good example of high quality audio engineering. I’d say , hats off to Walsh and Erdinger.



(Suggested by Francis)

Craftsmen RC-2, 6V6GT PP, 1947

When I first had a glanze at this circuit, I was happy with it. A total of three stages:Input 6J5 (= ½ 6SN7) , 6SN7 paraphase splitter also acting as driver to the 6V6 PP stage. It is simple, efficient

and it is a short signal path, just how we like it. But then I realized just how silly the DC scheme is within this amp.

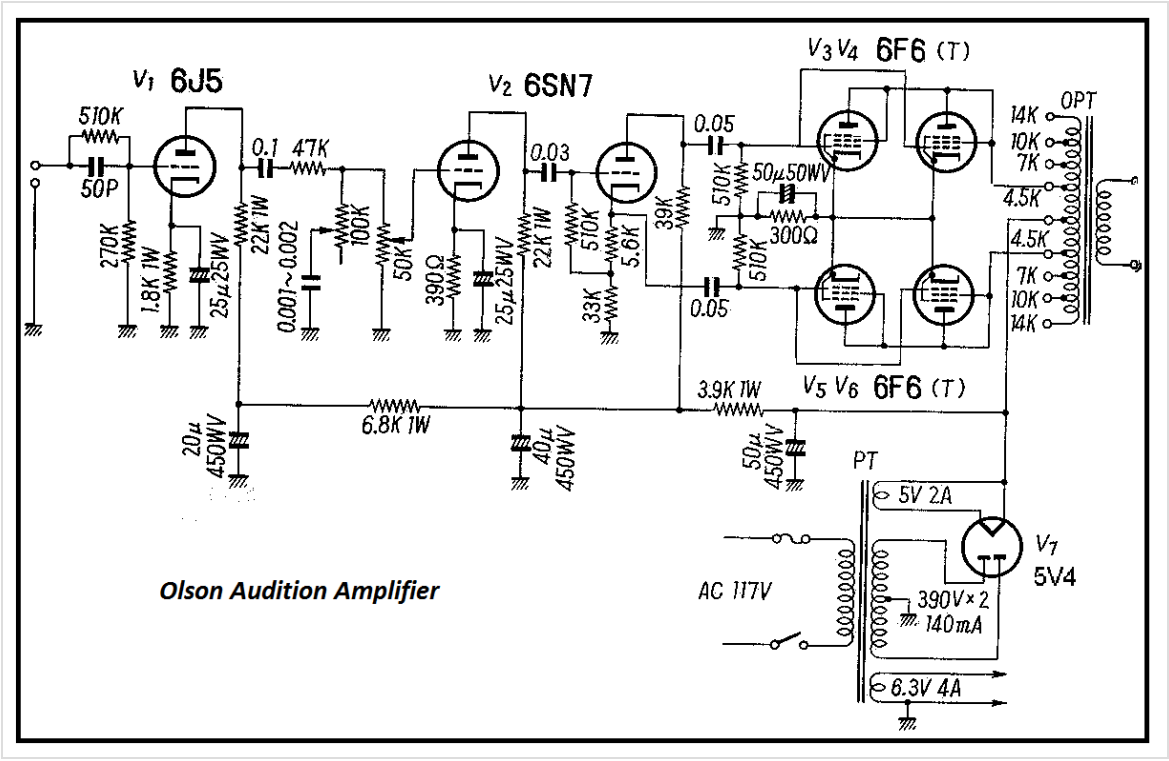
And another thing: The 6J5 is starved, not only with regards to voltage and current, but also due to the low heater voltage. (the 2R2 in series with the heater) It is sometimes a good idea to starve certain tubes , as it may reduce distortion. It is however, an “expert task” to get it right and it may very well be at the cost of the lifespan of the tube in talk. I will get back to the 6J5…..

The paraphase: I reject to the massive 470k Ohm plate resistors, as this clearly under bias the two triodes of the paraphase. It also decrease the HF range, hence pulse and transient response, due to the higher z-out. I suggest to reduce these two resistors by a factor 10 or so. Do also note the voltage divider of 47k to 1k at the cathode of the 6SN7G input. ?

What the heck is going on with this Craftsmen ?

The 6J5 input: The input 6J5 is equally poor set, 90 V – 19V = 71 Volts at the plate…..Why ? The bias is set at -11 Volts……Why ? ….. I also wonder about the purpose of that extra cathode capacitor, thus placing the input grid at a positive Voltage potential…..? Get rid of that silly 4k7 resistor and the 47n input capacitor. Change the grid resistor to 100k Ohm or less and ground it. Change the plate resistor to something between 22 and 47k . But do we really need this input stage ?…..I think not. The fact is that this entire amplifier needs to be redesigned, rather badly.

I might modify the whole shebang and build a new one, based upon the conditions given by the transformers. Stay tuned, but please dont hold your breath.



(Suggested by yours truly)

Harry Olson, Experimental 4 x 6F6 triode, 1946-50

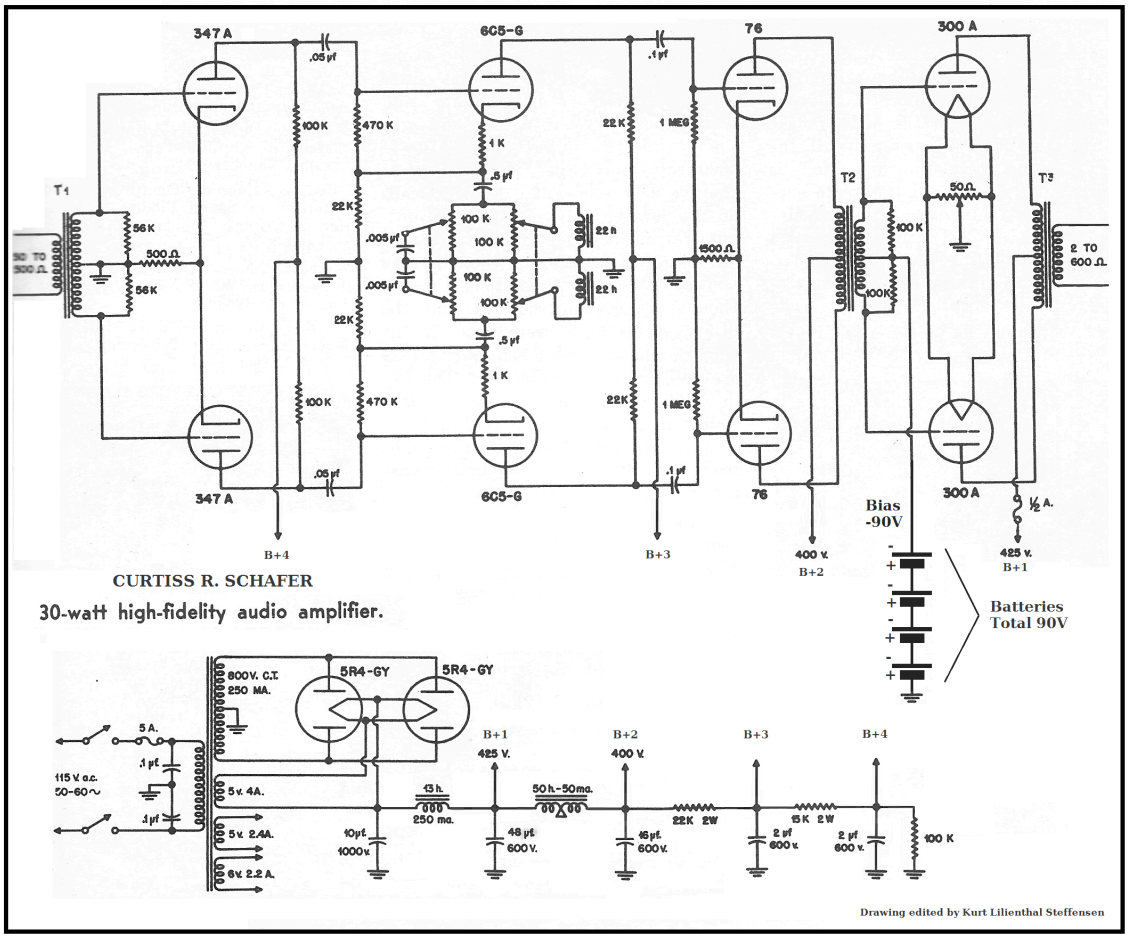
Triode coupled PP non feedback audition amp (1946-47 ?)
Published 1950, used to perform certain psycho-acoustic experiments. Never commercially produced.
Very elegant design. If you look carefully you will see that it is an abbreviated Williamson with an additional input amplifier. Despite 2′ and 3′ harmonic products below 0.4% at 400 Hz up to 7 Watts and against the mainstream – it had no feedback at all. Below 2 Watts the harmonic products is actually below 0.1% !. I need to add here, that I am somewhat sceptical about these figures. They belong from the book about tubes by Jean Hiraga, and I have not yet being able to verify these myself.

The working points are well chosen and the 2 harmonics from the first stage 6J5 are cancelled by the half 6SN7 voltage amplifier stage. 6SN7 is nothing but a twin triode version of 6J5.

The output transformer is RCA 214-T1, intended for universal use.

Tremendous design.

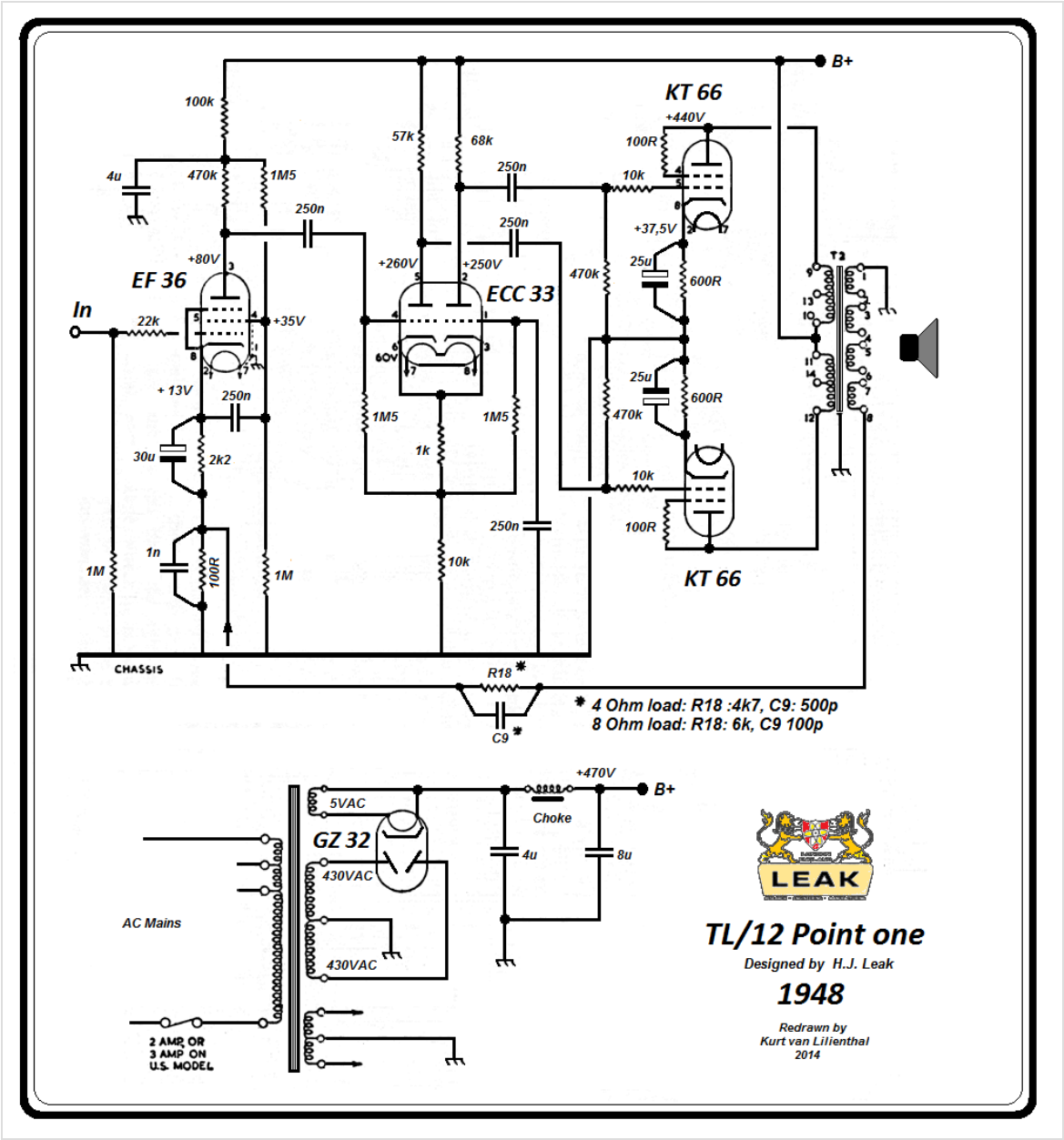
Hats off to Harry Olson.



Curtiss Schafer, 300B PP, 1947, published in Audio magazine.

Cool and well thought through non feedback triode design – against the mainstream. Battery driven bias ! A little dangerous, I would say, but most certainly hum free. I would remove the clever tone circuit and the entire 347A stage. T1 could be a 1:1 transformer. We simply do not need all that gain anymore. I would probably also swap the 5R4's to 5U4's or GZ34's for better regulation. That would also make it possible to reduce the needed AC by some Volts or better yet – make a choke input supply. It is a very nice amplifier , though, and I will dig further into such similar tube driven transformer amplifiers in articles to be published here in time.

Excellent design – I'd lift my hat to this.



LEAK point 1, KT66 PP, 1948

Harold J. Leak, London, England, was the first to release a commercial HiFi product on the market with a THD of less than 0.1%. Hence the name ”point one”.

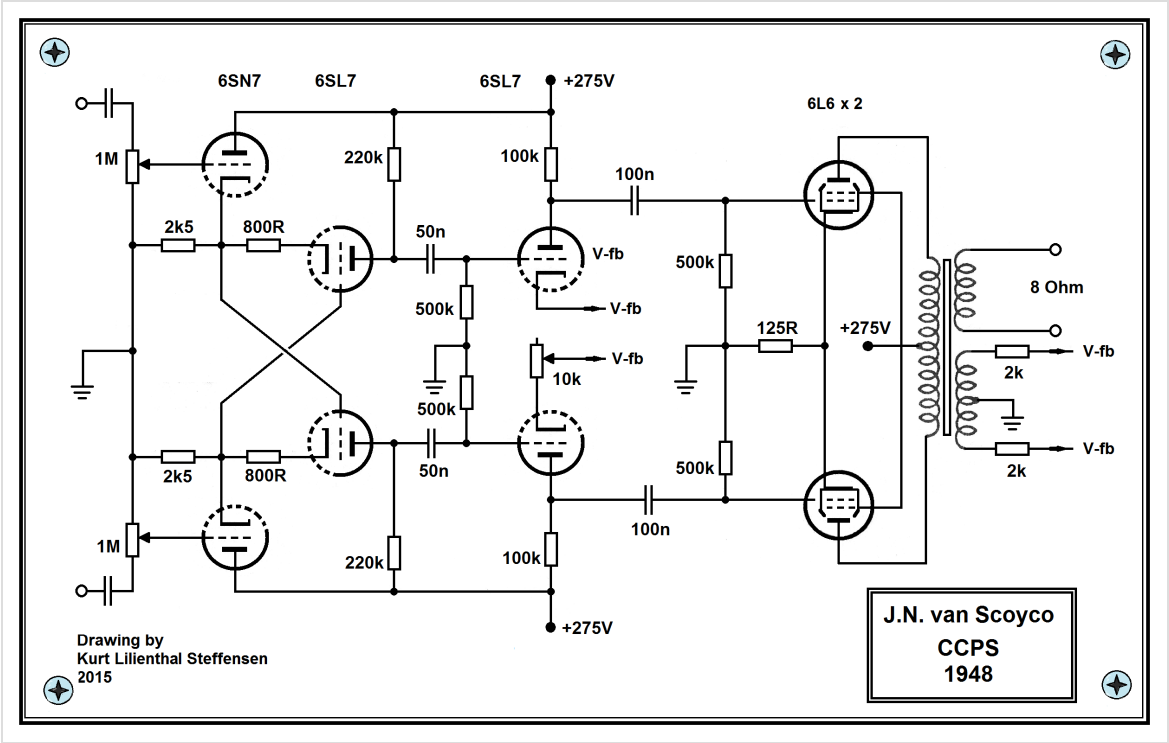
You might wonder how Harold Leak pulled that trick. Well, he did it with excessive feedback due to high overall gain, a good output transformer and a lot of intensive engineering. Simplicity is not necessarily an easy task – far from in fact. Looking at stage one we find that the EF36 are strapped as a Pentode for highest possible amplification. ECC33 is a high slope, medium mu twin triode, coupled with reasonable low plate resistors for better bandwidth to give an additional amplification of about 22, which is nice for a stage being both phase splitter and driver.. Do also note the high value grid resistors at the KT66’s makes them easier to drive. The 10k grid stoppers are there in order to prevent oscillation, due to the high overall feedback. All of this and the fact that Leak only demanded some 12 Watts of output from the triode coupled KT66’s allows the ECC33 to

drive the output stage with a minimum of distortion. A simple, yet efficient solution. Leak supplied a number of “Point one’s” to BBC, often modified for specific purposes.

It is possible to swap the EF37 to EF36 or even 6J7, without any problems. The ECC33 may also be replaced by a 6SN7. And if you do not have any KT66’s at hand you may use a cheaper 6L6GB/C or 5881.If you happen to have an EL37, that one will fit in nicely.

I really like this “Mullard 5-20″ alike design and if you do not care for the high gain, simply strap the EF37 as a triode.

I quite like the later EL84 PP version better, though…But modification is a very good idea.



Scoyco , Cross Coupled Phase Splitter, 6L6 PP, 1948

This is the original CCPS design by Scoyco published in “Engineering Dept.” Nov. 1948. The circuit was not aimed exclusively for audio, in fact phase splitting was only a secondary merit of the circuit. The circuit was developed for instrumentation and investigation of two individual signals, above ground. This is not a task suitable for our common single end input amplifiers. Scoyco’s circuit is a genuine differential amplifier. This means that it amplifies the *difference* between the inputs. Such feature comes in very handy for a phase splitter, thus the widespread perception of it as a phase splitter. It is a highly versatile circuit, capable of countless applications, other vice difficult with traditional amplifiers. But why not ask Scoyco himself to explain the potentials of the circuit……

Scoyco:*" It is often desirable that the input circuit operate with either single ended or pushpull input signals and produce balanced push pull output voltages with either type of input. Low input capacitance and low sensitivity to hum and variations' in plate supply voltages are also valuable characteristics of an input circuit. The cross coupled circuit combines these desirable properties with a large dynamic range of input signals. It will also function as a mixer for 'two input signals giving pushpull output voltages with output voltages which are proportional to the difference of the two input voltages. – Applications in audio systems include combined mixing and phase inversion, novel tone control circuits, and an unusual method of obtaining volume expansion or compression*."

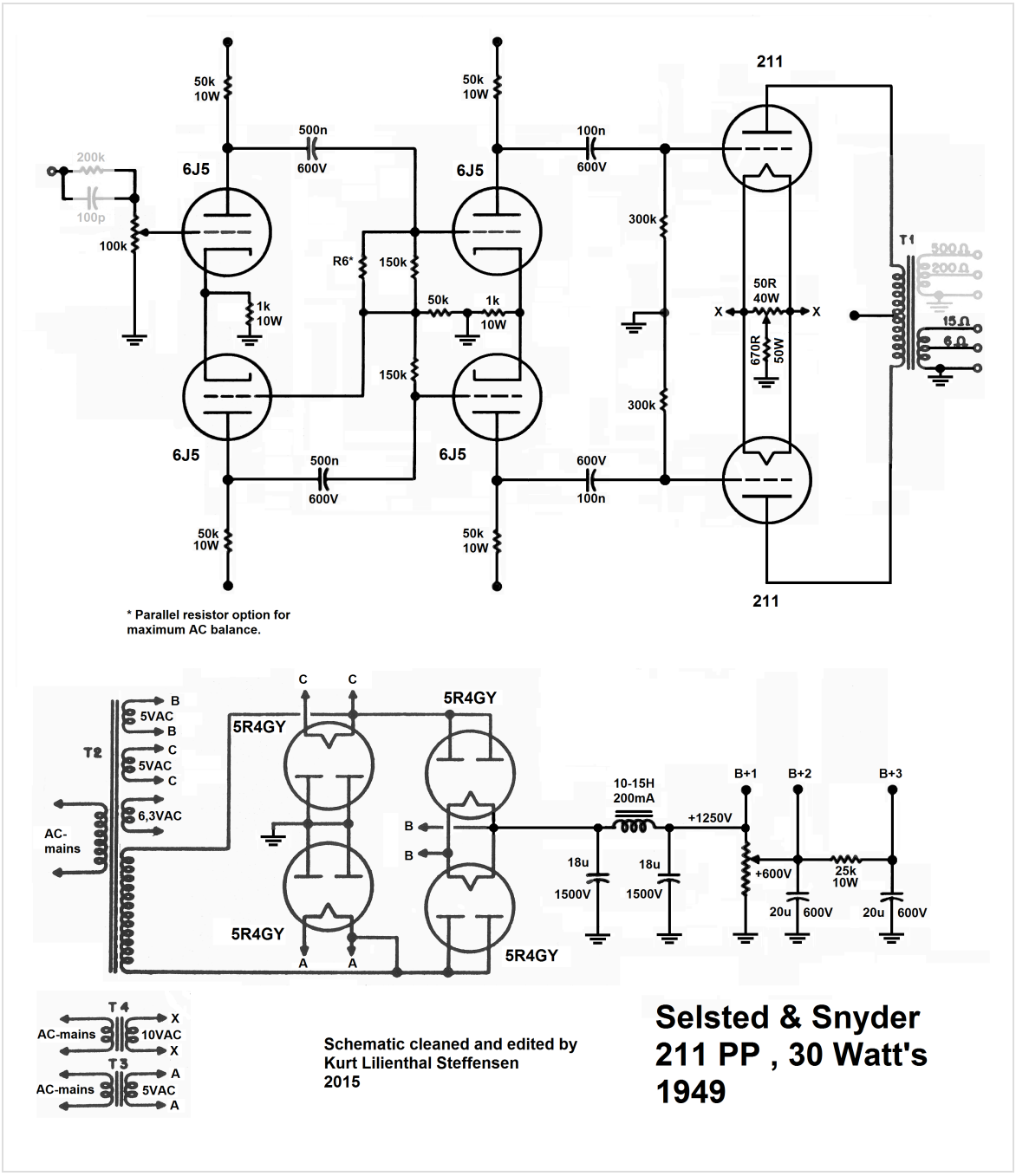
In the CCSP amplifier above consisting of the 3 twin triodes (6 triodes in total) , Scoyco's circuit are performing the entire signal processing needed to amplify the input signal, dividing it into two signals of opposite phase and finally driving the two 6L6's. That is not bad for a single circuit. the first two triodes , 6SN7, are strapped as conventional cathode followers.

Scoyco explains: *"The circuit of the cross coupled stage is shown in Fig. 1. Tubes V, and V. are connected as cathode followers. The grid voltage of V, is the difference of the output voltage of V, and V, and the grid voltage of V, is equal in magnitude to that of V2 but opposite in phase. If symmetry of tube and circuit parameters is maintained the voltage at the plate of V. is equal in magnitude to the voltage at the plate of V. but differs in phase by 180 degrees.*"

Very elegant indeed. I cant help thinking that V2 is not really doing much. I wonder if a fixed resistor (or a current sink) would not be a more linear and stable solution ?

Anyway – the amplifier that Scoyco demonstrates in the circuit shown is only meant as a technical note of the use as an audio amplifier.The 6SL7 is a notorious poor driver and the Voltage scheme for the entire amplifier is not optimal. If you would like to play with this extravagant circuit (I will 😉 , I suggest that you look at Marshall's CCPS amps and in particular White's Powrtron. Both can be found here in part 1.

SO – now we know, that is was not Audio Research or Kyokka that invented the CCPS, neither was it Marshal, White or Fraser…In fact it was…..**Dr. C. W. Lampson**, Princeton University, Maryland in 1945. At least he and Scoyco cross developed it independently of one another, just after WW2.



Selsted & Snyder, 211 PP , 1949

This is a wonderful design carried out by the two gentlemen Walter T. Selsted and Ross H. Snyder. The 211/VT-4C is a tremendous triode with outstanding sonic qualities. Here the 211's are driven in pure class A and the most crucial elements in securing the excellent merits from the 211 is the quality of the OPT, the driver and the PSU. (More or less in that order) Selsted and Snyder chose a universal/multi tapped transformer from UTC , possible not the best choice, but never the less the freq response of this amplifiers is only 1dB down at 20kHz and 3dB down at 20 Hz at 30 Watts output. Keep in mind that this is a non feedback amplifier and 6J5's are possibly not the best drivers at a 600V supply. Inter-modulation at 10W is less than 1% and 5% at 25 W, not impressive – but nice.

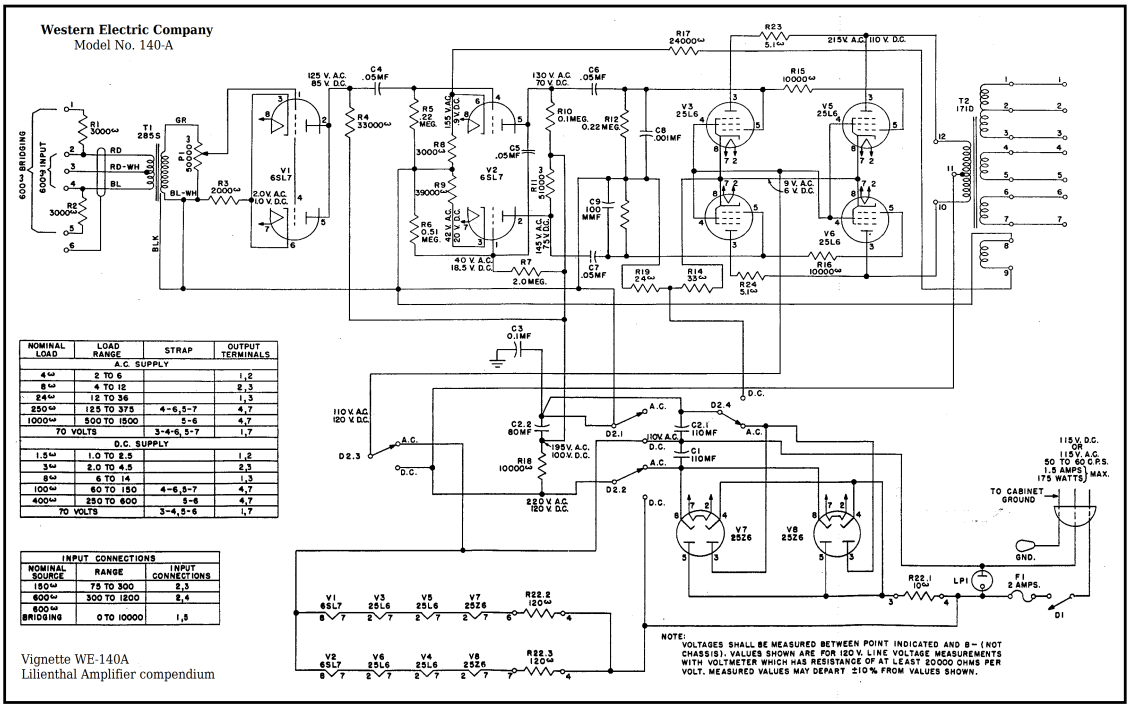
Although that 6J5's are single triode versions of the 6SN7's, I would not recommend using 6SN7's due to the high Voltage supply. A better solution today would possible be 6CG7 as the first triode and 12BH7, 5687 or the new ECC99 as the driver. This would have the additional advantage that the Voltage supply may be increased by 100 to 200 Volts. The four 6J5's only need an input Voltage of about 100 mV to drive the amplifier to full rated power. (Total gain of ca. 85 dB) Thats a little close to the edge for modern signal sources, in my opinion.I would prefer 1 to 2 V RMS input for full rated power.

The resistor marked R6 may be found by trial and error. Try with values between 1-2 M Ohms. The input series resistor of 200k and the parallel capacitor, should be omitted as modern signal sources have no problems driving a 100k Ohm load.

A little word on the power supply. 5R4G's are cheap and capable of very high peak inverse Voltages. But the Voltage losses are high in particular when bridged. This results in a rather soft Voltage supply meaning less good Voltage regulation. It is vital to use a good smoothing choke and if possible do increase the values of the PSU capacitors. If maintaining the use of 5R4G's, consider to increase the second capacitor to 30-50uF. (Min. 1500 VDC) The 100k 200 W slider (potentiometer) is a silly solution , although I understand why it was picked. (High wattage sliders were rather common as WW2 surplus back then) I would suggest a Voltage divider made of a 10-12k 50W alu-clad resistor connected to +1250V then a 10-15k Ohm 30-40W pot. and finally a 68k 15W to ground. This will also allow further smoothing by means of capacitors at the connections.

The output transformer must present a load of 8000 Ohms or more. The higher the impedance, the lower the distortion, but sadly also lower available power. This is a compromise at your choice. The open circuit induction must be min. 80 Henry. The isolation should be very good (Toroids not recommended) and it must be capable of min. 120mA DC continuously.

