The Wayback Machine - https://web.archive.org/web/20190319234953/http://lilienthalengineering.com:80/100-amp…

100 Amplifiers – Part 1 , 1916 – 45

100 amplifiers to lift your hat

(Was in 2 parts, now in 4 parts.)

I frequently change, update, delete or add stuff to the articles “100 amplifiers…”.(There is now about 200 interesting amplifiers here.)

You can help. I am always interested in pictures of the amplifiers here, (These will be accredited in your name) just as you are welcome to suggest interesting power amplifier designs from the period of 1916 to 1982.

Please, do drop me a note if there is *anything* you would like to comment on or add to the compendium. For matters of these articles, please write to : 100amplifiers at gmail.com

Thanks in advance…


TRADE
Thomas A. Edison
MARK
Edison





Photographs by **Warner Mansion house museum, USA**

Certainly the first commercially available audio amplifiers were mechanical acoustic horns. Here first Edison's famous "Talking machine" and below Victor's just as famous "Victrola" made exclusively for reproduction of music. None of these had any electronic or electrical items inside, yet acoustic recordings at their heights sounded better than most electric shellacs made from about 1925 to early 1950's . These acoustic machines are however an entirely other matter than this compendium, but they have to be mentioned, not least because they paved the way for modern horn loudspeakers and vinyl records.

We would also have to mention the transformer, that is capable of amplifying Voltage OR current. The first transformers were invented in the 1880's by persons such as Ferranti, Gibbs, Gaulard, Siemens, Blathy, Zipernowsky and Dèri. Their work was based upon Faraday, Henry, Oersted, Maxwell and many others. Transformers was used in early communication and telephone systems.

The worlds first loudspeakers were invented by Philipp Reiss and Graham Bell in the 1860's and Siemens invented the E*lectro-Dynamic* loudspeaker in 1877 – more than forty years before the later claimed Kellogg/Rice and Jensen (Jensen was apprenticed of Valdemar Poulsen, Denmark and came to USA in 1909) . These latter merely improved the Siemens loudspeaker. History is very subjective it seems.

The first 70 years of vacuum tube/thermionic valve audio amplifiers.

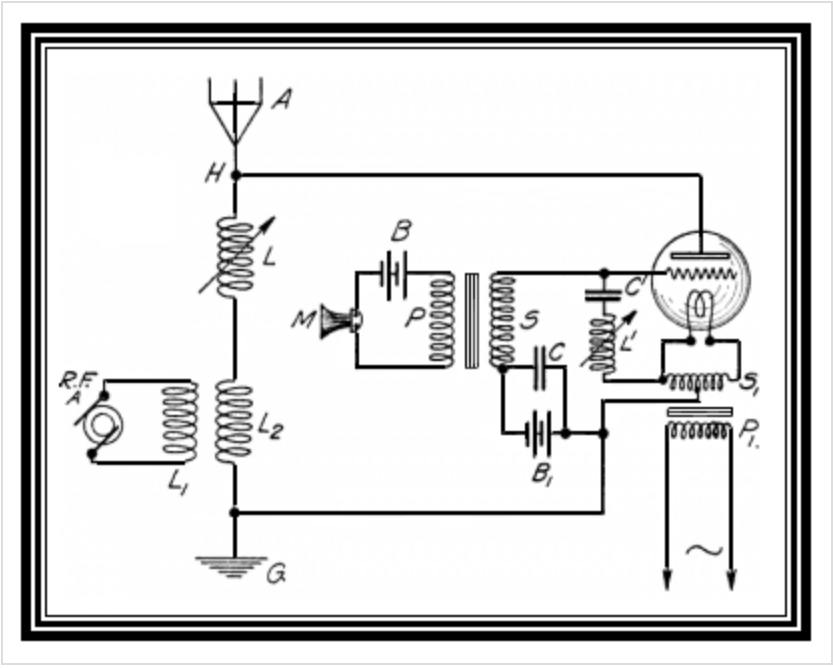
I have redrawn most of the original schematics. The point is to make the circuits clear and understandable at a glance. In the case of a stereo, integrated amplifier or receiver, I show only one **power amplifier** channel. I have not altered a single component or connection (Unless mentioned) , but I have removed most that had nothing to do with the actual amplifier. This could be text about the colours of wire leads, extra connectors, jacks for measuring, meter circuits, pre-amplifiers, component designations and numbers etc. All of such that is relevant for service of the original amplifier, but disturbs the reading of the actual circuit.



Radiodyne by Atwater Kent 4340 Model 10, 1923 from the collection of **Ernie Hite**, Photo: Charlotte ARC.

An good example of the beauty and decorative craftsmanship of these early amplifiers.

Here we go: **The Amplifier Compendium: “100 Amplifiers to lift your hat”**



The Pliotron Amplifier by Irving Langmuir, 1918.

This is the first true full wave vacuum tube power amplifier – *that I have been able to find*. All others before this was merely detectors, that at best amplified a positive or negative part of the wave or rectified it into a modulated phase signal as they were gas filled, soft vacuum devices and negative grid bias was not applied. Irving Langmuir, General Electric apparently designed a full working amplifier based on a high vacuum triode around 1916 – he named it ”The Pliotron” . Shown above is the 1918 transmitting version. I have no copy of the schematic for the 1916

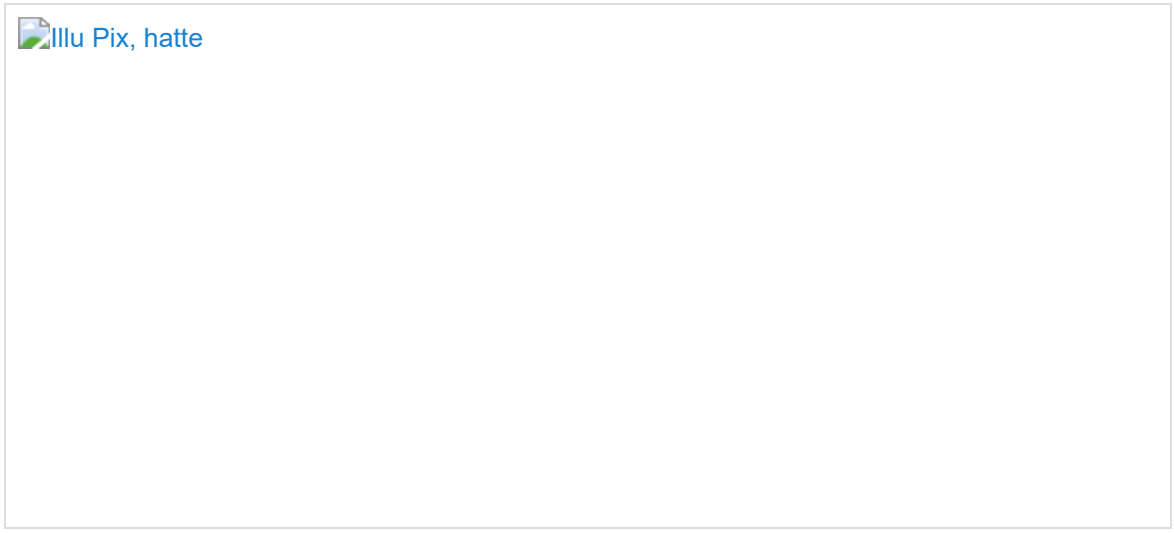
version available at the time of writing. (Read more about the birth of amplifiers in the preface to this compendium)

In the early days of electron tubes 1900 to 1918 or so, they really struggled to understands the principles behind the phenomenons that took place inside the bulb. Armstrongs contributions is often overlooked due to his ever lasting disputes with Deforest. It is interesting to read some of the articles and reports from the time about these matters. See – for more:
http://earlyradiohistory.us/1915reg.htm

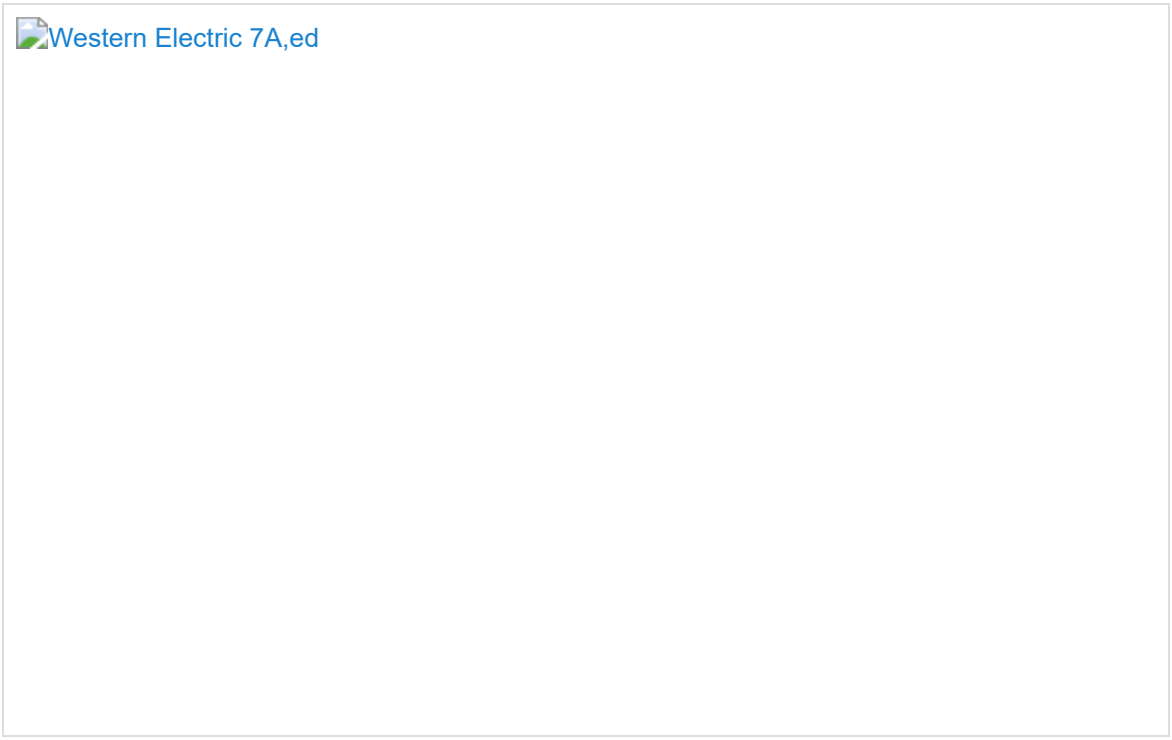
Langmuir achieved a perfectly good understanding of the electron flow and against mainstream he and a few others made hard vacuum tubes.This turned out to be the way to go. In the search for early amplifiers, I found dozens and dozens of patents from all over the world and it is impossible to give credit to any sole person. Langmuir vastly improved the incandescent light bulb, a thing he was capable of due to his high skills and knowledge of chemistry. In fact he and **Heinrich G. Barkhausen**, Germany, wrote most of the formulas we have used ever since when computing valve circuits. Langmuir studied in Europe and went to General Electric in 1909. Other important contributors to the early understanding of electron tubes was persons such as Child (Childs law and the Child-Langmuir Space Charge equation) , Gilbert Lewis, Walther Kossel, Germany. (And hundreds and hundreds more – please, keep that in mind)

The reason why I personally grant Langmuir the first genuine Audio Power Amplifier, is that he also played a major role in the understanding and development of the mathematics covering tubes.

We need to honour the good Irving Langmuir here in the company of where he belongs. Do note that Langmuir also called his early tubes for Pliotron's.



We owe a lot to Langmuir, Barkhausen, Armstrong , Fleming and all the forgotten persons behind the Thermionic – Space Charge – Vacuum Electron Valve/Tube.
Time to lift your hats, Ladies and Gentlemen….and bend…..bend deep..



Western Electric, 7A , 216A, 1922-24 ?

Flawless design, no hum, no resistor noise, no capacitor blocking. This is one of my favourite Western Electric amplifier design. At the days when it was made the components was not a thing to brag about, but keep in mind that this was a repeater amplifier – made for telephone communication. Build it today with high quality tubes and transformers and you will have a top class amplifier. Western Electric was a sub-division under the Bell lab. (Graham you know – ding ding , does that ring a Bell ?)



The Western Electric 216A triode. Photo from www.asyrua2.com (Seems to be cancelled)

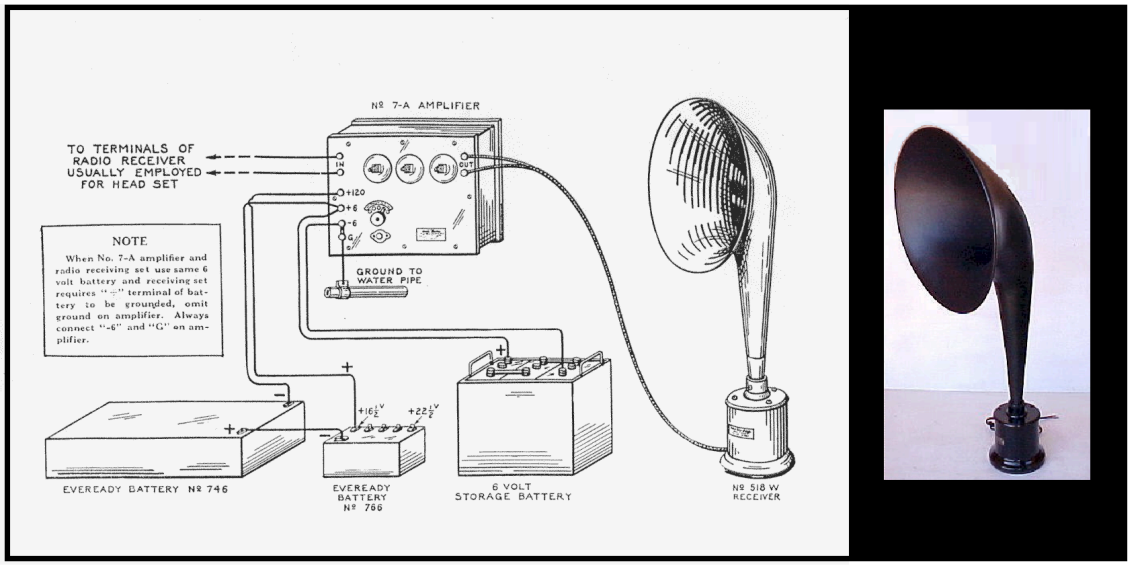
The 216A triode was one of the first tubes made by Western Electric. It was introduced in 1922 and apparently it was the first tube made by W.E. that was designed for a fixed filament Voltage: 6 Volts /1 Ampere. The u was a rather modest 6 ! The max plate Voltage rating was 150V. The 126A tube was apparently made exclusively for the 7-A amplifier. The ball shape of the early tubes was simply because that the technology of glass had already been incorporated in the automobile industry by the use of Edison's incandescent light bulb.

Push Pull was not a new invention, it had been used for small signal amplifiers and oscillators very early on, but WE made some of the first commercial PP power amplifier's.

I have been told by **Roger A Modjeski** (Music Reference, Beveridge etc.) that this amplifier was a set for domestic use – it came with a relative large horn loudspeaker called 10-D. The W.E. 7-A was intended to amplify headphone type early radios as well.



Western Electric, 7A, from the collection of Ernie Hite, Photo: Charlotte ARC



Set up chart for the 7-A and accompanied 10-D loudspeaker.



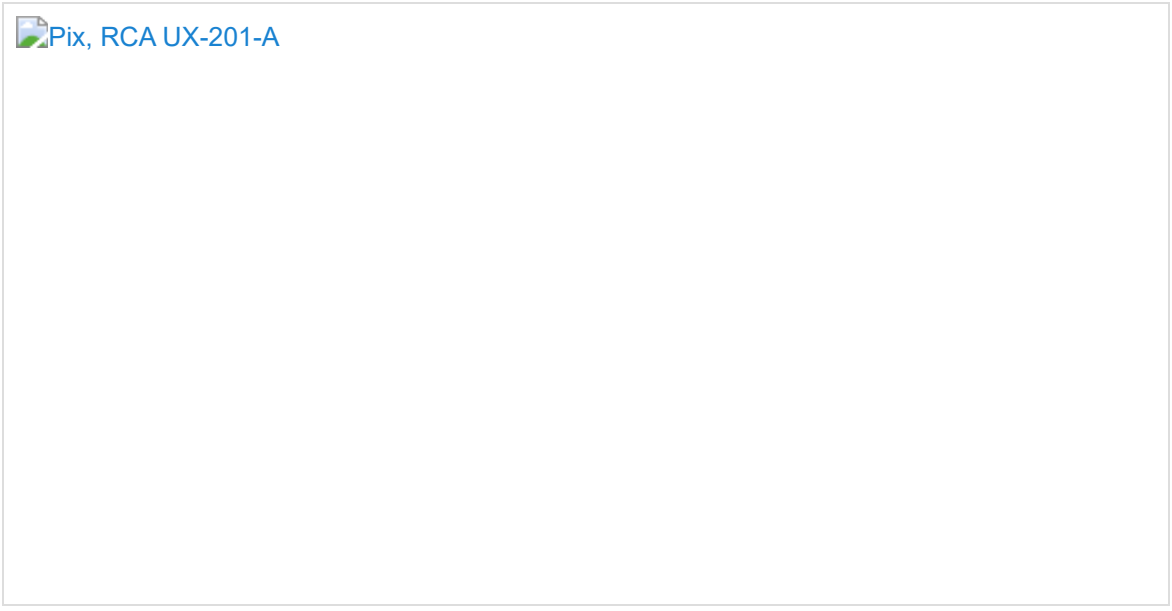
I will tip my hat to this – one of the first commercial amplifiers ever made.

Atwater Kent model 10, 4340

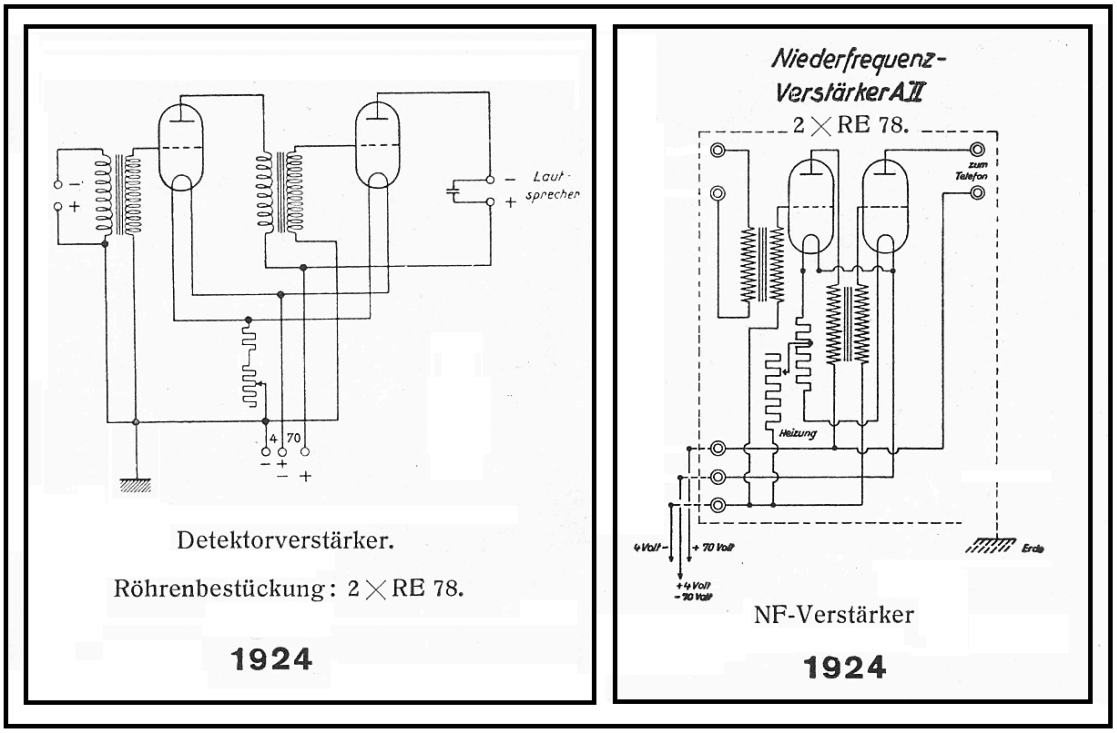
Atwater Kent, Model 10 4340 , 1923

An early battery driven amplifier for domestic radio. The output was meant to drive a headset. The capacitors are surprisingly small, but keep in mind that the available audio frequency range was very narrow in these early days of wireless. See photo of the entire radio set at the beginning of this part. Breathtaking beauty.

UX200 and UX201A was the first tubes sold by RCA (1920) , they were simply called “Radiotrons”. Much to my Surprise the UX200 was argon filled according to “Radiomuseum.org” ! It is a little strange as Langmuir and Barkhausen as early as 1916 proved that vacuum was a much better method for amplifying purpose. Both of these tubes were meant as detector tubes, although the UX201A could be used for audio output. RCA recommended max 90V and a bias of -4,5V, but would allow 135V and a bias of -9V in case of use as audio power stage..



RCA UX201.



AEG, RE 78, 1924.