The B+ and heater Voltages may be taken from one or more main transformer – whatever you may have at hand. But do take care that the 5 VAC transformers are well isolated. (Min. 2500 V guaranteed between windings and core)



Western Electric 140-A, 25L6 PPP, ca. 1948

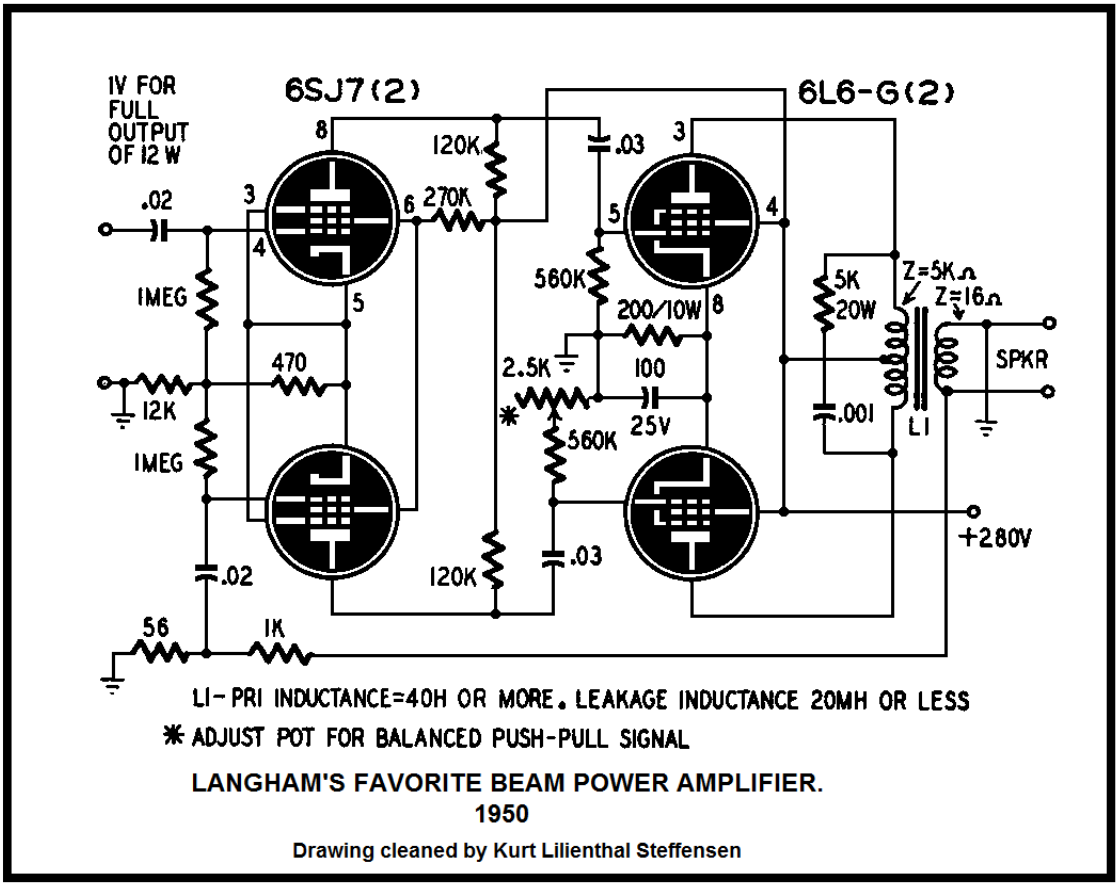
The 140-A is an unusual design for being a W.E. amplifier. This is on of the few W.E. amplifiers, that does not use original WE made tubes.

The amplifier is kept floating due to the input and output transformer and that the amplifier itself is not grounded anywhere. The input is a parallel 6SL7, likely because WE wanted high gain without sacrificing too much and the high end of the freq. The second 6SL7 stage performs the phase splitting and it is nice to see that the feedback is returned to the first triode of the phase splitter. This is how it should be made, when using this fb scheme and this type of phase splitter.

Another unusual aspect is the series string of heaters. This is not a good, from a number of reasons. High Voltage difference to challenge the heater to cathode isolation, if one heater opens they are all off and so on. Worse is that there is no power transformer. It is all connected directly to the AC-mains. Although the entire amplifier is floating, this may lead to many problems when used with other apparatus and not least – it is dangerous ! It was a quite common practice in TV-set's or low cost consumer units, in order to spare a main transformer. But it is disappointing to find that W.E. once made such a nasty solution. Anyway – it is easy to get by. Use an isolation transformer or for best performance use one or several transformers in order to connect all heaters to windings of proper Voltage.

You will need the following secondary windings:
120 VAC/140mA , (Or better 2 x 120AC to make a fullwave rectification)
6,3 VAC/1A (6SL7's),
25 VAC/1,5A (25L6's)
25 VAC/1A (25Z6's).
25L6 is not a 25V heater version of 6L6 as one might suspect, but a small 10W beam power tube.

Apart from the mentioned it looks like a fine amplifier.



Langham , 6L6G PP , 1950

James R. Langham wrote the interesting book “High Fidelity Techniques” , 1950. In this he states , as so many other notable audio designers did after WW2 – that he prefers triodes to beam power and pentodes, . He claims that although a beam power amplifier might measure better, he does not trust that we are measuring the right thing. Langham prefers to “trust his own ears, rather than curves”. Does that sound familiar ? There has to be an unknown factor like a “neutrino”, Langham ironically speculates. He also claims that we do not need more than 5 Watt’s of class A, in a normal living room. It is quite amusing to read, how Langham’s denies to accept that we are referring to class AB1, AB2 or B as push pull. Class B *has* to be push push and class AB would supposedly be *push*pull…… He he….

The RC network over the OPT is not there to prevent oscillation, nor to provide HF roll off, although it does so as well. Langham explains that the impedance of all speakers rises at high frequencies, and this will “overload” the 6L6’s. The RC network prevents that the load to the power tubes exceeds 5000 Ohms. “This is necessary to keep it from taking off” , Langham writes. “The quality of the output transformer is vital” – Langham continues.

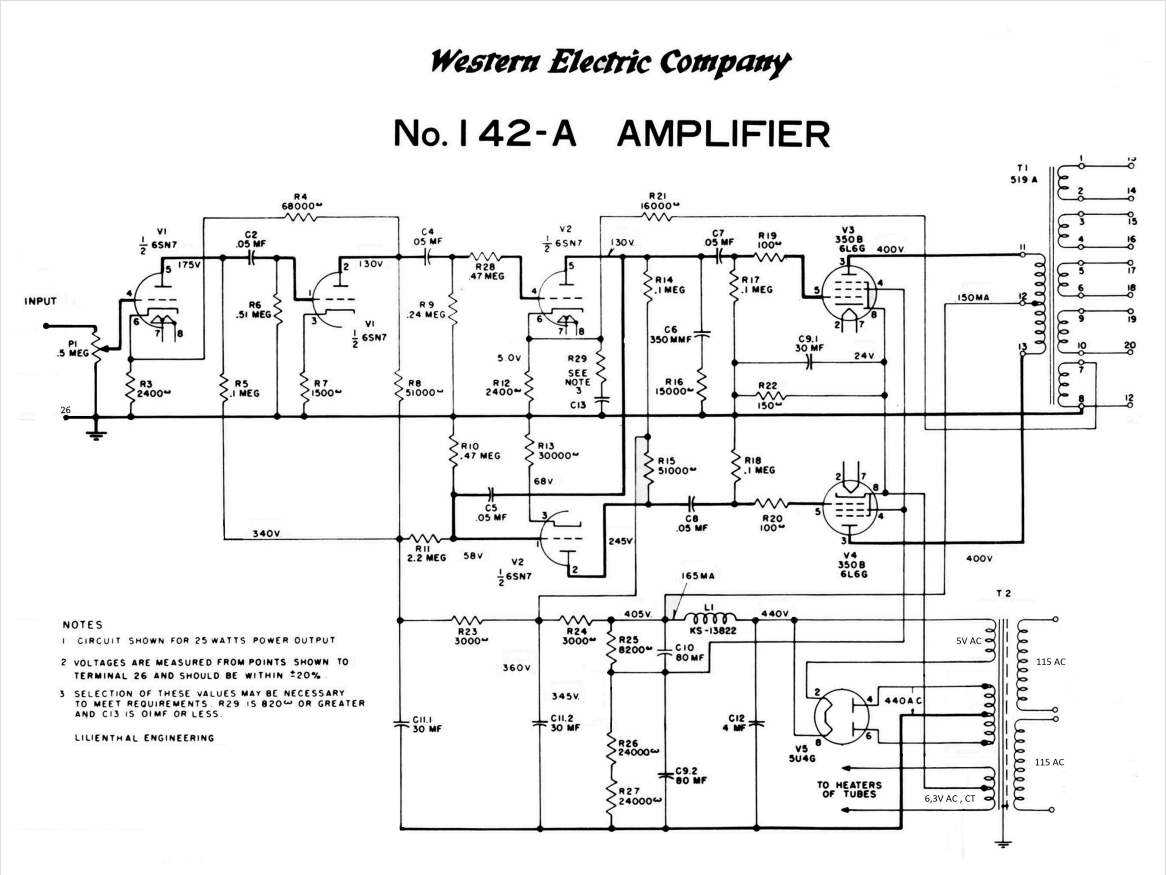
In this amplifier the well known long tail phase splitter made of two 6SJ7's is used to do all preconditioning ; Voltage gain, drive and phase splitting. It is symmetric and it is good.

6J7s's or 6J5's are just as good as 6SJ7's in this ciruit, and 807's may substitute the 6L6G's without any degradation in sound quality, according to Langham.

Langham prefers 2A3, 6A3, 6B4G or best 6B5G triodes. But the circuit shown here is the best beam power amplifier, that Langham has heard. It is "almost as good as a triode power amplifier". I really like that this amplifier is designed for 1 VRMS for full output. This is very unusual for times before – say 1970's or so.

The circuit in its basics was very common, in particular in the USA from the late 1930's to early 1950's.

Interesting and nice amplifier.



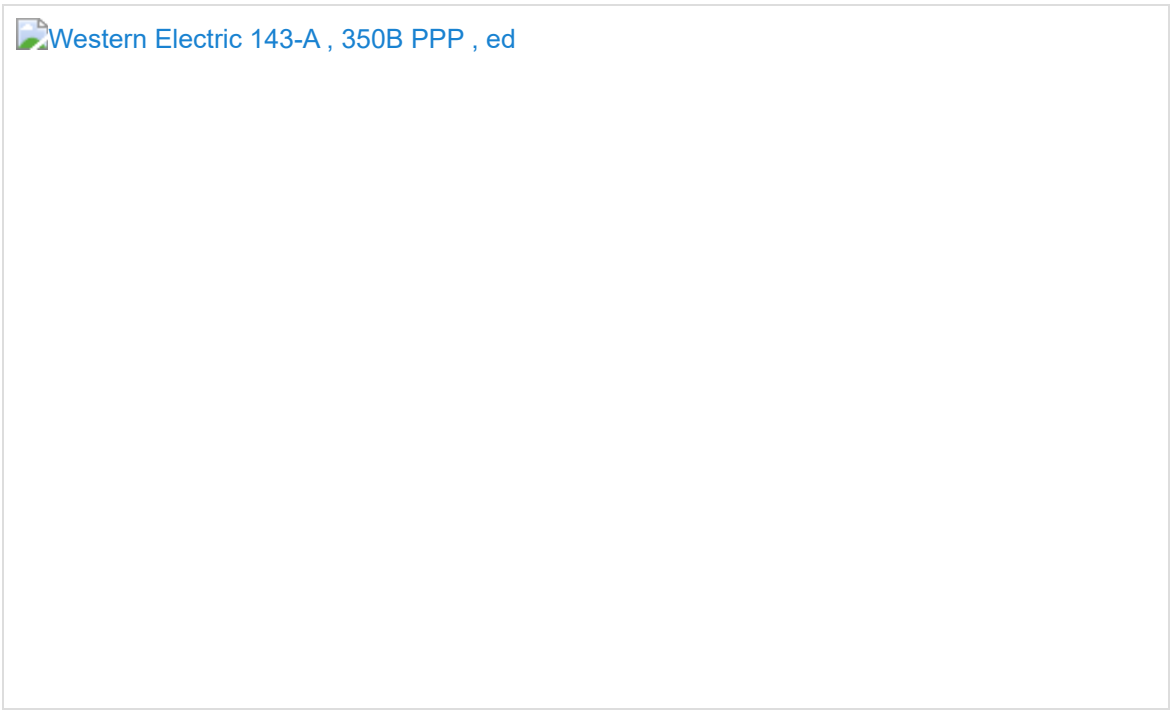
(Suggested by yours truly)

Western Electric 142A, 350B/6L6GC PP, 1948-52 ?

KS designation possible McIntosh. There is no global feedback here, but rather two short feedback loops. I am not fan of more than one loop, but when made this particular way the two loops does not interfere with one another. That's the way to do it. The phase splitter, however is unusual and I am not certain that I would want to do it this way. In order to outbalance the amplitude difference

between the two phase signals, WE chose to bias one of the phase splitter triodes by DC directly from the B+. Why not use a Williamson design with a close to perfect split load phase ? We could still maintain the two independent feedback loops, – I believe.

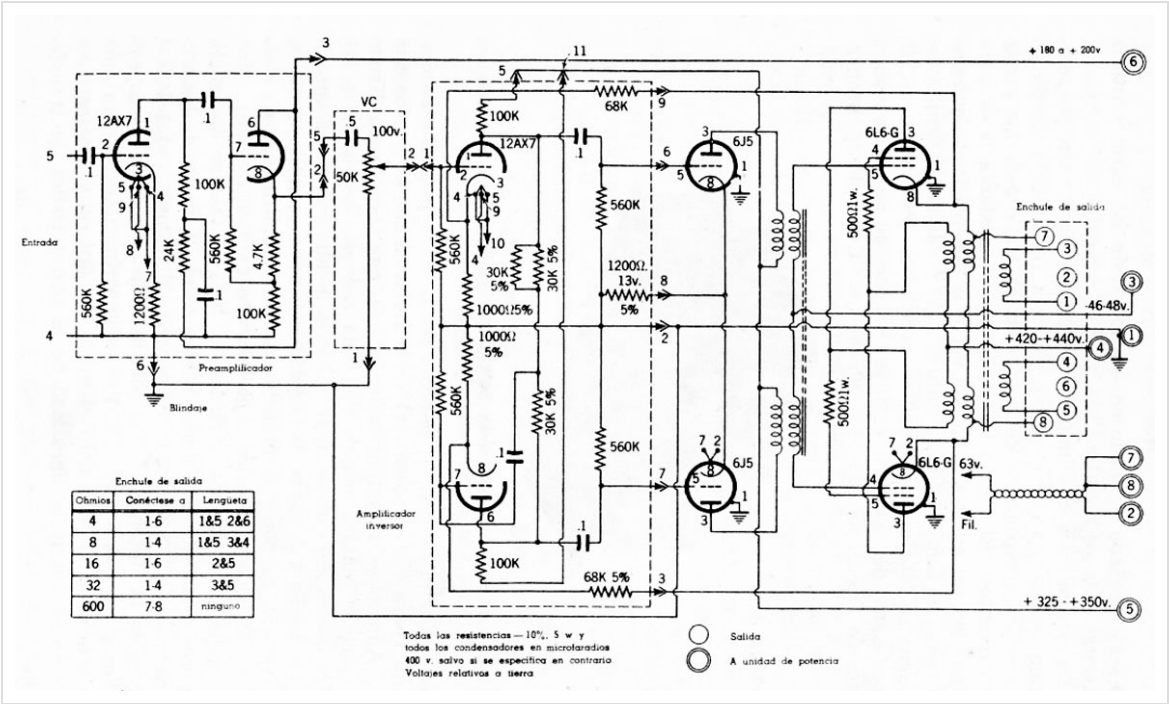
Well, I really like this amp. Perhaps my favourite WE modern design…



Western Electric 143-A , 350-B PPP, ca. 1948/50 ?

The 143-A is an advanced version of the 142's. Twice the power and a 6SN7 rectified bias supply. At the time of writing I have not yet finished the drawing of this circuit.


western_electric_141_142_143-730x1024



(Suggested by Joe Roberts)

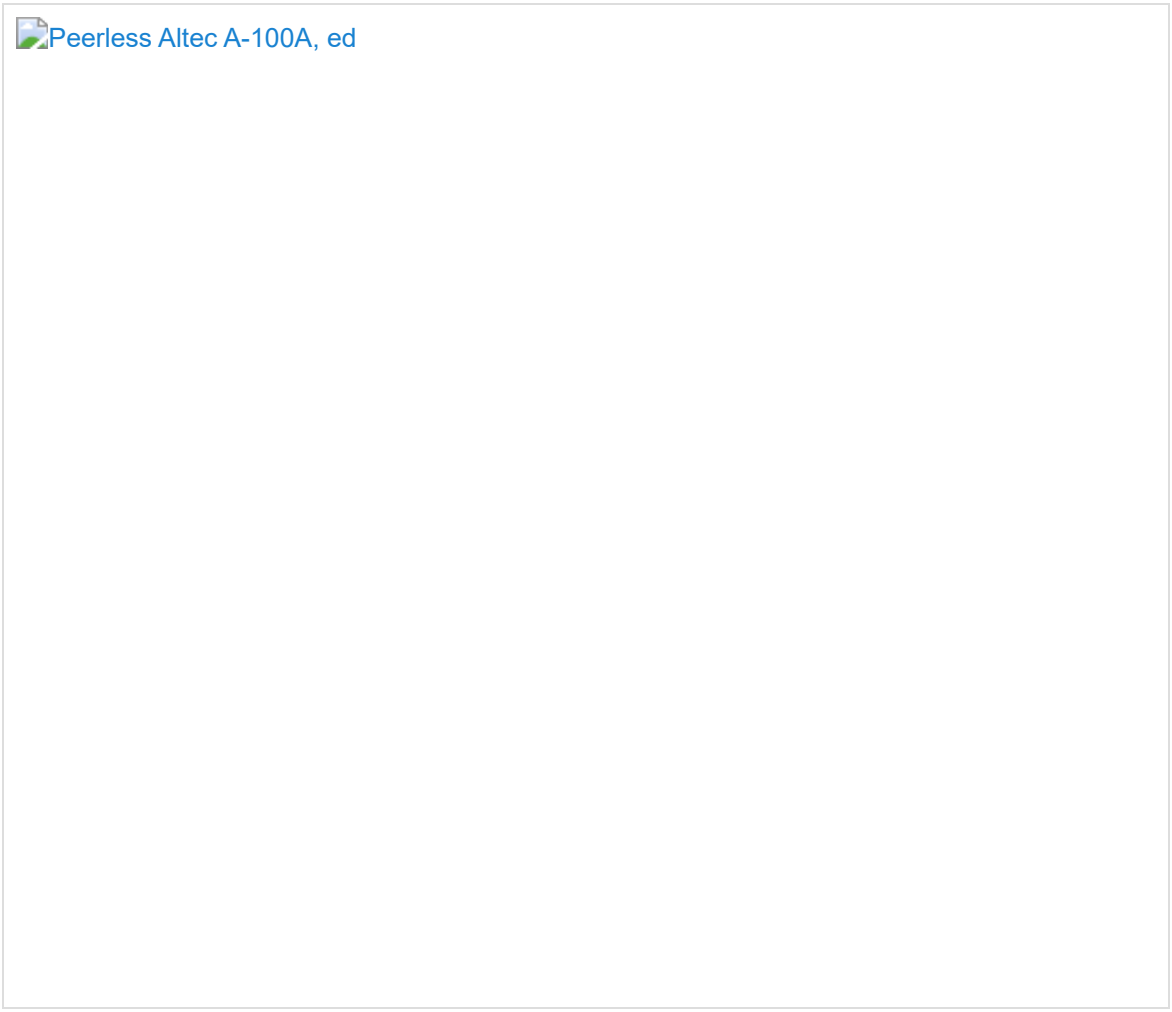
McIntosh 50W-1, 6L6G PP, 1949

At first glance it looks terrible complicated, but this is actually merely due to the way it is drawn. I might clean it up one day. In the meantime if we ignore the 12AX7 pre-amplifier/cathode follower, (In my opinion not needed for modern high signal levels anyway) , the actual amp consist of the 3 stages: 12AX7, 6J5 and 6L6G. The input 12AX7 Voltage amplifier forms the phase splitter as well. If I were to do it this way today, I would use a 12AY7 with solid state CCS for common cathodes and then ground one input side/grid for single end input. I really like the 6J5 interstage driver with active bias for the 6L6G's.

The amplifier also uses an bifilar wound primary OPT from which the winding is split into two windings in order to load the plate as well as the cathodes of the power tubes. Symmetric feedback from the cathodes of the 6L6's to the 12AX7 cathodes.

Sadly it is a class B stage. If you have one of these amps, I suggest that you bias it into the class AB area. You will loose some power, but you will gain in quality.

In later designs Mac pushed the scheme over the edge and was forced to compensate with capacitors and even chokes in series with the plate of the output tubes. Talk about two steps ahead and one back.
Frank McIntosh patented the circuit as the "Unity coupling". Insisting design and care for the detail made it work.
Well done, Frank….



(Suggested by Joe Roberts)
Altec Peerless A-100A, 6A5 PP, 1949

Ah yes…I know this amp. Designed by Melvin Sprinkle..one of my favorite engineers from the era. In 1936 Western Electric formed "**Al**l **Tec**hnical services" supposedly a division dedicated to service and maintaining of the pro-audio equipment made by W:E. But it didnt take long before Altec became a producer of high end professional gear themselves.In 1946 Altec took over the then bankrupt Lansing company and formed the famous Altec Lansing company. That lead to the production of the famous duplex and coaxial speakers, as well as the highly regarded "Voice of theatre" PA speaker systems. As early as 1947 Altec acquired the famous transformer company Peerless and the rest is history.

Back to the A-100A amplifier. This is a Williamson design with a twist, (Ignoring the pre amp, that I have left out)
The famous A-100A amplifier was sold as a kit called: "Peerless 10722″ or factory assembled as "Peerless A-100A". The amplifier appeared as an article/ad in the US magazine "Radio & television news", may issue 1950. There is more to this amplifier than meets the eye at first glance. The input stage is a pentode strapped 6J7, nothing special about that. If you have one of these amps at home, I suggest to triode couple that tube. Or better swop to a triode strapped 6SJ7. Next stage is a 6J5 phase splitter. The reason for the 6J5, rather than the twin triode 6SN7 here is the simple that it was made at the times of mono (6SN7 = two 6J5's) The cathode coupled driver

stage is a clever Sprinkle solution. This and the use of output triodes are the main reason why this is such a good sounding Williamson design. I would like to give the word to Mr. Sprinkle himself – in absentia. Sprinkle:**" *The legion of audio enthusiasts who have stuck by their triode amplifiers through thick and thin have been a hardy lot. They have been assailed by the beam power camp and have been deserted by commercial amplifier engineers, but through it all have held the bridge like Horatius. Through all the controversy they have always maintained that "triodes sound better."***



I could not agree more. Sprinkle regrets that despite the better sonic qualities, the efficiency of triodes are rather poor. Personally, I do not mind that much, but most certainly better efficiency is not a bad thing. In theory it is possible to achieve about 50% efficiency from a pair of triodes in a PP class A set up. In practice, however, this is very difficult as it takes current as well as high Voltage swing in order to drive the triodes to maximum swing. A regular plate loaded driver can provide the swing, but the plate resistance are too high to provide current drive. A cathode follower will provide the necessary current, due to the low z-out, but it can not offer the needed Voltage swing. Sprinkle's trick are simple, the cathode driven induction assures the wanted Voltage swing.

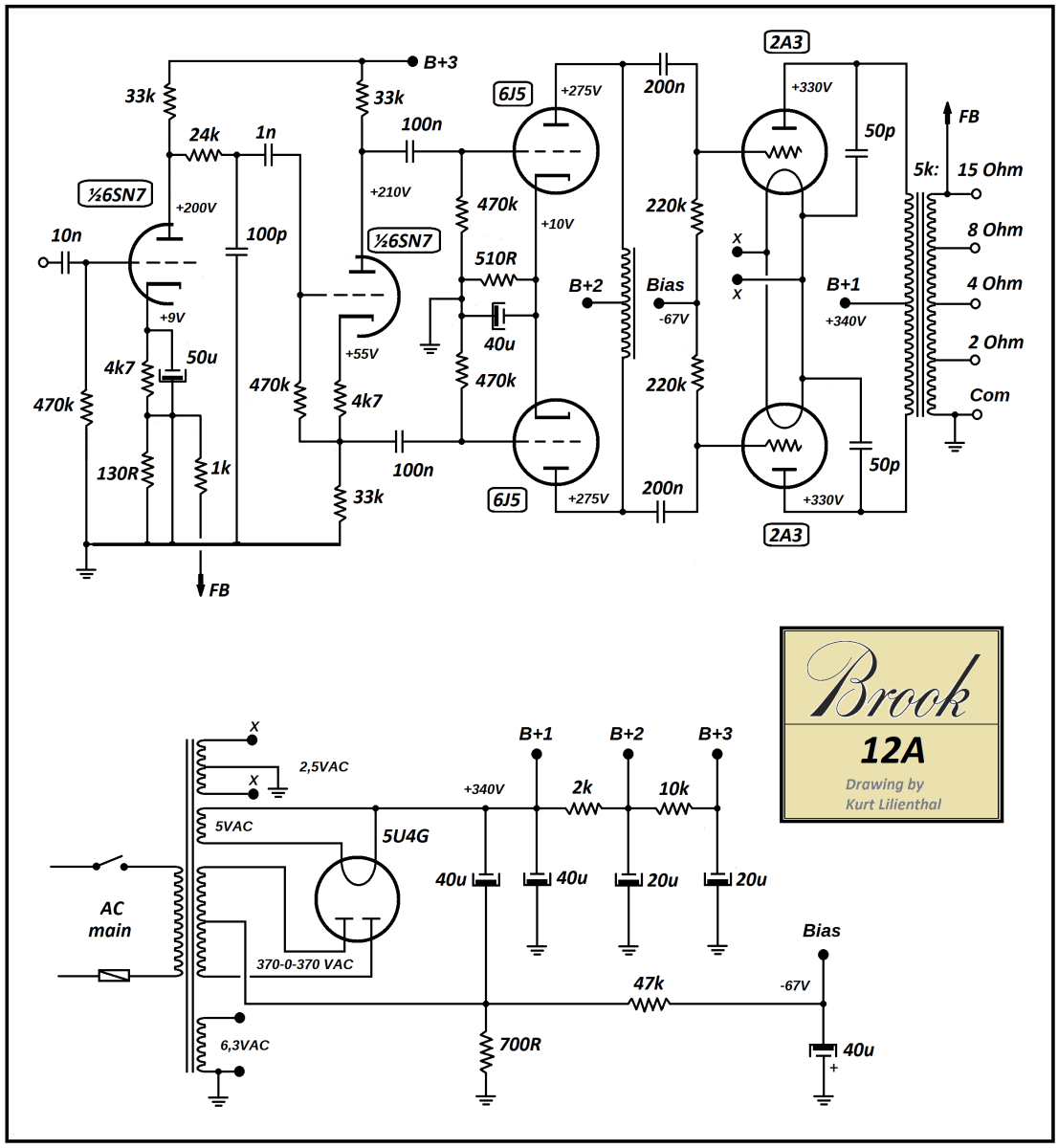
Sprinkle: "*Recently the writer has become interested in a circuit which makes possible 18.6 watts output from a pair of 6A5 tubes at a distortion of 5% total harmonics! This represents an efficiency of 49.3 %, a truly remarkable achievement. The amazing performance is made possible by two factors:*
(1) A good output transformer and
(2) use of a cathode follower driver."

The output transformer that Sprinkle praise are the well known Peerless S-240-Q. This is a 20 Watts, 5000 Ohm to 0-4-8-16 PP transformer, It accepts up to 90mA common current and a 9mA unbalance.

Sprinkle: *Most audio enthusiasts are familiar with conventional resistance or transformer coupling to Class A or AB, amplifiers. These systems are quite satisfactory within certain limitations, but fail when Class AB, operation is approached. The fundamental reason is that when the grid of a tube is driven positive, instantaneously, there is a flow of electrons to the grid, which when they flow through the grid resistor, or even an interstage transformer, produce a voltage which is additive to the tube's bias. The effect is the same as the bias developed in an oscillator's grid leak due to grid current. In the usual Class AB, design a special transformer, called a driver transformer, is used, which is a stepdown transformer.*
*In order to supply enough signal with a stepdown turns ratio, and also to supply power to the grids of the final when they draw grid current, it has been necessary to use a power tube as a driver. Another factor that touches a sore spot in constructors is the cost of a good driver transformer. The cathode follower driver overcomes these limitations. It has been pointed out that a cathode follower is not a voltage amplifier, i.e., the output voltage can approach but not exceed the input signal. However, and this is not as widely known, a cathode follower can be a power amplifie*r."

It is possible to interchange 6J5's, 6SN7's and 6CG7's without further change than sockets/socket layout.
The 6A5G is similar to the European R120. A stereo version sharing the power supply would demand half the values of the power supply resistors and up to double the values of the electrolytes. It may also be a good idea, to use either two 5V4's, a 5U4G or a pair of silicon diodes for rectification.

Thanks a lot to Melvin Sprinkle for this classic and many other good Altec/Peerless designs during the 1950's.



(Suggested by JC Morrison)

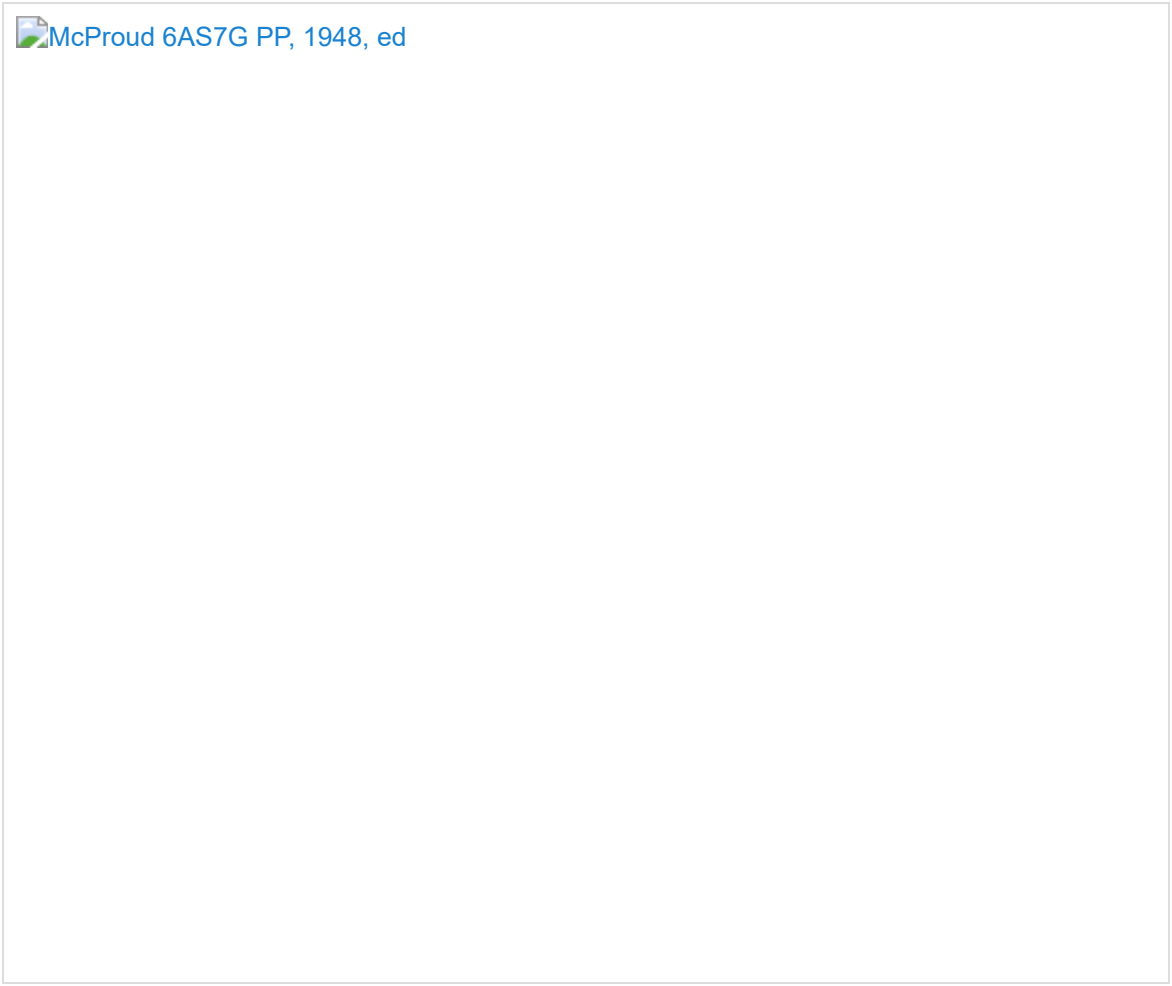
Brook 12A, 2A3 PP, (1949-50)

Williamson circuit. The first time I saw this circuit, I thought there was a mistake in the SAMS Photo schematics. There often are in my experience. However as I looked at it I realised that this was a clever and unusual way to obtain the bias for the two 2A3's. The PSU are not referred directly to ground, but goes through the 700 Ohms power resistor. The voltage over this are used to bias the 2A3's….He he….smart…This is what I call "Loop Bias". (Read more about this in Part 1) The Brook 12A is pretty much a flawless design. The relative low values of plate resistors improves the HF freq and pulse response. The choke loaded 6J5's can drive the 2A3's to Kingdom come..What more can we ask for ?

The later 1955 version 22A was pretty much identical, except it used 12AU7 direct coupled, 6C4 drivers and an OPT, without the 600 Ohm winding.(2, 4, 8 and 16 Ohm taps only)

Yummie good engineering.

The 12A had a preamplifier to match with it – called 12A3.



McProud 6AS7G PP, 1948

C.G. McProud founded the famous magazine “Audio Engineering” , in 1947. The magazine still exist as “Journal of Audio Engineering Society” – in short “JAES”. It was for many years my favorite magazine as a lot of the most important articles about audio appeared in this magazine. (There are some reprints of earlier articles out there in form of volumes called “Audio Anthology”. These are available from the excellent publisher “Audio Amateur” and “Old Colony Lab”)

From 1948 to about 1952 McProud designed several amplifiers based on the twin triode 6AS7G. He was quite fond of that relatively new power triode and found it compared well – perhaps slightly better than a pair of 2A3/6B4G/6A3.

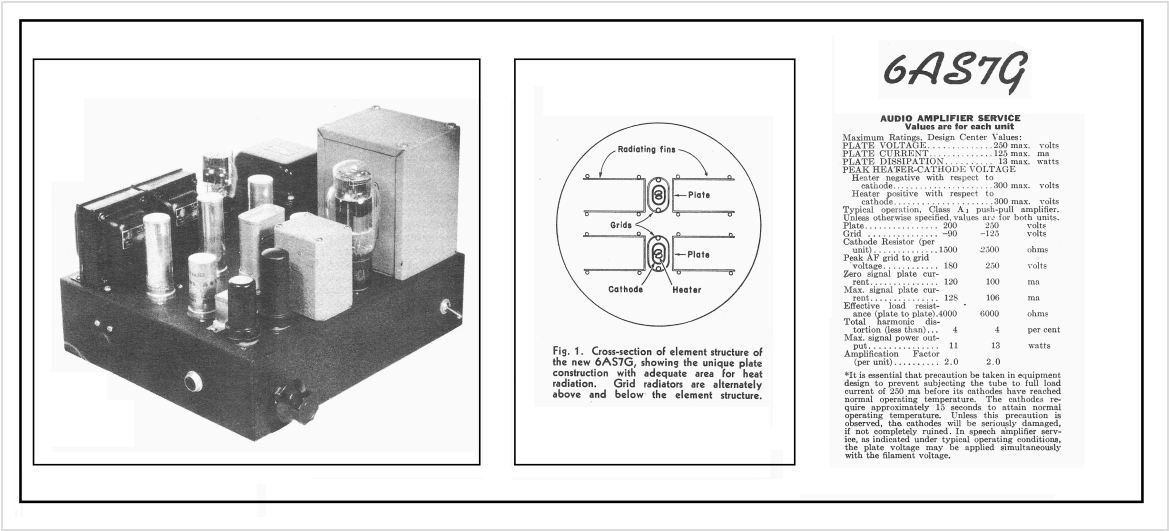


Fig. 1. Cross-section of element structure of the new 6AS7G, showing the unique plate construction with adequate area for heat radiation. Grid radiators are alternately above and below the element structure.

Fig.1

The max plate dissipation for a pair of 2A3's is 2 x 15W , as for a single twin triode 6AS7G it is 2 x 13W. The ri (plate resistance) for a 6AS7G triode is quite lower than a 2A3, but the amplification factor of a 6AS7G is only 2 , a little less than half that of a 2A3. This means that the Voltage swing needed to drive the 6AS7G is much higher. Bias for a class A coupled 2A3 at 250V at the plate is -45V. As can be seen in table 1 in Fig.1, the 6AS7G under the same conditions employs a bias of -125V. This means that the 6AS7G demands a Voltage swing almost three times higher than the 2A3 for full output. McProud solves the puzzle by means of a step up interstage and a parallel coupled twin triode.

The triode coupled 6SJ7 drives the parallel coupled 6N7 via a 100kΩ plate load. This is on the high side and it affects the HF roll off, but we need a high Voltage swing here as well, in order to "drive the driver". The 6N7 alone is responsible for the actual drive and phase splitting by means of the parafeed interstage transformer. This is indeed a heavy burden to put on that tiny 6N7 and I believe this is the weak link in this amplifier. The 6N7 twin triode does not allow plate dissipation of more than 1W per triode in the linear class A area , meaning a total of only 2W. The ri (plate resistance) is relatively high , some 11.000 Ω and a transconductance of some 3200 per section. I would expect a triode coupled 6F6, 6Y6 or 6V6 to do the job better. These are capable of more current and higher Voltage swing (= current "swing" to the interstage) and they all work nice as triodes and this would mean a lower ri, hence better grip of the interstage step up and lower distortion.

(Thanks to Dipl. Ing. Plamen Doynov, Rusland for pointing out some unclear parts in my previous text)

Apropos distortion. the THD is low considering the lack of feedback – 4% according to McProud's table in Fig 1. The intermodulation distortion for the 6AS7G amp, Fig. 2 , is nice up to about 1W , then it seems to skyrocket. The slope of the curve is steam beyond some 4-6W . This is actually not quite as bad as it may seem – intermodulation challenges most amplifiers as they are getting close to max power output. Lets try to compare it with something familiar. I am sure most of us has heard the Williamson design as it is quite difficult not to meet such animal, being the most popular

tube amplifier design ever. I chose the Sprinkle and Sarser's version as it was nearby and the intermodulation curves came with it.

At first glance we might consider the Williamson to be much better – as would be expected – this one being a pair of triode coupled 807's, 25W plate dissipation and 20dB of global feedback. But take a closer look, please. At low levels the Williamson is indeed better as it should be, due to the feedback. But the slope of the curve is indeed the same as the McProud amplifier, despite this one only have feedback from the second stage.(Via the 270k at the primary of the interstage returned to the 6SJ7 cathode)

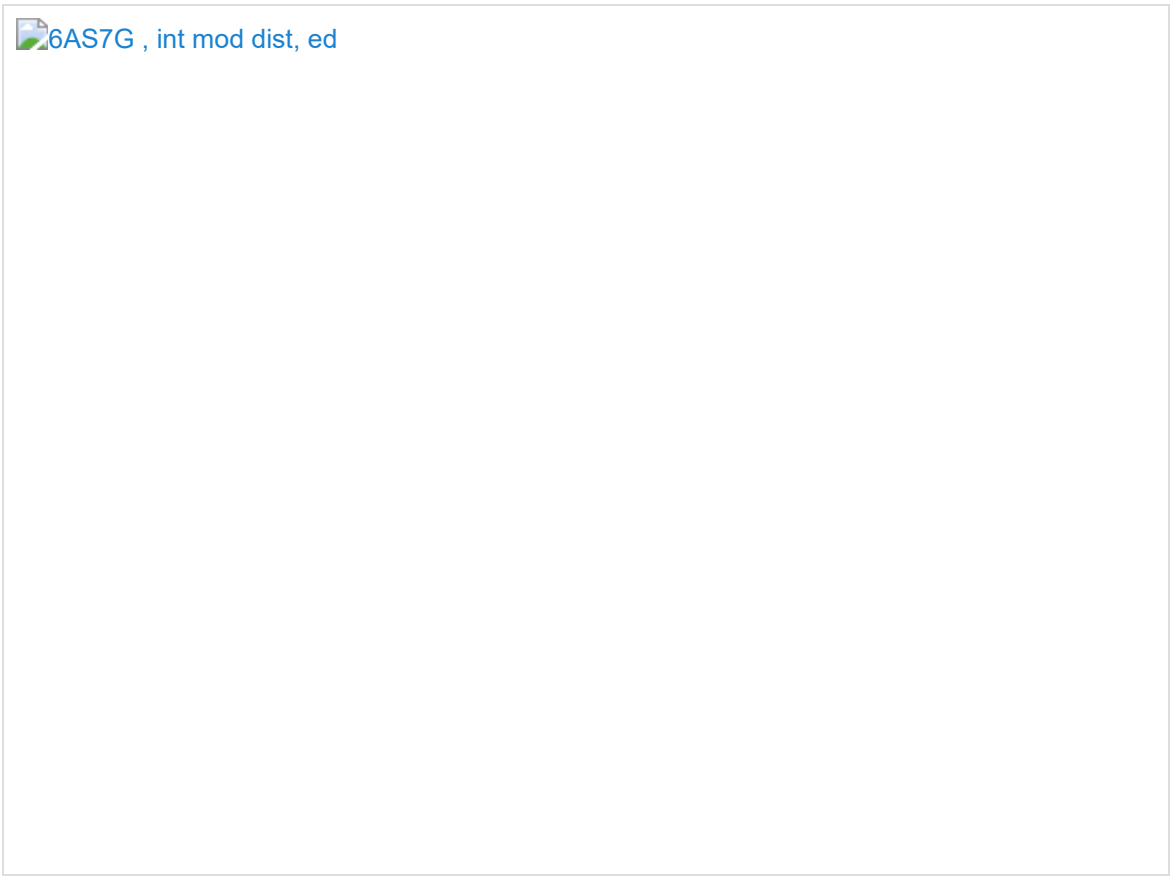


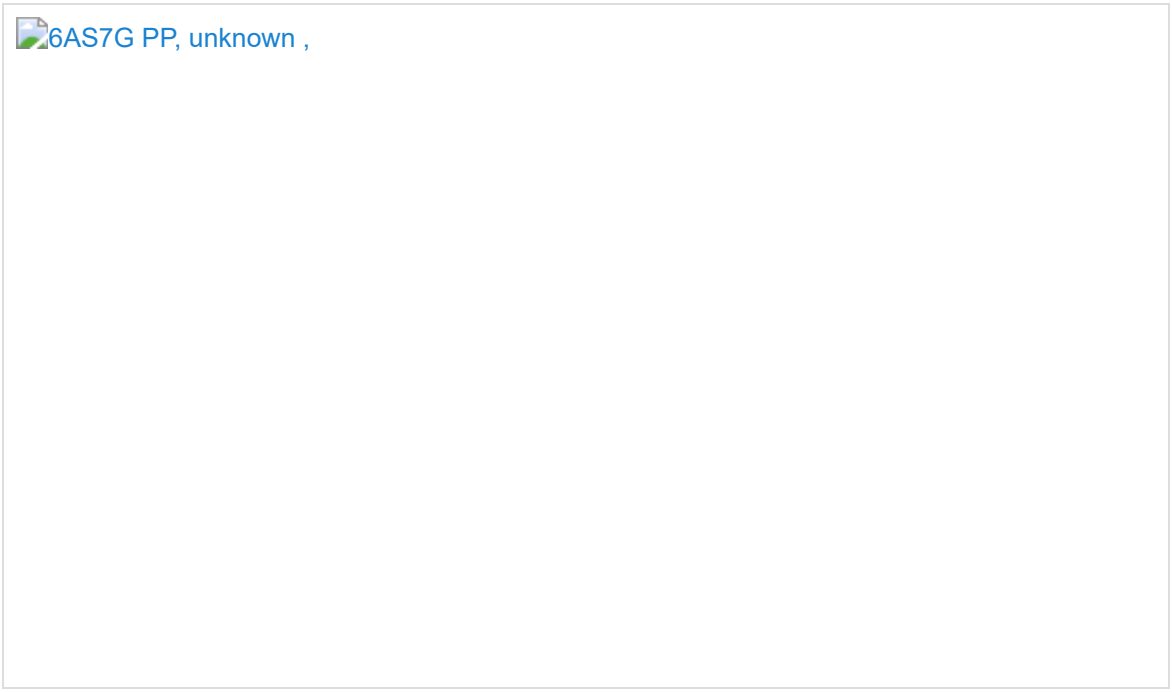
Fig.2

It is difficult directly to compare the two curves as the Williamson has a 0 point at 1W and a max distortion of 25%, and the McProud a = point at 1 mW and a max of 12%. But with a little "photoshopping" I have managed to squeeze the dynamic area of the Williamson curve in to the same area of the McProud curve – the 1W and 10W being the X-coordinate references and at the Y-axis I have matched the distortion coordinate points as well. It is now possible to compare the slopes of the two curves and they are actually quite identical. The slope of the Williamson may in fact even be a little worse that the McProud.

If we apply the same amount of global feedback to the McProud it would probably measure equally well at low signals and vice versa. Both amplifiers may be rated as 12 Watters, – less such at lower distortion and more at higher distortion. We are in a way comparing apples with pears.

McProud made a few minor improvements (according to himself) to this design, the most significant was a swop of the triode coupled 6SJ7 to a 7A4 (≈ 6J5) triode. I dont know if there is indeed an improvement in, as the 6SJ7 is amazingly good as a triode. But there you go :-)

We might as well, get over and done with the 6AS7G power amps. Here is a few more of that breed.



.This is an **unknown 6AS7G PP** design from my archives. Looks like a typical 1950's "Audio Eng." drawing. Nice symmetric design, I trust it sounds good. (Please, drop me a note if you know its origin)



Jan van Heijenoort, 6AS7G PP, 1948 and 1949.

These two amplifiers was published in Audio Engineering as “Techni-Briefs”. Heijenoort was inspired by McProud’s earlier designs and expresses his enthusiasm about the 6AS7G, which he claims is “superior to the 2A3’s in every respect”. The first design was meant to be driven directly from the discriminator (tuner) and a modified crystal pick up. Heijenoort prefered live concert FM transmissions as the best signal source in the 1940’s. I can vote for that too , at least way up in the 1990’s here in Denmark. Heijenoort keeps praising the 6AS7G’s as shown as the most natural amplifier he had ever heard. He is obviously a diehard 6AS7G fan. In the 1949 version he adds an input transformer and slightly modifies the thing. It is worth to note that Heijenoort supplies a higher Voltage to the driver stage. This is indeed the way to do it if you want to drive these low gain triodes to the full monkey.(Higher B+ allows higher Voltage swing)

Excellent design. I actually like it better than McProuds original.



Williamson 6AS7G, 1955.

Unknown designer, appeared in the Japanese “Radio TV and Electronics technique” magazine, 1955. Not much to say about this amplifier – it pretty much speaks for itself.



The armchair listener's amplifier, 1966

This amplifier appeared as a reader's letter to the Audio Magazine, Nov. 1966. I have edited it, as despite the super simplistic diagram it had several errors in it. I have also changed the main supply scheme as the B+ was tapped directly from the AC-mains. This is a "no go" ! Life is too valuable, in order to spare a proper main transformer. The Voltage doubler is an efficient method of using a single winding to do all the high Voltage. Just remember that you need twice the current as well. In the end Volt Ampere is Volt Ampere.

I quite doubt that the 12AX7 will drive the 6AS7 to its full power, but I am sure that it will deliver some 4-5 Watts without too much troubles. Perhaps a ECC85 or 12BH7 would do a better job here. The input is balanced, but it is possible to ground one side of the 12AX7 and make a single end input. The resulting AC unbalance may be cancelled by different plate resistors or for better results , use a FET/bipolar common Constant Current Source at the cathodes. A negative Voltage of some 10-15 Volts would be of advantage here.

This is the final 6AS7G amplifier, I will show here. I will at a later time pick up the thread about the huge family of series regulator tubes.



Keroes & Hafler Ultra Linear ,1952/55.

The so called ultra linear operation are normally associated with Keroes and Hafler. This is actually not fair as none of them invented this circuit. Several others made the circuit many years before K&H, for instance Telefunken in 1940 and not least Blumlein's patent of 1937. In Europe the circuit

was relatively well known, thus according to European patent laws it was not possible to claim a patent for the circuit. American patent offices, however are much more liberal and do not seem to care for such formality.**Thomas Danley**, (Danley sound labs. – probably the best power speakers ever made) once told me in a mail that a guy in USA had been granted a patent for the electrodynamic loudspeaker – this was in the late 1990's ! 

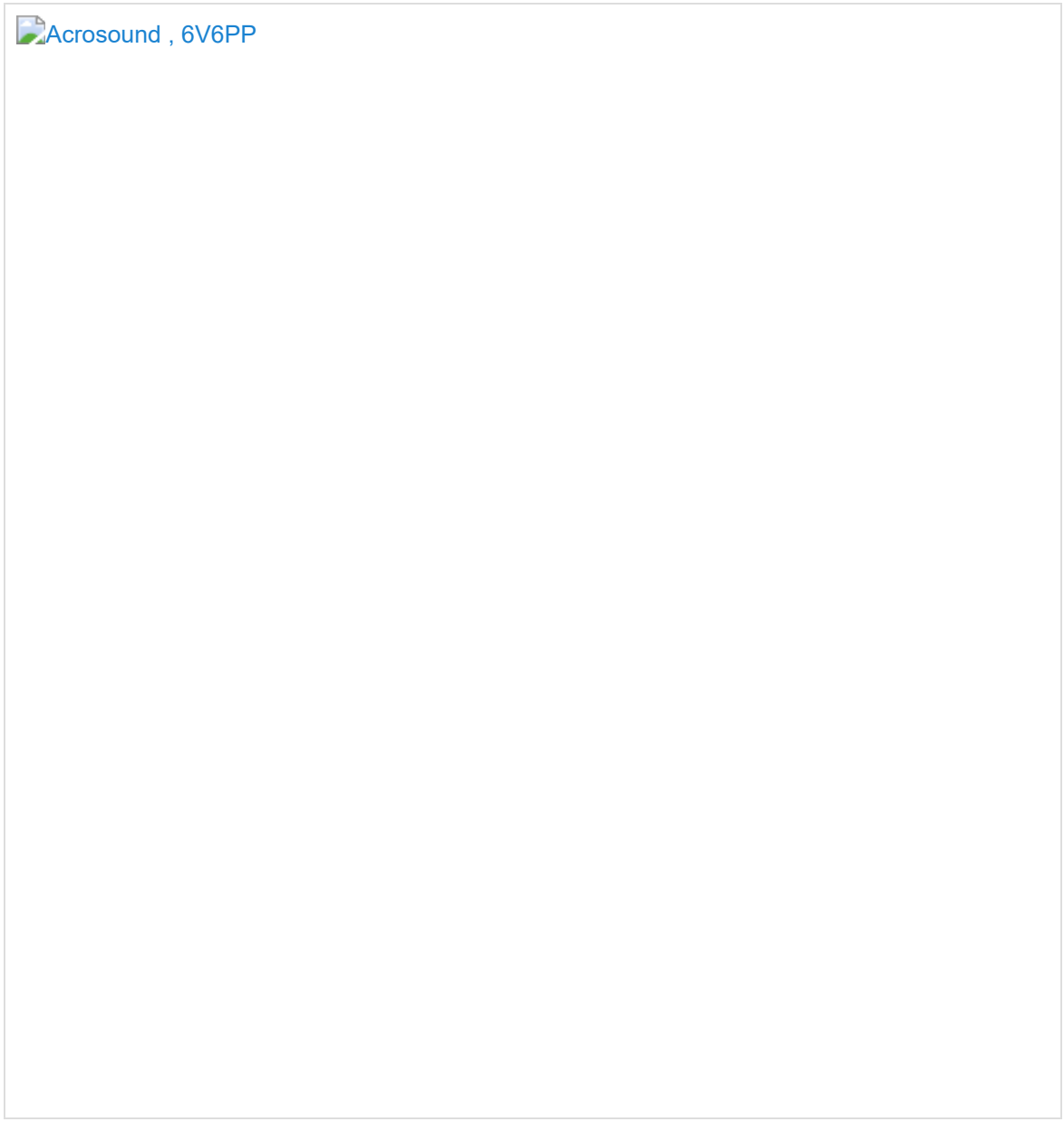
Anway – Acro transformers, owned by Keroes was issued the patent, hence able to collect royalties for many years. Keroes & Hafler promoted the wonders of the recent acquired patent very well indeed. The articles and flyers published by these two gentlemen basically created a school of power amplifier design and Ultra Lineare has ever since been the most popular OPT coupling for audio. Not much to say about the idea as it is pretty much self explaining. There is no real optimal point of where to make the UL tapping as it is a trade off, depending upon many variables and it is case sensitive.The feedback current to sg2 modulates the inner impedance of the output tubes, creating a weird distortion that may not appear when investigated by sinewaves. Often we use the 43% claimed by Keroes and Hafler , but really that was a gimmick. The closer we get to triode strapping, the more linear, but less the power and vice versa. Any pentode or tetrode may in principle be objected to the UL circuit.

It is a clever compromise between the linearity of triode strapping and the efficiency of pentodes/tetrodes, but it does come at a price. Kiebert rarely used UL and prominent persons such as **Williamson and Peter Walker** (QUAD) questioned the claims by Keroes and Hafler. The following appeared in an article written by Williamson and Walker for Wireless World, sep-1952*:" Articles have recently been published in the United States claiming the superiority of a so-called " ultra-linear " output circuit in which the output valves are used as tetrodes,with negative feedback applied non-linearly by connecting the screens to a tap on the primary of the output transformer. It is stated that the performance is audibly improved over that of triodes with similar degrees of negative feedback. The present writers do not believe this claim.The circuitry which forms the basis of these American claims for " ultra-linearity " and higher efficiency has, in fact, been familiar in this country for several years, and the technique has been further developed and used in a commercially produced high-quality amplifier."*

Of course Williamson and Walker had a significant point. The Ultra Linear operation that Keroes sold as being *better* than triodes was simply the speech of a salesman. Walker had been using "Ultra linear" as well as cathode feedback windings for some years, but he never claimed that they were better than triode operation, neither did he claim a patent for the idea.

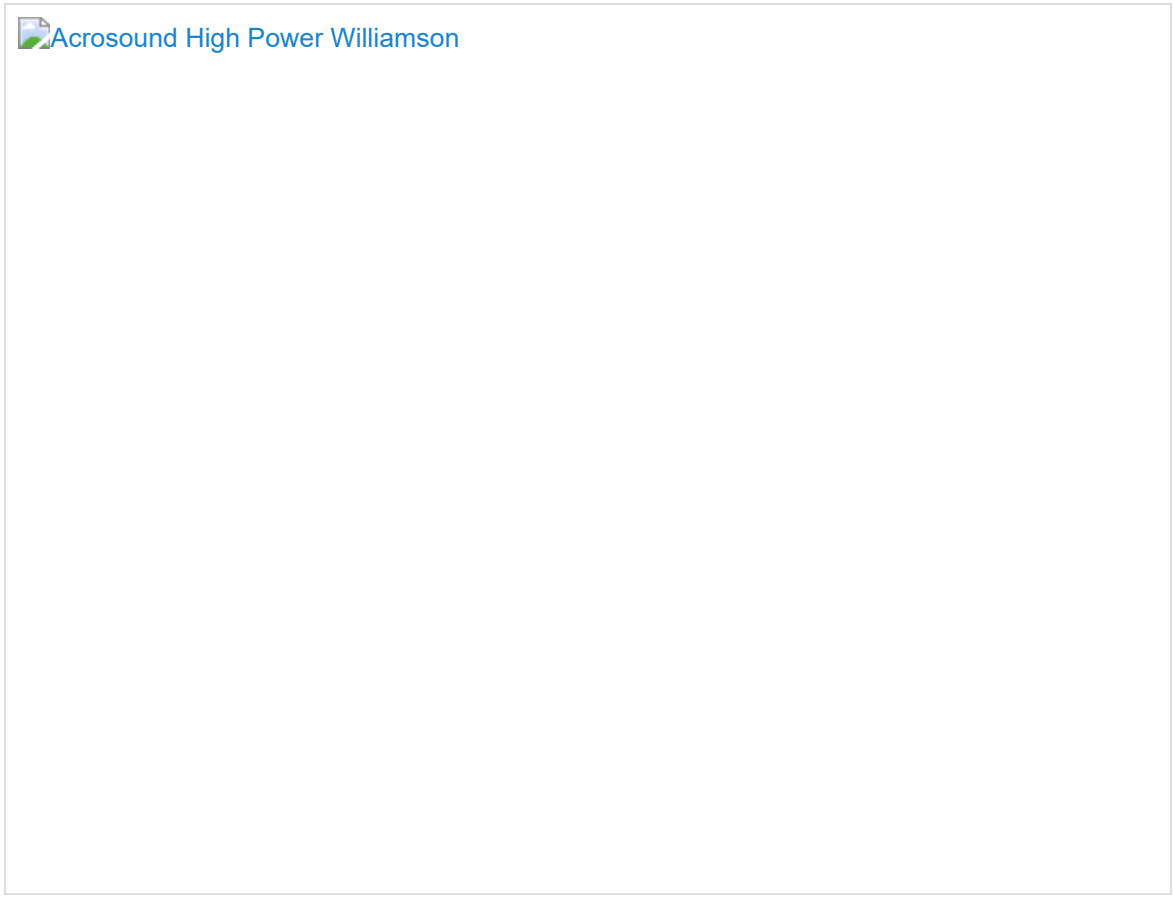
McIntosh patented the similar "unity coupling" in the late 1940's – it was granted in 1949 – according to my information. It is my belief that McIntosh used the cathode FB winding before Walker , but frankly I don't know.