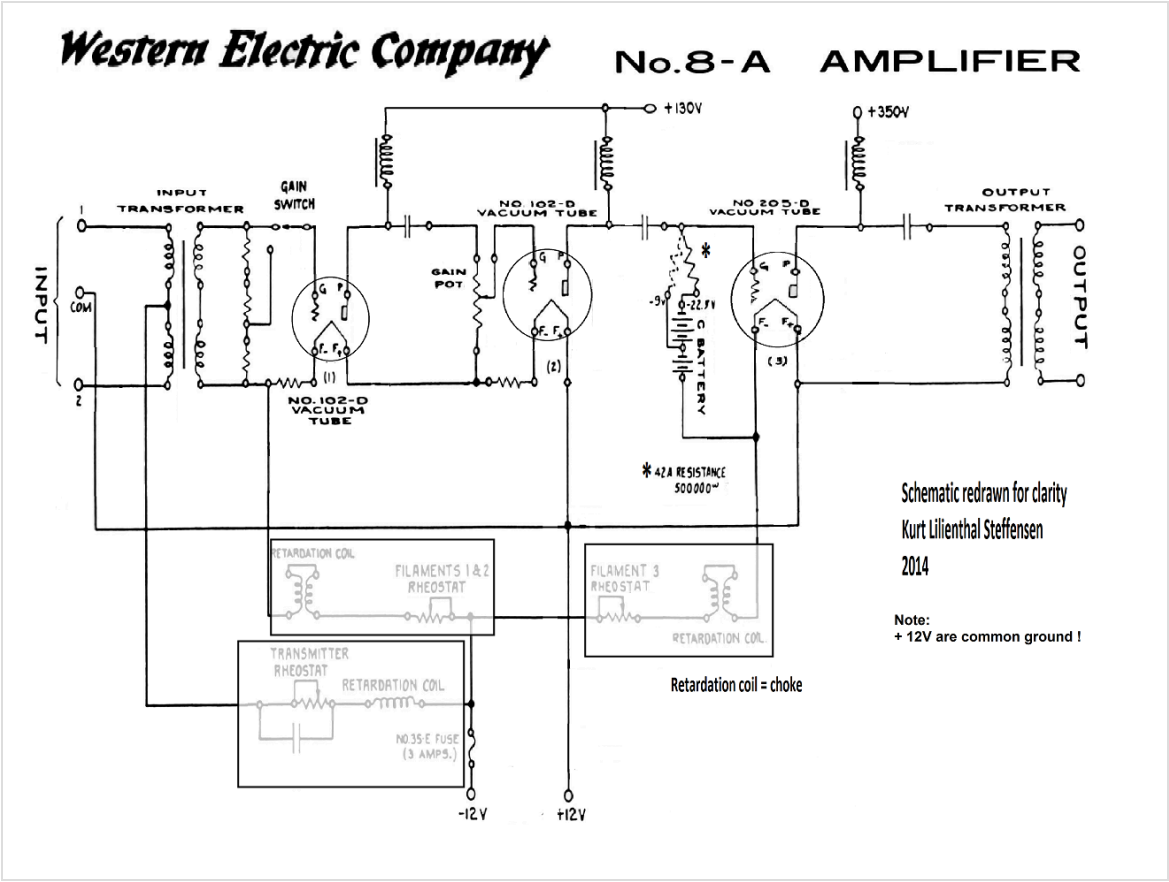
These two amplifiers are actually flawless in the sense that just like the WE no 7-A, they are operated exactly as we later learned to be the “optimal” method. No fumbling here, meine Herren. A similar amplifier made today with high quality components will be a true high end device. AEG was founded by Emil Rathenau in 1883. At that time AEG was competing with Siemens und Halske, but as early as 1903 the two companies jointed and formed a division called Telefunken. (A peculiar side note – the same year as these two 1924 amplifiers was introduced, Siemens invented the ribbon band microphone. I am sure it was a lot better than the common carbon microphone) A.E.G = *Allgemeine Elektrizitäts-Gesellschaft* which in English means: General Electric Company. Now that is indeed funny.





TELEFUNKEN
RE-78

Hats off to Emil Rathenau, Werner von Siemens, Johann Georg Halske and all the other German pioneers.



Western Electric 8A/B, 205D, (1925)

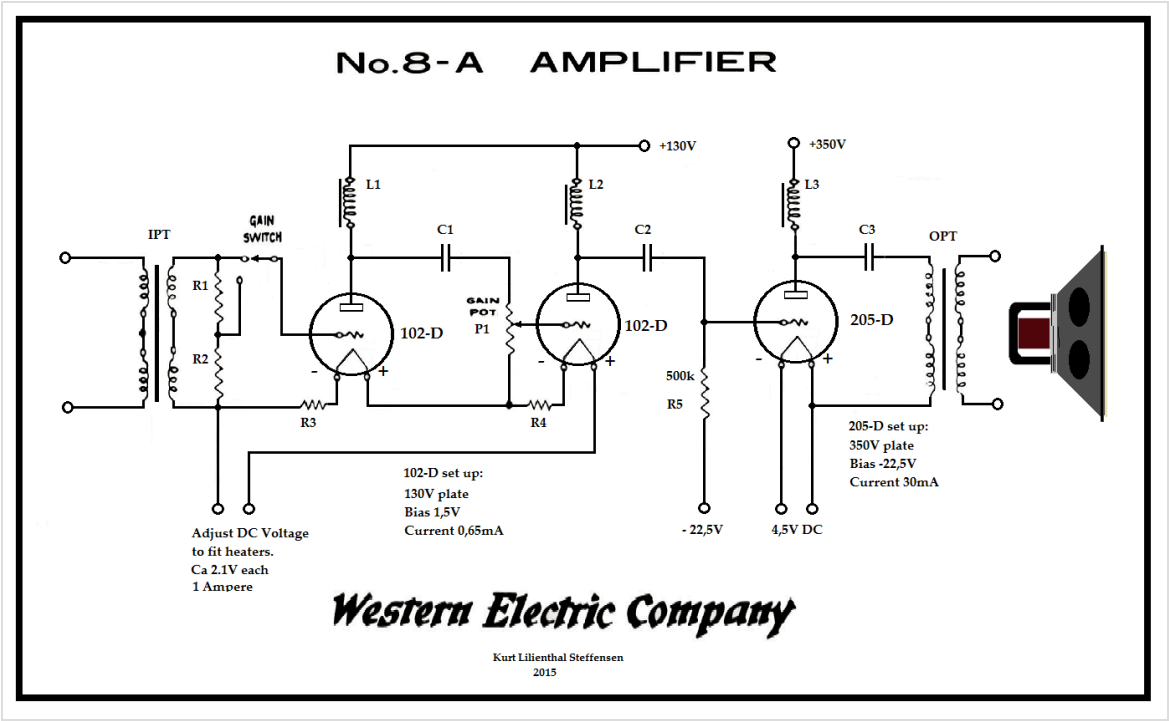
A very early W.E., all iron SE amp. Two transformer coupled 102D stages and a 205D output. It is all battery operated, which means that at the days of its origin there were no hum at all, as the AC main net was not yet developed. The “unlogic” tube symbol probably came from Deforest. Amusing that they refer to the chokes as “Retardation” coils……

Pix Western Electric 8-A

The WE 8-A is indeed a beauty.

I have received some mails regarding the W.E. and other early schematics. Many find them difficult to understand. It is certain that they are often drawn in a rather non rational manner, but perhaps more difficult is that the parts are often connected in ways we would find unusual today. I have redrawn the circuit – once again, now only with the necessary components. I think you will find that it is indeed very easy to understand. There is one thing, though, about the original circuit that is a little odd. If you look carefully at the circuit above you will note that the +12V are common and that there is a Voltage potential of 12 V present at input. This is indeed weird, but I suppose it is meant to bias a carbon microphone. Anyway, we will just ignore that feature as it is of no use to us, not using such microphones as the signal source.

Here is the re-redrawn version of the circuit. I do not think that further simplification is possible:



Should you want to make a *copy of the original circuit* you will need a 7 to 12V battery to supply the heaters and make bias for the two 102D's. The 102D's are supposed to draw 1 Ampere through the series coupled heaters. This means that the bias is made by the current through the resistors R3 and R4. The bias should be about 1,5 Volts, meaning that these resistors should be of 1,5 Ω each. That would demand a supplied Voltage of 2V+2V+1,5V+1,5V = 7 V. The reason for the use of a battery of 12V or so, is that as the battery wears out and the Voltage falls it is possible to maintain the correct current/Voltage with the help of the originally suggested rheostat (variable resistor) in series with the battery. This is also why it is possible to connect the grid resistor of the 205D to a lower bias Voltage, maintaining suitable idle current as the 350V battery Voltage falls.The "retardation coils" = chokes are meant to isolate the filament cathodes from one another AC wise. This is not necessary in the case of indirect heated triodes.

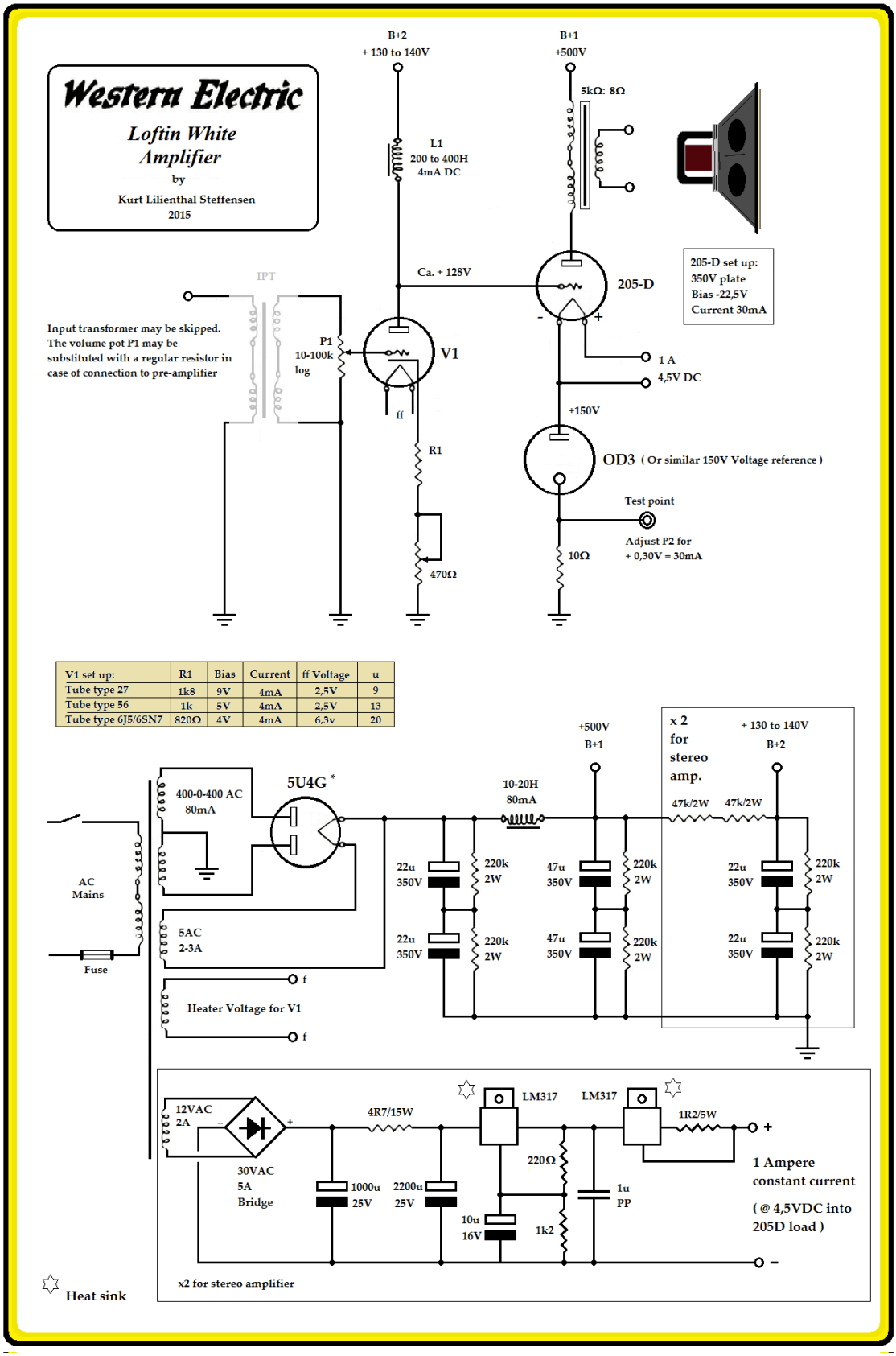
The input resistors R1 and R2 could be just about anything, that would insure the correct loading at the primary side of the input transformer. The plate chokes L1 and L2 could be 100H to 600H – I would guess that the originals are rated at less than 50H, as the low freq roll off was not critical back then.

The gain pot should be a logarithmic type of min. 100kΩ. The capacitors C1 and C2 would be fine at 10-22nF. The plate choke L3 for the 205D could be 10-30H , that capacitor C3 of 47nF to 100nF and the output transformer should be 4-8k Ohms. That would insure you a staggering 800 mWatt's or so to play with.(0,8 Watt)

Should you rather prefer to make a modern high quality version of this old W.E. darling, I suggest that you dump one of the input stages as the gain in the original circuit is crazy high for modern signal levels. You may keep the input trannie, in which case a 1:1 or similar low ratio type will do fine. I would also suggest a regular plate output transformer, instead of the parallel plate choke load. This will insure the full output power of almost 1W at 1V RMS in. Actually we do not need to

find a pair of old 102D's for a stereo set. Just about any triode with a mu of 20-30 will do a very good job, say a 6J5 single triode or a 6SN7 twin triode for both channels.

Whilst we are at it why not try to get the best out of this little neat circuit. The small 205D does not draw much idle current , we may utilize this fact to our benefit. Allow me to introduce the worlds first "Western Electric Loftin White Glow Discharge Diode Voltage Regulated Amplifier".
"WELWRA" in short – what a silly name 



WELWRA, 205D SE, 2015.

This amplifier does not really belong in the historic content of this compendium. But I could not help adding it, due to circumstances. 1) The 205D is once again in production. 2) The **W.E**. 8A circuit is a very typical circuit of the time. 3) The direct coupling of the Loftin White is a design from this period as well. 4) Low current power tubes such as the ones developed with limited battery power in mind, leans to a Loftin White circuit with the later regulator tubes.These will usually not accept more than 40mA at Voltages above 100 Volts 5) I receive quite a lot of mails from people asking how to modify these classics into DIY suitable modern amplifiers. – Thus – here it is..

This capacitor-less gas regulated DC amplifier has yet another significant feature that was not possible back in the golden age of triodes. The filament cathode of the 205D is fed from a **constant current source**. What really tends to hold the tube characteristics as constant as possible in a space charge vacuum tube is the temperature of the filament. In order to keep this tight, we need a regulated fixed current, rather than fixed Voltage. This is particular true for direct heated tubes, but actually goes for any electron tube. The DC Voltage from the originally used batteries is by nature hum free. Although it is possible to make an constant current AC supply, I would like to keep this design noise free. Hence the constant current DC power supply. Another advantage of the regulated current is that it does not mess with the signal as much as a regulated Voltage would do. This is important in a direct heated triode design. The Voltage measured at the filament of the 205D should be around 4,5V +/- 20%. The important thing is that the current of 1 Ampere is constant.

It is possible to use just about any triode you would like for the input, providing that it can run in class A, with a bias of more than 1 V and about 130 V at the plate. High mu triodes such as 6SL7 or ECC83/12AX7 hardly qualifies here and they will easily be driven into clipping with a line signal. Neither will they sound too good in such set up. (Operating in the non linear area) Much better is triodes such as the ones suggested. The plate choke is critical and although this is a vital part of the possible sound quality, you may substitute it with a regular resistor. This will demand a higher B+2 Voltage. 22 to 47k will do fine and you will need to decrease the two 47k Voltage drop resistors at the PSU accordingly.

As the whole amplifier only draws some 30 mA + 4 mA = 34 mA in total (or 68 mA in a stereo set) , we can use just about any rectifier we would like. The 5U4G is a common rectifier, but 5Y4GT, EZ81, 5R4G etc. will do just as good. The rectifier will have to withstand 2 x 400 VRMS at the anodes. The important thing is that we end up with Voltages close to the suggested 500 V, when the amplifier is on.

Any 150V gas regulator will do, as long as it accepts min 30mA continous. The OD3 is similar to VR150/30, QS150/40, G150/3D and many others.

It is always particular critical to fit and adjust the Voltages in a DC coupled amplifier. Any failure in the “driving” tubes may lead to catastrophic meltdown. It is therefore important to be careful and investigate the available Voltages before connecting real tubes. You will need to invest in a few power resistors in order to test the set up, before applying tubes. In the case of the constant current heater supply for the 205D, it is quite easy. A 10 Watt (or more) resistor of about 4,7Ω should be used to adjust and confirm this supply. As we want it to supply a constant current of 1 A

into any load (Within capability !) , we should read a Voltage according to this over the attached resistor. In the case of 4,7Ω, we should read 4,7V. (4,7Ω x 1A = 4,7V +/- the precision of the resistor)

It is a little more difficult to test the B+ Voltages. Now, if we want to apply a load of 34mA between the 500V point and ground, we will need a resistor of 500V/34mA = 1470Ω. 500V x 34mA = 17W. A resistor of 1k4 will do (1k3 to 1k5 is OK) 25W or more in order to be on the safe side. You can use the same resistor to test the gas regulator. (OD3) Although it will not allow the full current, it will do fine.

In case of a stereo amplifier we will need half that value and double the power. (Or simply two of the resistors 1k4/25W)

(BE CAREFUL !. This resistor gets VERY hot and the Voltages present are LETHAL !!!) Solder a wire from B+1 and ground to the resistor or use GOOD high quality high Voltage clips. Place the resistor at a non conducting surface (Like a thick dinner plate) and connect a multimeter by means of probes with alligator or other clips. This way you do not need to hold the pins with your hands. (Important !)

You can now test if the PSU delivers a Voltage close to needed. If the Voltage is too high you may ad a resistor in series with the choke or swap the rectifier to one with a higher inner resistance. (5R4G for instance) When the PSU delivers between 480 to 510 V with the load resistor connected, you can attach the pre amplifier tube and adjust for lowest possible Voltage at the plate of this tube. (Keep the resistor load connected during this test) And be ready with the on/off switch.

When the Voltage at the plate of the input tube is 124 V or less, you can connect the 205D. Turn off the amplifier and remove the resistor load. Now insert the 205D and slowly adjust 470Ω pot until you measure 0,30 V over the 10Ω cathode resistor.

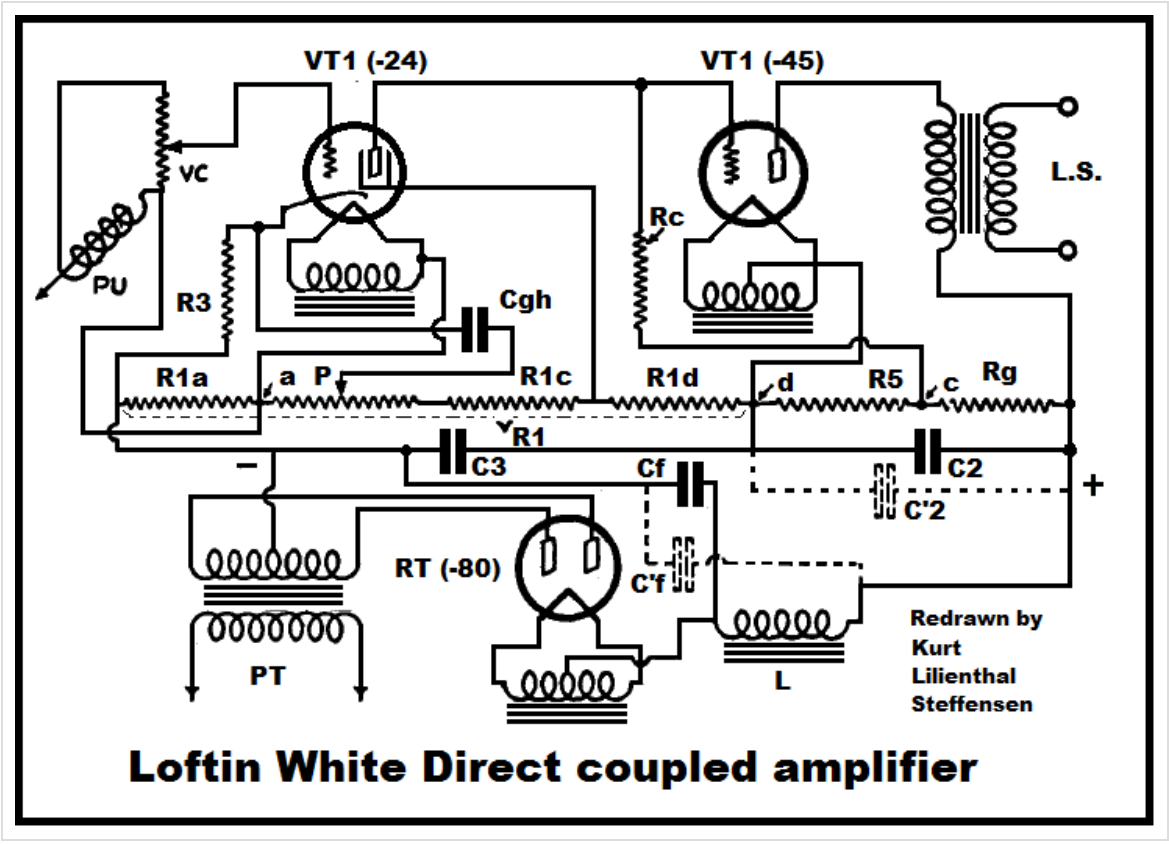
Voila – you are there….Happy listening.

(It is also possible to use such tubes as the 45 or similar in the WELWRA circuit. In the case of the 45, the B+1 should be ca + 425V, and the Voltage at the input triode plate about + 94V. The 45 tube will draw some 36mA, which is still within the limits of OD3 and it will provide you with a tremendous 2000 milliWatt’s into a load of 4-5kΩ)



New production Psvane 205D (left) besides a Vintage Western Electric 205D. Photo courtesy by **“DHT Rob” www.dhtrob.com**

Vintage 205D’s has become very expensive, but Psvane and Fullmusic has started to produce this early triode once again. It ought to be a piece of cake, with modern technology and materials and I would guess that these are at least as good as the original. We have learned a lot about tubes and materials since the early 1920’s. The Fullmusic 205D is equipped with perforated plates. Now, these plates does not do any good besides from looking good. Actually the perforated plate decreases the surface and material density, thereby decreasing the max anode dissipation as well. Mesh plates increases the surface thereby increasing the maximum allowable plate dissipation as well. At least in theory. Anyway, they are both good alternatives to the originals made by Western Electric, Northern Electric and STC, London. The English types were called 4205D. The later E version is just as good, likely a little better. (205E and 4205E)



Loftin & White, 1929.