Update March 2015: I accidentally found a letter written by Peter Walker to Wireless World, Dec. 54 in which Walker claims that he drew attention to this application as early as 1943. The "British gang" obviously preferred cathode loading to sg2 loading. Used this way the degeneration also applies to triodes. Keep in mind that Blumlein was English and that he and Walker must have known about one another – at least by name.



Acrosound Ultra Linear 6V6.

This is a neat little circuit by Acrosound. Not much to comment here. You may readily swap the 6V6's to EL84's. I would also suggest that the input resistors of 470k, should be swapped to 47 to 100k – you may at the same time use a 10nf capacitor instead of the 50nF. As we do not need that much gain it is also a good idea to change the 100k plate resistors to 47k. This will improve the HF roll off as well. It is always worth to experiment a little with the feedback resistor and capacitor. The 680MMF , does not mean Mega Mega Farad, neither does it mean milli milli , but rather u u (micro). This translates to pF.



The Acrosound High Power Ultra Linear Williamson.

This is a pretty conventional Williamson design, except that it uses UL coupling and EL34 or 6550/KT88 instead of the original KT66's. The 1M input resistor should be changed to 47k or 100k for lower noise pick up. I would also increase the value of the electrolytic after the choke. The same goes for the electrolytes in the bias circuit. Note the innovative inverse use of the filament transformer. I would also suggest a couple of 10 Ohm resistors instead of the cathode fuses.

That's all, folks.

.



(Suggested by Francis)
Craftsmen model 500, KT66 PP, 1950

There seems to be several 500 models ?
Yes – another classic Williamson design. Simple and elegant. Choke PSU input – nice..Do also note that the filaments are lifted and referred to the cathodes of the KT66's. This improves the noise (hum) figures and may prolong tube life. Fully adjustable bias level and DC balance, despite auto bias. It has to be WW pot's in order to last, I believe, but yet another good detail. Not much need/room for modifications. This circuit are pretty much mature. I would look into the plate Voltages of the first two stages, though. The two Voltage dividers 22k and 33k, clearly indicate that it is possible to raise the plate Voltage to these triodes. 8V, 8mA at 250 V plate would be very nice indeed.



Photo from: www.wowhififever.com , collage by K. Lilienthal

Interesting – and actually weird – that this common Williamson circuit was patented and licensed from Western Electric.
Quoting radiomuseum: *“The Radio Craftsmen” seems to be founded in 1947 by John Cashman who before worked at Hallicrafters Radio Company. The schematics-licenses often came from Western Electric or RCA.*
Ed Miller and Sid Smith were the two major engineers until mid 50’s. Ed Miller was the founder of Sherwood when he left RC in 1952 or 1953. Sid Smith left 1953 and joined Marantz where he got 1954 the post as chief engineer. “

We have then here drawn threads between Western Electric, Hallicrafters, RCA, Sherwood and Marantz. Not to speak of Altec Lansing and so forth and so back…
Interesting indeed….



Musicians Amplifier Senior, 845 PP , 1951

This amplifier was one in the series of amplifiers by Sarser & Sprinkle known as the “Musician’s amplifier”. The first one was a Williamson design that Sprinkle slightly modified and converted to US tube types 807 and 6SN7. The amplifier shown here was meant as a high quality amplifier primarily for domestic record cutting applications. (And alternative to expensive tape recording back then) It is supposed to be driven by the Williamson amplifier – but of course any suitable amplifier may be used as long as it is capable of driving the interstage transformer. The musicians senior will provide 40 Watts of sparkling triode class A. The freq response merely limited by the quality of the OPT.

845 is a tremendous good triode. It was originally developed as one of the strings in a series of 50 Watt triodes. 845 is the low u version , 211 is the medium u and 805 is the high u version. The production techniques and materials for tubes improved fast and most of the original 50 Watt's series are capable of plate dissipation between 75 and 125 Watts.

As no one needs a 5-600 Ohms output and no one cuts their own home vinyls anymore (Well – I am sure there is one or two out there doing exactly that) – I have shown the amplifier with a "regular" tapped 0-4-8-16 Ohm output transformer. The 4 Ohms tap are grounded, hence providing a balanced configuration for feedback to the grids of the 845's. The fb totals to a very modest 4dB. It may be entirely omitted without affecting the overall performance much. Sprinkle suggested a load of 4000 Ω to the 845's. I suspect that was a qualified compromise in order to achieve the additional 500 Ω winding for cutting. A better load would be 5000 to 8000 Ω. The B+ Voltage are not critical. anything from 800 to 1200 Volts will do.

PSU: The main transformer supplying the B+ is a 1180 – 0 – 1180 VAC, 300mA type. The chokes may be anything from 2-3 H and up. They must be able to handle at least 250mA and isolation must be very high. (3-5kV tested) I have moved the two chokes from the ground leg of which they were originally inserted to the positive Voltage line. It makes no difference at all for the task, as it does not matter where in the loop these are positioned. In fact it is nice to have them at ground potential as it demands less with regards to isolation. But the secondary of the main transformer are "connected" to ground via the parasitic distributed capacitance, hence it may very well introduce noise products related to the alternating mains freq. These will not be cancelled by the smoothing circuit. In practice a little experimentation may decide the best place for the chokes.

The capacitors are paper oil, but a series of modern electrolytics and suitable bleeders in parallel with a good high Voltage capacitor may be a better solution. (Rifa may be our optimal choice) This series of electrolytics may be decoupled by a high quality high Voltage capacitor.

The adjustable cathode return resistor is a risky business and absolutely unnecessary. I would insist that it is divided into a fixed value and an adjustable value. Say 2-300 Ω each. It would also be a very good idea to implement a small resistor of 1 to 10 Ω in the legs of each centre tap of the cathode return in the heater supplies for the 845's. This will allow measurement of DC balance and individual bias value. (I have indicated these resistors at the schematic) It may alternatively be measured via the copper resistance of the primary windings, but this is a troublesome and very dangerous method.

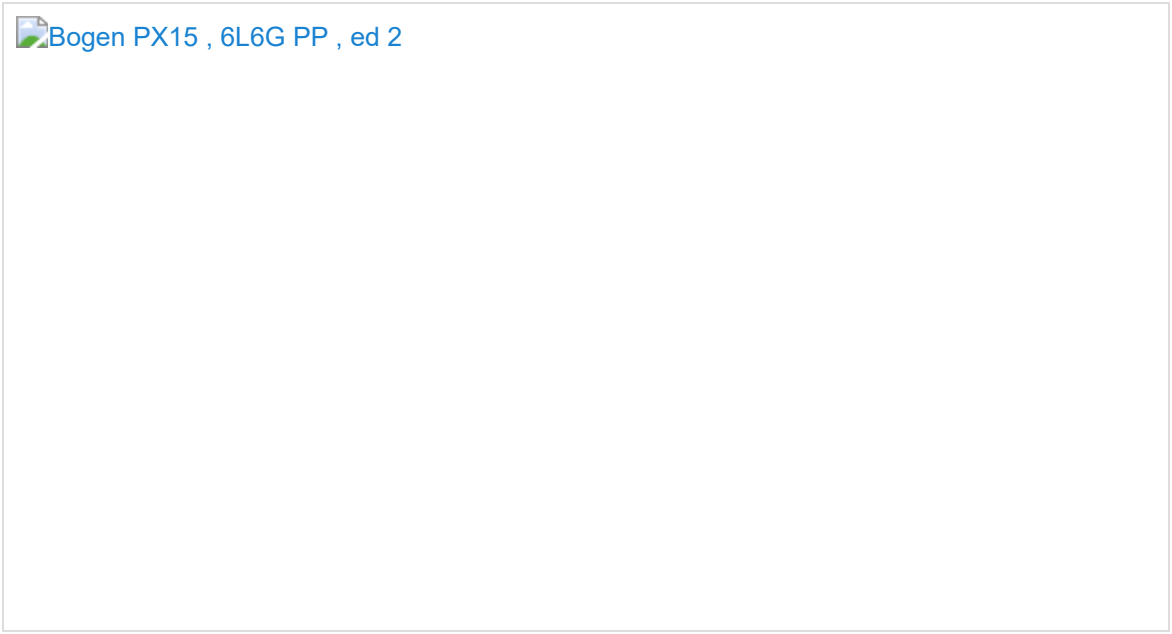
The amplifier: The two gentlemen behind this amplifier drives the 845's pretty hard. The idle current are adjusted to 125mA per tube resulting in an idle plate dissipation of 114 Watts ! (+ 915V at the plates due to copper loss at the primaries) The reasoning behind this torture is that Sprinkle and Sarser adjusted the 845's to the lowest possible IM distortion at 40 Watts out. "Increased tube failure. if any, will be a low price to pay for lower distortion on records" – they stated (Audio Engineering, Jan. 1951). Well, this may have been the case in the days of which a surplus 845 was cheaper than a 12AX7. But today we cant afford that luxury. Anyway a much better solution is to provide a higher load to the 845's. 4k Ohms is definitely at the low side , 5k is better and even 10k will not be too much.

Finally a word of warning. Do not attempt to build these high Voltage amplifiers unless you are fully aware of what you are doing and knows how to assemble it into a safe and reliable construction. (Mechanical as well as electrical)

To quote Sarser & Sprinkle: “USE EXTREME CARE WHEN WORKING ON THIS POWER SUPPLY.THE HIGH VOLTAGE PRESENT IS LETHAL.YOUR FIRST SHOCK MAY BE YOUR LAST, AND DEATH IS SO PERMANENT”. (Yes, they wrote this in high capitals)

Sprinkle was probably best known for his work with Altec Lansing and Peerless. Sarser was a professional musician playing the violin in classical orchestras. Both were dedicated audiophiles.

It was actually not unusual to design a high power amplifier, meant to be power driven by means of power tubes. Other power driven audio amplifiers from this period:



(Suggested by Francis)
Bogen PX-15, 6L6G PP, 1949

Designed by David Bogen.

The Bogen PX15 , PA Amplifier was a design with a pre-amplifier 12AH7 twin triode used as input Voltage amplifier and second stage Voltage amplifier. PX15 is equipped with two stage LC tone controls. That is quite impressive, as although LC designs makes very efficient filters, they are also by far the most expensive. PX15 has an additional input stage made of a 12SJ7 pentode. This one could only be linked in for extra gain. Enough of that – we are only dealing with power amplifiers here.

The driver and phase splitter is a paraphase coupled 6SL7. The high impedance of the 6SL7 does not make it the best driver choice in my opinion. But this is a PA Amplifier and the need for gain was important back in the 1940's. The cathode Voltage for the two 6L6G's is provided by means of the idle current of the 6L6G's feeding the filaments of the pre amplifier tubes. That is a pretty unusual pull. Not only does it provide bias but is also eliminates AC hum in the pre amplifier. Nice touch. There is further current drawn from the B+ via the 15k Ohms resistor. This is likely made so in order to get it all flying during upstart, but it also maintains a rather fixed bias and might cancel some noise products. No local feedback is provided due to the "extra" current from the B+ and the decoupling of the series filaments. Even if no decoupling was made, the bias would remain quite stable.

Do note that the lower part of the 6SL7 paraphase triode is not decoupled. This means that the gain is quite lower than the input triode, that is partly decoupled.
The "para" signal to the second triode is taken from the voltage divider 220/15 k Ohm and global feedback is taken to the cathode of the input triode. (75/1 k Ohm) Thus a good, but not perfect, balance is maintained. The feedback is taken from a separate winding at the outputtransformers. This is good as it prevents oscillation and such related problems in case of a capacitive load. But it may very well introduce false error signals if this winding is used simultaneously for for another load.
The paraphase driver has since the 1950's been the most common used in guitar amplifiers.

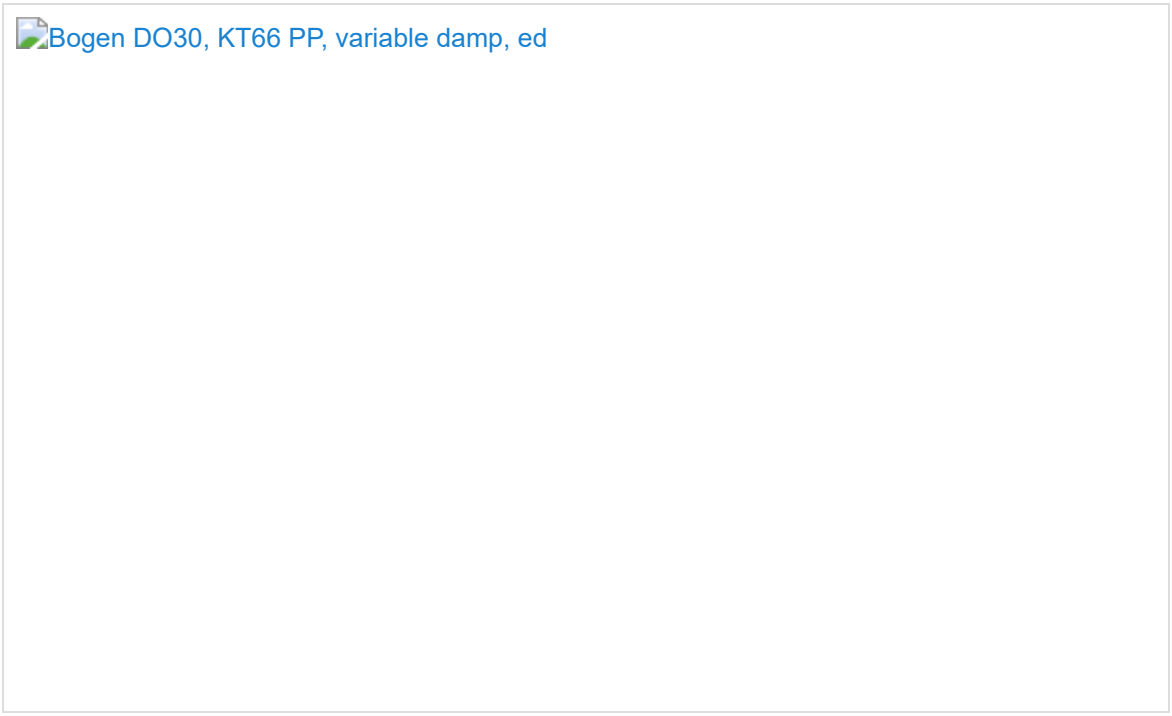


BOGEN PX15 , “mk II”

A later version of PX15 used 12AX7 as paraphase driver and two 5Y3GT for the rectification. It is worth to note that the idea of B+ current to the cathode is maintained and even expanded to the input triode. The global feedback is very low and beyond some 12kHz there is none at all, due to the high pass filter of 33n/390R.

The heater voltage is referred to the cathodes of the output tubes. This is a good , but forgotten practice, that reduce noise from the heaters and actually prolongs the life of the tubes a little.

As we are now talking about Bogen amplifiers, I would like to use the opportunity to discuss the Bogen DO30, KT66 PP.



Bogen DO30A, KT66 PP, 1954

There was in particular two main features of fashion amongst audio amplifier design during the 1950's. The best known being the "ultra Linear" or distributed load and one that still lives on. The other feature was a mere suspect design often referred to as "variable damping". It is sad that the variable damping did not survive as there is several splendid virtues associated with that circuit. The Bogen DO30 is a rather conventional Williamson design, but it is equipped with exactly this simple, yet complex feature. The reason I picked the DO30 as an example of this circuit is that unlike most of the "damping" amplifiers of the period, the Bogen DO30 uses standard components to apply the adjustment. Thus it is possible for anyone to try the idea for themselves and judge whether they like it or not. The DO30 uses conventional feedback via the loop at top of the schematic – 33k to 22p//100k returned to the cathode of the 12AT7 input triode. The variable damping or *current feedback* for a better term, are made of the resistor network 200R, 25R pot and not least the two small resistors R47 and R27 of which the latter are in series with the speaker load. This means that the current passing through the speaker develops a proportional Voltage over these resistors that may be returned to the input cathode as current feedback. The actual circuit of the two current sensing resistors are grounded between these. This means that if the Voltage is taken from the R27 Ohm resistor alone, positive current feedback are applied and if the Voltage are taken from the R47 Ohms resistor (facing towards the output sec winding) negative current fb are applied. The 25 Ohm potentiometer adjusts this. If this pot are places between the values of these two resistors (about 1/3) , the AC Voltage developed are cancelled and hence set

in neutral position. In other words the 25 Ohm resistor and the two small sensing resistors form a bridge circuit.

Now, what is the point of this variable damping or current feedback. Well, this is indeed a can of worms and much to complicated to get in details with here, but lets read the headlines. The damping factor is a simple relation between the “inner resistance” of the amplifier (z-out or ri) also known as the generator impedance and the impedance of the actual load , meaning loudspeaker. DF = Q = speaker impedance/z-out. At least this is the theory, in the real world it is much more complicated and a thing that often is forgotten or ignored is that a real speaker also reveals a resistance made of the copper winding. An 8 Ohms speaker will usually show a copper resistance of 5-6 Ohms. Hence no matter how much damping – how high the damping factor the speaker will always be affected by the copper resistance as a series equivalent as well. Despite this paradoxical fact, current feedback works, both as positive and negative feedback and also due to the fact that what really drives the speaker is not the Voltage across it, but the current that passes through it. (This is also why I like current fb)

But lets stick to the conventional theory here and discuss what *also* happens without the complication of further worms. (If interested, please read my article “Power distortion” at the “PEARL archive” created by Bill Perkins, Canada) All speakers has ringing, oscillations and similar naughties being worst around the resonance point or points. Our bass speakers (woofers to some of you – woof woof) has a large and serious resonance usually around 20 to 50 Hz. This is an area we would be best served by staying away from. FAR away in fact as the resonance point are also a point that is impossible to control. It responses to even the slightest stimuli – even a fraction of a Watt is more than plenty to trigger the problems: distortion and “wild” diaphragm movements. The bad thing is that is not possible to avoid that frequency with a conventional amplifier. With regards to ringing, lets put it another way. Say we expose our speaker to a transient, being that a drum beat, a hard accord on a piano or whatever. This will give the speaker a kick and as everything else that is kicked it needs a little time to settle at its rest point. It moves forwards as supposed, but then back kicks and perhaps a little ripple before it stops moving. These ringings equals to distortion and can be very nasty to listen to if not controlled. Control means *damping* = *damping factor* = *Q*. But damping is a relative matter – too much damping is just as bad as too little damping. Critical damping is when damping equals to Q = 0,5. Not two sets of speaker are exact alike and the necessary damping depends upon a number of variable, not easy to calculate, not speaking about the conflict in damping from the point of view of transient response and overshoot. The easiest, most simple way to handle this unpredictable scenario is by variable DF. This will allow you to adjust it yourself, according to your specific speakers, set up and listening room, not least your personal taste and preferences.



Above some hard evidence copied from Bogen lab results. This shows that it is worth to experiment with current feedback or current drive. The figures pretty much speaks for themselves, but note how the amplifier are keeping away from the dangerous high impedance at woofer resonance in fig. 9.

We might dig a little deeper into these matters if there is interest. Please, provide feedback to me at: 100amplifiers “at” gmail.com

---



(Suggested by yours truly)

Fletcher & Cooke's cathode follower OTL, 1951

This extremely ambiguous design appeared in the November issue of the American "Electronics". It is pretty unusual for the time and even today it would be considered as a rather extreme design. Capacitors and transformers were a weak link in those days, all though considerable improvements had taken place, compared to the components available before WW2. The best paper oil capacitors and C-core transformers were very expensive. Fletcher and Cooke's goal was to make an amplifier capable of reproducing signals from 2 to 200.000 Hz. The reason is not that

we a able to hear such extreme frequencies, neither that any audio signal source would deliver such a range. But in order to avoid phase shifts in the audio range of 20-20.000 Hz, such extreme is actually necessary. Luckily phase deviations beyond some 7-10 kHz means little or nothing, as the human perception system ignores the multiple reflections of such high notes. Other vice we could not stand listening to most speakers or signal sources. Output transformers stretching to some 40-60 kHz will do, but most certainly 100 kHz or higher is better. I like the philosophy and ideas behind this amplifier and I adore that no means were spared in order to reach the goal. Fletcher and Cooke suggests five versions of the amplifier, the smallest one using four 6AS7G's per channel, the largest one using twenty pieces per channel. This is very extreme, even considering that the two gentlemen were only making a mono version, as stereo was not yet commercially available. (stereo was released in 1958) The version shown in the schematic is the 8 tube type, delivering some 6 Watts. The largest version capable of 33 Watts will need 1600 Watts continuously from the mains. A stereo version 3200 Watts ! , the heaters alone will draw 40 x 2,5 A = 100 Amperes. Such animal will be a nightmare with regards to balance, heat and possible failure. How do we match or balance 40 twin triodes ?. LOTS of heavy and expensive iron. Very difficult to build as well. A better choice of output tube would be the 6336 or much better 7241/7242, 6C33 and similar. If you wish to build one of these amplifiers, I will be happy to provide you with the transformers, but really we would make a better, cheaper and much more reliable amplifier with a good output transformer. Even if we kept the 6AS7's as output tubes – two such would bring you some 5 Watts with a decent output transformer. Anyway – to the hardcore OTL fans that wants to make a Fletcher Cooke, I suggest that you sacrifice any two of the first four stages in the pre-amplifier. We really do not need that much amplification anymore. I would also suggest that you alter the low freq roll off, that is the same at all stages. Such method provokes low freq oscillation related distortion phenomenons. Go in 1/3 – higher or lower – either resistor or capacitor.

I love the no compromise attitude of this amplifier, despite it being an OTL design.



TELEFUNKEN V-69a, F2a11 PP , 1952

The Telefunken V-69 is an interesting amplifier of stringent symmetric design. The Telefunken V69 series is a typical German design of studio audio amplifiers made

from the late 1940's up to the 1960's. Lots of such German amplifiers made use of the balanced phase inverter types, and very often so, to act as the driver as well. A thing that often puzzles me with regards to Western Electric designs and other push pull designs equipped with input transformers, is that this very input transformer is followed by some sort of electronic phase inverter. If you insist on an input transformer, why not use it as the phase splitter as well ? All we need is a centre tap. Telefunken were obviously thinking in the same terms and here the input transformer does indeed handle the phase splitting. Excellent….

UPDATE: Due to a mail from Frank Blöhbaum, Germany, I have momentary withdrawn a large part of the vignette covering the V69a Amplifier. Frank Blöhbaum correctly pointed out that my analysis with regards to the feedback scheme was wrong. I apology for this mistake. It turned out I had made an incorrect drawing in my notes and was actually partly analysing the "wrong" amplifier.

Thanks a lot to Frank Blöhbaum for spotting the mistake. I will upload the material again, once I have corrected it for the error.

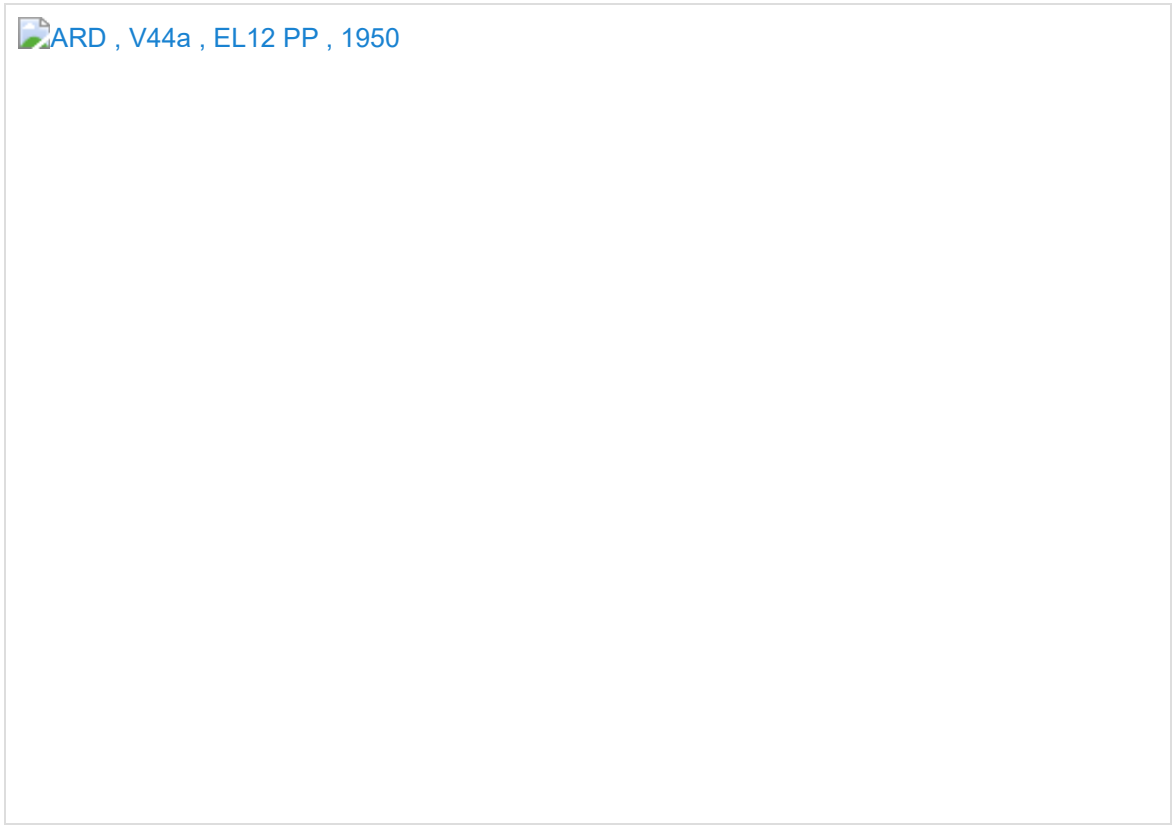
The EZ12 rectifier is an indirectly type developed by Telefunken and introduced in 1938. Although the Telefunken datasheets recommends the use of series resistors it was hardly mandatory as Telefunken themselves ignores that advice in the V69. EZ12 was the predecessor for GZ34 that came in 1954. Note that EZ12 uses German steel socket and 6,3V heater.

EF804s is a special quality, low microphonic, low hum, long life, high reliability, tight tolerance, vibration shock proof, non interface cathode , – pentode…..phew…designed for LF applications. Socket is noval. It is vital for this valve that the heater voltage is kept as close to 6,3 volts as possible. I would apply regulated DC voltage – LM317 or similar. EF804s was a common used pentode in German sound studio and broadcast equipment.

F2a11 is one of the best tetrodes developed for audio. A pair will easily provide you with 30-40 Watts in to a 5kΩ load. It is amazingly linear as a triode as well , some 20 Watt's into the same output transformer. A single one may deliver some 5 Watts with less than 350V at the plate.

V-69 was made in three versions. The last model V69b used efficient solid state diodes and swapped the loop bias into conventional active bias. The higher Voltage and lower regulation due to the solid state diodes increased the output power to 35 Watt's and improved the distortion figures.

Not more to say about the Telefunken V69 for now. A less known, but very similar design was used in the German ARD V44 introduced in the late 1940's.



German Rundfunk Studio Amplifier, ADR V44a, 1950

Above is the second generation of the V44. First generation was designed shortly after WW2.



QUAD II. KT66 PP, 1953

Peter Walker made this classic to come with his best known classic – the famous electrostatic speaker.

In my first vignette about this beautiful QUAD II, I didn't give this amplifier the credit it actually deserves. We are so accustomed to this old classic, that we tend to neglect the real virtues of the amplifier and the ingenuity behind. It is actually a very neat and clever design.The output stage is dead good, but I usually convert the input stage. Is that HiFi blasphemy ?

Keep in mind that Peter Walker was limited by the measuring tools available and the high costs of components in the 1950's. For a lab the size of QUAD, I will assume that he had instruments capable of measuring THD down to about 0,1%. The tolerance would have been around +/- 100% and harmonics higher than 3'rd would have been ever difficult to measure. Only a few high end labs at the time was capable of measuring higher harmonics much below some 60 dBs/0,1 % and it was very troublesome and time consuming. (And unreliable)

The input signal is taken to a pentode coupled EF86. The phase is inverted by a second EF86 strapped as a Paraphase inverter. This pair shares a common cathode resistor, which improves the phase splitting, reduces distortion and increase the gain. The voltage divider of the common cathode resistor; 680R and 100R is connected in the signal path on the KT66 grids. This is quite unusual, but it does reduce distortion a little further. (Not much, though) A feedback signal from the secondary of the OPT is connected to the voltage divider of the cathode resistor. The screen grids of the EF86's share a 100n capacitor. The purpose is to cancel voltage difference caused by signal, thus maintain a fixed voltage here.

The best part of this amplifier is the output stage. The two KT66's is loaded at the anode as well as the cathode. This is referred to as a distributed load. This type of output loading is *similar* to the Ultra Linear coupling. But it differs in a few major ways. Ultra Linear coupling may be considered as a mix between a triode and pentode/tetrode coupling. (Usually taken at 43% of the winding turns, but this particular point is actually not important) The gain, hence efficiency, of the Ultra Linear output stage is still high, although somewhat reduced. Some reduction in distortion takes place partly due to the local voltage feedback, but more so due to the better linearity of the approached triode strapping.

The distributed anode/cathode load is rather a mix between a cathode follower and a common plate loaded output stage. The local cathode voltage feedback reduce distortion as well as inner impedance, hence lower output impedance of the KT66's. This results in a better grip of the OPT and a higher damping factor. These improved merits, however, is at the cost of gain and efficiency. This means a demand for higher voltage swing in order to drive the output stage. The distributed load has often been recommended as a 50/50 split of the primary winding's ala' McIntosh. Meaning that half the load is placed at the plate and the other half at the cathode. Such designs is indeed rather difficult to deal with , due to the poor efficiency, but Walker chose a design in which the cathode load is only with about 10% of the winding's, equal to 20% of the total load impedance. Doing it this way means a grid voltage swing we can deal with. Despite of this Walker only manage some 15 Watts from the pair of KT66's. This should be compared to a triode coupled Push Pull KT66 that will do the same 15 Watts. A triode coupled KT66 is remarkable similar to a PX25 triode. It is possible to achieve close to 50 Watts from a pair of Ultra Linear coupled KT66's with a B+ of about 525 V and a UL tapping of 40%.

The "weak" points of the QUAD II, is the "cheapskate" PSU and to a degree the EF86 input stage. I am personally not particularly found of the EF86 and find that many other pentodes sounds better. If you have a vintage QUAD II at hand, I suggest that you swap the 100n signal capacitors and the 25u electrolytic that decouples the common cathode resistor of the KT66's. These often leaks, reducing sonic quality and might in time damage the output stage. In fact I would change all

resistors and capacitors. Modern components is a lot better. You will find that most of the vintage resistors in the QUAD II , has driften quite a lot. The part list is small, the costs now a days is low and very well worth the effort.

And whilst you are at it, consider to do a little active modification.



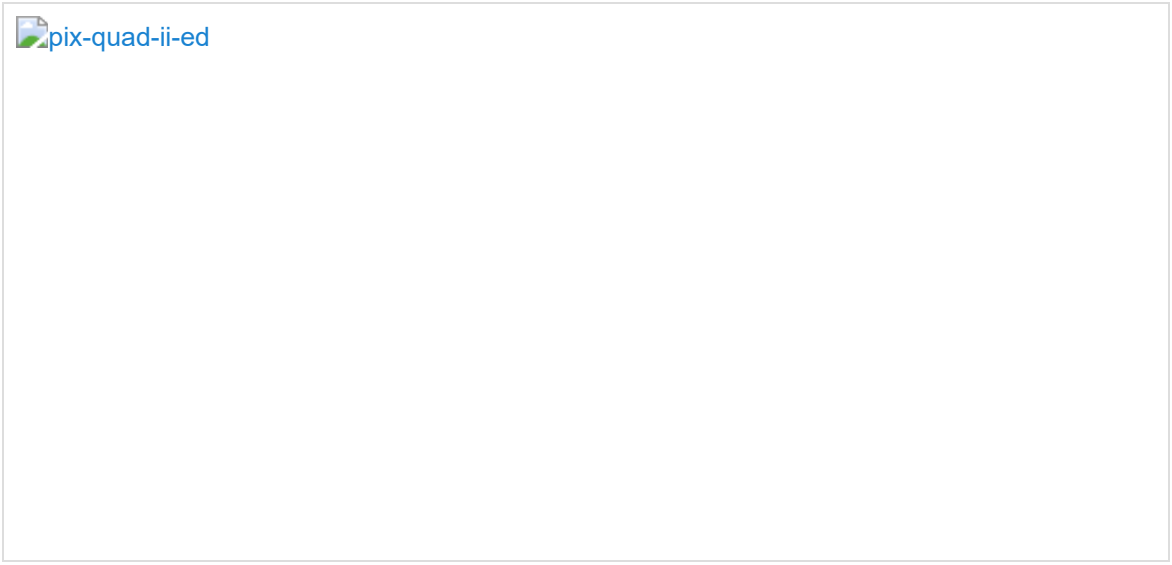
Suggested modification for the QUAD II.

You can swop all the components marked with red or some of them, just as you prefer. Extending the PSU voltage dividers will improve regulation, signal ripple and noise. AT least, please, change the 1M Ohm input resistor – it gives me the creep..

The OPT is good, but nothing special. The “open” construction will allow you to interfere with the individual windings. The cathode winding may be moved to the top of the plate windings, allowing conventional loading or even Ultra Linear coupling. Lots of fun possible with this old QUAD.

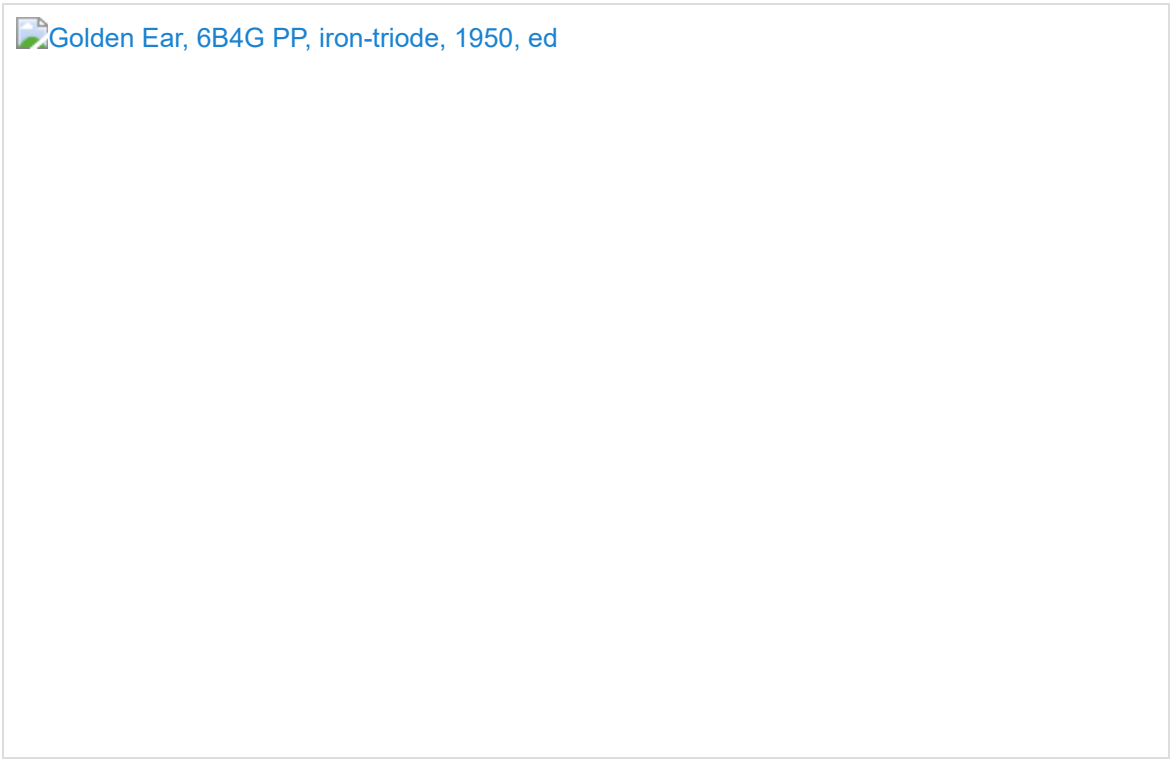
The common troubles of the QUAD is leaking of the transformer compound and leaky capacitors. I once had a set in for repair , of which one of the mono blocks was acting weird. The set had passed through a couple of workshops, that had given up in making a diagnose. It turned out that one side of the plate windings had a bad winding, that occasionally opened. Modern copper wire is better (pure) and the enamel much more reliable that what was the standards in the 1950’s.

I have not yet been able to verify if was Walker or McIntosh to first use the “distributed load” configuration. Walker and Williamson experimented with Plate/sg2/cathode loading very early on (according to an article by the two gentlemen that appeared in WW in the 1950’s), but decided to leave out the sg2 loading. They apparently disliked the name “Ultra Linear” and did not like that application much.



QUAD II and accomplished Pre-Amplifier

The QUAD II is indeed a nice amp and the aesthetic design is timeless. The pre-amplifier is not my cup of Thea. But then again – I have never heard a good preamp made before 1970…



GOLDEN EAR AMP by Joseph Marshall, 1950

The ”Golden Ear” amplifier is not a particular amplifier as most seem to believe, but a series of schematics by Joseph Marshall. (Not to be confused with Jim Marshall of the British Marshall guitar amplifiers) These appeared as construction articles in US magazines such as Radio Electronics and Audio. It is difficult to estimate exactly how many amplifiers Marshall designed using the “Golden Ear” term, but I know of six types of which the first was published in the April issue of Audio, 1950. (Shown above)

This first Golden Ear amplifier was an all triode transformer coupled amplifier using 6B4G at the output.

A letter by B.E. Beggs to Audio, May 1950 showing once again how hard it is to “be the first” :

“*Sir: I note with interest the article “For Golden Ears Only,” by Joseph Marshall, in which he states that the amplifier represents the nearest approach to perfection achieved in three years of experimentation. I further note “with the exception of a few elements, which may lift eyebrows slightly,” that my eyebrows were lifted more than slightly. Upon reading the article with care and studying the schematic, I discovered to my amazement that the circuit is very similar to one published by the writer in the January 1946 issue of Electronics in which the circuit appears on page 155. My design utilized essentially the same basic feedback circuits, the identical transformers, and the center- tapped choke to maintain the driver output in Class A. I should like to congratulate Mr. Marshall on doing a fine bit of test work and on applying to my original circuit the cross neutralization as described by Paul W. Klipsch in the same magazine some sixteen years ago. George E. Beggs, Jr*”

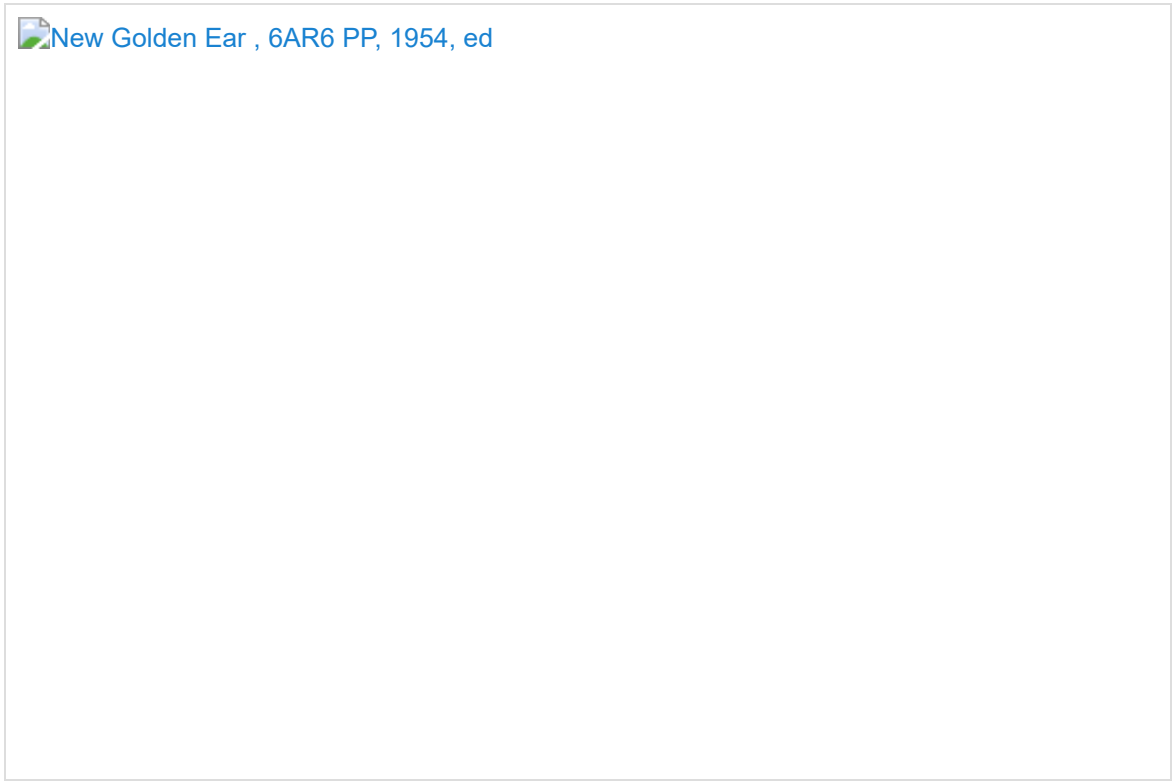
The later models all applied the cross coupled phase splitter that we would today possible consider the trademark of the Golden Ear amplifiers. (The cross couple was developed by J.N. van Scoyoc, 1948)

NOTE: I AM NOT QUITE DONE WITH THE VIGNETTES ABOUT THE GOLDEN EARS, BUT DUE TO SOME MAILS REGARDING THESE AMPLIFIERS, I HAVE DECIDED TO PUBLISH THE SCHEMATICS AND TEXT AS IS. – MORE TO COME LATER.



GOLDEN EAR JUNIOR, Marshall, 6V6G PP, 1953

This amplifier appeared in Radio Electronics,Nov. 1953.



GOLDEN EAR, Marshall, 6AR6 PP, 1954

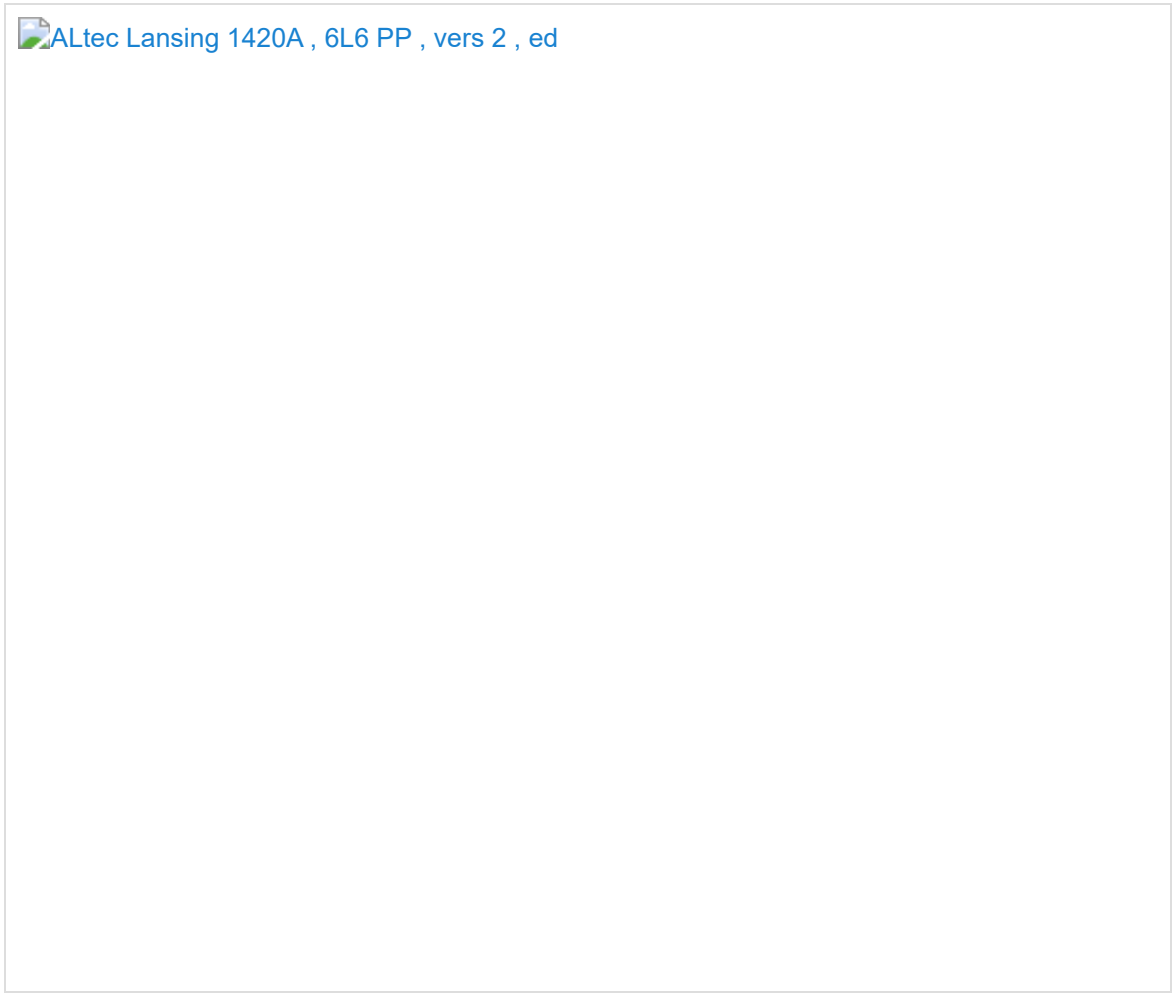
This amplifier appeared in Audio magazine, Jan. 1954.



GOLDEN EAR LABORATORY, Marshall, KT66 PP, 1954

This was the culmination of the Golden Ear amplifier series. It was published in Radio Electronics, Aug. and Sep. 1956. (I seems to remember, however, that Marshall later made yet another amplifier design – something like “guilding the musicians amp” ?)

Anyway I will discuss these interesting Golden Ear amps in a little more detail later on. For now the schematics are here for you to enjoy.



(Suggested by Joe Roberts)

Altec 1420, 6L6G PP, early 1950's

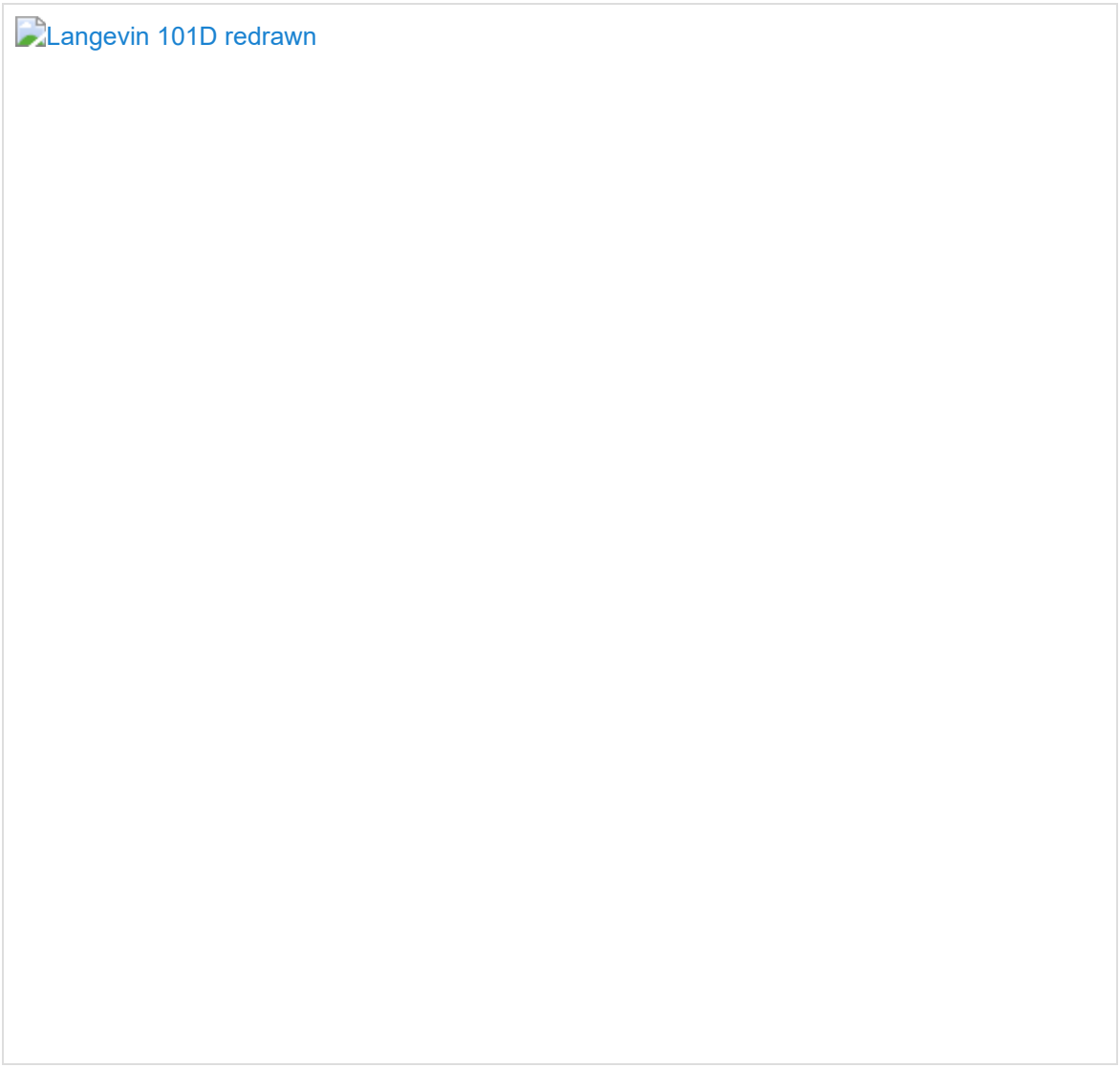
There is several things worth to talk about in this amplifier. First of all, although it may not be immediately evident is is indeed a Williamson design. The cathode followers attached to the 6SJ7 drivers counts as one stage.

The 6SN7 cathode follower driver also applies bias for the 6L6G's….And the low output impedance from the CF is capable of driving the 6L6's in to grid current. (Class B area) This will produce a respectable figur of up to 40 Watts from a pair of 6L6G's…..Quite nice…. But all that gain !

I would probably triode strap all the 6SJ7's. 6SJ7 is smashing good strapped as a triode. (Very similar to 6SN7 in fact) That would cool the amplification, improve headroom as well as freq response and transient merits. I would probably also AC couple from first stage Voltage amp to phase splitter in order to increase the plate Voltage. A plate choke would come in handy here. At least I would go a long way in order to increase the cathode to anode voltage of the first two 6SJ7's. DC coupling preferred.
The power stage is driven in to grid current AB2.. I would adjust to AB1 and sacrifice a little power for sonic quality. Some 20-25 Watts should be possible.

PSU choke input, filaments lifted, two parallel 5U4's..Nice…

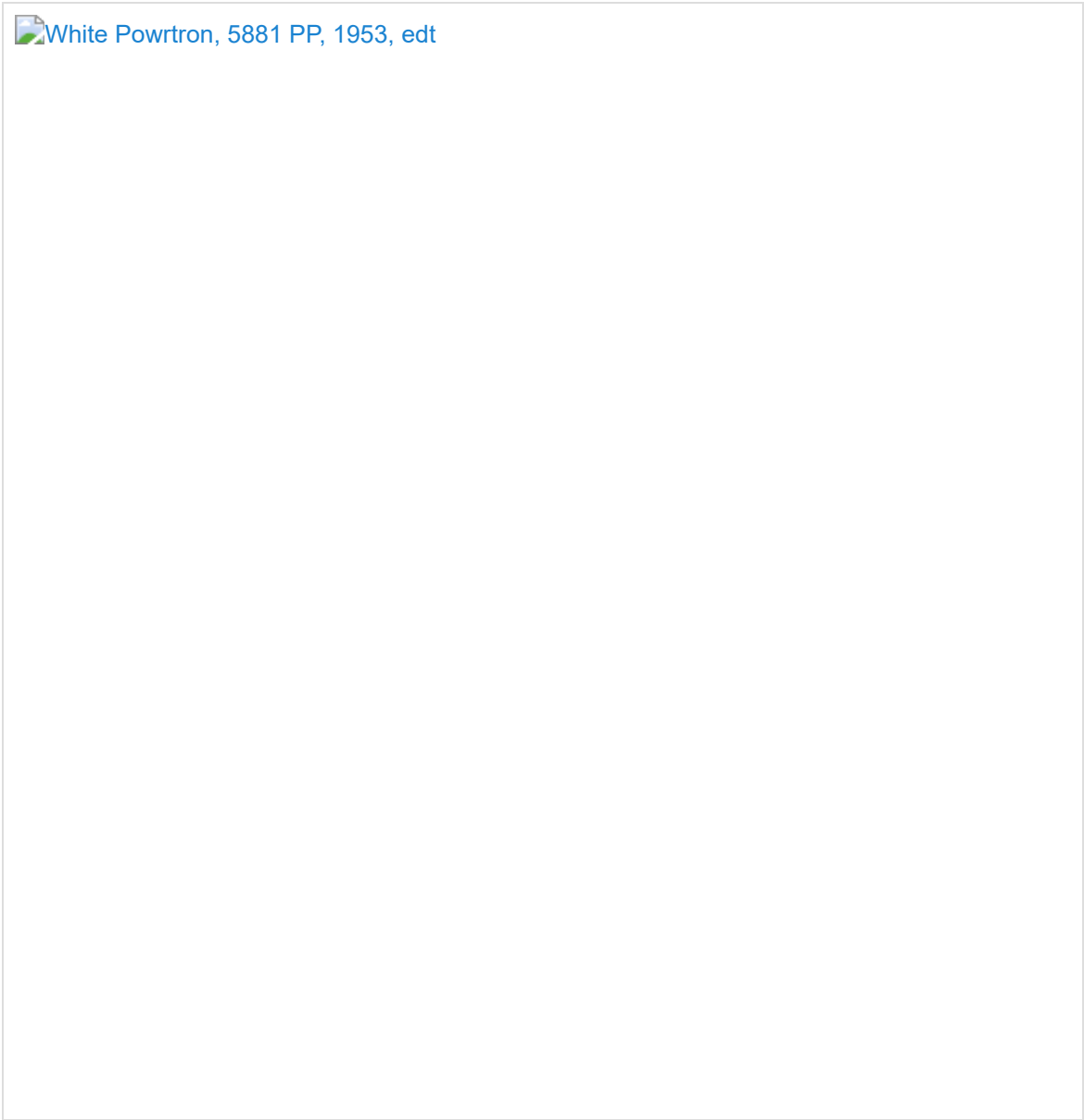
Great amp…



Langevin 101D, 4 x 6L6G PP, ca. 1952

This Langevin (W.E. regie) is a nice straight forward proven high quality design, just as I like them, but it comes with a twist or two. The floating paraphase phase splitter also acts as Voltage amplifier and driver. Nothing weird about that, but almost as a W.E trademark the possible transformer phase split option is ignored. This is a "feature" of W.E. design, that will remain as a mystery to me. The feedback is incorporated by means of a tertiary fed to only one part of the signal halfs. Another mysterious solution. Why not use a center tap and feed it back as a balanced signal ? Or simply use the secondary with a grounded midpoint. I suspect that WE did not trust the winding techniques back then to be accurate enough for phase splitting. It was most certainly possible, but maybe they did not considered it worth the extra cost to make a precision transformer.

Do also note that the OPT is compensated by means of two 4n capacitors. This amplifier was certainly made for steady state PA use, rather than best possible domestic reproduction. A modern version or possible modification would be to apply balanced fb and take full advantage of the input transformer by letting this so the phase splitting as well. That would also allow the two 6SJ7's to be triode coupled. 6SJ7's performs outstanding as triodes. If you do not need the extra power a pair of 6L6G's will deliver some 40-50 Watt's into a load of 4-6k. The original Langevin OPT would be 2-3k Ohm.



White Sound, Powrtron 5881 PP, 1953.

I have never heard or seen this amp in real life, but it sure deserves to be mentioned here. It appeared first time in the US magazine "Audio" , november 1953.

Stan White – the designer of this amplifier is a hard core Joe. He is scientist in physics and meteorology and audiophile music lover. White designed some remarkable speakers in the 1940's and 50's. Some of these designs are still being produced today.

Some 10-15 years ago, a German HiFi magazine managed to get their hands on this old amplifier. They were stunned about the high quality and 3D stage. The circuit is simple, but do not let that fool you. A lot of effort has been put in to this amplifier in order to maintain as little phase shift as possible. Do also note the use of choke input PSU for better regulation. According to White Voltage regulation is of the utmost importance. I could not agree more.

Stan White, 2001: "When revisiting the POWRTRON design, it was discovered that there have been many improvements in electronic components since 1953. The electrolytic capacitors for power supplies have higher voltage capability and much higher capacitance. There are now non-inductive coupling capacitors that have lower ESR and are more compact. There are non-inductive wire wound resisters, frame grid audio triodes, beefed up EL34, 5AR4 tubes etc. Transformers have better high voltage insulation, better transformer iron and better lead wires. Pots are more reliable etc. The life of modern amplifiers can be better than it was 50 years ago. All of these things are improvements over 1950's amplifiers. With the upgraded parts, lower distortion and longer life is achieved. There are those who feel that amplifiers made from obsolete designs with obsolete parts are better. If shorter life span and high distortion are "better" then better has been redefined. Jack Benny's Maxwell does not perform better than 2002 Volvo's. This is so even though a Maxwell costs more in today's market."

I am perfectly in agreement with White here as well.

White also says:" Many audio parameters are physics based and generally not dealt with by electrical engineers. This is one reason POWRTRON is different. POWRTRON was designed with physics criteria, not electrical engineering cook book techniques."

I think this statement will be recognised by many DIY geeks…..

And no, this particular power tron it is not a bad spelling from my side, White wanted it to be spelled without an "E"…….