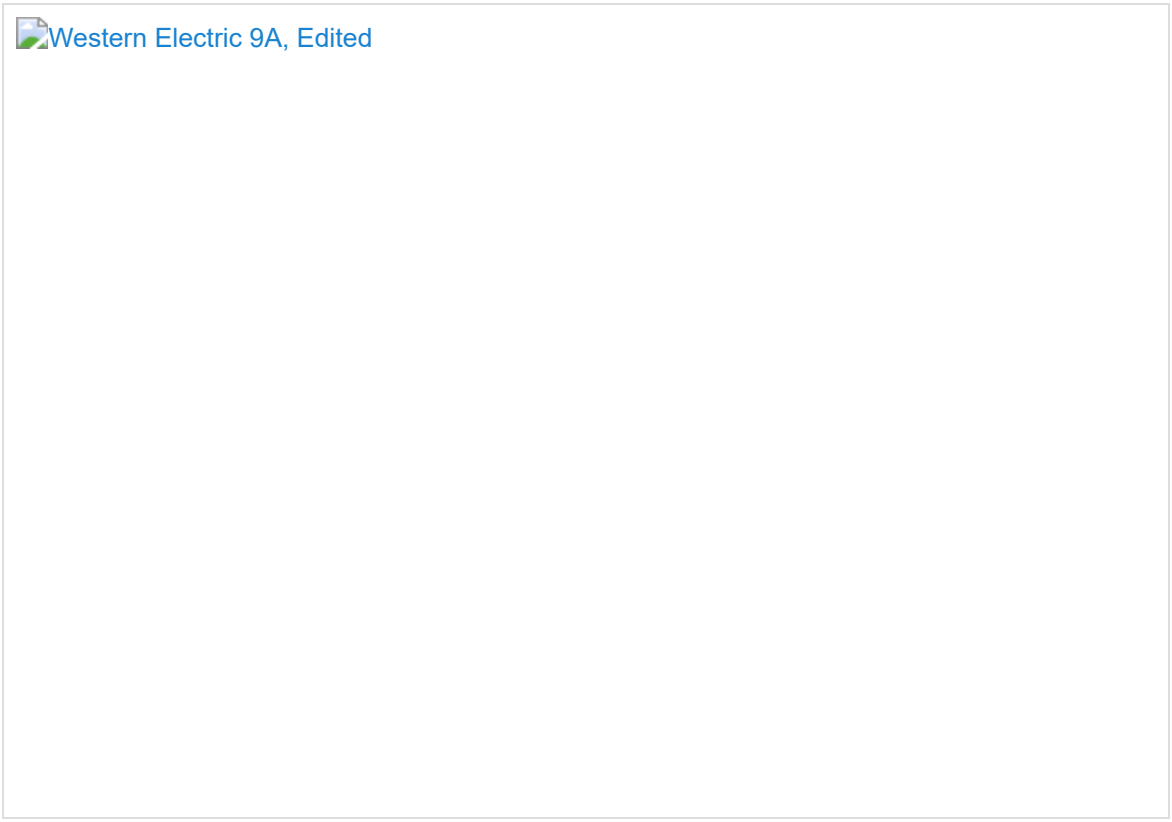
These early Joes; Loftin and White was the first to get rid of that leaky, lousy and expensive capacitor they made back in the 1920's. Direct coupled power amplifiers were quite common in the early 1930's. Capacitors were expensive, poor and often quite unreliable. We are lucky to live in times of which passive components are no longer of such a limiting factor.

I like the idea of direct coupling simply because it has no capacitors to mess up the phase, limit the LF or to steer into recovery problems. But I think it comes at a price. First of all we need a lot of high Voltage and that is not really what I long for, secondly and more importantly the danger of errors. In a DC coupled power amplifier any runaway, bad soldering, poor pin contact are most likely to lead to catastrophic failure killing the output tube and possible damage to rectifiers, chokes and so on. I really care too much about my precious vintage triode darlings in order to fully trust that nothing will ever go wrong. These reasons was exactly why the "Direct coupled amplifiers" were abounded as quickly as they had been adapted.



Early 45 triode (245 Tungsram) , author's collection.

This original L & W uses a 24 pentode to drive the 45 power triode – directly…..650 Volts of power behind. L & W benefits from the use of a tetrode as the sg2 is fixed in the current loop, thus assist in maintaining the DC values as intended.
These guys were brave in more than one way – and at least we need to touch the hat in honor to Loftin and White…Well done, guys.



Western Electric 9-A, 205D PP , (1930)

Another beauty from the hands of the Bell Lab. This is still one of the best circuits for high quality Push Pull. The filament and Bias network is supplied from batteries. It is worth to note the two chokes. The choke in series with the OPT acts similar to a constant current source, which in this case improves the linearity. The choke in series with the filament acts the same way, although here rather preventing the audio signal to pass, but refereing these to the ground. Do note that the filament battery is grounded at the positive note. The 9-A was made for “Sound Projector Systems” = cinema. I would not mind a bunch of 9-A’s for my private 5.1 system. The 9-A is remarkably similar to the 42-A, shown later in this compendium. They only differs in the grid/cathode decoupling and in that the 42-A is entirely powered by AC-mains.



Western Electric 10A, 4 x 211E PP. (Early 1920's)

During my research about Western Electric, I kept stumbling upon a circuit called "Western Electric A-10″. It did not seem to be a genuine Western Electric to me, hence I ignored it. But as I frequently got this circuit in my search results, I finally got a little annoyed and decided to publish the schematic of the real 10-A . The "false" circuit called A-10 has nothing in common with the 10-A, but it may be that it is somehow inspired by later WE circuits. It does show some resembles to

the WE 124. It could be, of course that someone incidentally labeled the schematic as Western Electric ? Anyway – The real WE 10-A is the one above.

The circuit is as simple as it gets, not much to say here. Although the plate Voltage could have been sourced from a battery of about 750 Volts (Yes, they really had and used such monsters back then) I suspect that the plate's was sourced from a rectifer PSU. Each 211 will draw something like 80mA x 750V = 60 Watt's. That is a total of 320mA and 240 Watt's. That would provide us with a comfortable amount of 50 to 60 class A triode Watt's. Quite nice.

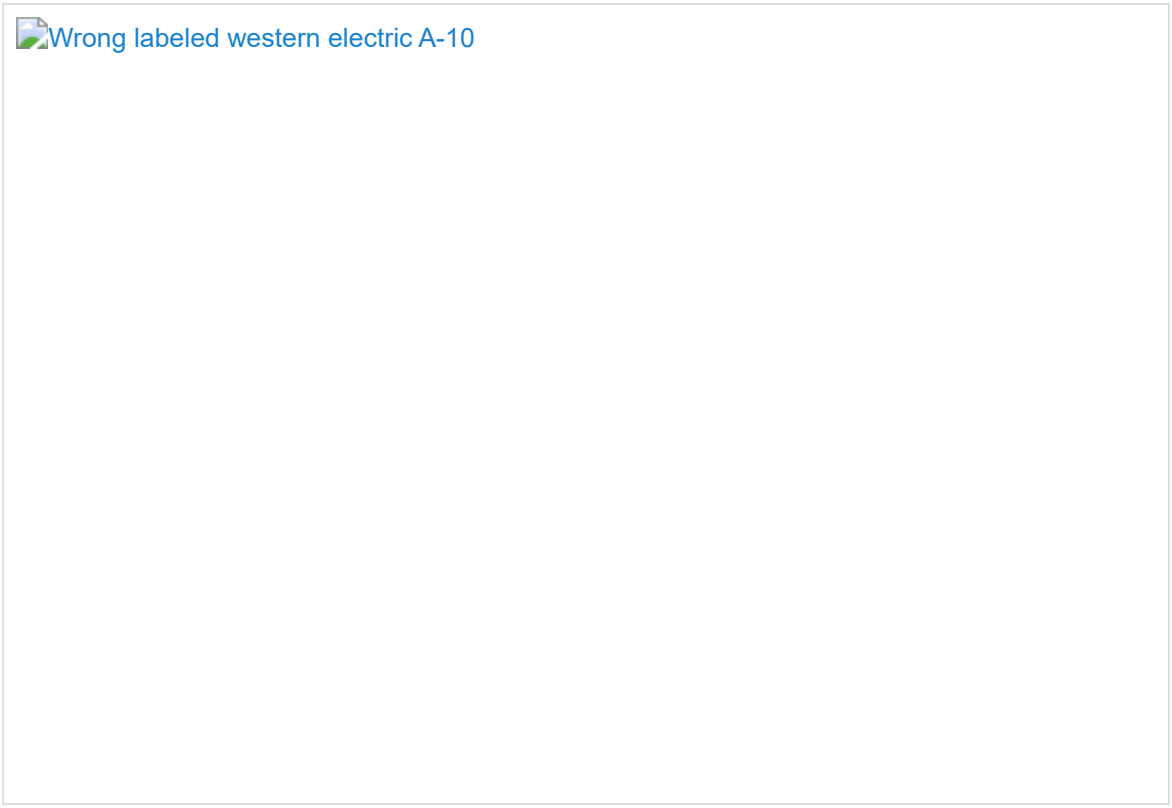
The grid bias and filaments was indeed supplied by battery packs and that will insure a totally hum free performance if the anode Volts are properly smoothed. I have myself made a Single End 211, fed by a DC regulated filament and it sounds absolutely stunning. No noise at all. The 10-A amplifier is not difficult to drive from the point of view of Voltage swing. But as it represents a pretty low load 1:2//12k = 3000Ω, demanding peaks of 12mA, we will need a small power amplifier to drive it. Apparently WE suggested that it should be driven by WE 9-A, which is a 205D Push Pull, capable of some 4-5 Watt's.

That will do it. It is wonderful to gaze at this almost 100 years old circuit and realize that it would still to this day be a rarely high quality power amplifier.

Western Electric developed the 211-A in 1923. Later 10-A models used 242's triodes – 242's is very close equivalents to 211's.

If you consider to play with this circuit, but do not need as much power, it is easy to do with only a pair of 211's. All you need to change is the OPT. 5 – 6000 Ω will do nicely. The input transformer is not critical as long as it splits the phase. Anything between 2:1 to 1:3 is fine. (2:1 will demand double Voltage swing – some 70-75 Volts, but is will reduce the current by 4) Go for the best quality you can find.

Down below is what I suspect to be a mislabeled or "false" Western Electric circuit. Possible a schematic from a Japanese magazine, that has somehow been mistaken as a Western electric. If you know anything about this schematic or that it indeed exist as a WE circuit, please let me know. Western Electric produced a receiver called A-10 in the late 1920's.

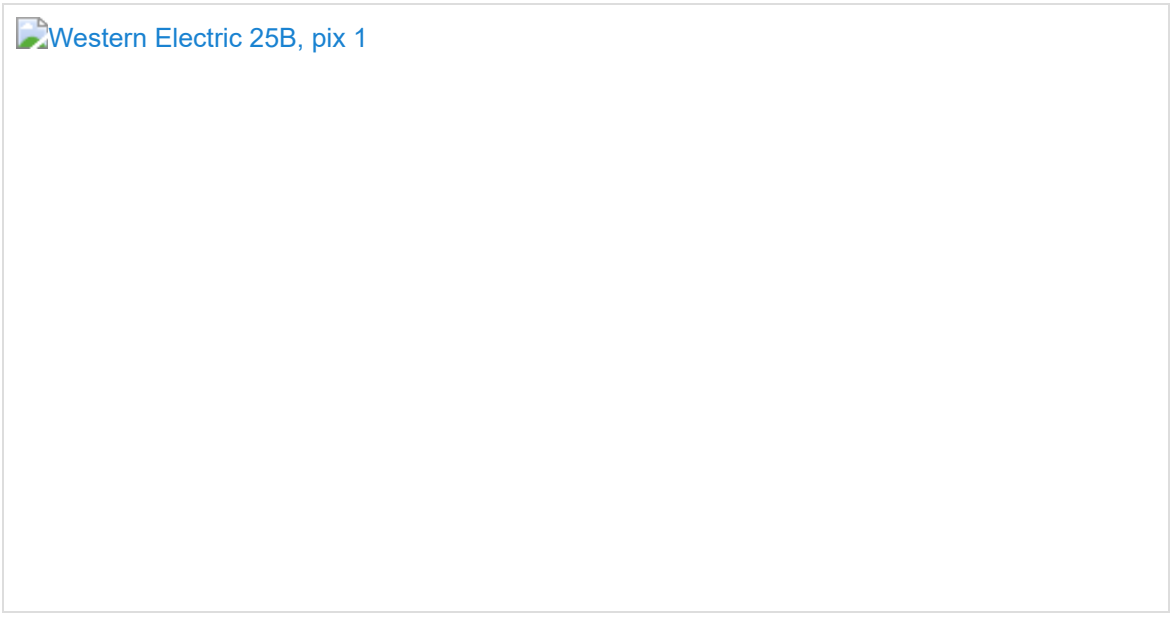


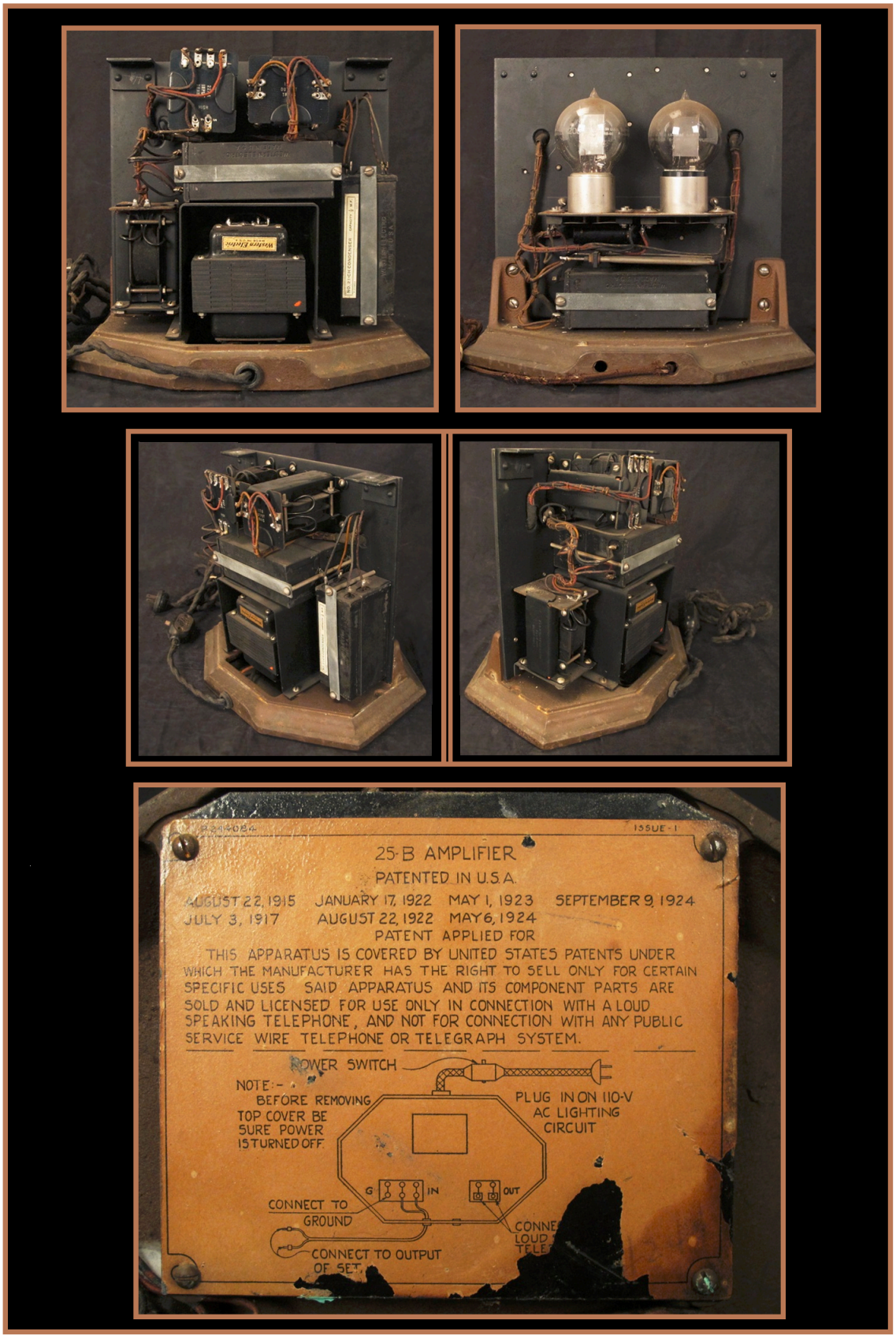
Mislabeled WE. A-10 Amplifier.? This may be a fine circuit, but it is not a W.E. design.



Western Electric 25-B , 205-D SE , ca 1925

Yet another W.E. amplifier of supreme simplicity. I did not plan to write about this amplifier, as it is “only” an exact single end version of the 42-A amplifier – or to be more precise, the 42-A is the push pull version of the 25-B. But when I saw the pictures of the inside of this very early amplifier I was blown away by the quality and modern build. All resistors back then were wire-wound, meaning they were very stable and produced almost no resistor noise at all. The transformers and chokes looks like something made in the 1950’s or early 1960’s. Excellent mechanical lay out. Do also notice the huge 2 uF capacitors. No wonder they were so extremely expensive back then. I am impressed and I really like the odd look of this amplifier. You may wonder why WE used a 205-D as a rectifier as diodes/rectifiers were invented several years before the triode. Well they did make rectifiers at the time, but as the AC-main power distribution was not yet common and batteries was often used, the demand for rectifiers was not high. Western Electric themselves made rectifiers very early on for instance 214-A in 1922, which was basically a 211 with the grid removed and closer spacing or 219-A in 1923. This was a 212 without grid and closer spacing. Other rectifiers were such as the argon filled, capable of several Amperes. These were used for projector lamps and so on. Other good reason for using the power tubes as rectifiers as well, was in the maintenance and service. A worn power tube, would do fine as a rectifier and in case of an emergency all tubes were interchangeable.