I have received some letters regarding this amplifier. Ralf, Germany finds the schematic confusing and asks me to explain how it works. It is actually pretty straight forward – I have redrawn the schematic below and trust it is now easy to see what is going on.(I have left out the input cap and the 1M Ohms resistor) Lots of info in text books and at the internet about the cross coupled and many other phase splitters. I would like to use this opportunity to recommend **John Broskie's** EXCELLENT tube site: **www.tubecad.com**

This site is first class top reading. It is fun, interesting, original and educational. What else can you possible ask.? Ah yes – it IS free…….!

J.B. is a master into the art of equivalent circuits and virtual design. This gives the word “armchair designer” a new meaning. Dont challenge this man in the discipline of equivalent circuits. He is capable of turning a classic Volkswagen into a Skt. Bernard dog or a danish blonde into danish bacon. (Hmm……that may not always be *that* hard)

Here is a link to John’s notes on basic strapping of triodes: http://www.glass-ware.com/Tube%20CAD%20Circuit%20Guide.pdf



Stan Whites “Powrtron” , 1953.

The cross coupled phase splitter needs a low z source to drive it, hence the use of cathode followers at the input. Do note that White uses **current** as well as **Voltage** feedback forming **power feedback**, this is indeed what defines the White “Powrtron”. (Read more about this in my notes about “Power Distortion” from the 1990’s to be found at PEARL’s archive by Bill Perkins, Canada)

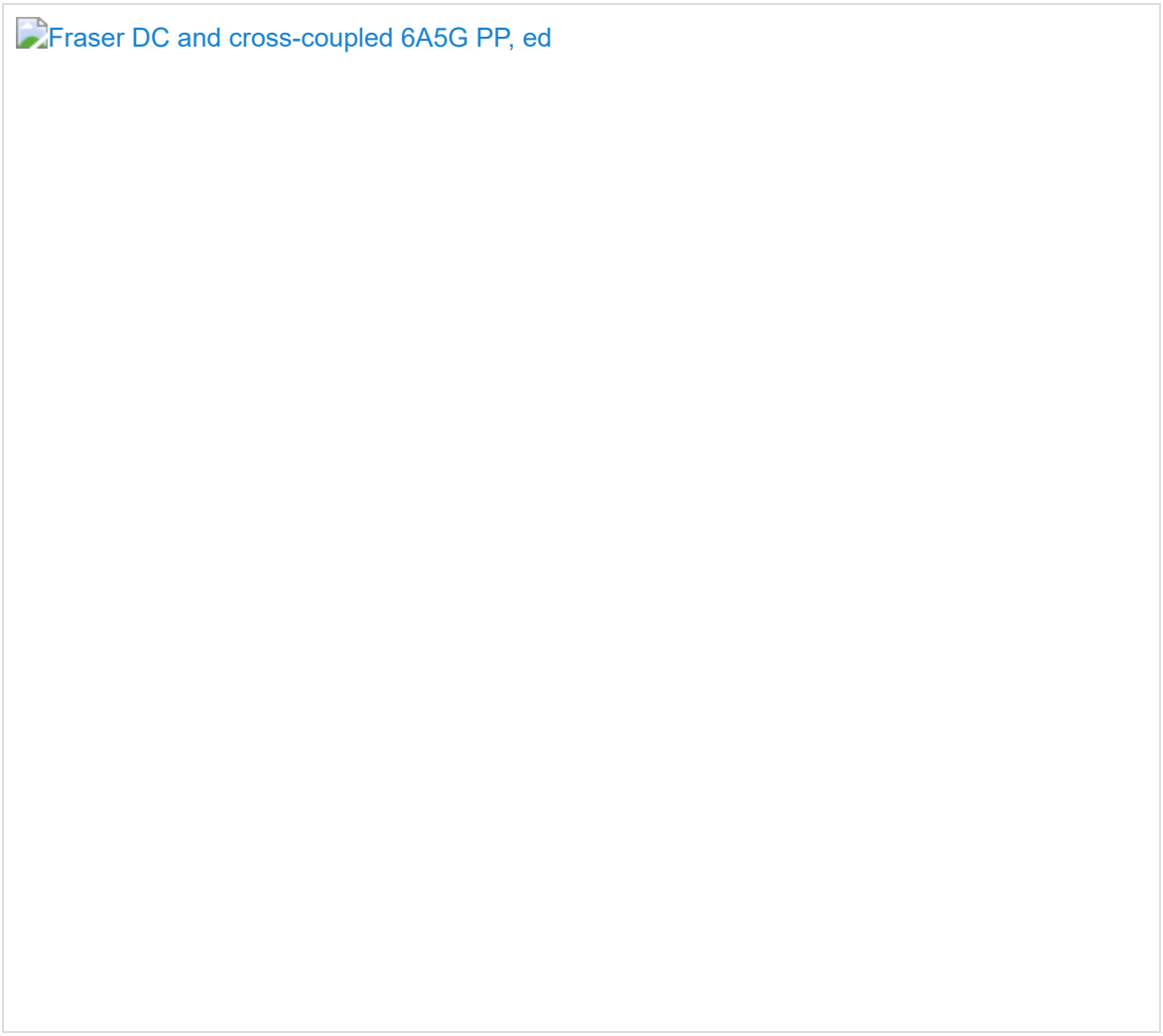
I have received a letter from Mr. (FH) Gibbert, München. Thank you very much.

Mr. Gibbert's kindly points out that this amplifier is based upon the "Golden Ear" design by Joseph Marshall and that the cross coupled phase splitter was first brought to light by "someone called Scoyoc".

I am in agreement here, at least with regards to the cross coupled phase splitter. It might have appeared in my original text (Now edited) that I honoured the cross coupled phase splitter to Stan White. But it was never meant that way and to my best knowledge neither did Stan White ever postulated. I do however believe that the Powrtron circuit is an original design by White – although he may very well have been inspired by Marshall.(That was the purpose of Marshall articles anyhow – please, see also my vignette about Marshall's Golden Ear amplifiers)

It would be difficult to use the C.C.P.S. in any design with a pair of output tubes and not resemble other such designs. White's amplifier differs from Marshall's later Golden Ear designs (The first Golden Ear did *not* use CCPS) in a major way by the use of global current and Voltage return to establish power feedback.

Talking about these early designs with CCPS, here is another one – that precedes both of the designs by the two mentioned gentlemen.



Fraser, DC coupled 6A5G , 1951

A major advantage in the use of CCPS is that due to lack of capacitors, there is almost no phase shift way up in the kHz range. This allows the use of a very large amount of feedback, thus the impressive specifications of these amps. Fraser takes this to another extreme by the direct coupling to the output stage as well. It is a fragile circuit in case of any – even a minor flaw in the current path. But it may very well be worth the chance – nothing ventured , nothing gained.

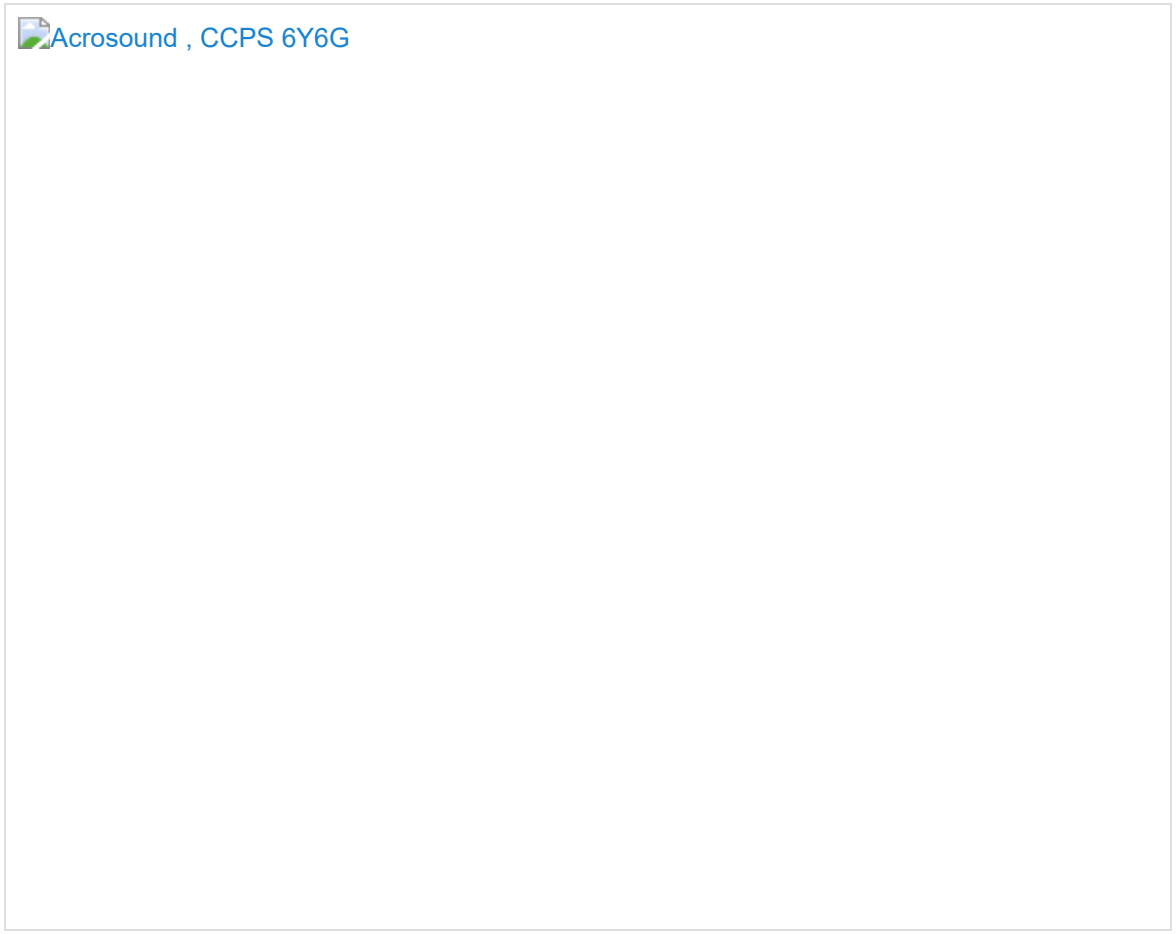
Fraser even glows the entire CCPS by means of DC current. (This is 1951 !) Hats of to Mr. Fraser.

The Cross Coupled phase splitter was developed by **J.N. van Scoyoc** and appeared the first time in Radio electronic engineering edition., Nov. 1948. (The original design apparently used an input transformer ! ?)

It is difficult to find further information about Stan White. Until recently he had a website ”www.stan-white.org” , but it is now closed. This could sadly be due to the passing of White (He must be an older man by now)
The text I have quoted by Stan White was taken from this homepage when it was still going. White apparently produced some weird speakers called ”the shot-glass speaker” until very recently.
In the June 1956 edition of US Audio an advertisement from Stan White announces a motional fb tweeter capable of squarewaves up to 70kHz ! I wonder what ever happened to that speaker ?

Hats off to Mr. Powrtron

Here is a couple of Acrosound CCPS designs:



Acrosound CCPS Ultra-Linear 6Y6.

This is a lot of tube power to drive a pair of 6Y6's. Expect some 10 -12 Watts at the exhaust in practice. Anyway – It may be worth the effort as the 6Y6 is a very good beam tetrode. I would not hesitate to swap the usual crazy large 1MΩ input resistor to a more moderate 100k or so.



Acrosound CCPS Ultra Linear 6146.

This is a serious design. 1650 VAC is a matter that calls for a lot of caution. The cross coupled phase splitter is followed by a driver that is cathode loaded to the 6146 output. Do also note that the plate and sg2 windings are separated, which allows a lower Voltage to the screen grid, despite the use of Ultra Linear topology. Elegant….

I like the three smoothing chokes. The choke loaded input offers better regulation than the conventional electrolytic input at the expense of a lot of “lost” Volts.The swinging choke is not really necessary if you can afford the space and size of a regular choke. Swinging chokes are not better that regular chokes, but they may prove better if physical sizes and weight are comparable. Do I need to draw attention to the 1MΩ input resistor ?

Cool and dangerous circuit that calls for respect in both contents.

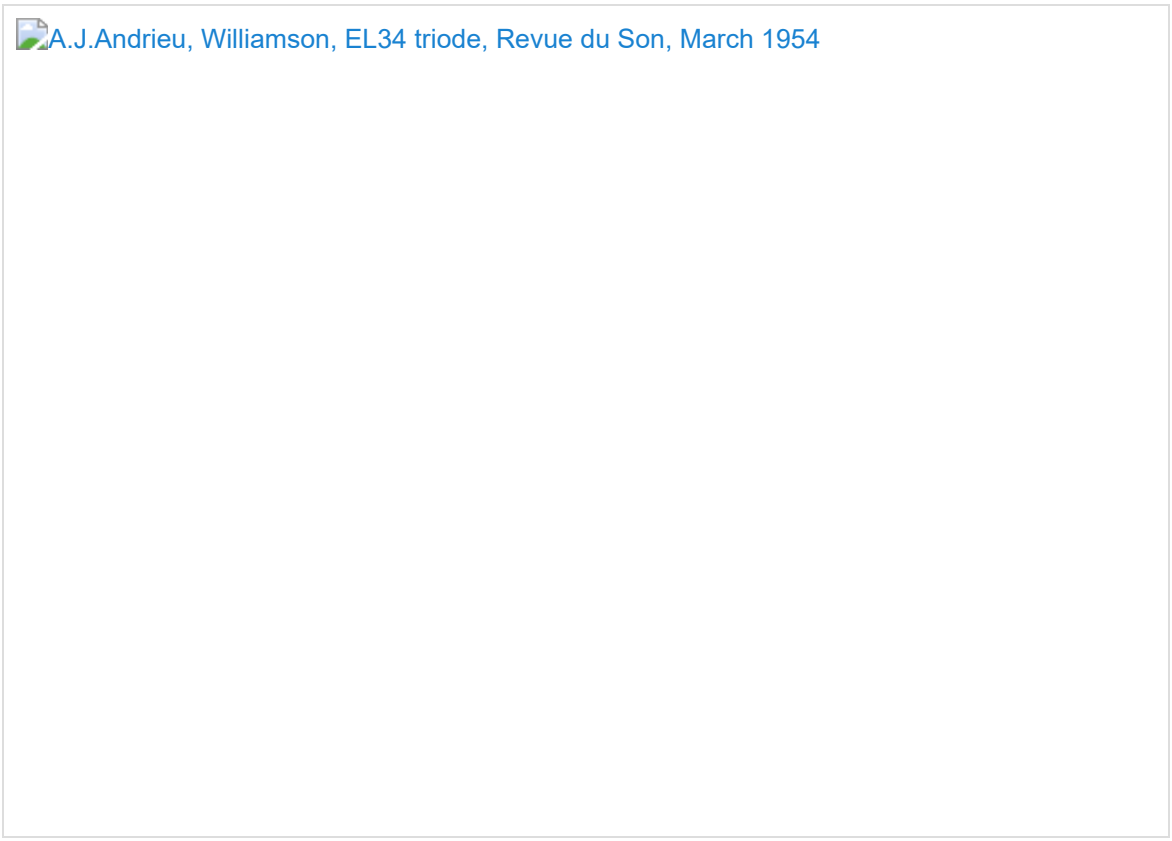


(Suggested by yours truly)
Krohn Hite UF-101, 4 x 6550 PP, @1954

Designed by Dick Burwen. A grand tour in advanced design to fight THD.
I don’t know how it sounds (It was a laboratory amp) , but at 50 Watts it measured:0.005%@1kHz, 0.03%@15Hz and 0.02%@10kHz. IM distortion 0.005% at 100W peak. Less than 0.0015% at 35W – 1kHz.
Phase deviation max 2 degrees 15Hz to 30 kHz
Load 2,4,8, and 16 Ohms.

The use of the three multi switches and the way it is drawn, makes it almost impossible to overlook the circuit in my opinion. This amplifier is unusual in many ways. It uses a plate and cathode loading similar to McIntosh, but the output stage does not appear to be symmetrical. While looking at it, it strikes me that it is kind of a large sinewave and square “generator”. It looks to me as it is engineered with the oscilloscope as the reference and by means of strategically well placed capacitors and positive as well as negative feedback it is forced into good square and sine behaviour. The signal at the plate of the upper input triode are distorted beyond recognition, but then later forced into a square again. This is bad engineering from an audio sonic point of view, but it is a master stroke if you want to design a lab/industrial power amp for test purpose. And this is exactly what Burwen was doing. Keep in mind that this amplifier was meant for use as a power source of low distorted sine and square signals, for vibrating and power test in the audio range. And this task are well accomplished.

I have discussed the amplifier slightly with Dick Burwen and he told me that the limiting factor back then, when it was designed, was the OPT. He wished he could had used some of the later available, like McIntosh’s.
Nevertheless we need to lift the hat to these impressive figures – probably the lowest on any valve power amplifier design.
BTW, Dich Burwen hates valve amplifiers and considers them as – I quote. ” A vacuum tube amplifier should really be regarded as a nice piece of furniture with wires, that glows in the dark”
He he….mine sure does…



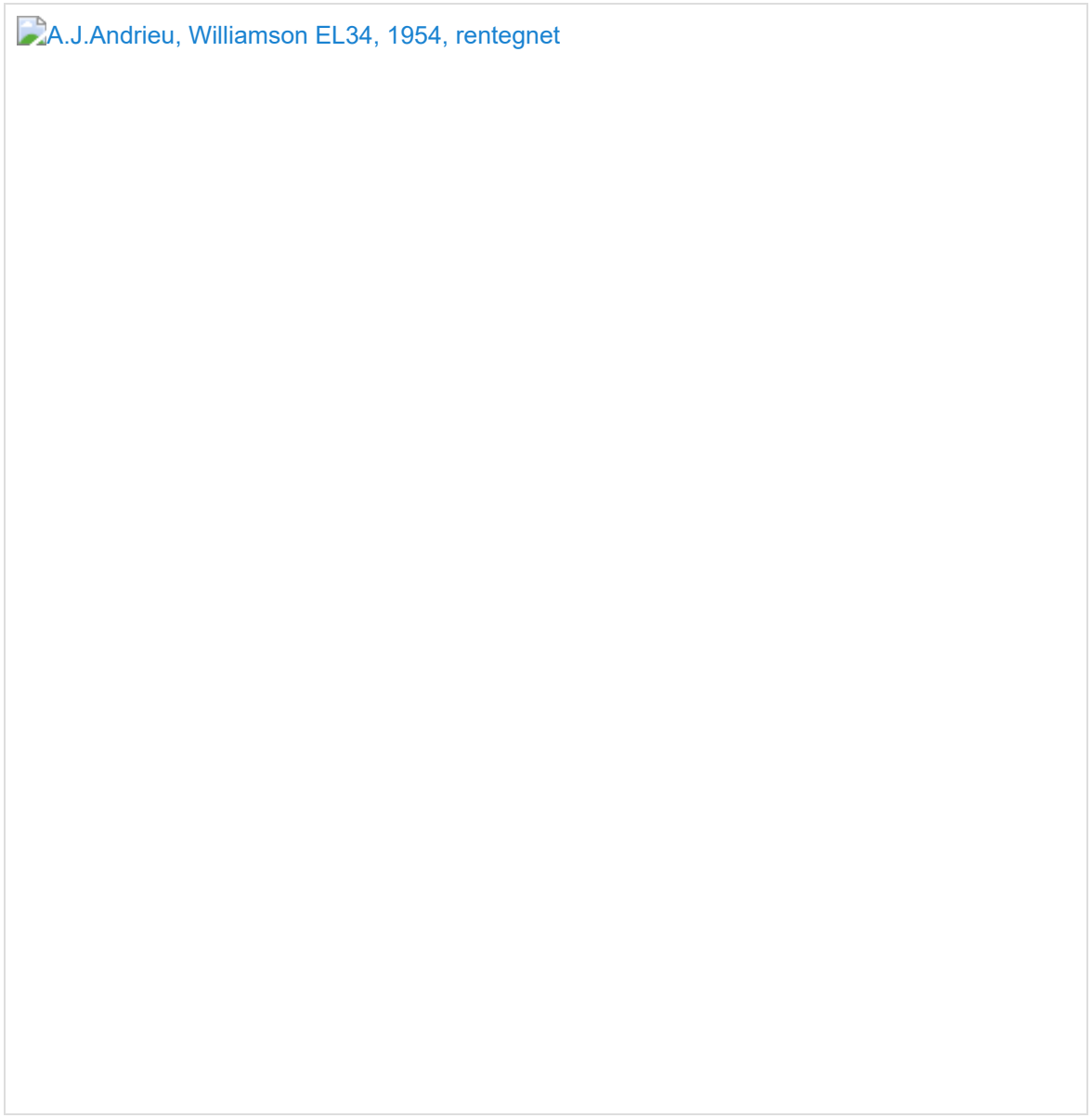
A.J.Andrieu, EL34PP, 1954

This amplifier appeared in the French “Revue du Son” , marc , 1954. I don’t know why it is drawn in that silly way, but it was a common practice in France. If you look at it carefully you will spot the well known Williamson. Why then – you might ask, do I want it here. Well, this is a rather unusual Williamson design and no means were spared over quality. It is a full Williamson with two power full output valves and two power supplies, yet Monsieur Andrieu was only heading for 7,5W class A. But there is more to this amp than quality over quantity. The first input triode are active biased via the current loop at the GZ31 PSU. I do not quite understand why this should be a necessity , but it provides “high gain” (6J5=6SN7= u20) and it allows feedback to the full cathode resistor. Note that as a result there is also a DC potential of a few Volts at the grid of this valve and there ought to be an input capacitor incorporated. The input 6J5 are AC coupled to the phase splitter EL42 with a 100nF cap. This allows higher Voltage at the first triode, but introduce some phase shift as well. Capacitor phase shift means nothing in a non feedback amplifier, but it limits the possible amount of global feedback. The two PSU is a luxury method of Voltage supply isolation. This way the first two stages are completely isolated from the driver/output stage.

The clever thing about this amp is actually the phase splitter. EL42 is a low microphonic small rim-lock base 6 Watt’s power pentode. Here it is triode coupled, which means that due to the high current and low ri compared to a regular 6SN7, ECC82 or so, the split resistors can be made very small. In this design they are only 1k Ohms, which is a fraction of the usual 22-100k Ohms. By means of this little trick the capacitive influence on the AC balance , both with regards to frequency

and HF linearity are practically eliminated. And it will drive the following stage with ease. This is indeed a Williamson to talk about.

Bien fait, M. Andrieu.

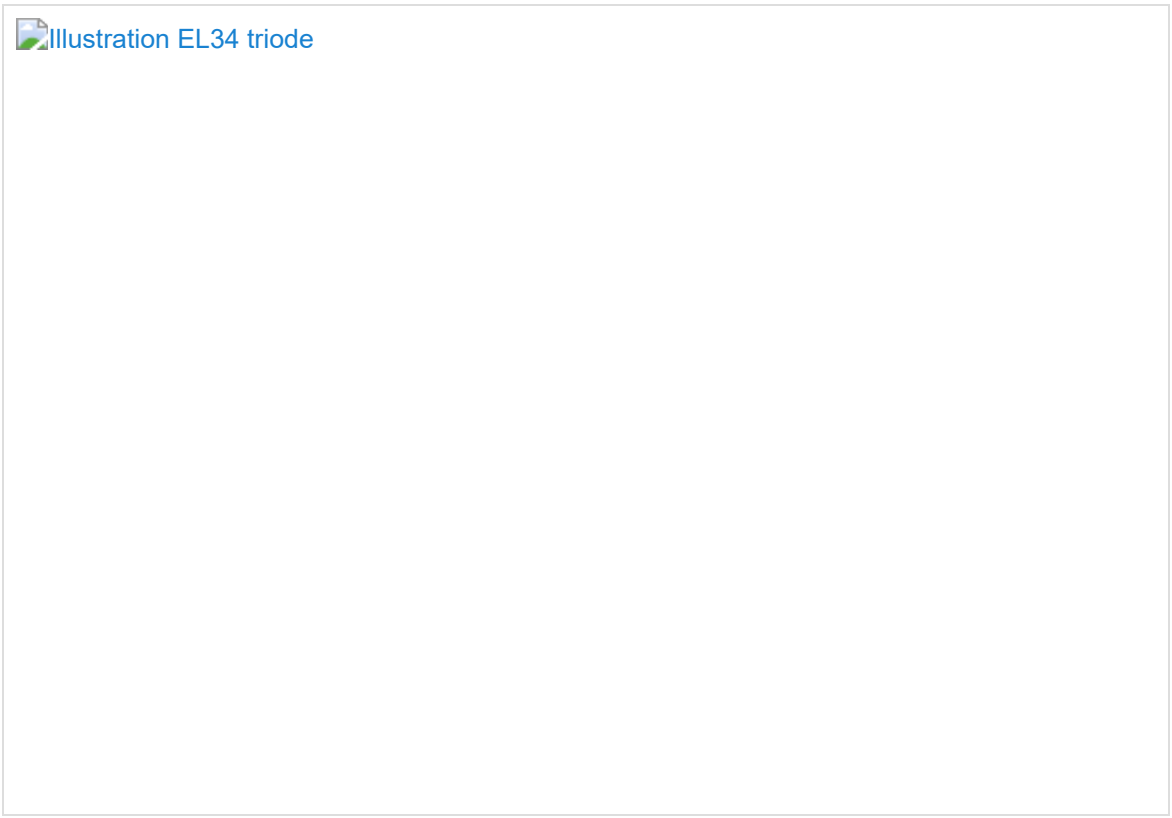


The Andrieu Williamson LBA.

I decided to redraw this schematic in order to analyse it a little deeper. This French amplifier differs from the mainstream in several ways. There is two separate power supplies, one of them with a choke-loaded input to supply the power stage, it has loop bias for the input and output, it is AC coupled input to concertino phase splitter, the concertino is made of a power triode and finally a genuine triode coupled EL34 output stage.

The EL34 is not triode coupled the usual way, in which the acceleration screen is connected to the cathode and the screen grid to the anode. Here both the acceleration and the screen grids are

connected to the anode. This makes it a genuine triode. This manner is only possible with pentodes in which the acceleration screen is not internally connected to the cathode. See Fig.1

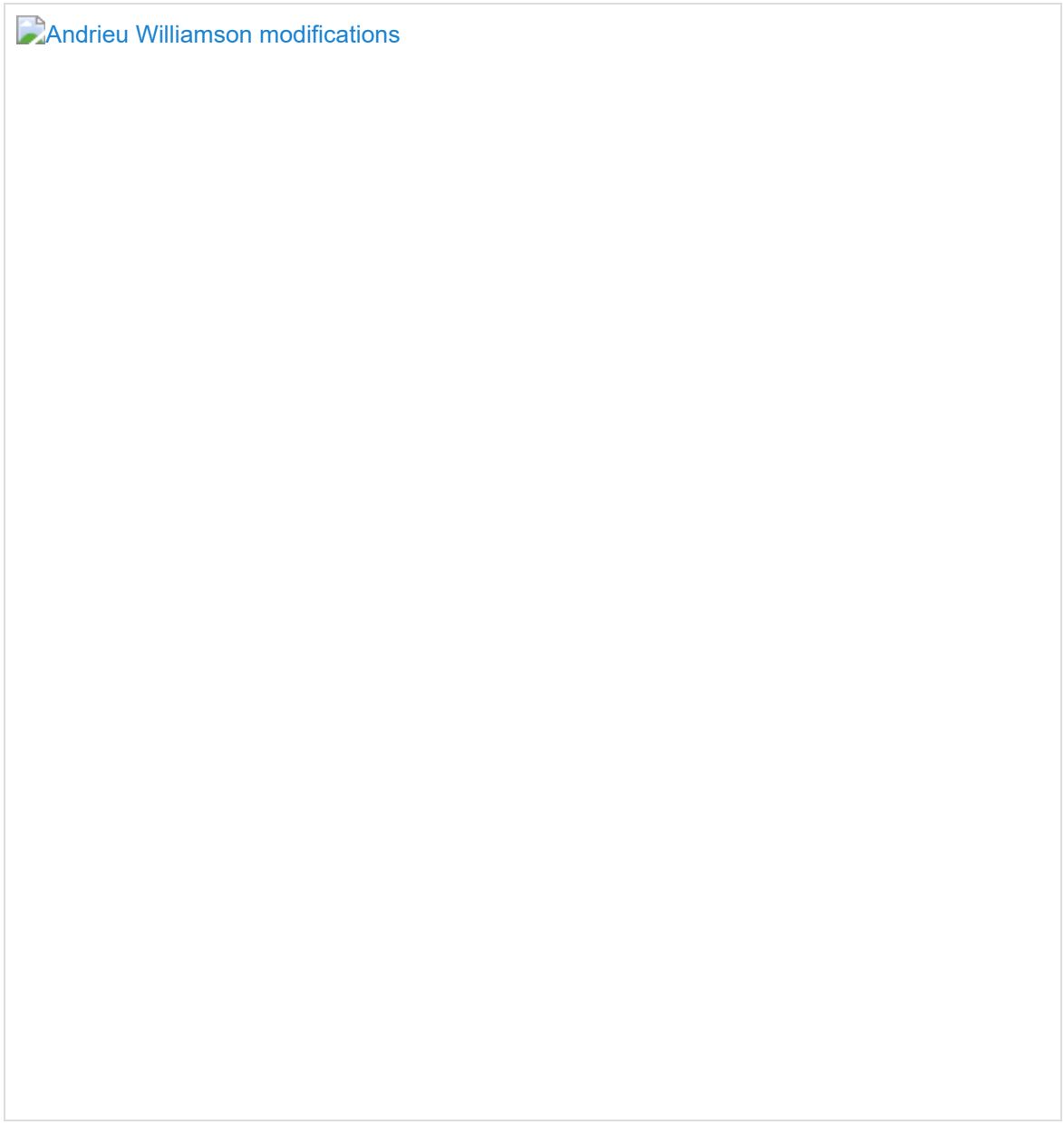


The acceleration grid in EL42 is internally connected to the cathode, hence this pentode can not be connected as a triode in the same manner as EL34. The triode coupled output stage does not provide much power, usually we may obtain about 20-25% of the dissipated plate power as power output. This French Williamson will deliver some 8 Watts at 300 Volts, dissipating some 20 Watts per triode. At 375 Volts it should be possible to drag about 12 Watts of class A from a EL34 pair and if we couple them as AB1 with about 400 Volts at the plates, we could expect some 16 Watts in to a load of 5000Ω. It would seem as if M. Andrieu valuated sonic quality over quantity of power.

Now, the split-load phase splitter made of the triode coupled EL42 is a very high quality version of the concertino approach.This is because the inner impedance of the triode is very low and the “high” current drawn load resistors as explained in the description at the beginning of this vignette. The cathode degeneration (local feedback) is at its maximum as the grid and the cathode resistors are connected directly to ground. This method, however, limits the headroom to the bias Voltage. I have not been able to calculate the exact current through the EL42, but I was surprised to find that the total current drawn from the 6J5 and the EL42 is equal to -17V/4k = 4,25mA. This may be an error in the original schematic – at least in my opinion this apparently low current does not take full advantage of the idea of the triode couple power pentode as phase splitter.

The input 6J5 is AC coupled via the 500nF to the concertino. This has the advantage that it is readily possible to optimize the Voltage for these two stages. (Read more in the Williamson article

that will be present here later) The 50kΩ plate resistor is in my opinion at the high side – so is the 500nF capacitors through the entire amplifier. I would recommend 22-33kΩ for lower distortion and higher HF roll off and 100 to 220nF capacitors in order to avoid low freq capacitor recovery in case of transients. I would also question the advantage of the loop bias to the input triode in this amplifier. It acts exactly as a regular decoupled cathode resistor providing maximum gain, but in this particular case of loop bias it is necessary to incorporate an input capacitor as the grid is negative compared to ground. Do note that this input capacitor is NOT drawn in the original schematic ! The loop bias does in this case add a further low freq pole by means of the 100k and 8uF components at the loop network. I see no reason for making the loop bias as such here. I would suggest a scheme like the one I have shown in Fig. 2 below. We do not need much gain in order to feed the drivers and the EL34 does not need much voltage swing either. Hence we can do with a rather moderate gain in the first stage for lower distortion and better freq response. This way we can do with a single capacitor from the input to the second stage, instead of three. I would also recommend a bootstrapped concertino, as this will provide better linearity, more headroom and a high load impedance at the input.



I am not found of the loop bias method for the EL34's as carried out here. Why let another valve provide the bias ? In case of failure or just simple ageing, the bias to the EL34's will change accordingly.

Neither do I like that it is not really possible to adjust the bias in any clever way. I would suggest to dump the entire loop bias circuit, as it does not do much good in this particular circuit. A fixed bias Voltage made by a simple MC7924 or similar will do the job. This way it is possible to adjust the bias individually and match the current of the output valves. By reading the Voltage over the two 10Ω resistors with a multimeter , it should be quite easy to adjust the current. A reading of 0,100 Volts = 100mA. (0,050 = 50mA and so on)

With regards to the entire amplifier , no components are particular critical. 47k is just as good as 50k and 330k is just as good as 300k. The same goes for the component values I have suggested. +/- 20% or whatever you have in the junkbox may do.

The 6J5 may be substituted with L63, 6SN7, 6CG7, 6FQ7 or most other medium u triodes, such as ECC82/12AU7. There is no need to go for another pentode than the EL42 – it is cheap and very good, but of course must small power pentodes will do just as good.

Finally a word about the electrolytes in the two power supplies. The PSU that supplies the output stage is a choke input breed. This means that it may shortly reach 450VAC x 1,41 = 634 Volts + regulation ! In particular if the output valves are removed, does not draw any current or are adjusted for low current. This will simply make the electrolytes explode. I would strongly recommend that you use two electrolytes of 350 VDC in series – preferably with a bleeder of about 220kΩ/1-2W over each electrolytic. Better safe than sorry, right ?

Happy building.



(Suggested by yours truly)
Kiebert's 45 W Williamson, 1954,

Very cool designer – top class circuits – one of the few at my top 5 list. Yet , Kiebert is as good as unknown in the DIY community as well as elsewhere…..This is sad in my opinion, because Kiebert was so much ahead of the others at the time and still to this day his circuits are way better than the 99%. I wonder why nobody discusses his circuits and why no one has copied or learned from these master class designs…?

Anyway – Kiebert was a hardcore Williamson fan. He did not use any of the values from the original circuit – he hardly used anything at all, except the circuit blocks. Kiebert was fast to spot the weaknesses in the components and feedback scheme of the Williamson, but also to recognise that the circuit itself was close to ideal. . When we look at the circuits of Kiebert we can actually sense that these are circuits of high technical insight and that they are very carefully designed. Nothing is random or made from what was at hand. Starting at the input, Kiebert uses a 100 k Ohm pot ! ..Now this is in the mid 1950's and some 30-40 years ahead in time. So much better that the usual 0.5 to 1 M or more, that was common way up to relative recent.. Then he uses the 12AY7 instead of the usual 12AX7. This alone improves all merits of the amplifier, from noise to freq response. Then a 5687 as driver, which provides a lot of headroom, in fact oceans of such compared to 12AX7, 12AT7, 6SN7 etc. This is indeed very clever and again way ahead from the usual at that time, even compared to 90% of today's driver topology. Kiebert always used 12AY7 as input and phase splitter, followed by a 5687 as the driver. This is a combination that I have learned to value and used from time to time myself. But Kiebert does not stop there. He really wants the power and juice out of that driver – hence the cathode follower…..same headroom 5687. And why not avoid the AC coupling, drive directly and bias at the same time…. :-)

Kiebert continues the tour de force and wants to hold that cathode follower tight by Voltage regulation from a 12BH7. Do also note the clever filament scheme, the use of swinging choke input, and two parallel 5V4/GZ34 for best possible regulation and soft start to prolong tube life. I wonder why he used the filter constants to bypass the plate resistor at the input and to the grids of the 5687. I am also a little puzzled by the 82 Ohm resistor at sg2 of the 807's. Why not a 100 Ohm ? But then with Kiebert I just know there is a good reason and I won't question this. I am amused by the weird way Kiebert draws his circuits. Don't you just love these miles long resistors ? I have redrawn the circuit a little as it was kind of a mess….I spotted an error in the circuit while doing so, that I felt was amusing, hence I left it there….. Do you see it ?

I will give you a hint….Look at the PSU…..

Yup , Kiebert uses solid state to supply the negative bias. That is good engineering too….Have you found the mistake….?……These two solid state diodes are turned 180 degrees….The negative side faces to the AC instead of the bias…. He he…..

Sadly this model is a class B design, however all we need to do is to adjust it in to the class A area and we are all flying.

Apparently Kiebert fancied the 807's as most of the designs I know from his hand uses these. He did make a 70 Watt 6146 PP and a 100 Watt 4 x 300B PP for BBC.
Kiebert took a few cool audio power amp patents in 1959 as well.

Kiebert you were a sleeper't, but now you are a keeber't……I hope that I have hereby printed your name into the history of audio technology.

Hats off to Kiebert.

McIntosh MC-30, ed. 1960 vers.

Mcintosh MC30, 6L6GC/1614, 1954

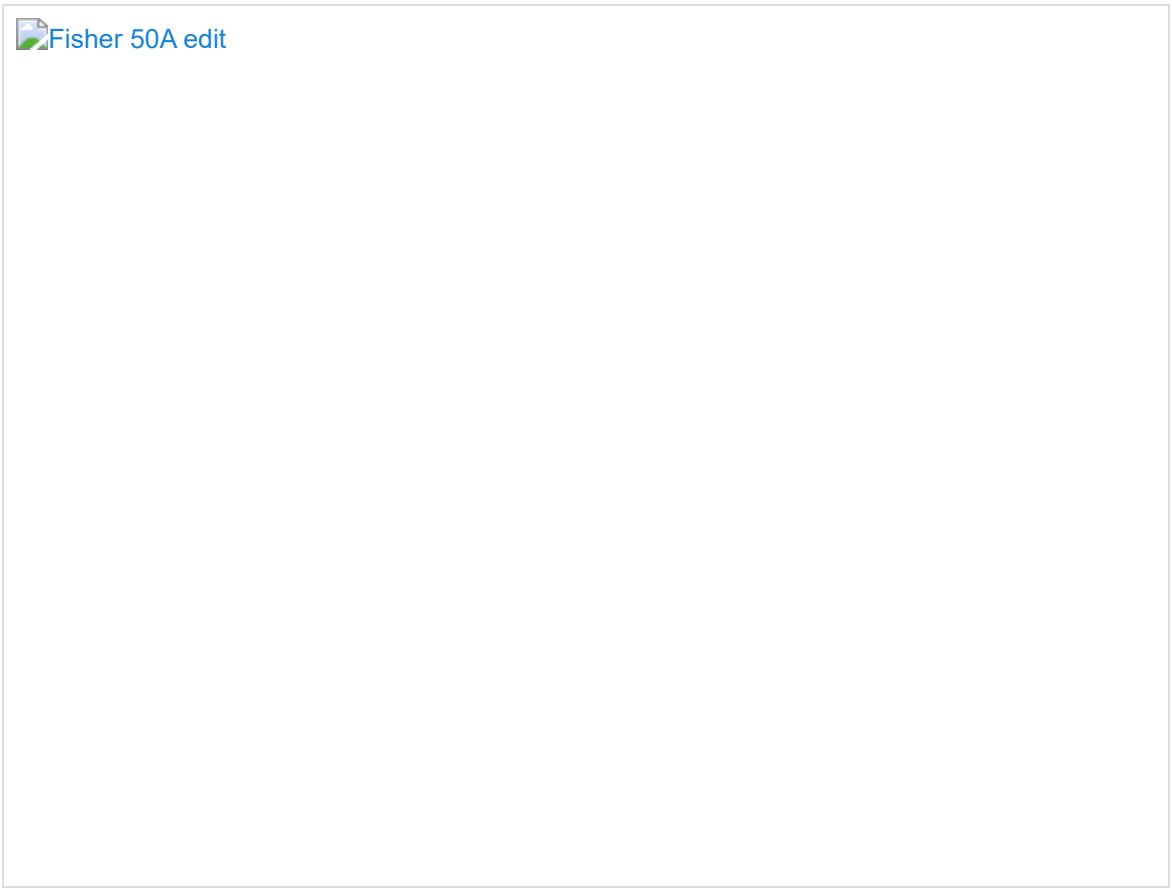
Frank McIntosh here took the Unity Winding scheme to another extreme with regards to feedback. For one reason or the other the McIntosh team found it necessary to add inductors in series with the plate to avoid HF oscillations. Mac uses a 12AX7 in the driver circuit – this is normally a "no go", but in this case it is all right as he uses it coupled as a cathode follower. 12AX7 is not a bad CF, due to the high mu. Personally, I would never use it…But there you go…

The really interesting part of the Mac's is the output transformer and the way it is implemented. In order to get away with a high quality class B circuit, McIntosh needed a way to reduce the leakage reactance of the OPT. This was accomplished by means of a clever bi and tri-filar winding method. Note that the cathodes of the output tubes is loaded as well. Peter Walker did the same in his QUAD amps. Peter Walker himself claimed in a Wireless World issue, that he did it first, but I am

not sure this is correct. I intend to get back to the McIntosh amplifiers for an in depth analysis at some point.

I personally like the earlier models better, but it is very impressing that McIntosh manage to get 50 Watts out of a pair of 1614/6L6's…

The MC-30 is indeed a neat design.

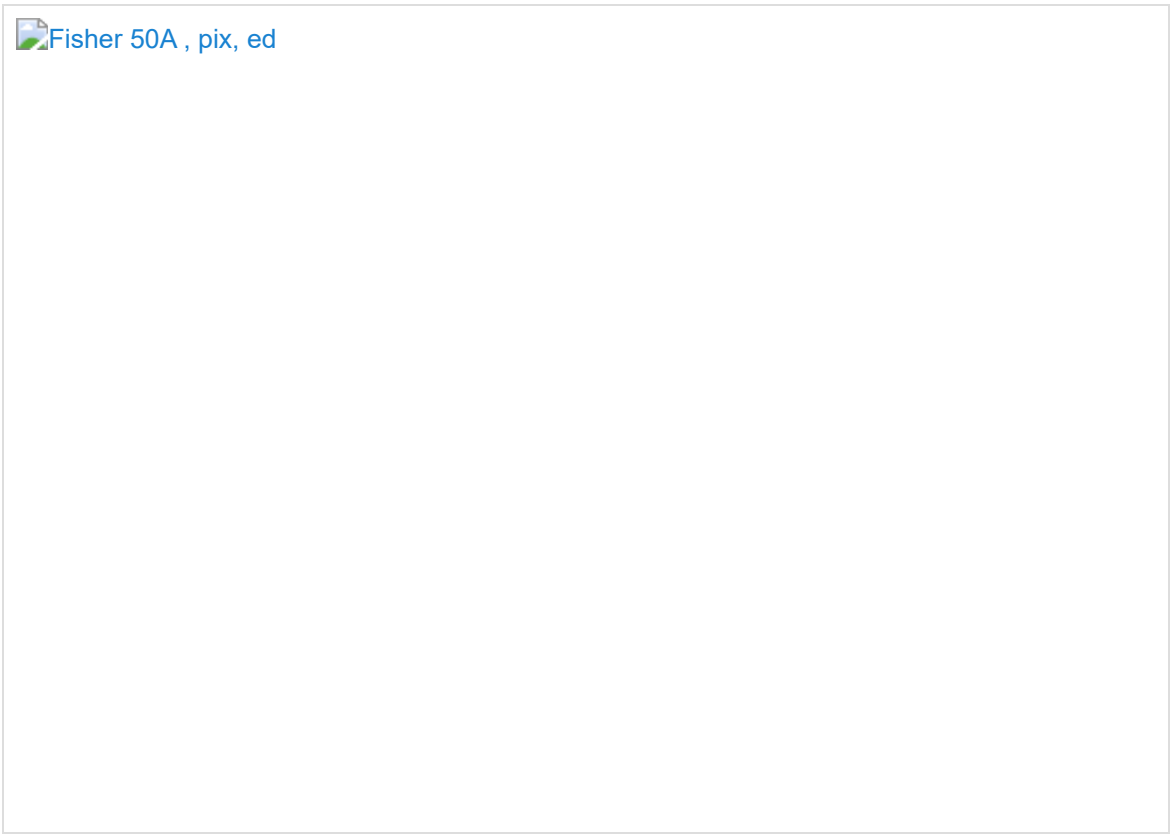


Fisher 50A, 1614 PP, 1954

As far as I know Fisher made 3 versions of this *all triode* coupled amplifier. The 55A being the last. The difference between model 50A and the 50AZ are minor. The 50AZ uses 6CL4's for the driver stage. The Fishers 50 series came with separate preamplifiers and tuners.

What we are looking at here is obviously a Williamson design, but it has a few unique details that parts it from the mainstream. The bias Voltage is regulated, which is very nice and unusual. But the best part is the interstage driver. It is a quite radical solution, as the 1614's are not really difficult to drive, all though it does need a higher Voltage swing, being strapped as a triode . With a transformer it is possible to drive the 1614's,way in to the peaks of class B if needed. By placing the transformer at the cathodes of the two 6S4's the output impedance of these is very low. This means that the transformer will be delivering its best and current in plenty to feed the hungry grids

of a class AB2 or B stage. I will reveal one of my “secret tricks” here. If you want to learn how to get the best of a class A amplifier, learn how make a class B amplifier. All the tricks in the book for class B, translates to high quality when used in a class A application. All of them !

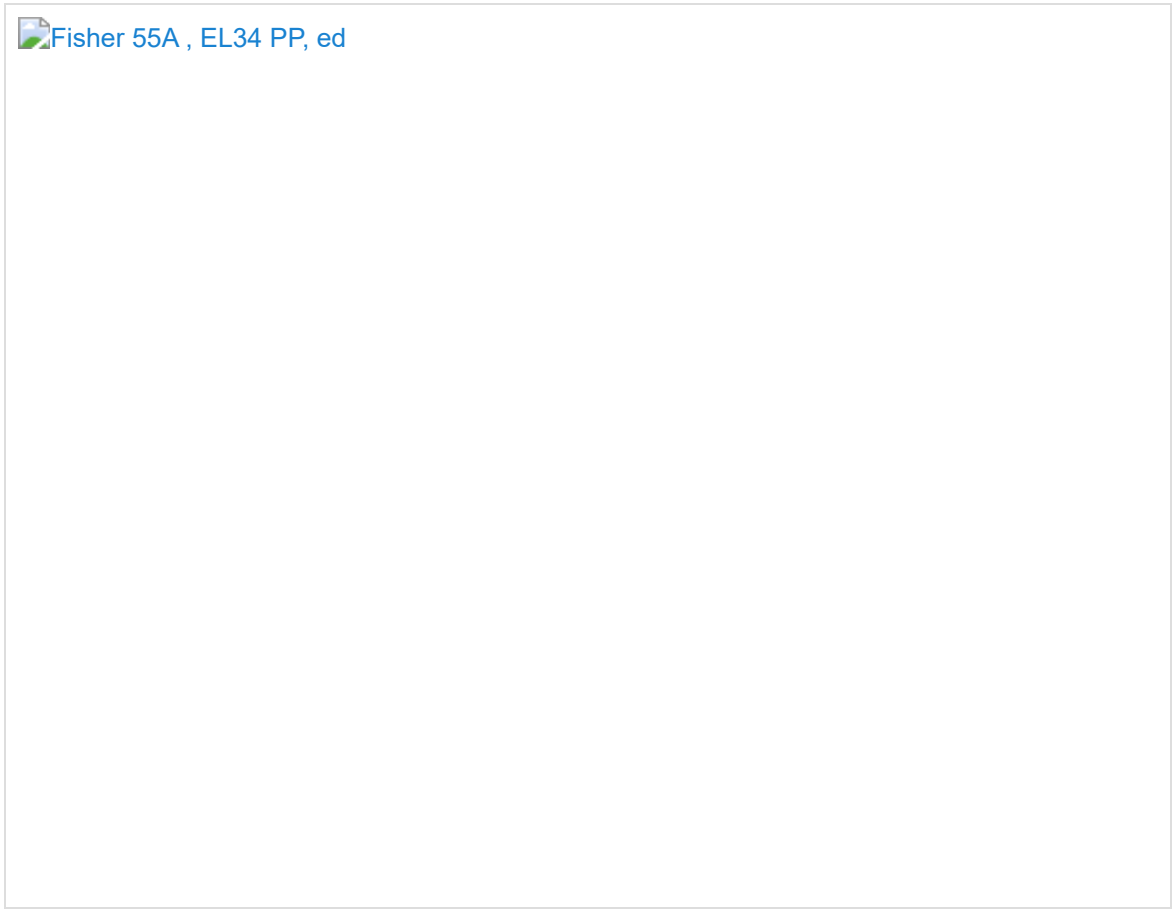


Pix from: www.soundup.ru

The feedback network to the cathode of the 12AU7 is quite weird. The series combination of the 150u and the 2k2 is in parallel with the 2k2 cathode resistor, which means that the feedback signal to the 1k is distributed between these. This means that further phase shift takes place as far as I can tell. I will need to investigate that a little closer one day. If you have any bids on the course of this network, please do not hesitate to drop me a mail.

The 1614 are metal envelope tubes, rather similar to 6L6. I personally prefer the later glass types.The two 5V4G rectifiers maintains a stiff and low z power supply. Note the choke input that regulates well, just as it smooths and cleans up. Very good engineering indeed.

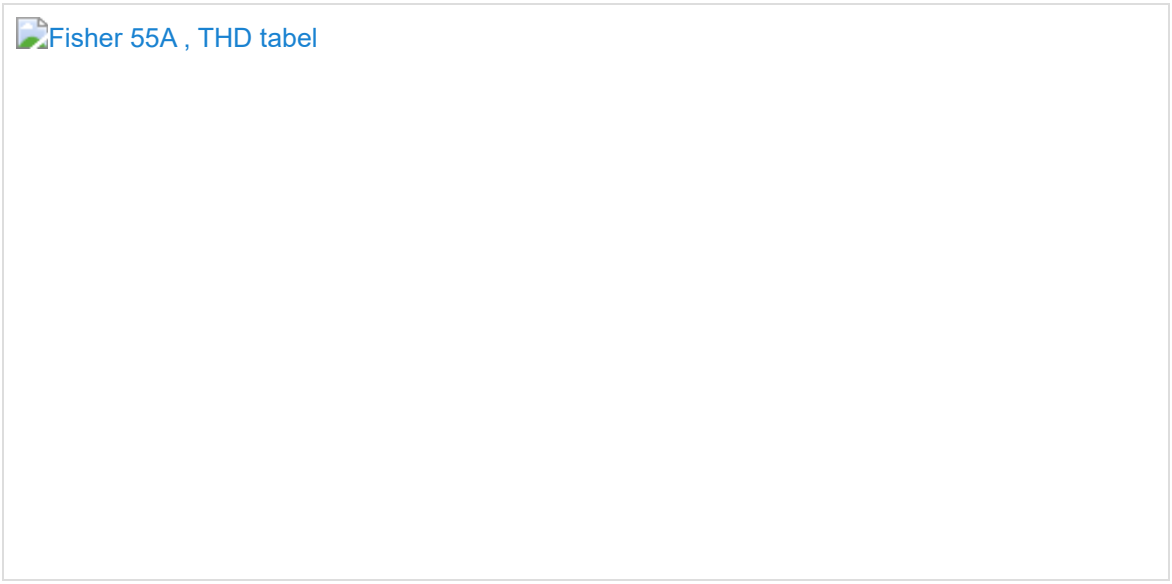
The “extra” pre-amplifier that I have framed does not do any good in a modern world of line level signals. I would simply skip it. I would also suggest that a 12AX7 or pentode would do a better job as the bias regulator, due to higher gain. This could be a 6AV6, 8AV6 or 12AV6.(Different heater Voltage) These are all single 12AX7 triodes with a pair of diodes. Maybe it would actually be possible to make use of these diodes for the bias Voltage ?



Fisher 55A , 6550/EL34 PP, 1956?

The 55A is pretty much the same as the 50's. But the differences plays a major role. First we note the input is different. There is feedback from the plate of the second 12AU7 triode to the cathode of the first input triode. Then we note the popular variable power damping feature of the early 1950's. This means the a small part of the current signal is feedback to the cathode of the second triode. This triode is grounded via the fb network at the output. Further there is Voltage fb from the 16 Ω tap to the grid of the phase splitter.

As much as I like the current/Voltage fb approach, a thing I call "Power Feedback" *, but you may call it whatever you prefer – as much do I worry about *feedback inside feedback*. Perhaps loops within loops is a better term. In the 55A the Voltage fb to the grid of the phase splitter is also fed back to the cathode of the input, hence it introduces a "false" signal that is again fed forward and returned and so on. This means a complex distortion phenomenons, that does not show up in a regular THD test. It may however be found in a spectrum analysis as high order harmonics in orders of say the 9'th to as high as the 100'th or more.



I have not heard this Fisher 55A but the intermodulation data above, indicates that Fisher to some degree had it under control. I would however suggest – at least to experiment with removing the first input triode, thus the fb to this. Feedback is not an absolute science in my opinion, as we do not yet know how to evaluate the complex signal we know as music. The power feedback may also benefit from some experimentation in the form of trial and errors , as it is so complex and case sensitive. This applies to any amplifier in my opinion.

Do also note that the HF cancelling capacitor over the primary winding at the OPT is now removed. Possible due to the new fb scheme or a better OPT. (Or both)

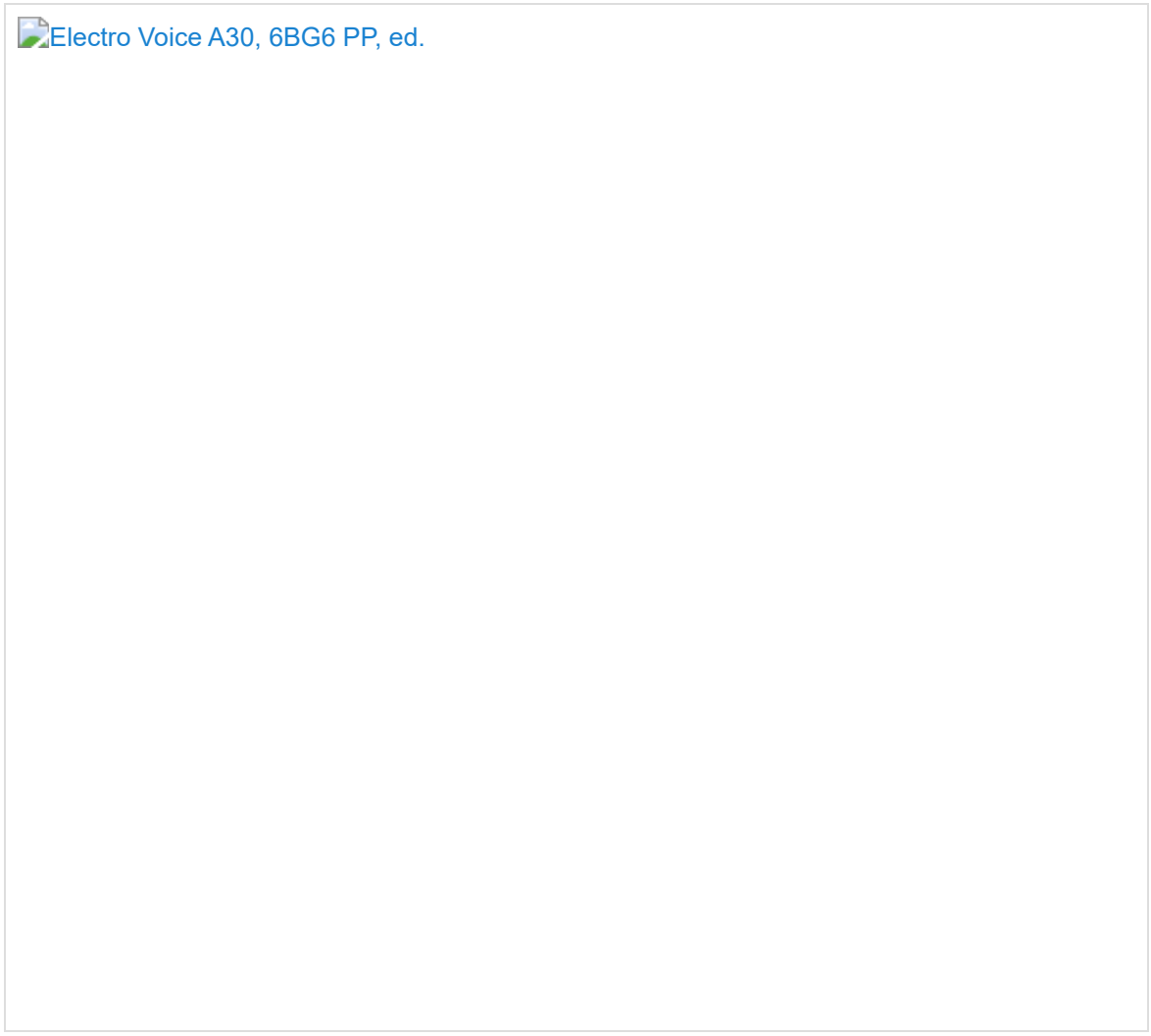
The driver tubes in the 55A are changed once again, these are now a pair of triode coupled 6CL6's. The output tubes is a pair triode of coupled 6550's or EL34's. Fisher recommended both. The parallel rectifier's is 5W4G's or GZ34's, also per Fisher's advice..

The output tubes are grounded via the small resistor in the current monitoring meter. It is a neat feature to be able to read the current when adjusting bias, but it is relatively useless as it only measures the total current of the two tubes. It does not tell if there is any *difference* between the two tubes. I always recommend to use a resistor of 1-10 Ohm at each individual cathode leg of the output tubes.



I really like the ingenuity of the Fisher 50 series and I feel they are well worth some effort in experimentation. Certainly they are good templates for an extra high quality audio amplifier.

Hats off to the fishermen.



Electro Voice A-30, 6BG6 PP, 1954

The Circlotron by Alpha Wiggins (Now, thats a name..) of Electro Voice. The A-series of power amplifiers made by E.V. in the 1950's are good examples of the innovation during the aftermath of WW2. Damping factor control via current feedback and a number of ways to incorporate the OPT into local feedback or simply distributing the load via the cathodes and/or the screen grid was popular in the 1950's. Electro Voice made use of DF control and Cathode loaded OPT. But they brought the CF loading scheme a little further by the use of the so called "Circlotron".