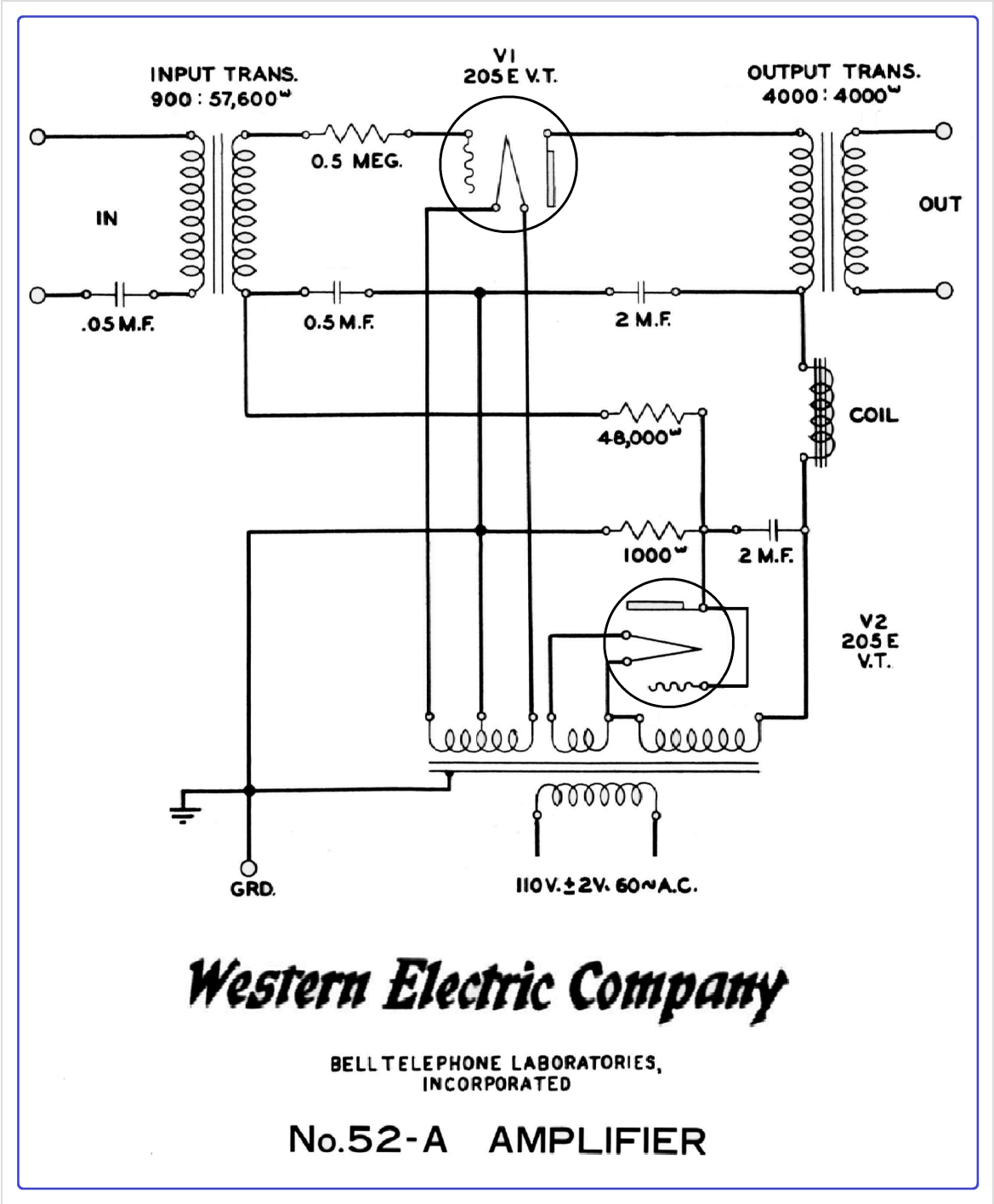




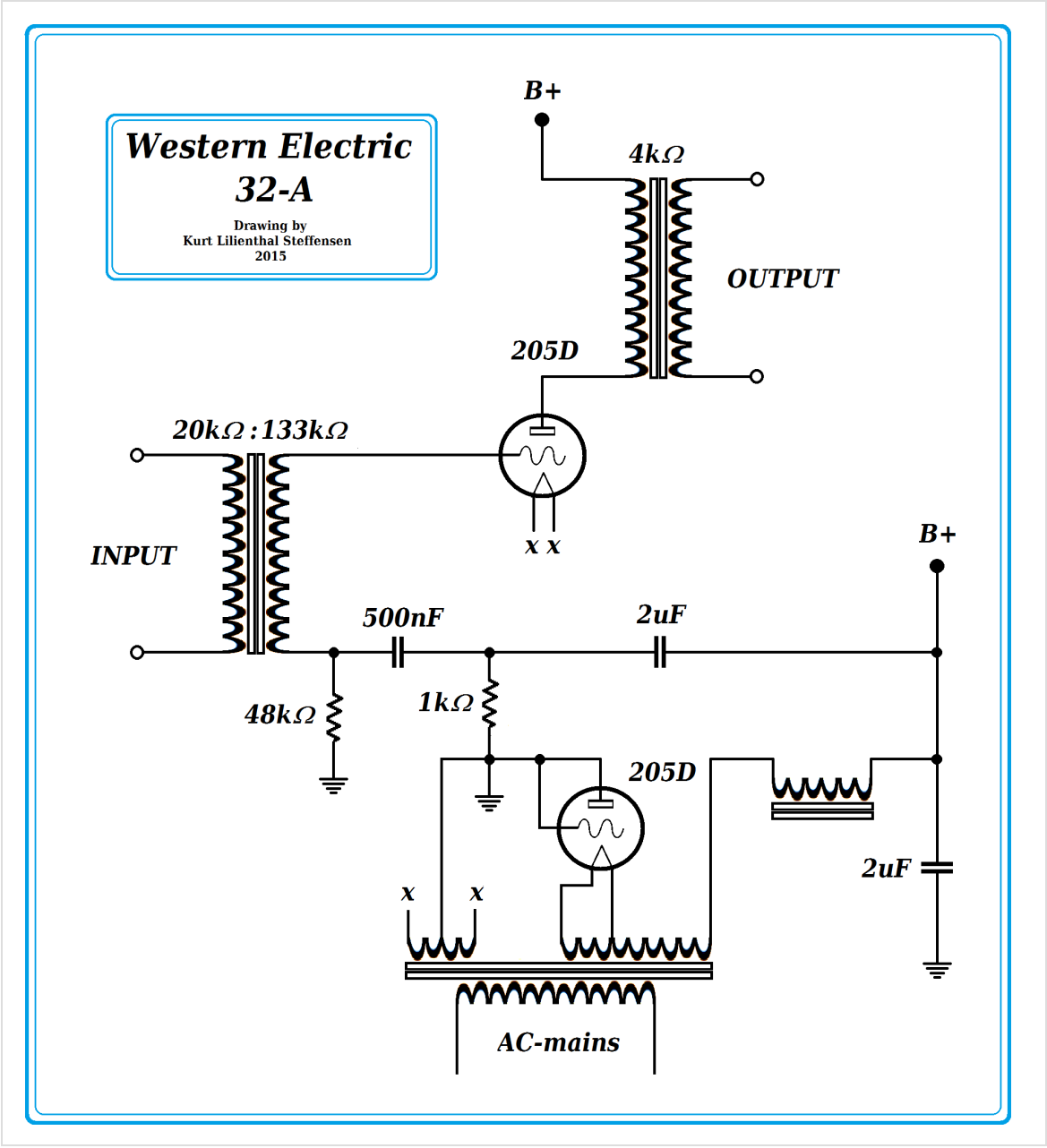
The early amplifiers from the beginning of the 1920's were just as often used for speech amplification , meaning telephone as for radio. Keep in mind that amplitude modulated radio were still at its very beginning in 1922. The wireless telegraph in the form of "Hertzian waves" (radio waves) had been introduced by Marconi , Braun and Tesla shortly before WW 1. In fact there was

only one radio station in USA in 1922, transmitting AM on a regular basis, as far as I know. It began in 1920 by the station 8MK in Detroit, Michigan. Please, correct me if I am wrong here. Electric phonographs was not on the marked before 1925. The 25-B was intended mainly for amplification of telephone communication as the sticker above suggest.

Western Electric produced dozens and dozens of amplifiers based upon the 205 power tubes. I have at least some 20-30 schematic covering W.E. 205′ amps in my archive. The later 52-A models is basically the same as 25-B, but the 205-E tubes was taken in use.



Western Electric 52-A , 205-E SE,



Western Electric 32-A, 205-D SE, (Power section) ca 1930

Another amplifier from WE, that glamours in plain simplicity. But do not be fooled. This is an advanced circuit, despite the few components. The power supply is a choke input, which is good for high regulation. (Low deviation from average Voltage) But the rectification is half wave, which is poor for the same reasons. One of the power supply capacitors is returned to the cathode resistor of the 205-D. This provides a degree of regulation and noise cancelling. But what is really interesting is the grid to cathode decoupling by means of the 500 nF capacitor. This is probably the first amplifier from WE that uses this little trick. It will be dealt with in detail at the 92-B vignette later. Apart from the mentioned, this amplifier is quite similar to the earlier Western Electric single End amplifiers. (8-A and 25-B) The unloaded input transformer is prone to ringing, due to the excessive high turn ratio, but high gain was mandatory in vintage amplifiers .

The Western Electric “grid to cathode coupling” trick explained.

The grid to cathode coupling is one of four famous “W.E. tricks” that has been discussed in audio tube circles for decades. The opinions and explanations are many, but this particular trick is rather simple.

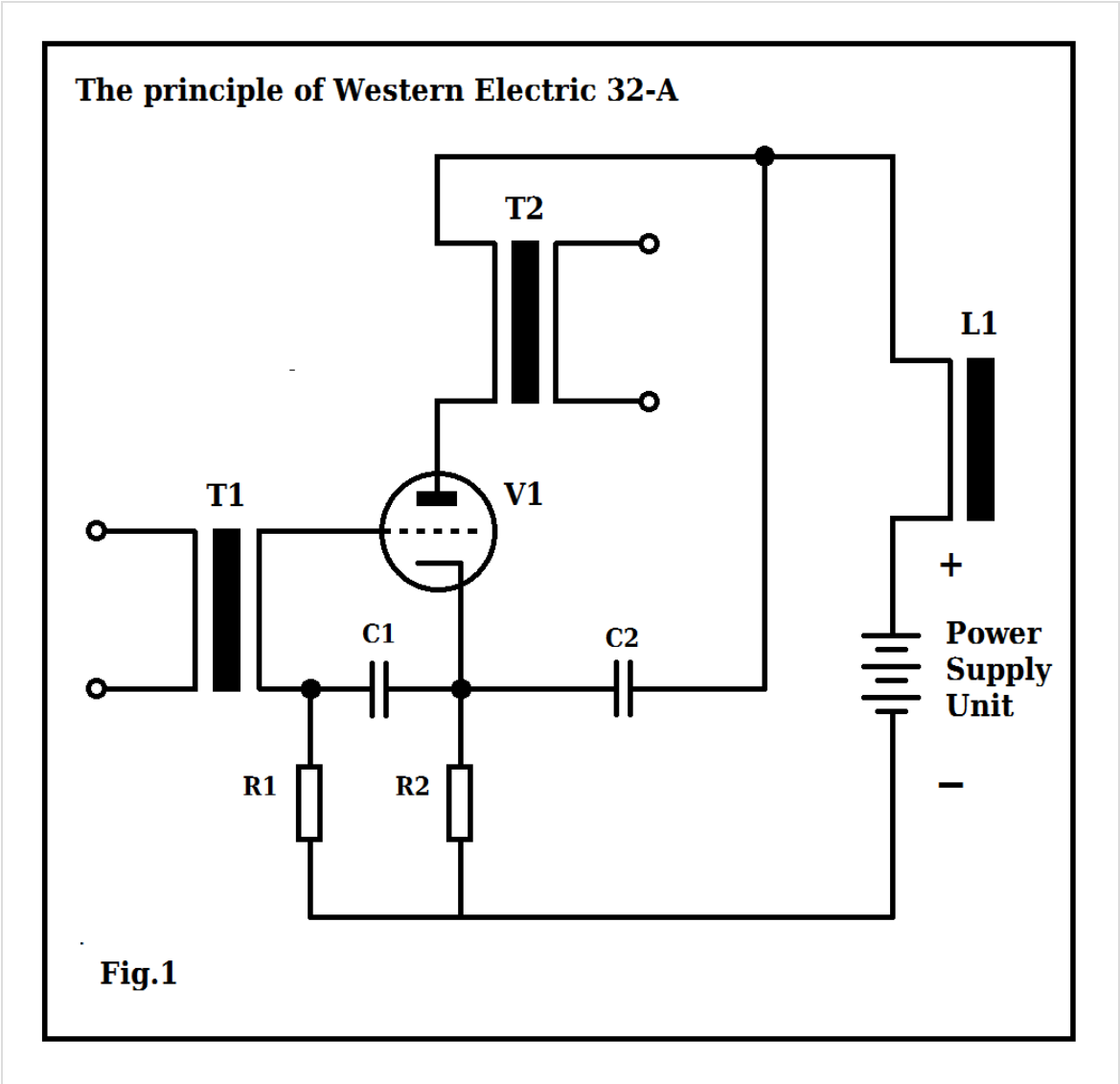


Fig.1 This is the network of the Western Electric 32-A power output section – cut to the bone. Let’s for a moment ignore the output transformer T2 and the capacitor C2 and deal only with the network of C1, R1, R2 and the secondary winding of the input transformer. These are the only components involved in the relation between the grid and the cathode.

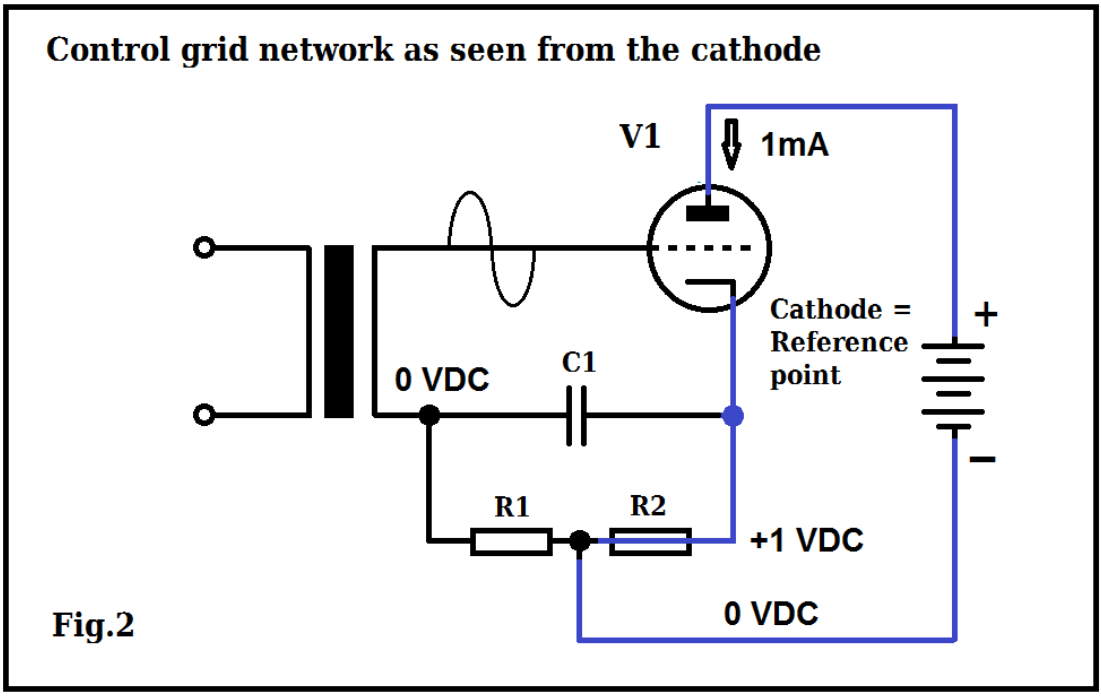


Fig.2 The cathode is connected to the secondary winding via C1, that bypasses R1 + R2. This means that the full signal Voltage of the winding is present *between* the cathode and the grid. C1 is in other words in parallel with the series combination of R1 and R2. In the W.E. 32-A amplifier, C1 is 500nF, R1 is 48k and R2 is 1k. C1 in parallel with R1 + R2 equals to a RC parallel HF bypass filter:
$1 / 2\pi \times 49k\Omega \times 500n = 6{,}49$ Hz

This means that the “roll off” of the amplifier is about 6-7 Hz, a very low value even by modern standards.

The DC current path is shown in blue. Auto bias is provided by the idle current of about 1mA through the cathode resistor R2. ($1mA \times 1k\Omega = 1V$) The cathode is hereby lifted 1V above ground and as the cathode is the reference point – seen by the tube – the grid is 1 Volt negative, seen from the cathode.



Fig.3 This is the same circuit, only here is the winding of T1 connected directly to ground. The AC signals passing the cathode is *also* connected to ground via C1, this means that the secondary winding of T1 is connected *between* the cathode and the grid – exactly like the circuit in Fig.2.

However – the resistor that is bypassed by C1 in Fig.3 is only 1kΩ. In order to achieve the same "roll off" freq of 6,5Hz (– 3dB) as in the Fig. 2 circuit , we can calculate : Hz = 1 / 2π x R x C = 1 / 2π x 1k x 6,5Hz = 0,000024 F . This is 24uF.

In the circuit in Fig. 2 we bypassed a much larger resistance 48k + 1k = 49k, meaning that the capacitor should be equally smaller. Using same equation for a 49k resistor : 1 / 2π x 49k x 6,5 = 0,000000499 , we find we would only need a capacitor of 500nF.

That was indeed a very advantageous swap in the 1920's – still is to some degree. Capacitors were very expensive back then and a 24uF capacitor would have been at the size of all three volumes of "Lord of the Rings". (The *books* – that is) And the price would have been something like a monthly regular salary. For that little extra resistor they got a much smaller, much cheaper and much more reliable, better quality of capacitor.

You may ask then – why did they want that capacitor in the first place..? Gain , brother, for the sake of gain. They simply could not get enough gain back then – them poor basters. Well, to be perfectly correct, the capacitor also provides a lower inner impedance of the tube, hence a higher roll-off. But gain was the issue.

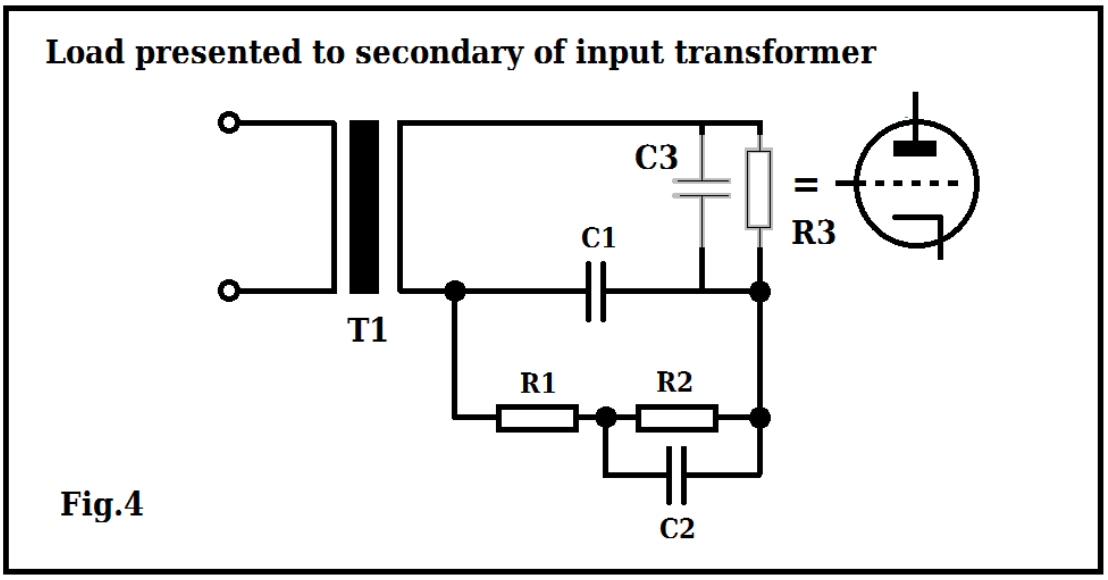
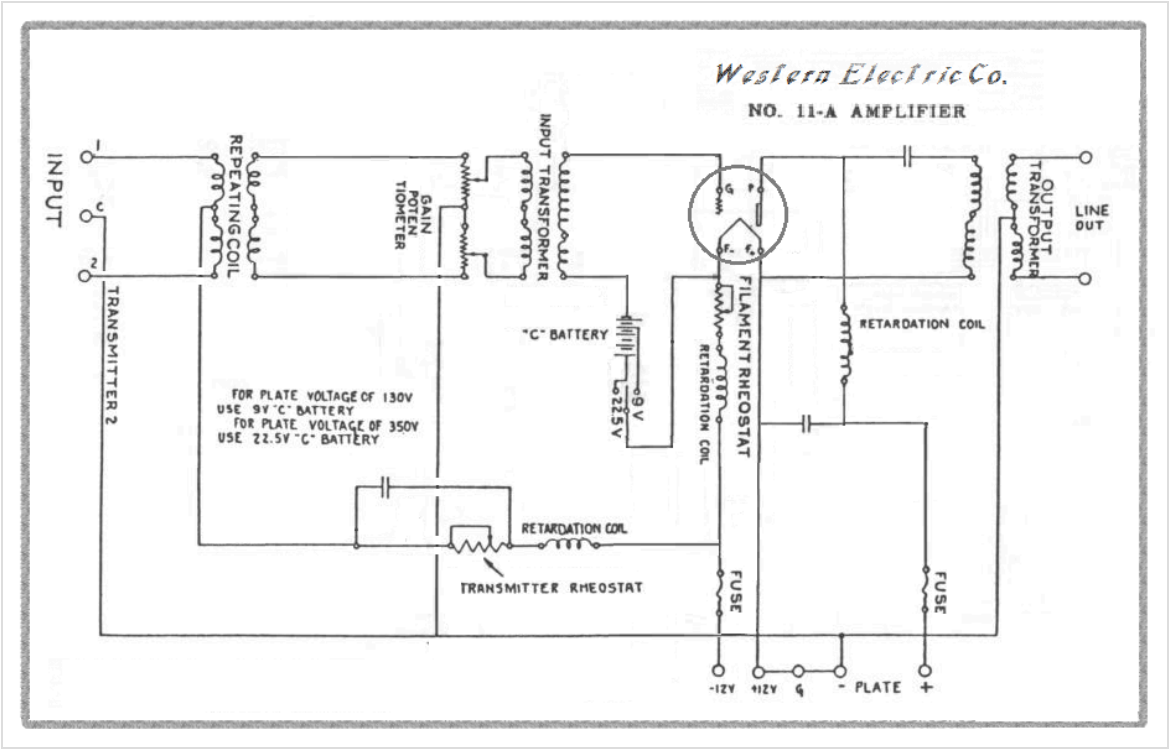


Fig.4 The secondary of the input transformer in the 32-A is kept floating and unloaded as there is no resistor bypassing the winding. This means that the only load that is presented to the secondary is the *very small capacitance* and *very large impedance* at the input of the tube. In Fig. 4 this is represented by the imaginary capacitor C3 and resistor R3. This load is seen through C1 in parallel with R1 in series with the parallel combination of R2 and C2. I will spare you for the calculations here, but the load is negligible – in practice none. This is usually not a good idea, as the transformer is not damped.(The higher the transfer/turns ratio, the higher the need for a proper load) Such “unload” practice may lead to overshoot, ringing, signal dependent oscillations and all sort of nasty. Although hardly a thing to worry much about back in the days of such poor freq range as in the 1920’s, – at best 100Hz to 5kHz, it is a fact we need to address today.

I will get back to the WE grid cathode trick in the analysis of W.E. 86-B.

Western Electric performed the same little trick in the W.E. 11-A, only by means of a grid/bias battery.



Western Electric 11-A , 205-D SE, ca 1928

Direct grid bias – and a lot of iron…..6 pieces and a single tube. Boy – those were the days.

The Western Electric "Parafeed load" trick explained.

Well, strictly speaking, this is not a trick performed only by W.E. at the time and neither is it the circuit that is commonly known as parafeed today – as DC current does pass through the output transformer, but lets not get too deep into that for now. The oddity about this particular circuit is that the capacitor C2 is returned directly to the cathode. (See Fig. 1 in this vignette)

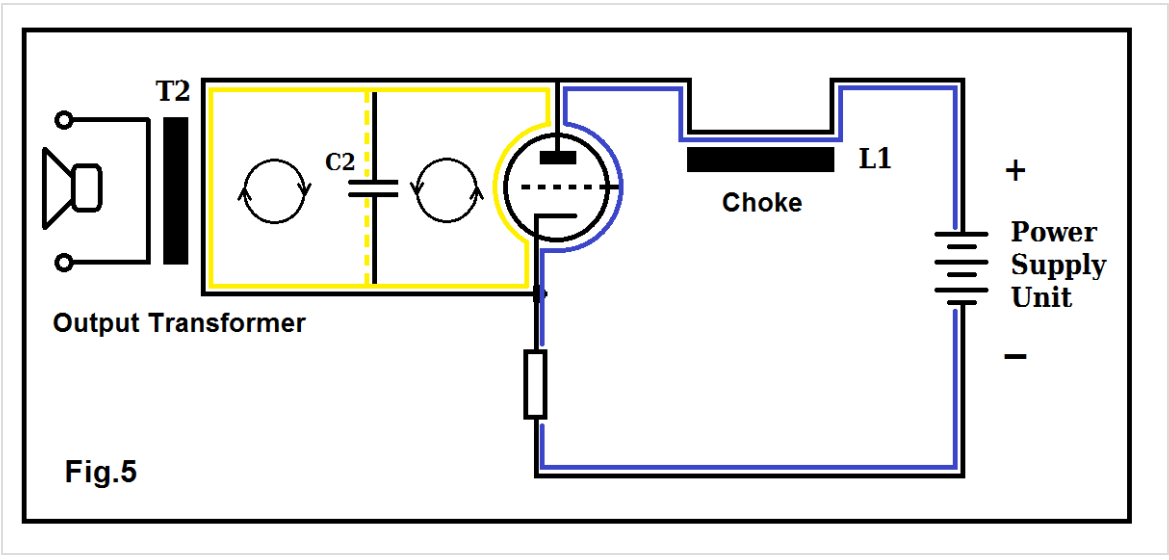


Fig. 5 shows a possible *equivalent circuit* of the W.E. 32-A parafeed output. The blue line indicates the DC path* (Loop) and the yellow lines indicates the AC signal loop. Now, the choke L1 acts to

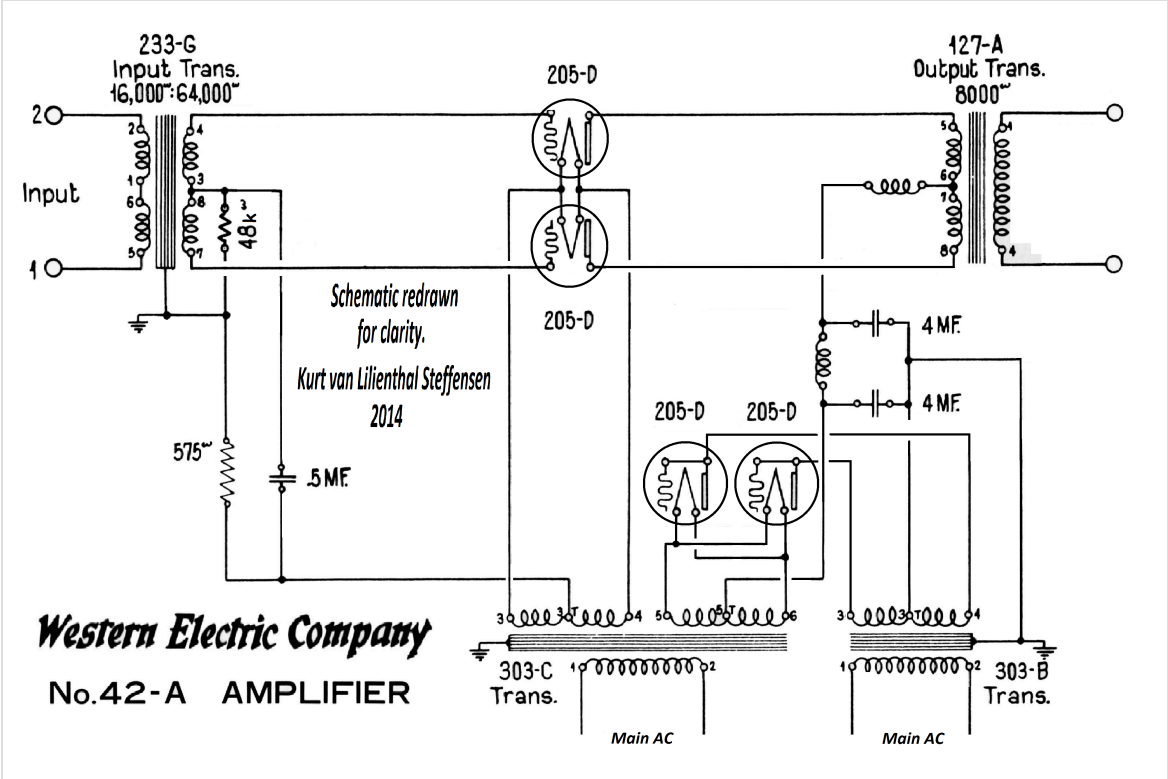
a high degree as a constant current source – this is the very nature of induction. The output transformer T2 is in parallel with the tube. This means that the AC signal current is split between the OPT and the tube. When less AC current passes through the tube, this very current is passed to the OPT and vice versa. The sum being equal to one another = 0. This is at least the ideal theoretic situation. Seen from the power supply, there is no AC current drawn, only a steady DC current, provided that we drive the amp in class A. Thus we do not load the power supply with *signal current* and a reasonable steady fixed Voltage is maintained.

The capacitor C2 is in parallel with the tube as well – it is connected between the cathode and the B+. This increases the ripple rejection in two ways. Some of the ripple is feed to the cathode, meaning that the ripple Voltage are common to the cathode as well at the plate. This cancels some of the ripple. Further cancellation is performed by the “Voltage divider” that is equal to the impedance of the tube and in *series* with the impedance of the OPT. (Keep in mind that we are talking *equivalent* circuits)

In the entire 32-A amplifier , the current loop of the grid circuit and the current loop of the output circuit are isolated and kept out of the DC loop. This is indeed clever engineering.

That said, the capacitor C2 might form a sort of signal oscillation/resonance in certain cases.

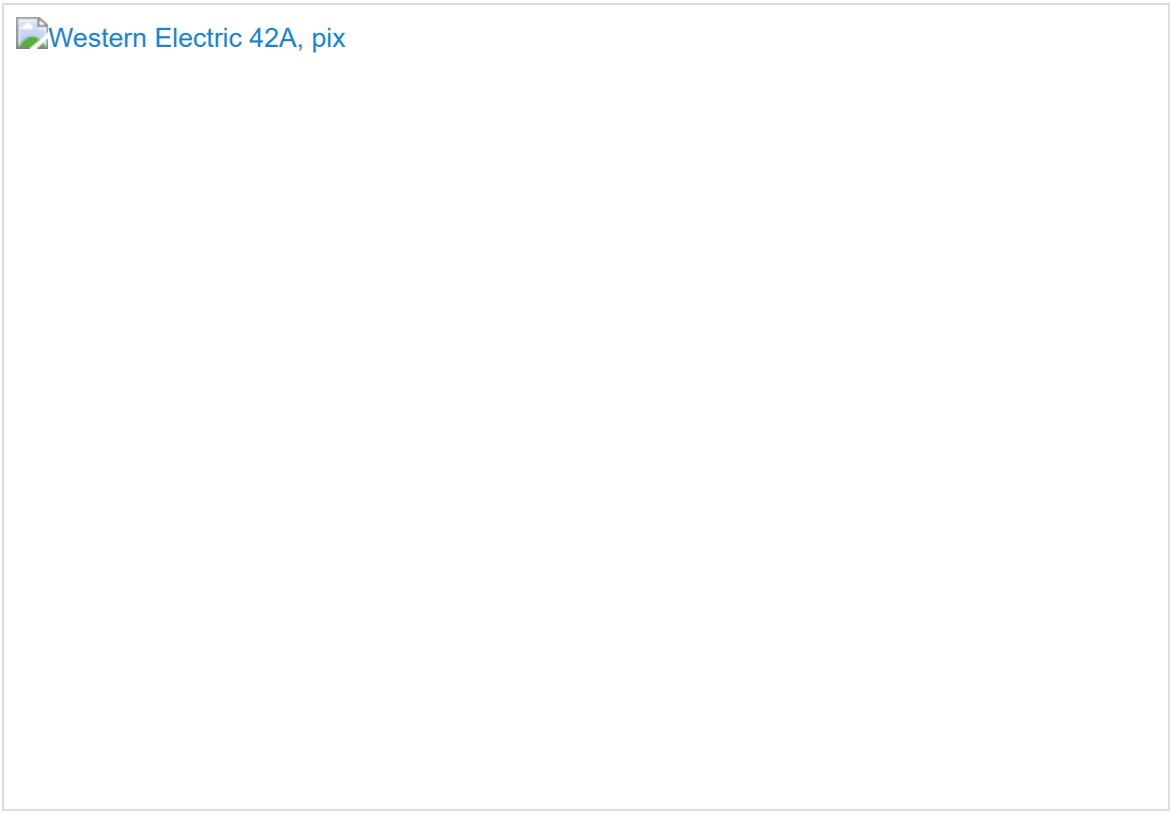
*In practice the DC current passes through the primary winding of the OPT.



Western Electric 42A, 205D PP and 205D rectifiers. 1928

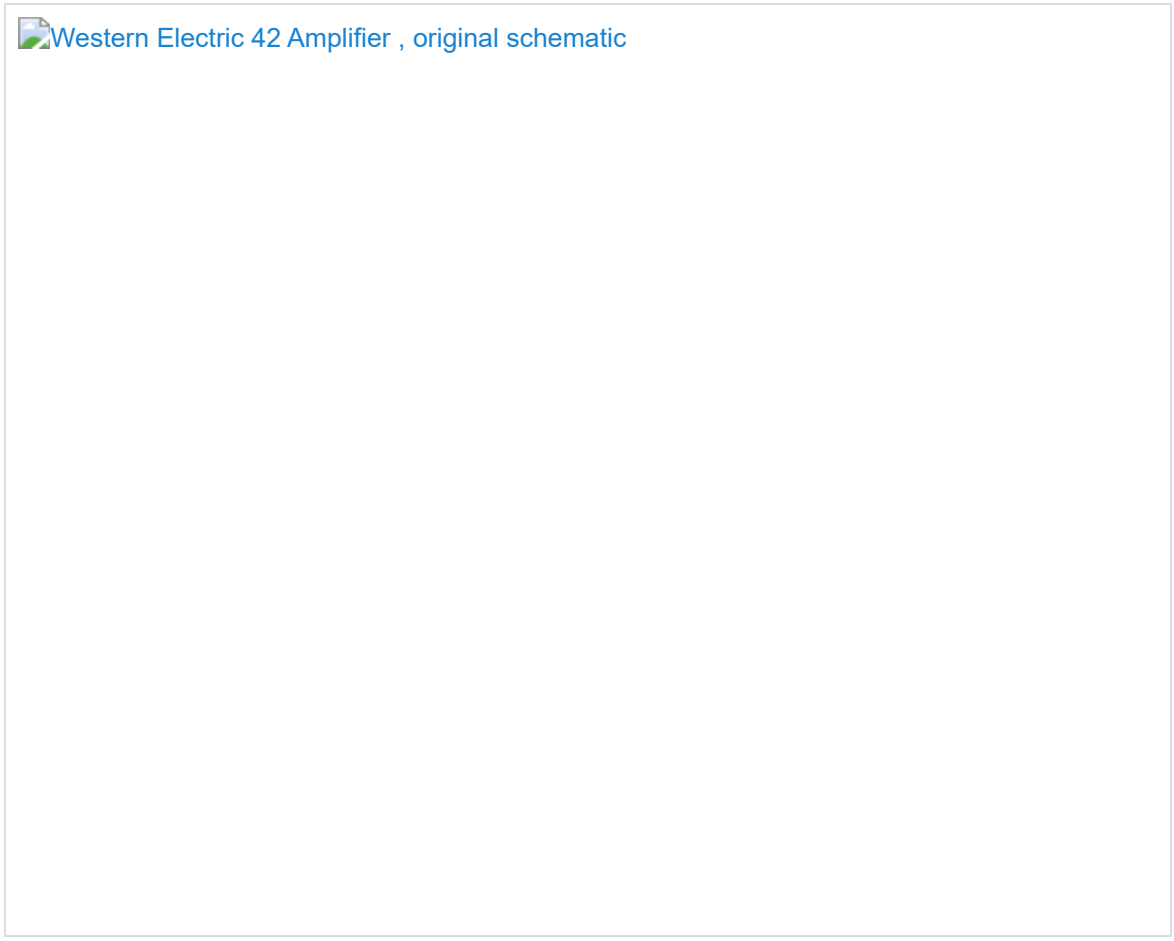
This brings us to the push pull version of the 25B. Same simplicity.Tubes and iron really goes well hand in hand…Input phase-splitter and step up. We would not need that much gain today, but we can trade it for a better transformer with lower turn ratio.

Roger A Modjeski (Music Reference) will go deeper into the designs of 42 and 43 – later on.



(Picture from “Soundup.ru”)

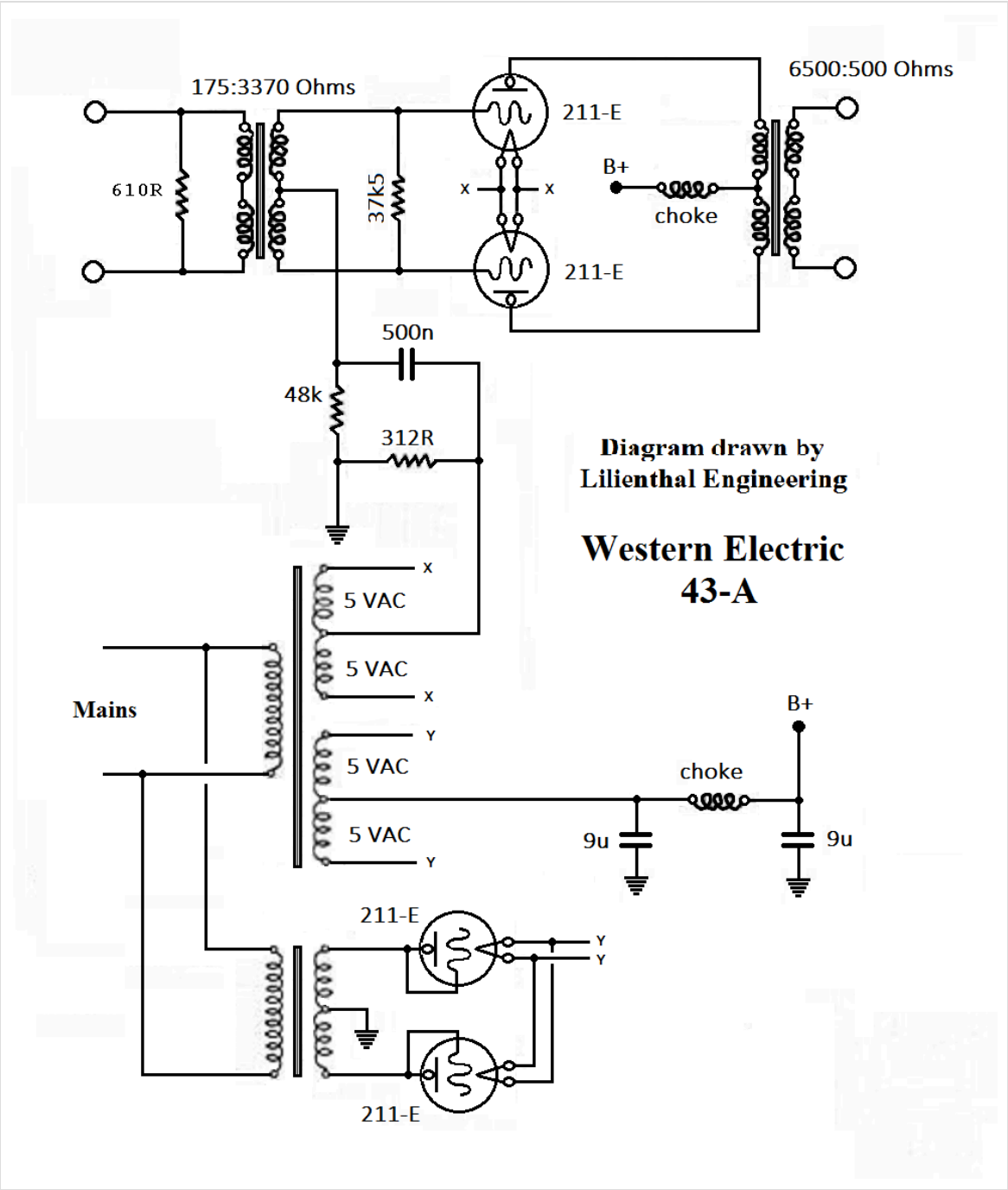
The non decoupled choke ahead of the output transformer acts as a “constant current” induction. This will improve the linearity and reduce distortion and is still used today by some “cost no issue” hardcore tube audiophiles. Anyway – this is pretty much a plug and play amplifier. Add a volume pot and you are there. That is – if you can get your hands on some 205D’s.



The 42 series of amplifiers, was kept going to at least 1936 , as the 1936 schematic above confirms. Nice to see that W.E. finally dumped the silly “Lee de Forest tube symbols”.



Typical western Electric cinema rack sound system using 41, 42 and 43 amplifier. (1931-32)

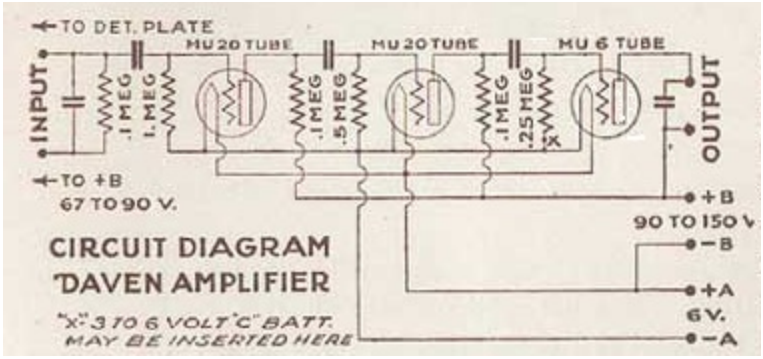


Western Electric 43A, **211 PP and 211 rectifiers. 1928**

43A is the same circuit as 42A….Only big as a desk….and 211's instead of 205D's. Much much larger transformers too. This is about as simple as it gets. Awesome. Both models used the W.E. grid to cathode trick, that is discussed in the Vignettes regarding W.E. 32-A and 86-B.

Later 43 models used 242′ triodes.





(Suggested by Joe Roberts)

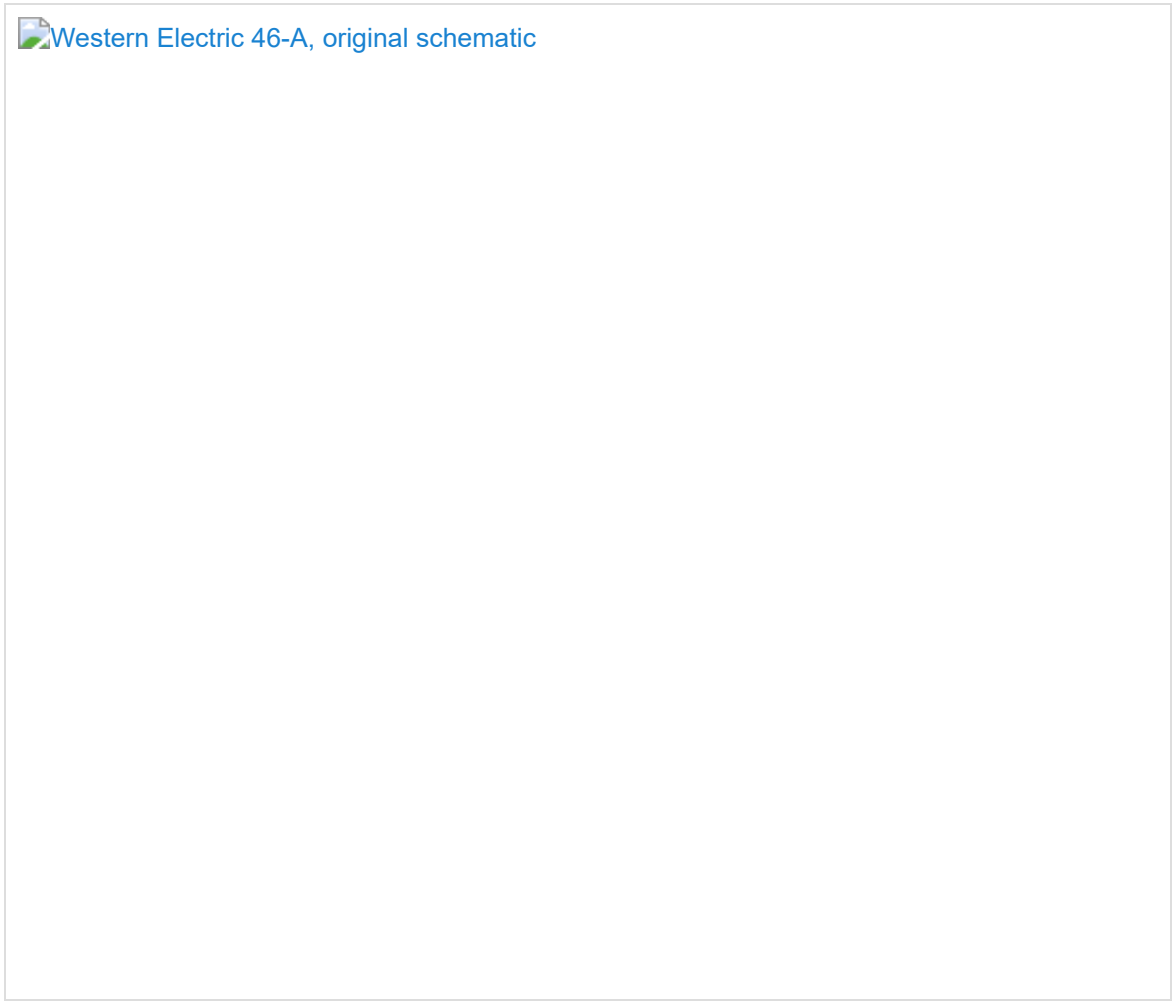
Daven Resistance Coupled Amplifier, 1926.

This is most likely the worlds first all resistor and capacitor amplifier.Simplicity speaks – a cute little 3 stage SE thing. It looks like modern SE amplifiers, the batteries would make it advanced High End.. Keep in mind that an OPT (Output Transformer) are supposed to be applied at the power output. No hum from rectified products here. No main supply nets to disturb either.(1926)

Excellent.



The Daven RC coupled amplifier. From the collection of Ernie Hite, Photo. Charlotte ARC



Western Electric 46 A/B/C/D/E/A-46-A , 205-D PP, 1927 to 1933

Western Electric made dozens and dozens of amplifiers based upon the small 205′ power triodes, I have at least 20-30 schematics of various such. The 46 series was made from 1927 to 1933. Several modification notes were published by W.E. between these mentioned generations – some was probable made to solve specific issues that the system engineers experienced from diverse theaters (Cinemas).