The Circlotron is a bright circuit. The use of separate power supplies for the two output tubes allows the two current loops to be braided with one another via the load (OPT or speaker) , hence acting in parallel AC-vice. The major advantage of this is that the load needs only be 25% of that of a conventional power stage, of which the output tubes works in series. A pair of 6BG6 operated in a traditional PP configuration would need a load of say 8000 Ohms plate to plate, but as a Circlotron only 2000 Ohms or less.(EV loaded them with 1000-1600 Ohms) This allows us to wind a better output transformer as the winding turns ratio is equally lower. But there is yet another advantage of the Circlotron. The entire primary winding represents a full load to both tubes as the circuit is a common bridge. This means that signal current will always pass the full primary, hence no switching issues can occur. This spells good transient response as well as the best suitable class B design – to the best of my knowledge. It is often claimed that the Circlotron is only good for

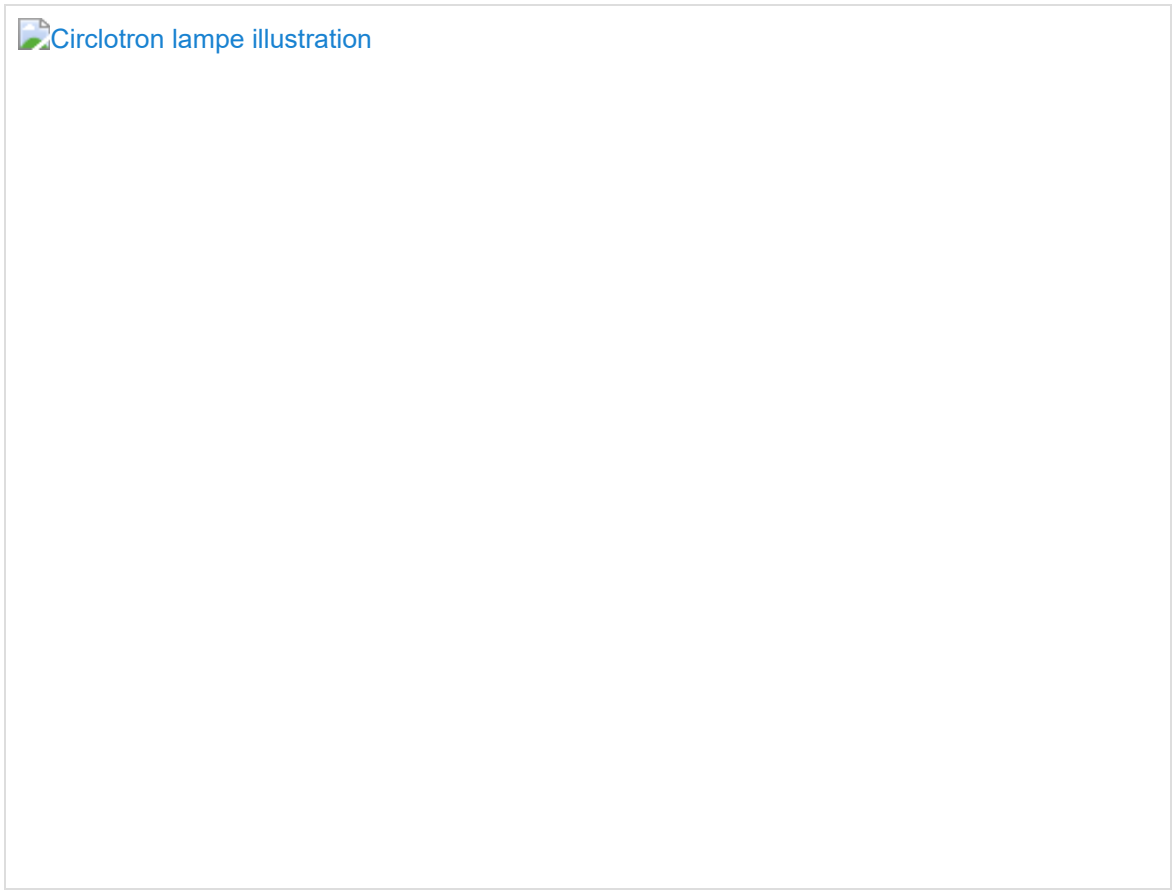
class B. This is not true. *The Circlotron is equally good in any class of operation*. I will dig much further into this clever circuit in a dedicated DIY article later on.

The A-30 is a conventional Williamson design, however with Circlotron output and DF control. The output stage are operated in the area between class AB2 and B.

The 12AX7 and 12BH7 Williamson design was used in the entire A series of E.V. down to the very values of each component.

There is two to three versions of this amplifier. The early ones had 6BG6's at the output, later models were swapped to 1614. (Similar to 807)

The E.V. A-series: (Numbers refers to power out in Watt's)
A15: 2 x EL84
A20: 2 x 6V6
A30: 2 x 6BG6, 1614 or 807
A50: 2 x 6550
A100: 4 x 6550
A430: 2 x 6BG6



Circlotron explained.

The two PSU leads current into the transformer from opposite directions, thereby cancelling the current in the transformer. It sounds a little weird and might look a little weird too – but it is actually quite simple. Now imagine that we connect a battery to a lamp. The lamp will draw current from the battery and by such it will lighten up. The current is said to run from + to – . If we connect a battery more – 100% like the first, only with the *opposite* polarisation a current of the exact same magnitude will run in the opposite direction, meaning no Voltage difference, hence NO current. (+ 100ma – 100mA) = 0 mA.

As these two “forces” are 100% equal they will cancel one another and the lamp will no longer lighten up. In the case of a circlotron we must imagine that the tubes are in series with the batteries, here shown as the lighting lamps and that the dark lamp is the output transformer. Hence, no current passes through the transformer. The Circlotron circuit is not quite as simple as the batteries and lamps illustration, but the principle is spot on the same.

The purpose of removing DC currents from the OPT is that it allows us to make a better transformer or at least make better use of the one we have. In a conventional Push Pull configuration the tubes works in *series* from a signal point of view. This means that the load must be twice that of a single tube. In case of the Circlotron the two tubes works in *parallel* , meaning half the load of a single tube or 25% that of the load for a traditional Push Pull series arrangement. The Circlotron seems to be used only as a cathode loaded amplifier. I have no idea why, as it may just as well be implemented as a plate loaded amplifier.

In many ways the circuit is similar to the Philips PPP, Sinclair Peterson, Futterman, Coulter etc. As **Thorbjørn Lien** from Norway pointed out in a discussion we had, Frank MacIntosh makes a somewhat similar trick, only with one single PSU.
In my opinion the Circlotron circuits are the best we know for OTL amplifiers, but unfortunately dangerous to the speakers in case of failure.

Wiggins was not the only one that happened to think in the terms of a “currentless” bridged output transformer. We know that at least two other patents based on that idea was filed in that period.

Cecil T. Hall was the first to apply: June 7, 1951. This was granted, thus published March 29, 1955
US Pat n o: 2705265
Tapio M. Köykkä, Finland applied Sep 2, 1952 and was granted and published Nov 10, 1954
Finnish Pat no: 27 223
Alpha M. Wiggins applied March 1, 1954 and was granted/published march 25, 1958
US pat n.O 2828 369
Update: I have recently learned that in 1953 two years after Koykka had filed his patent, he published the circuit in the German Funktechnik 7/1953. That lead to an attractive job offer from Westinghouse as well as a request for a license by Electro Voice (Wiggins). Koykka thanked no to the Westinghouse job, but granted the license to Electro Voice only to find that the following year Wiggins himself applied for a patent covering that circuit in USA. What a gentleman ! Anyway , Wiggins gave the circuit that simple name that allows us to distinguish this particular circuit from other similar circuits. Wiggins later on learned that Hall was in fact the first to apply for a patent and

he had to settle for an agreement with Hall. Koykka never got a dime. Koykka's patent was only valid in Scandinavia.

More can be learned about this inventive and brilliant mind
at: http://www.kolumbus.fi/epap/voimaradio/

The Circlotron/PPP/CCCC by Matti Tapio Köykkä , Finland.

It is sad that Koykka is little known outside Finland. Apart from being one of the two inventors of the Circlotron circuit (Hall being the other – please read more under Electro Voice above) , Koykka also invented the MS stereo (Ortophase/Ortoperspekta) and he was the man who discovered TIM distortion, brought to fame by Matti Otala. Koykka designed dozens of advanced speaker systems as well. Very large horn speakers to be specific.

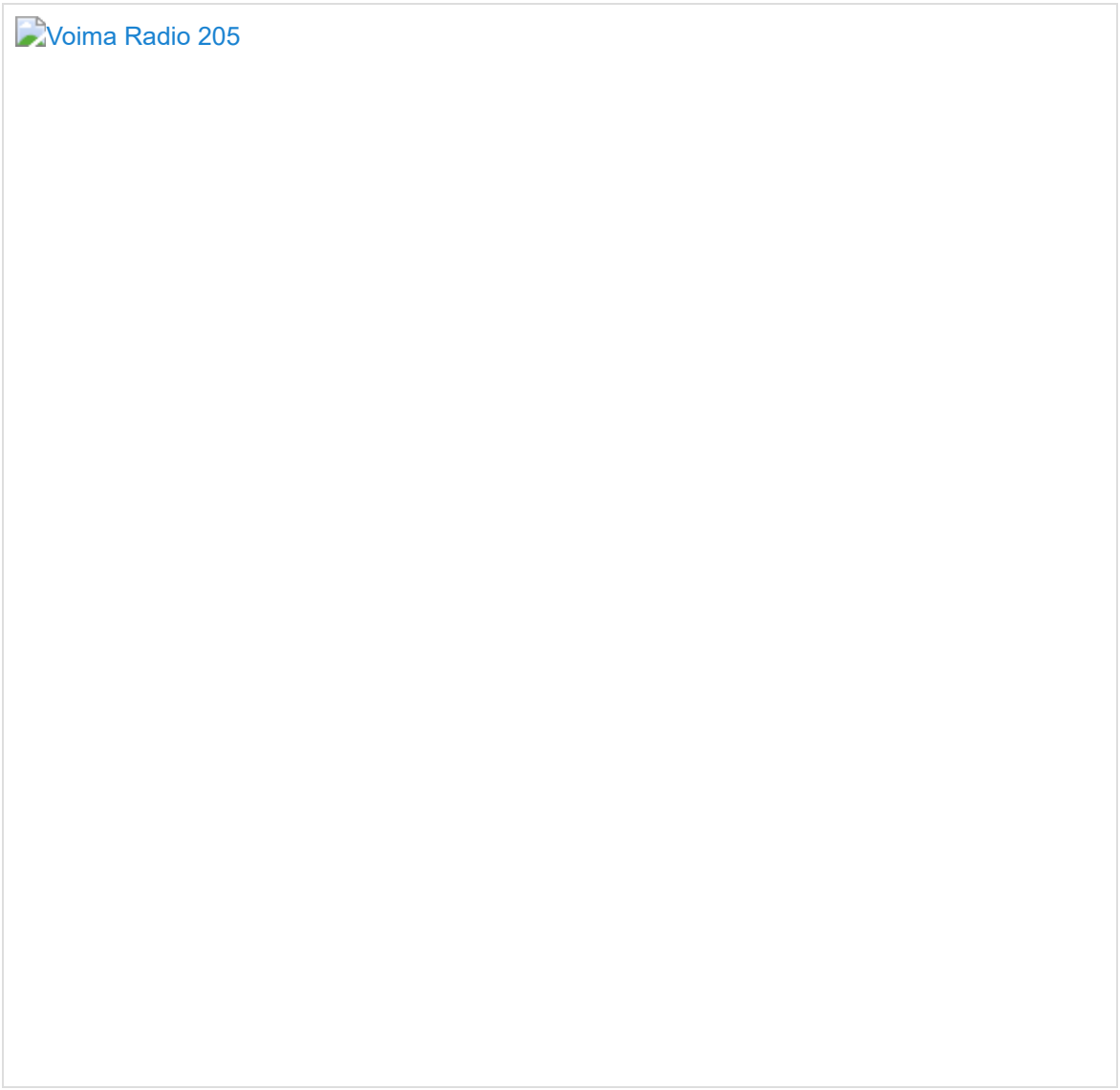
Koykka made several variations over the circlotron theme. Some used ECC85 as input valve, multi tapped OPT and so on. The Voima amplifiers are very rare as relatively few was build. Koykka supplied the market in Finland and most likely had some export to Sweden and Russia.

Koykka probably would not mind me calling his design for Circlotron. I think the name is good, because we all know the specific circuit it refers to. PPP does not implicit calls for two PSU – Circlotron does

Koykka had some pretty unconventional viewpoint about sound – in particular at his time. He did not believe in THD tests and he considered sine waves as a much to simple simple signal in order to test devices for reproduction of music. I could not agree more. Koykka was clearly a man capable of thinking out of the box, thus challenging conventional comprehensions.

None of the Koykka amplifiers I have seen uses global or loop feedback !

This is extremely unusual at the times of the 1960-70's.



VOIMA RADIO, model 205, Williamson EL84

Model 205 is the well known Williamson topology, but a rather unusual of such.

1. No global feedback.
2. Input and phase splitter. A ”tilt” tone control. DC-couple Voltage divider from the plate of the input valve to the grid of the split load phase splitter.
3. Large grid stop resistors.
4. No decoupling of cathode resistors = local fb.
5. Cathode + plate load output. (triode coupled EL84’s)
6. Extra smoothing ”in between” Voltage divider and electrolytic.

The reason why K. use a Voltage divider between input and phase splitter is in order to maintain a suitable plate Voltage for the input triode. He is sacrificing some gain here, but as there is plenty of overall gain this means nothing. 300mV at the input drives the amplifier to full power.It may add a little noise, but this is insignificant for most use.

The large anti oscillation grid stoppers hardly affects the sonic quality in any negative way – and it is indeed a lot better than resistors or RF chokes at the plate of the output valve.

Do note that this particular amplifier from the hand of Koykka is NOT a Circlotron.



VOIMA RADIO , model A2-20 , EL84 Circlotron

I am still writing this chapter about the amazing Koykka and his company VOIMA RADIO.

Much more to come. Please, stay tuned.

In the meantime:

Hats of to T.M. Köykkä, gentlemen……..



Carad Radiogram , EL34 PPP , ca 1960

This is a rather typical, but little known circuit from the golden days of PPP/Circlotron.

Carad was located in Belgium and produced a number of products for audio, but are probably best known for their production of components, such as switches. I have kept the pre-amplifier simply because the second ECC83 is part of the power amplifier. It provides bias to the phase splitter by means of the direct coupling. Apropos note the CF input for pick up. That is very unusual and it is merely a impedance changer. The upper high freq of this amplifier is sadly limited by the ECC83 driver, that will begin to fall already below 20 kHz, due to its high z-out. The output transformer (Tapped auto) may be wound to go well beyond 200 kHz.



Kinoverstärker , unknown origin, EL34 PP, 1960.

I have four sources of this schematic with minor or no differences. None of the sources offers any documentation or reference about the brand or the person responsible for the design. It appeared

in the German magazine “Funkschau” 1960 No.9 as “PPP Kinoverstärker mit kreuz gekoppelter Vorstufe” . No further identification provided.

It is possible that it was designed by Alfred Zechendorff, Nuernberg, Germany, but no evidence or documentation is available to the best of my knowledge.

This is indeed a BEAUTIFUL and captivating design. Much better than the Electro Voice circuits. Balanced feedback to the balanced phase splitter (As it should be, but often is not) and possible the most astute use of the grounded OPT. (Tapped autotransformer) Stunning symmetry from a single end input signal. This is SO clever and simple.

The impedance of the OPT shall be some 1000 to 2000 Ω. The exact value is not critical.

There is a few issues to this almost perfect design worth to mention.

1) The 50u capacitor shunting the Voltage reg. G11 , is a very bad idea. It will decrease the lifespan of the G11 drastically and It may lead to oscillations and all sorts of problems. It may have been an error at the schematic I have at hand, as a *small* capacitor may be fine. (50n may be all right, but go for as small value as possible or none at all) The capacitor will cancel noise.

2) The 500Ω cathode potentiometer of the EL34’s should be replaced by a fixed value (2-300) and a pot.(2-300) in order to avoid adjustment into the high current area.

3) I would also question the 100R resistors in series with the plates of the EL34’s. I do not know why they would want it here, but I suspect in order to prevent runaway or oscillations. A better approach is cancel this resistor and instead increase the sg2 resistor to some 220-470 Ω.

It would recommend smoothing chokes in place of the 100R/20W resistors. Whilst we are at it perhaps a full DC-coupled CCPP ala´ White’s Powrtron. (In order to get rid of the ECC83 , that does not fit well into my ears) I would maintain the 12BH7 driver.



Münning CCPS Circlotron, EL34 PP, 1960 DDR/Bulgaria.

Thanks a lot to Plamen Doynov, MSc AEE, Sofia, Bulgaria for helping me identify the designer and origin of this circuit. (Plamen maintains the homepage: http://valveheart-bg.com)

As can be seen this is almost 100% identical to the Funkschau circuit above and it has not been possible for me to find out who originally made the circuit, but I do not believe this is a coincidence. Münning however uses the ECC85 twin triode as input amplifier, just like Koykka used to do. I would prefer the 12BH7 as driver to the ECC82 – but both will do the job. The half way EZ81 PSU here – is a little weaker and more noisy that the GZ34 full wave rectification used in the Funkschau version.

Do note that Münning feeds the plates of the second stage (ECC83) from the plates of the input triodes. This is a variation I would like to experiment with myself one day.



RCA , MI-9377A , 6L6G PPP , 1954

The MI-9377 is a perfect example of the **paraphase** phase inverter. The paraphase is one of the first phase inverters ever used and we can trace it back to the early 1920's. It is here used to drive four 6L6's directly and this is all there is to this little gem. The lack of cathode decoupling capacitors, stretches the linearity of the 6SL7 paraphase at the cost of gain. This does also increase the output impedance of the paraphase, leading to lesser HF range, but that meant little in practice for this beautiful PA amplifier. The original design has a HF filter of 470Ω and 3n3 attached over each half primary winding at the output transformer. I have left out this filter in my drawing as it does not make much sense, when using the high quality transformers of today. The purpose of the filter is to prevent forward feedback, due to phase shift in the OPT.

The advantage of using four 6L6G's is more power and half the loading impedance needed of the output transformer. The price is a little more complex design, with regards to balance and twice the current presented to the PSU. RCA met this challenge by adding another rectifier, which lead to half the losses compared to a single rectifier. (5U4G) The amplifier is equipped with a current meter that allows the current of each tube circuit to be monitored. It is , however, not possible to adjust the bias of any of these, making this feature a little pointless.

The feedback is taken from a separate winding, which means that the amplifier is stable into almost any thinkable loading. Each 6L6G has a current limiting resistor of 47Ω at the plate, also meant as a safety measure for this potential hard working PA amp. In case of normal domestic use, you may wish to remove these resistors.

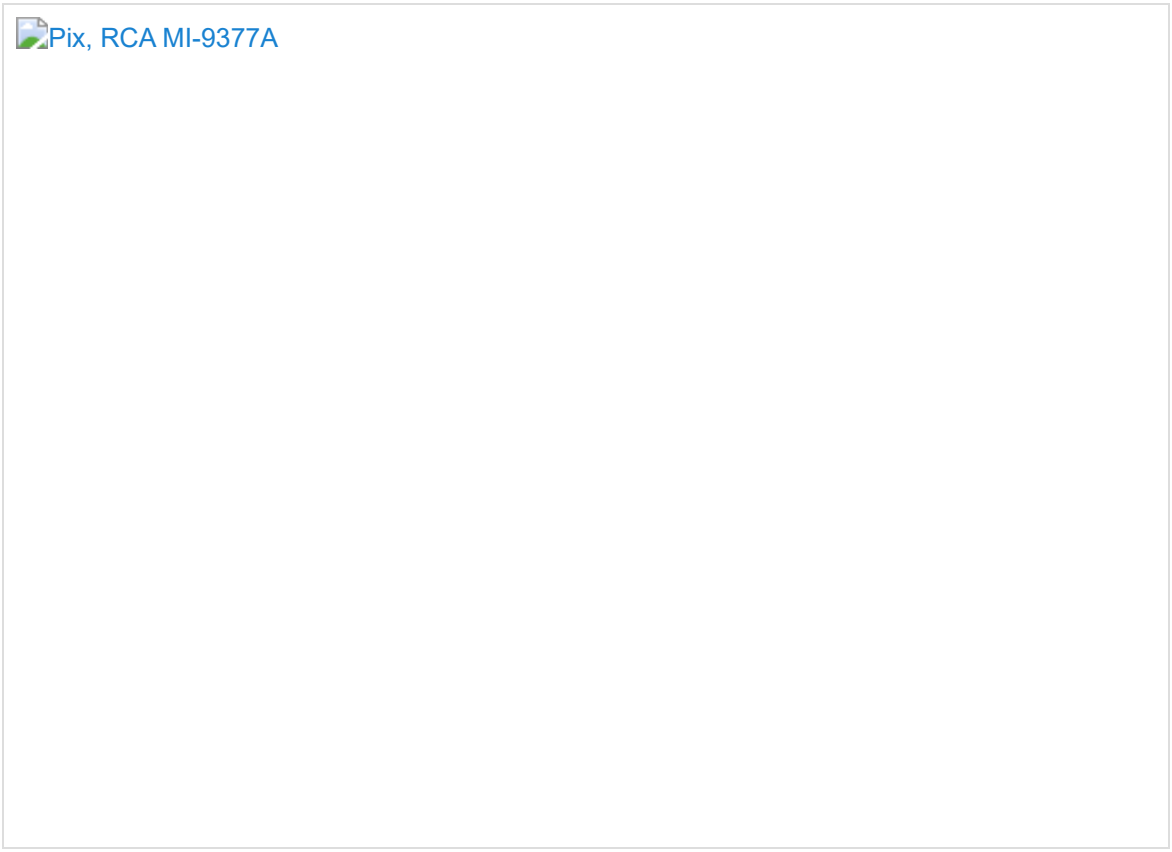
The most interesting part of this amplifier is the use of the two voltage regulator tubes, aka "Glow discharge diodes". The OC3 operates at 105 Volts and the OD3 operates at 150 Volts, giving a regulated voltage of 105+150 = 255 Volts. This voltage supplies the sg2 of the 6L6G's directly, which insures a high regulation of the 6L6G's. The output from the two series coupled regulators supplies the 6SL7 plates as well, via the 3k9 voltage dropping resistor and the 40u stabilizing capacitor. This also isolates the two currents from one another.

Now, this is all good and , but the interesting part is that the current drawn by the voltage regulators are fed into the common cathode resistor of the 6L6G's. This extra current, forces the 6L6G's to work in class AB2/B. Not an easy task for the high ri, low current 6SL7. But there you go, this is a PA amplifier.

A funny thing, I could not help thinking of when studying this neat little circuit is that if we connect the regulator tubes directly to ground instead of the common cathode resistor, the 6L6G stage will be changed to class A. (4 x 50mA = 200mA , 0,2 x 90 = 18V) The main transformer seems to be able to provide this current, judged by the size of this as seen at the pix. If it gets too hot – you need to change it back. (There is a small potential risk of burning the wires in the 350 VAC windings, if these are underrated. I doubt this is the case, but now you have been warned)
Another possible change is to double the 90 Ohm resistor to 180 Ohm 8 (5W) and only use a pair of 6L6. (or KT66) In this case the 7,5 and 15 Ohm taps at the output transformer, is to be considered as 4 and 8 Ohms taps. The output will be about 10 Watts class A with a pair of 6L6G's.

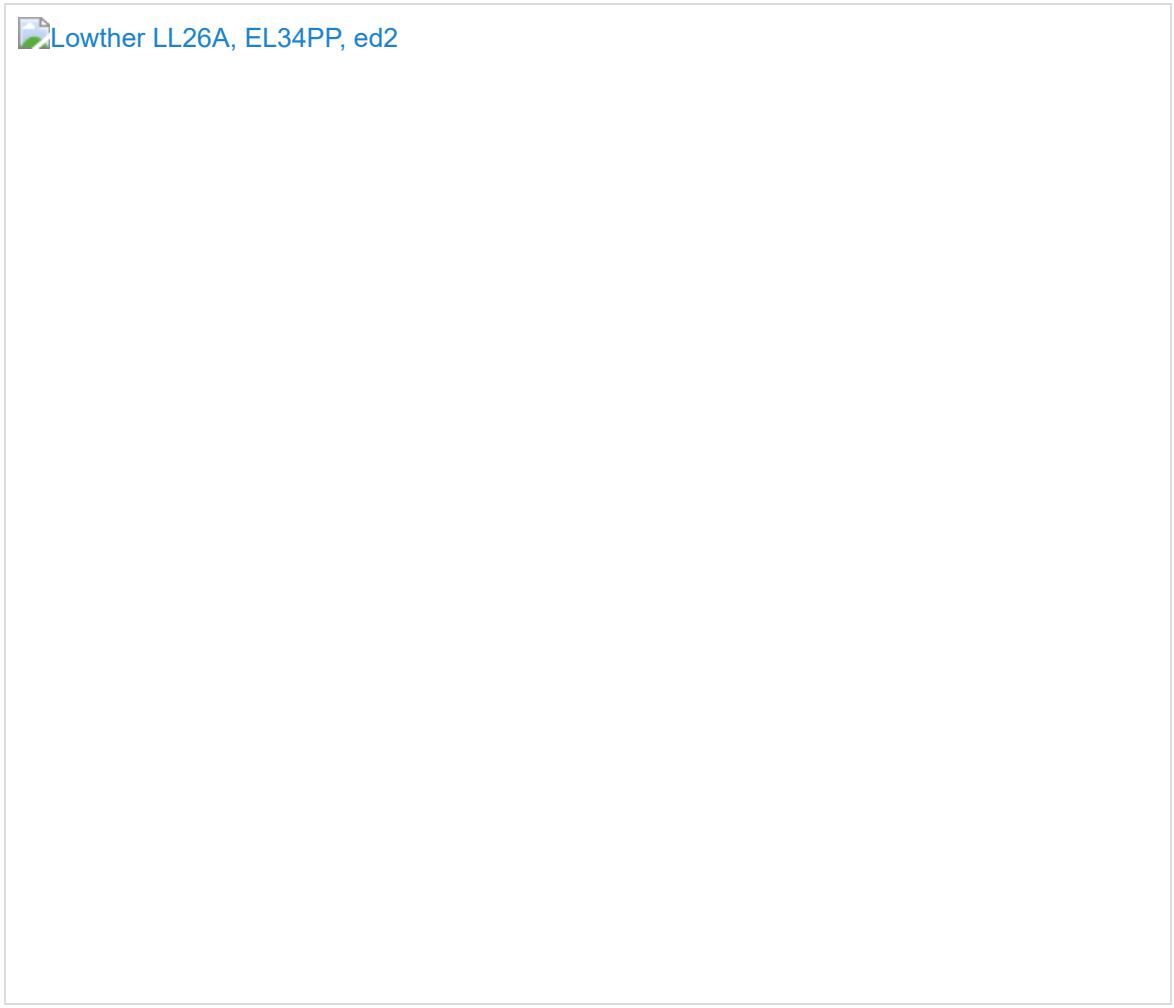
Another little curious thing one could to do with this amp is to remove the decoupling capacitor of 40uF from the common cathode resistor. This will pass the ripple artefacts to the cathode resistor, hence to a relative degree cancelling this nasties. Depending upon some variables and unknown, this may be good, poor or something in between. Trial and error is the tool.

Lots of possible fun with this amplifier, I would say.



RCA MI-9377A. Pix courtesy of www.soundup.ru

Sure looks nice……



Lowther LL26 , EL34PP , 1959

Lowther Voight are best known for their famous PM 2, -4, -6 loudspeakers, but they actually made quite a few amplifiers as well.
Paul Voight (1901-1981) began his career at JE Hough ltd. in 1922 and already then he developed several speaker units of which the later models are based. In the midst 1930's Voight met with O.P. Lowther and they formed the Lowther Voight cooperation. It has not been possible for me to find schematics for the early 1930's Lowther amplifiers , but I have a few diagrams from the 1950's production.

The LL16 and 26 is the familiar Mullard 520 circuit, but they differs in one or two significant aspects. The first thing we notice is that the input pentodes is triode-coupled. This is not a major change, but it improves the sonic quality over the 520 by quite a margin. Next thing to notice it the long tail /Schmidt phase splitter with a pentode current sink. These two little details in combination drastically improves the Mullard 520 circuit in my opinion.



Lowther LL16, EL34 PP, 1955

The LL16 is almost a clone of the LL26 and the same comments apply here .



Lowther LL15, EL34 PP, 1959

The LL15 is quite similar to the Mullard 520, but instead of the input pentode, Lowther decided to use a “cash coded” ECC82. The AC unbalance are here kept under control by the means of different anode resistors at the driver. Quite nice – I had this amplifier several decades ago, but I can’t remember in detail how it sounded. I may have tweaked and played with it – it is all in the mist. Anyway, it went to a better home as new adventures kept coming in those days.

This is an empty space in honour to those magnificent amplifiers that were invented in the minds of thousands of imaginative engineers, but never made it to the drawing board of the laboratories.

Hats of to the virtual amplifiers of the past.

If you have found errors, poor spelling, bad language or otherwise stupid postulates from my part, please, feel free to drop me an email. I am happy to receive feedback – positive as well as negative…Reach me at :100amplifiers at gmail.com. (You know where to fill in the @)

Thank you for reading.