Global Negative Feedback , 1928

Harold Black and Harry Nyquist, Bell Labs. gave us the feedback scheme. I am sure that the hardcore kiss DHSET fans questions this idea,
but trust me, we would not be any good without feedback.
That said – I love the simple non feedback SET too….

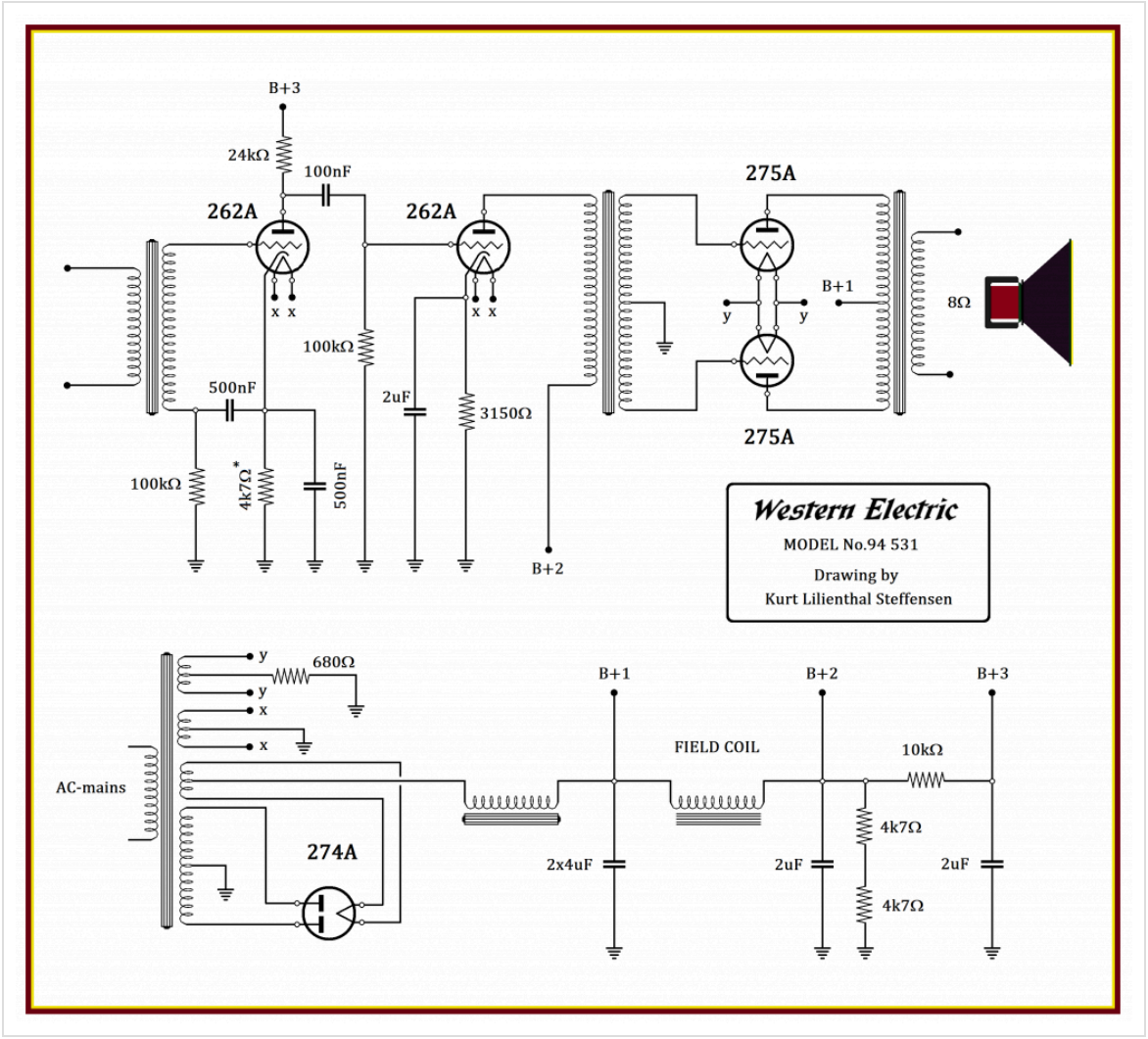
In the early days of telephone communication problems with noise and distortion was a big issue.The guys at Bell and WE struggled to find solutions for communication. Better repeater amplifiers and microphones was a top priority. Lots of noise, weak signals and high distortion was

just a part of the deal. Keep in mind that tubes had just entered the communication technology a few years before.

Long distance was in particular a problem due to the series of repeaters. In 1921 AT &T gave the task of coming up with a solution for this problem to Harold Black at Bell Labs. At the late 1927 Harold Black presented a negative feedback amplifier with a distortion reduction of 1000:1. (Wrongly claimed to be 100.000:1 – in the IEEE article) The Swede Nyquist, also at Bell Labs, worked out the maths behind the negative feedback scheme. In 1928 Black applied for the patent.

http://www.ieee.org/documents/proc_scanpast0211.pdf

As always with significant inventions and discoveries, it may be questioned whom was the sole person behind. **Alan Blumlein, England** made and patented a feedback amplifier before H. Black , UK Patent 425 553. Blumlein, however, used feedback only as a mean of controlling output impedance and mentions nothing whatsoever about the other important merits that are affected by FB. **Paul Voight, England** also made a feedback amplifier before Black, UK Patent 231 972 , but Voight provides no broad information about the properties gained, neither were any equations suggested about the virtues of the feedback scheme. Finally is it known that Philips in Nederland was investigating feedback, but no proof of their findings are brought to the public – as far as I am aware. Hence in my opinion, we need as it is commonly agreed to accredit the feedback scheme to Black and Nyquist.



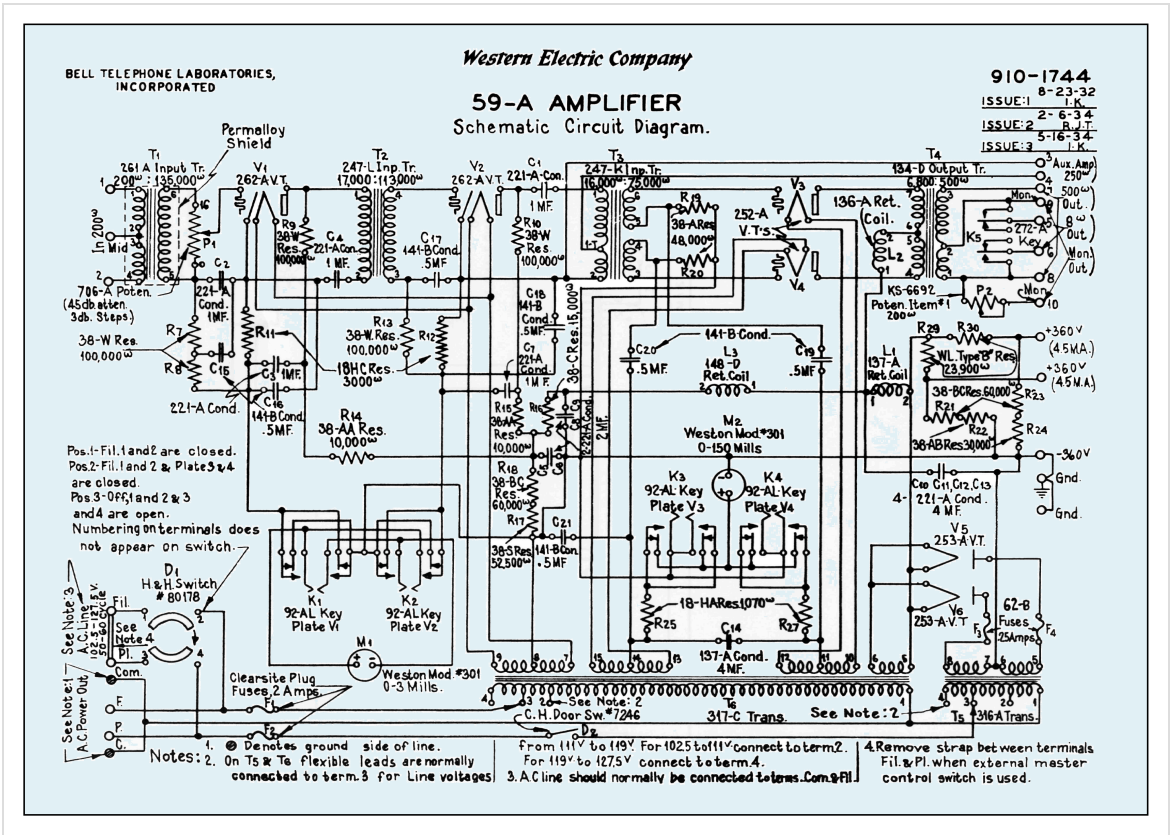
Western Electric 94 531, 275-A PP , 1932

Now, how about that. A **Western Electric 275A Push Pull**…..!

This predecessor of all the famous 300A and 300B amplifiers is unfortunately a long forgotten W.E. design. The 94 531 was made for portable projector systems. Portable cinema in the early 1930's meant that you had a lorry to carry some 500kg/900-1000 lbs of equipment – or more.

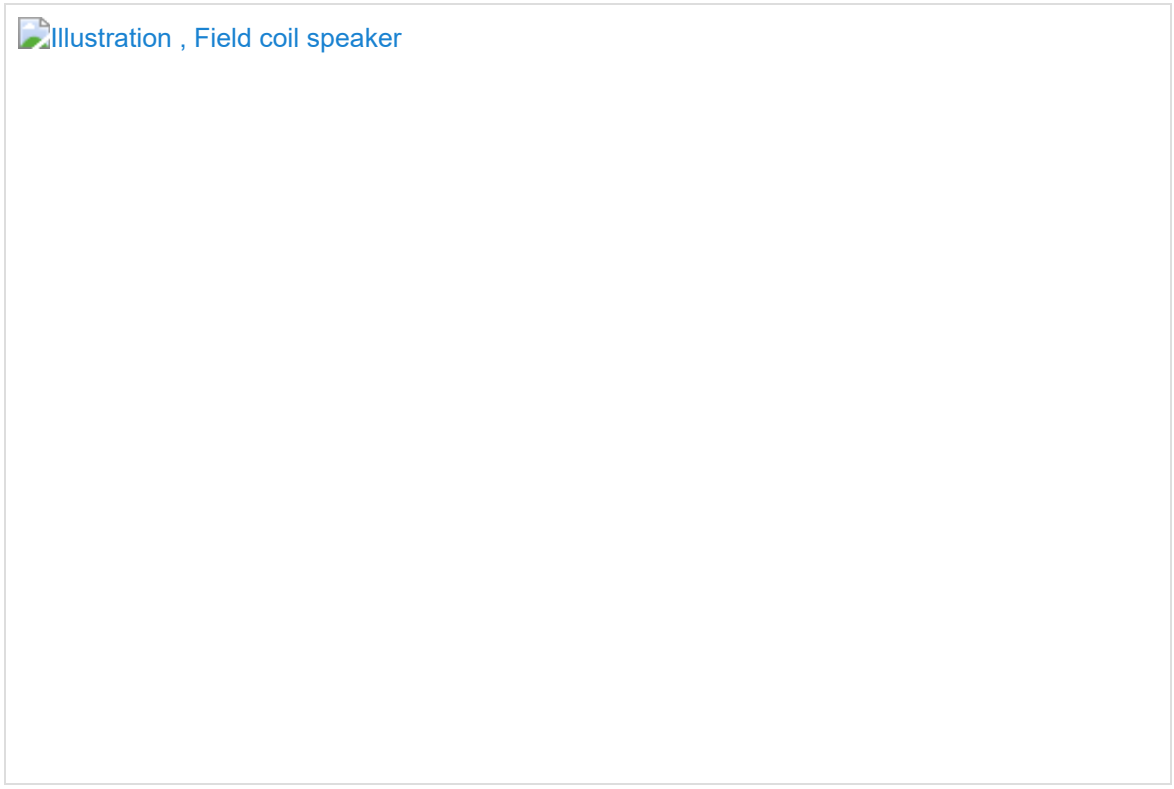
This is indeed an intriguing design. The "W.E. grid to cathode trick" used only at the input stage, then a conventional amplifier acting as driver and phase splitter and finally a pair of 275's sharing a common cathode resistor. The power supply uses choke input for optimal passive regulation and the field coil of the loudspeaker is used as the second choke. I cant help but smile and rejoice this elegant and simple design.

Personally, I prefer the 275 triodes to the 300B's, but certainly they are both wonderful triodes.

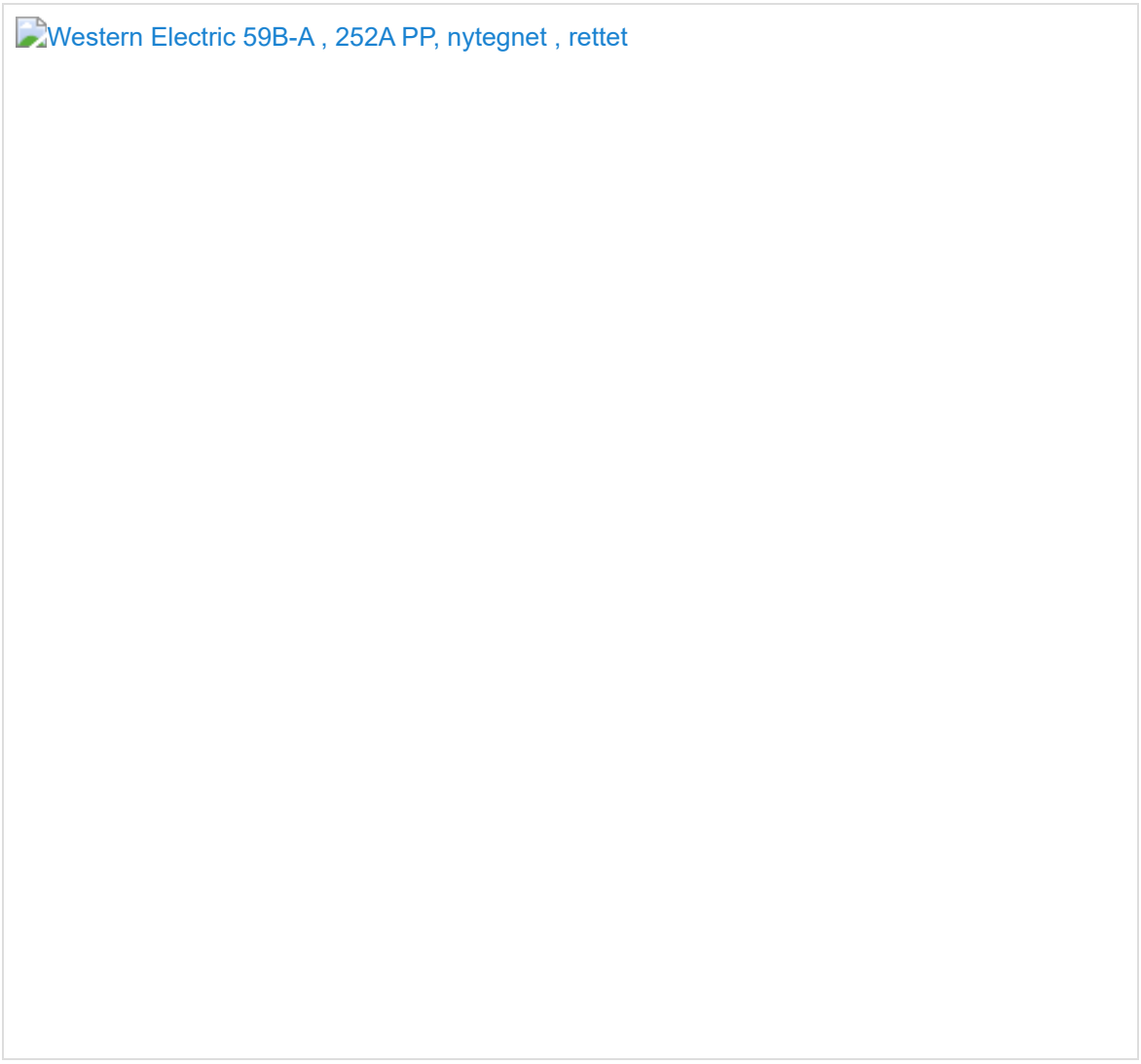


This is a copy of the original schematic – I can understand why so many find it difficult or impossible to read these old schematics. It is frankly a mess, too many crossing lines and so forth and so back. The schematic I have drawn is an EXACT copy of this diagram – I have however, left out the relays, meters and circuits associated with these and only drawn the actual amplifier.

Field Coil Loudspeaker explained.



Modern loudspeakers are based on permanent magnets, see fig. A. Before strong permanent magnets were available – at least at a price, field coil loudspeakers were used. See fig.B Instead of a permanent magnet, DC current was passed through a coil made of thousands of turns around an iron pole in order to provide a strong magnetic field. The strength of such magnet is expressed by the Ampere turn ratio. (Current in Ampere x turns of coil) The disadvantage of field coils is the heat developed by the current through the copper wire. Now, the coil used to induce the magnetic field in the iron pole is equivalent to a smoothing choke, hence these field coils were often used for smoothing the power supply as well. This is all you need to know in order to understand the implementation of field coil speakers with amplifiers and power supplies.



Western Electric 59-A , 252A PP , 1932

Yet another forgotten, but delicious W.E. amplifier from 1932. This precious design uses the W.E. “grid to cathode trick” in full. (See 32-A and 86-B) Note that this trick has advanced at the input stage in that one more capacitor is connected from the 25k – 25k Voltage divider to the cathode. I have not yet figured out what the guys at the Bell Lab intended to do with this addition and maybe I never will. Any suggestions out there ? The cathode resistor is decoupled as well, however only above 100 Hz. (Read more about this in the Western Electric 86-B vignette) Stage two is dressed with the same circuit.

Even the output stage use the “grid cathode trick”, here by means of the two 500nF decoupling the 48kΩ resistors giving a fn of 6-7Hz. The smoothing constant current alike choke that connects the output stage to the power supply, cancels distortion as it attempts to prevent differences between the two output tubes. … Beautiful….

Do also note the use of a genuine input attenuator and the Permalloy shielding of the input transformer. The usual choke input power supply that seems to be mandatory for W.E. at the time is followed by yet another smoothing choke and this is “assisted” by two single plate 253-A rectifier diodes. Nice…

I'd have to say, though – back off that gain…. Use 1:1 input transformer and a similar low turn ratio at the inter-stage transformer. Even better, dump one of the 262's as well…The 252's draws some 40mA, meaning that a peak of 40 Volt will provide full output. This means that we can do with a gain of 40 times from input to the grids of the 252's, in case of a 1 V RMS input signal.

Unfortunate, it is, that the 252-A triodes are just about as rare as moon dust or honest financial CEO's. But do not fall apart – it is indeed rather similar to many of the other 25-30 Watt triodes of that time, except perhaps for heater Voltage or/and sockets.

Wonderful design…..Hats off to the Bell team – once again.



Western Electric 82-A , 271A PP , 1933

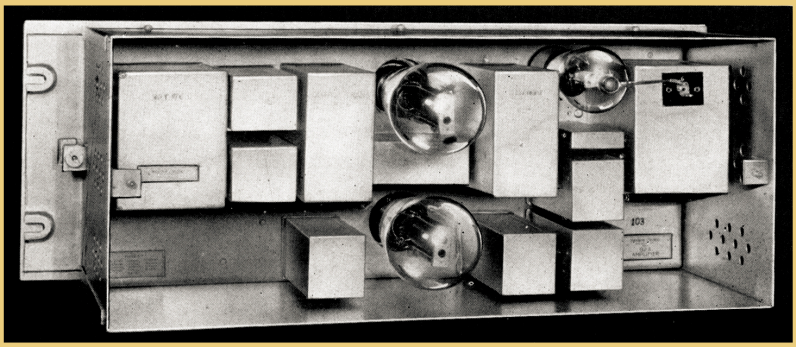
This circuit is unfortunately also little known to the tube and WE enthusiasts, but I think it is important as I consider this and the 59-A to be the early power output circuits that finally led to the famous and most disputed output circuits used in the 86 and 92 series.

The 262 input stage makes use of the clever "grid to cathode trick" and is further parafeed and preceded by a large induction choke of 384H that is decoupled to the cathode by a 1uF capacitor. This capacitor feeds ripple to the cathode, hence providing ripple product in phase at the plate and cathode. This reduces the efficient ripple.

Now, the output stage is a breed of its own, but looks like a plausible missing link between the grid cathode trick used in 59-A and the advanced circuits used in the 86 and 92 amplifiers. The cathodes of the 271's are returned to ground via individual 1kΩ resistors (The 10,1Ω is only used to fit a current meter) , that meets and share a small 20mH coil induction before ground. This 20mH coil and the common 4uF at the cathodes of the 271's are meant to cancel differences, meaning distortion at the output. This circuit is a lot easier to comprehend that the later complicated circuit used in the 86's and 92's amplifiers.

The gain in this amplifier is a little more than one thousand. This is – as usual – much too much for modern use. But in this amplifier it is mainly due to the high turn ratio of the input and inter-stage transformer. The voltage gain of the input transformer is: √200 Ω / 110 kΩ = 23,4 times and the inter-stage add another 3 times. For a modern copy or modification, I would either avoid the input transformer, thereby dumping the grid-cathode trick, or simply use a 1:1 transformer. The inter-stage trannie should be close to 1:1, as well. A turn ratio of 1:0,5 to 1:2 is fine as long as the secondary has a center tap or is made of two equal windings that has to be coupled in series. Such lower turn ratio will also greatly improve the quality of these transformer, as it affects the high freq response in a negative way, when we need to wind transformers with such high step up ratio at such high impedance.

I would expect an output of some 5-7 Watts from these terrific 271 medium power triodes.



82-A Amplifier with rear cover removed

SPECIFCIATIONS

General	Two-stage, fixed gain, transformer coupled, high level line or monitoring amplifier.
Input:	Operates from 200 ohms.
Output:	Normally operates into 500 ohms.
Load Carrying Capacity:	Output level + 24 db with less than 1% total harmonics introduced by the amplifier.
Gain:	Approximately 61db.
Vacuum Tubes:	First stage—one 262A; second stage—two 271A in push-pull.
Filament Supply:	2.32 amperes at 10 ± 0.3 volts AC or DC.
Plate Supply:	Approximately 55 mils at 375 ± 25 volts DC.
Dimensions:	Overall—Height 7″, Length 19″, Depth 7½″.
Weight:	Approximately 25 pounds.
Finish:	82A-15—Standard (Mat—Dark Gray; Rear Cover—Aluminum.)
	82A-3—Black.

Western Electric

Distributor in the United States

Graybar Electric Company

General Offices: 420 Lexington Avenue
New York, N. Y.

Distributor for Canada and Newfoundland

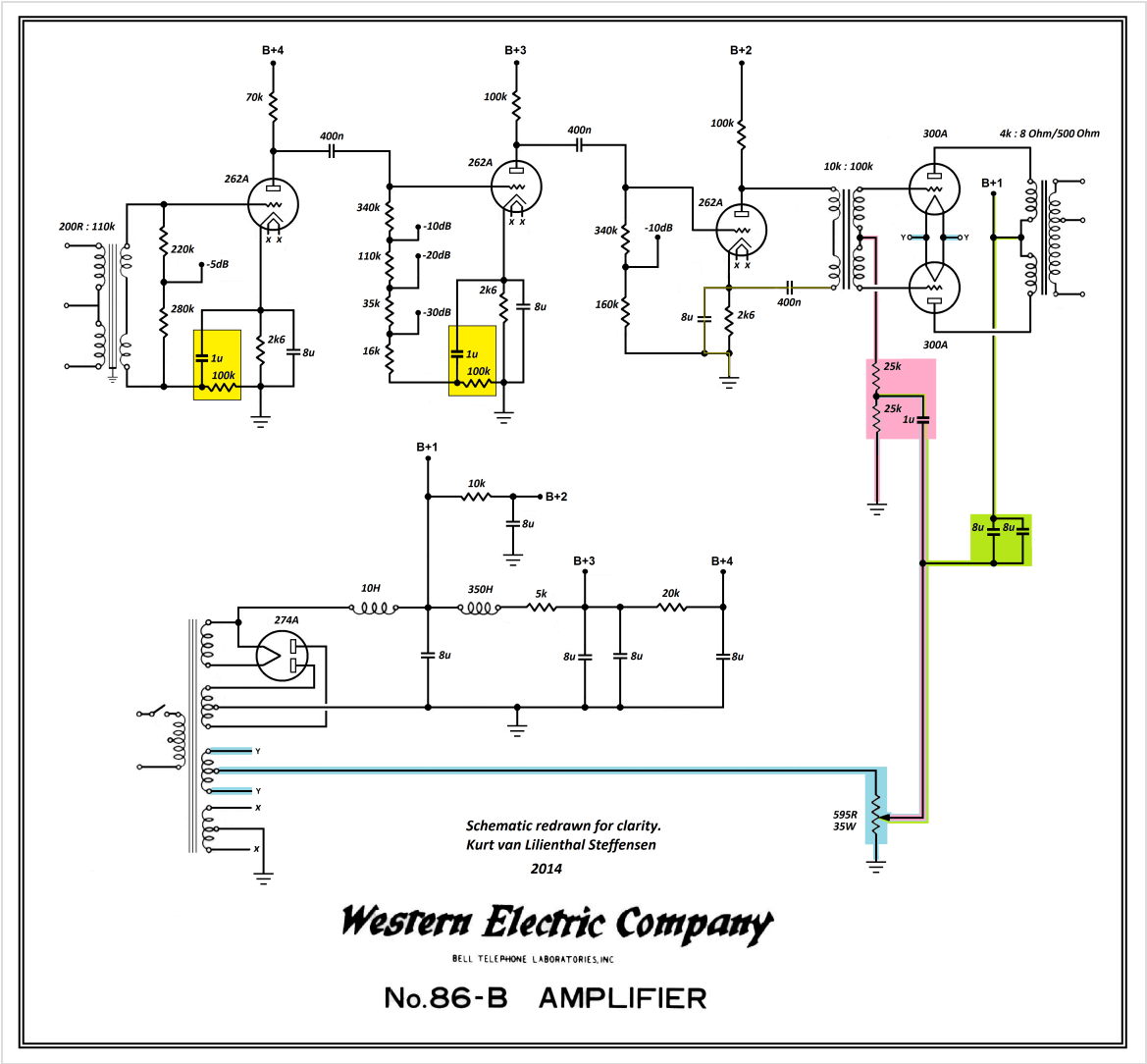
Northern Electric Company Limited

General Sales Offices: 1261 Shearer Street, Montreal, P. Q.

Foreign Distributors

International Standard Electric Corporation

67 Broad Street, New York, U. S. A.



(Suggested by Jan Schlatved)

Western Electric 86-A/B, 300A PP (1934 ?)

I can dig that….Transformer input, two 262A triodes, then a 262A coupled to a step up transformer phase splitter and finaly the output. Crazy much gain with modern eyes. But this amplifier was meant to amplify the low signal from a photo cell. (sound by light on film)

The Western Electric “grid cathode trick” further analyzed and measured.

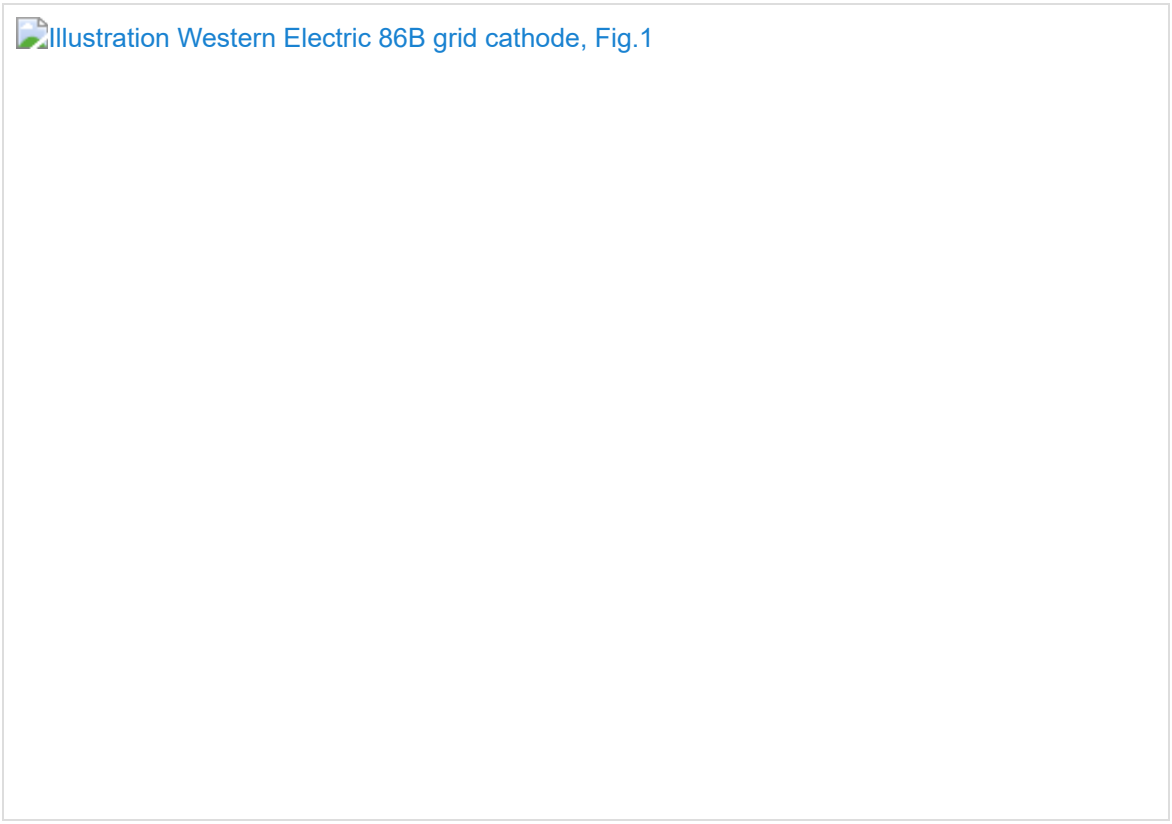


Fig.1 is the “grid to cathode trick” as discussed in the 32-A vignette. The differences between the 32-A and the 86-B circuits being the addition of the 8uF capacitor that bypasses the cathode resistor and decouples the cathode to ground. The two series resistors of 220k + 280k that concludes the current loop of the secondary winding of the input transformer is also different that 32-A, in which the secondary was unloaded.

The blue line indicates the DC current path.

The green line indicates the signal AC that passes through the tube via the 8uF capacitor. This AC signal is in parallel with the tube, the plate resistor (not shown) and the grid circuit of the following stage – indicated by the red line.

The input current loop is isolated from the other loops and kept away from ground (See Fig. 2) This advantage is lost in the *input circuit* of stage two (red line) . The signal current here passes through three capacitors: 400nF, 1uF and 8uF on its way. This leads to a phase deviation of -270°. I fail to see the advantage of this network, but I will investigate this circuit throughout soon and update here.

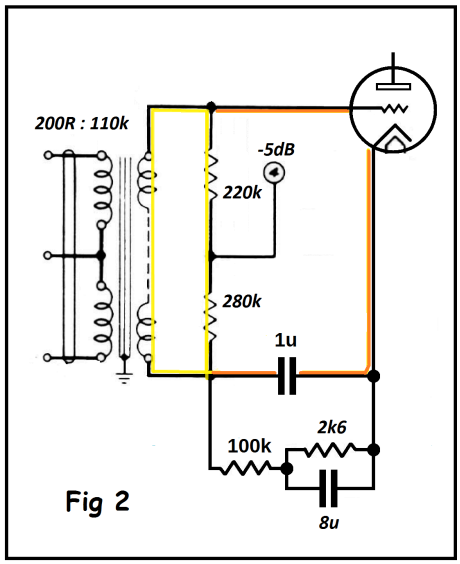


Fig. 2 shows the input loops of the AC signal. The primary of the input transformer represents an input impedance decided by the turns ratio of the 220k and 280k= 500k resistors at the secondary. It is common sense to load the secondary with real resistors as it dampens the transformer and presents a well defined load at the primary input.

The “main” current loop is indicated in yellow. A small fraction of the current is passed through the input of the tube via the 1uF, marked in orange. This loop is in parallel with the two load resistors. The 1uF capacitor is in parallel with the series parallel combination of 100k-2k6//8u, but the signal passes through the 1uF cap.

I have discussed these W.E. tricks with **Peter Sikking,** Berlin (see: http://ultra-fi.blogspot.dk) Peter raised some good and relevant questions that made me dig a little deeper into these Western Electric quirks. Hence :

Lab test of the Western Electric grid cathode trick.

In order to test how this circuit acts in a lab test, I had to change a few parameters as we are only interested in the actual circuit. The turn ratio of the original input and interstage transformers and the high impedance involved will introduce all sorts of oddities that would disturb and blur the results, making it impossible to judge if these belonged to the circuit it self or was caused by another factor. I have therefore decided to use a 600 to 600 Ohms transformer. Now, as I also wanted to see with my own eyes, if the W.E. trick improved anything else in the relative narrow audio freq range they had to deal with back then, I did not want to use a modern high quality transformer or other vice rely on a circuit spanning from say 2Hz to 200kHz. There simply was no such thing in the 1930’s. Hence, I picked up a vintage Peerless Altec Lansing transformer – a good one, but not a crazy good one. This one has -3dB at about 20kHz. I use a 6SN7W triode, as it is quite similar to the original 262’s, and it is a triode I am very familiar with. The actual test circuit is shown below.



Fig. 3 is a verification of the original W.E: circuit.

The plate resistor of 22k is a 1 Watt, Electrosil “Glass Tin Oxide”, the two capacitors of 330n is polypropylene types – 400V produced by Arcotronics. C2 is a mill. grade Silver tantal, R2 is a Philips 1 W metal film, R1 is a high quality carbon film and the load resistor of 470k is a 0,5 Watt carbon composition by Allan Bradley.

The following equipment was used and connected permanently as shown in Fig. 3:
1) Signal source: Krohn Hite Model 4400 Ultra low distortion oscillator
2) Oscilloscope: Tektronix 7603
3) Spectrum analyzer: Hewlett Packard 8535B , 20Hz – 40MHz
4) Multimeter: SOAR 4010
5) Stabilized Power Supply Unit: Danbridge

The combined load represented to the 6SN7WGT is:470k//1M//1M//1M + 22p+30p+15p+Xp = 195k + ca 100p.

We wish to compare the W.E. circuit to a conventional circuit. Both of these circuits can be made with the cathode resistor decoupled or not decoupled. This means that we have four circuits to test. The input circuit of the W.E. 32-A, does not provide any load to the input transformer. I will show how this affects the quality.

Sep 10 : I am for the time being working on an extensive laboratory test of the W.E. circuit. I expect to be finished and publishing the result within a week. Some of the aspects of this circuit has been

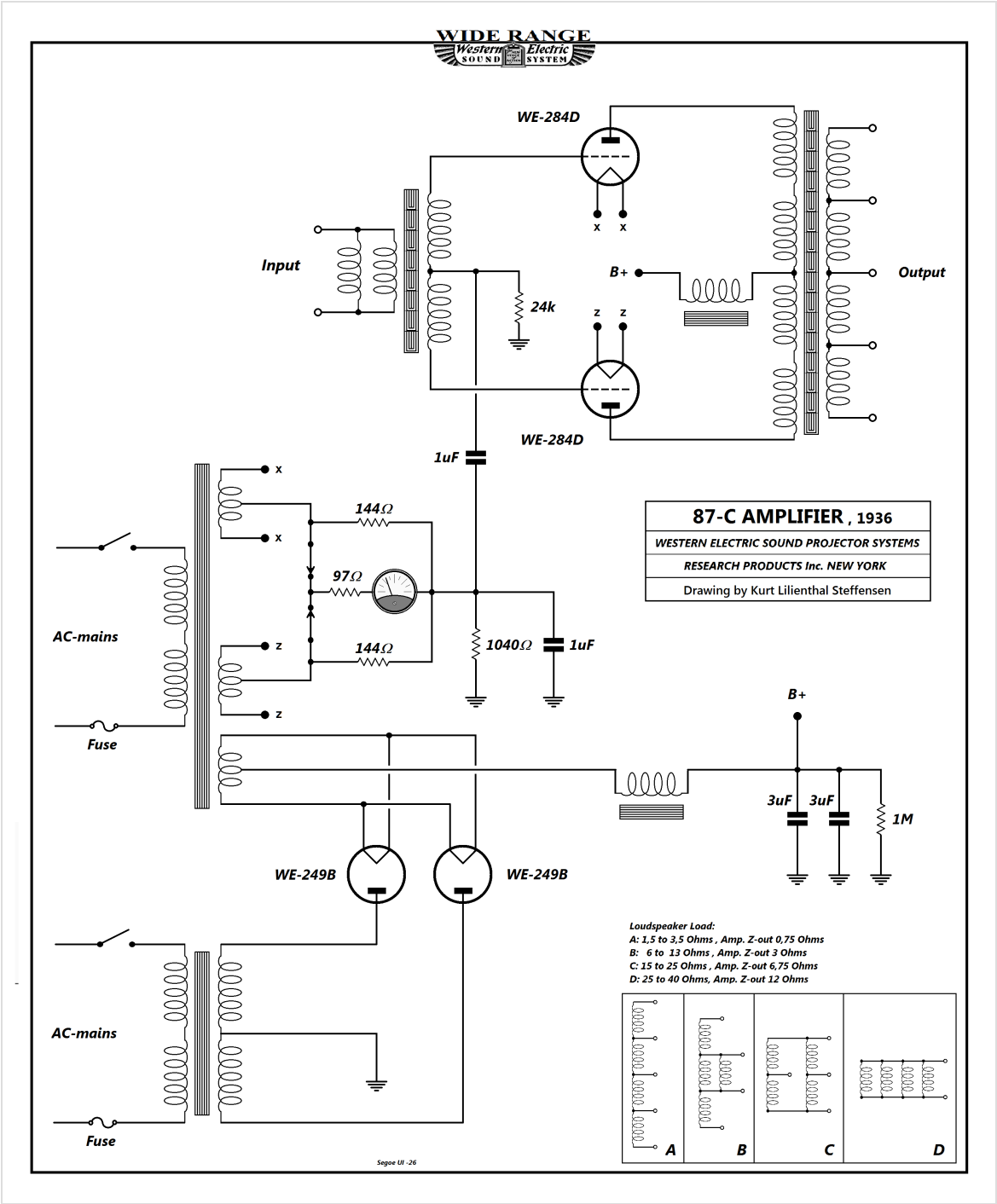
a surprise. Stay tuned for more.

I am currently in the process of building the output stage and perform some experiments （As time allows in my spare time） I will publish the results from these experiments and the analysis about this W.E. trick later on.

More to come about this fascinating amplifier.



A true WE classic.



Western Electric 87-A / 87-C , 284-D PP , 1936

Western Electric 845 Push Pull…!! Hallelujah….. This amplifier is also little known among the tube enthusiast and W.E. enthusiasts, but it is indeed a magnificent circuit that deserves a prominent place in this compendium. (284-D is equivalent to 845)

The 87A amplifier was available in 1935. The difference between the models A, B and C , was only the input transformer. The 284D triodes runs in Class A, hence provide 50 Watts of delicious triode power into any load between 1,5 and 40 Ohms. This little trick is carried out by means of four identical windings at the primary side of the output transformer. By connecting these in parallel,

series or parallel/series (See the illustration in the schematic) a proper load is matched to the 284D's. (50 Watt's into 8Ω/ max 1% third harmonic)

I cannot quite figure out the exact voltage and bias in this amplifier. But it is certainly around 1000 Volts, give or take 200V. I am confused about the power consumption of 400 Watt's as stated in the manual. The filaments of both 284D's and 249B's totals to 100 Watt's. Most certainly Western Electric does not burn the remaining 300 Watt's away in the 284D's. I then suspect that the 400 Watt's is the max. consumption at full power out, but that conflicts with the given power output of 50 Watt's. Maybe they allow the 284D's to run into positive bias, but does not specify the amount of power out here ? That would make sense.

The power supply is a choke input type, hence a very stable voltage are provided. The current bleeder of 1MΩ is on the low side – but there you go….. The AC voltage to the 349B's must be rather high. 1000 VAC or so. I gather that the primary impedance of the OPT is around 8000 Ohms. Higher than 7000, and lower than 12000. But any value between these figures is perfectly sensible.

The 284 and 845 power triodes was both designed for audio. The 845 was a common type, but only a few manufacturers, besides W.E., made the 284, – Amperex being one. The 845's is usually the thick graphite type of plate. Both uses thoriated tungsten filament. The plate characteristic differs slightly between the two, despite that they are very close equivalents. Brown Bovery made an equivalent known as T-110-1. Other equivalents is CUE-845 (by United Electronics Company), 38145, C845, CV735 and VT-43. The Russian GM70 is not an equivalent, although a similar – but less linear triode.

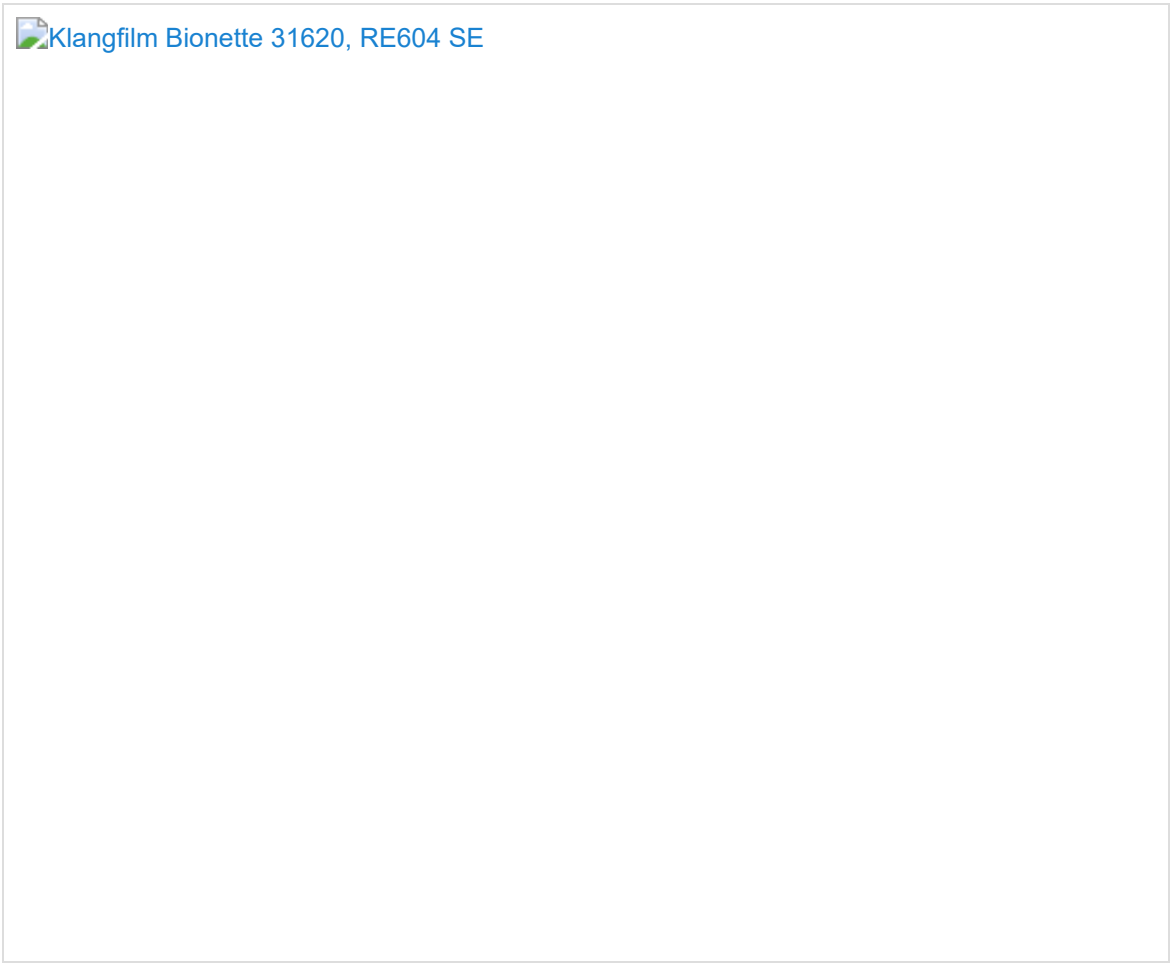


Western Electric 284D power triode.

Boy – don't you just love these high power triode amplifiers ? The 87's amps was supposed to be driven by a WE 1086 Amplifier (86-B , 300-A PP) . What a tour de force in tasty triodes……This type of amplifier was referred to as "Booster Amplifiers".

Enjoy……..





Siemens, KLANGFILM and Telefunken RE604 amplifiers , 1928 to 1936.

The RE604 triode was introduced in 1928 (a year before the British PX4 and American WE 300A) and was widely used until 1936 when the successor AD1 slowly took over. The Klangfilm Bionette shown above is a brilliant example of the series of amplifiers made for cinema, theatre and similar PA by Klangfilm and Siemens. The Bionette is cleverly biased from the network in the current loop of the PSU that works in a manner similar to cathode bias. The parafeed choke plate loads of the first two stages is a wonderful touch. I do not quite understand why they would place a 20k Ohms resistor in series with the choke as it reduces the Q factor quite a lot, but I guess they wanted to reduce the plate Voltage.

I have got this mail from **Andreas Schubert** :

“Reading your page the Klangfilm 31620 diagram is simply in error.This happened frequently with Siemens diagrams and was even more likely in the “simple” old drawings of pre-war cinema equipment.It does not work, the grid must be connected to the other side of the choke, the bottom choke side grounded, where to connect the 250pF cap must be found out by comparison with an actual amplifier. We built a Klangfilm 32622 RE604pp stereo amp for ETF and this diagram was also in error.

Best regards,
A.S.”

Thanks a lot, Andreas Schubert. I have now marked the error in the original schematic in red and drawn the correct connection. Now as we are at it, it happens quite often that when the “autobias” circuit is placed in the DC current loop, outside the normal signal/AC loop, it is misunderstood and maybe even doomed as not working. I had always wanted to redraw this particular circuit in to a schematic that was easier to read and understand, hence this mail simply triggered the opportunity to do so.



The Klangfilm Bionette 31620, RE604 SE.

As can be seen I have removed the input and DC-supply circuit for the cinema photocell and the AC-winding for the lamp. This leaves us with the actual amplifier and power supply. As Andreas Schubert points out, the grid of the RE604 is drawn incorrectly at the original schematic. The grid has to be connected to the signal side of the choke. I have here drawn it correctly.

In principle the 250pF capacitor is not necassary. The grid choke simply just needs to be grounded. But most grid chokes can not handle DC-current , due to the mix of high permeability alloy and lack of airgap in the transformer core. This means that even the very small current drawn through the large 500k Ohms grid bias resistors may saturate the core of the gridchoke. Thus the 250pF cap.

Anyway – lets have a closer look at this Single End Klangfilm amplifier.

The first stage is choke loaded and the cathode is returned directly to ground. The bias (negative grid Voltage) is supplied to the grid via the 2 MOhm grid resistor. This calls for an AC coupled input, hence the 5nF input capacitor. The advantage of fixed bias and plate choke is highest possible gain. The 20kOhm resistor is not optimal as it decreases the Q of the choke circuit, but is probably there in order to avoid too high Voltage at the plate of the REN904.

The second stage REN904 is connected to the previous stage via the volume potentiometer of 1M Ohms and is isolated DC vice by means of the 55nF capacitor. This stage however is coupled as a regular resistor loaded amplifier by the 80kOhms plate resistor. The cathode is returned directly to ground and biased in the same manner as the first stage.(Loop bias)

The RE604 output stage is biased the same way as the previous amplifiers, however the grid is AC vice (Read: signal) strapped to a grid choke. The filament of this direct heated triode are connected directly to ground via the center tap (midpoint) of the heater winding.

Loop Bias explained.

Right, that brings us to the weird “loop bias”. You might wonder where the heck does the negative Voltage come from ? Well, it is really very simple indeed. Imagine that you have a 9 Volt battery and connect nine 10 Ohms resistors in series with the battery. This means that there will be 1 Volt over each resistor. You may then connect any point between these resistors to ground and consider this point as our 0 Volt reference point. This means that we can have any “supply” from minus 9 Volt to plus 9 Volt. Plus 5 Volt will present minus 4 Volts at the other side an so on. Having two batteries of 1,5 Volts in series will allow us to make three different supplies simple by deciding where to ground the batteries.

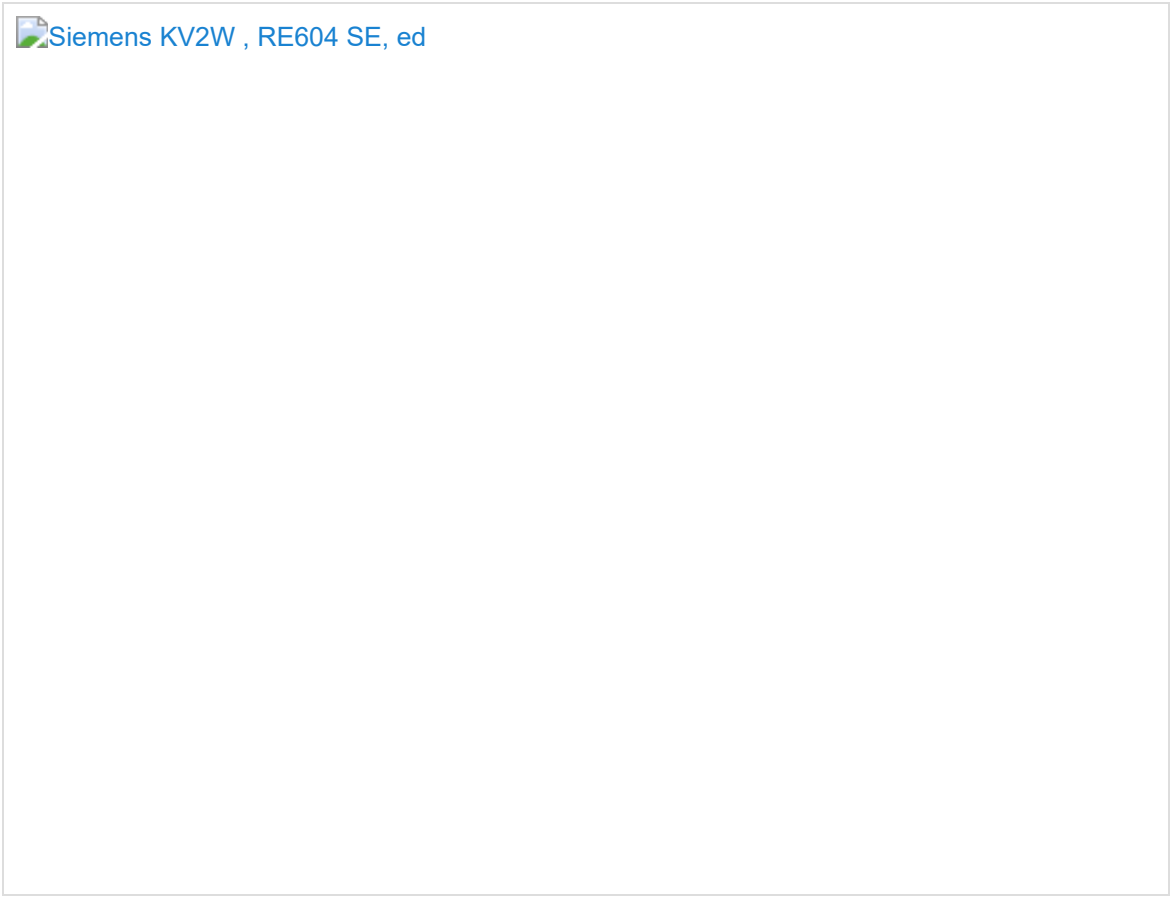


At the illustration in Fig.2 above the two 1,5 Volt batteries are connected to ground at the plus pole. This means that we have a minus 3V supply. Swap it around as in Fig 4 and we have a plus 3 Volts supply. If however we connect the midpoint of the two batteries to ground as in Fig 3, we have made a +/- 1,5V supply. Simple as that.

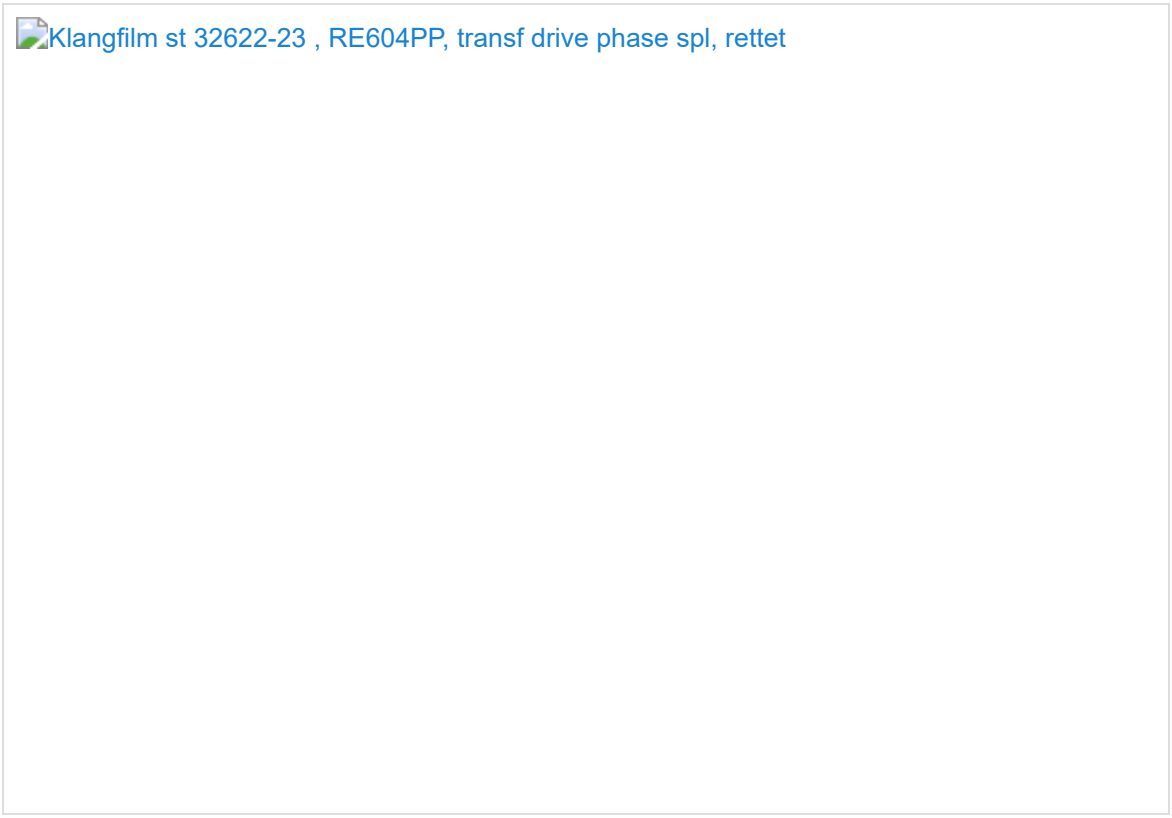
In the Klangfilm amplifier the three valves are DC vice connected as the lamps above in Fig 1. The “secret” is the two resistors I have marked R1 and R2 in the redrawn schematic. The lamps above are connected the same way as the valves in the amplifier. The DC idle current passes through two resistors, in this case 1k Ohm and 100 Ohm. That means that a total of 34 Volt + 3,4 Volt are developed over these two resistors due to the total of 34mA drawn by the three valves.

If we ground point C, as in the amplifier we then have + 262,6 Volts at the positive pole at the battery and -3,4V at point B and finally – 37,4V at point A. (34+3,4= 37,4) If we ground at point B we have – 34V at point A and + 3,4V at point C and + 265,6V at the plus pole. If we ground at point A we only have positive Voltages available. Point B would be + 34V, point C + 37,4V (34+3,4) and + 300V at the plus pole.

This is how the “weird” loop bias works and thus how the negative Voltages are made in this Klangfilm. It is not quite the same as the normal autobias made by the DC current through the cathode resistor as the negative Voltages in the Klangfilm are (more or less) fixed by means of the large the 1 M Ohm resistors and the 1uF capacitors that maintains the Voltage developed over the resistors R1 and R2. But the principle – or method if you like, is absolutely the same.



Above is another typical amplifier made by the German trio. This one is a **Siemens KV2**and it is remarkable similar to the Klangfilm. (The Siemens and Klangfilm often were) This one, however has resistor loaded anodes. Should you happen to have a pair of RE604's both of these circuits are good candidates for a modern amplifier – a little modification needed of course. The signal filters must go and the signal capacitors, as well as the smoothing capacitors are too small for modern use.



The Klangfilm St-32 622, RE604 PP, 1928-32 is partly made by the same current loop bias method as the SE versions. The first stage RENS1294, listed as a HF *exponential*pentode (Whatever that means) has the auto cathode bias that we are familiar with. The second stage is a nice interstage triode phase splitter – again however – with that degrading resistor in series. (Is it there to protect the primary winding in case of tube failure ?)

A field coil speaker may be employed, should you happen to have such laying around.

Building a Loop Bias Amplifier.

As with most or more likely all power amplifiers made before the 1960-70's, the input sensitivity is way too high for modern use. The cure however is simple, remove a stage or two or in case of a high gain input pentode, turn that one in to a triode.

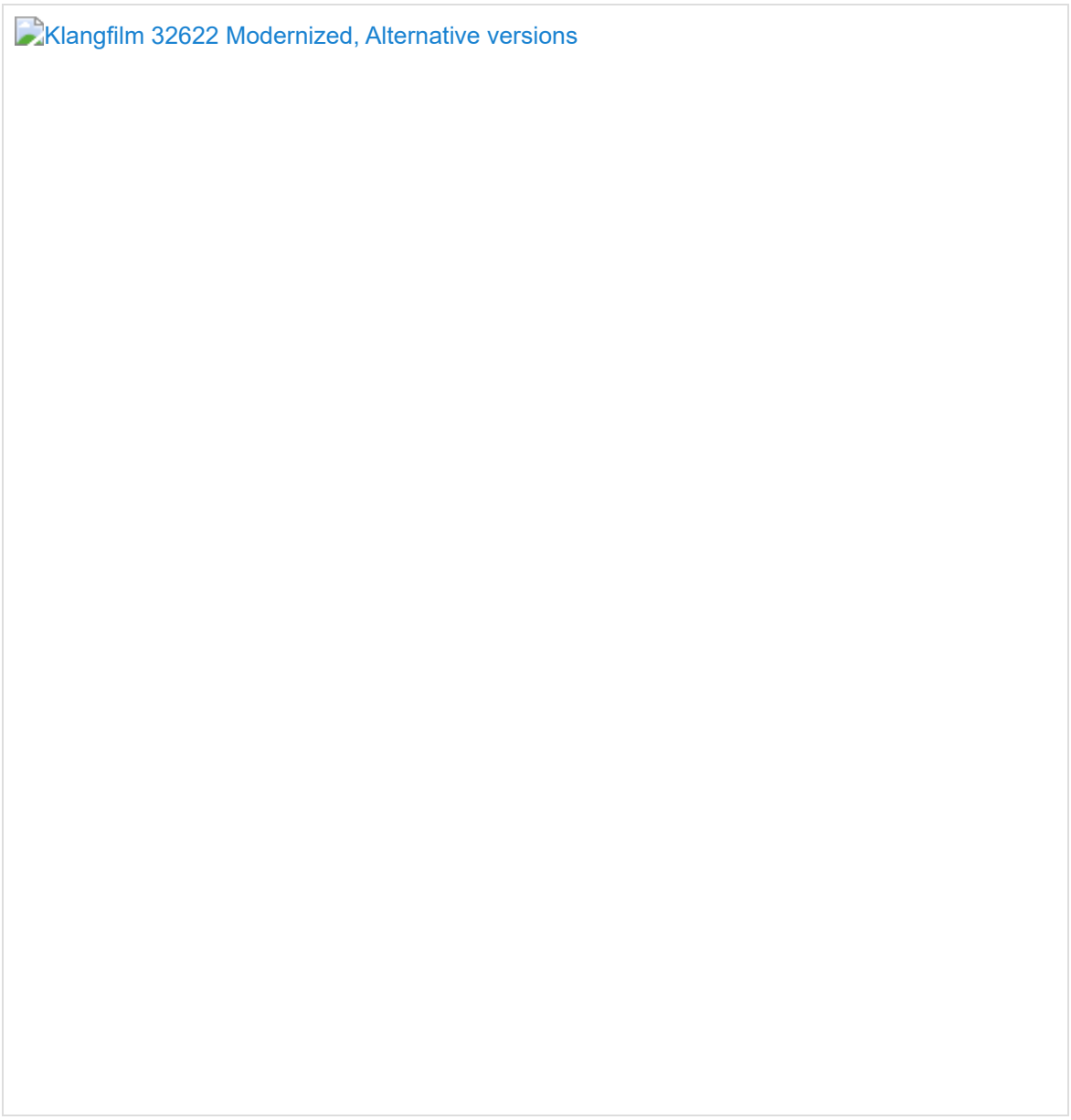
Lets first transfer that old Klangfilm in to a modernised version.



KLANGFILM LBA.

This is how it may look slightly modified, but keeping the loop bias intact. Just about any 12 Watt triode will do. 200 to 300 Volts will suit most such triodes. The interstage phase splitter transformer T1, could be just about any one available, providing a turn ratio from 1:1 to 1:3. A triode coupled PL84 or EL86 is quite similar to the RE604, all though the gain is higher. We don't mind that. A PSU DC Voltage of about 180-200 Volts will be fine and a pair of PL84's will deliver some 4-5 Watts of class A, quite similar to a pair of RE604's. The OPT load should be around 2,5 to 5 kOhm.

If you happen to own a phase splitting transformer with an airgap allowing a little DC current, you can do even better. As most 12 Watts triodes are quite easy to drive, we can get by with a little total gain.



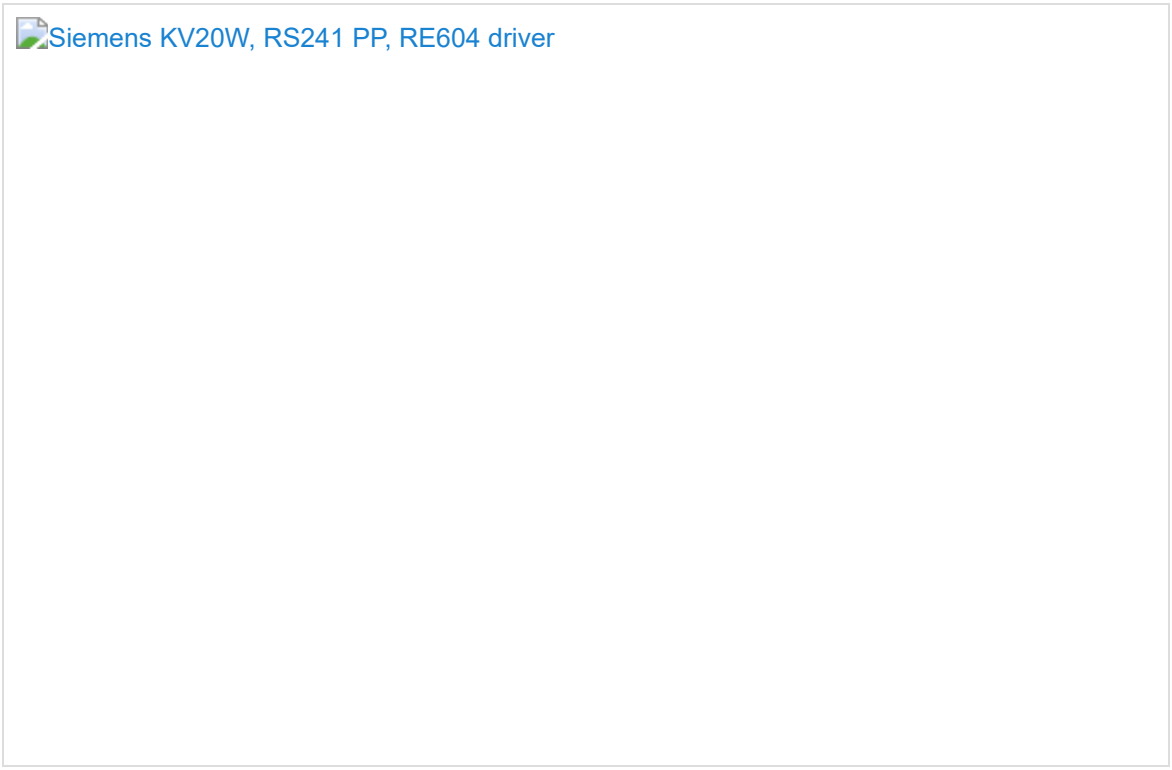
The alternative versions above shows a few examples of a modern Loop Bias Amplifier. (I do realise that officially there is no such term – but there is now ;-)

In case that you would want to play with the adjustable bias network I have suggested in Fig.3, be aware that adjustment affects all valves in the bias loop. It will be a painstaking task to adjust, but it should be well worth the effort.

Of course you can upgrade these circuits to any higher power valve, should you want more power. Pentode or tetrode mode is fine too, should you prefer that. It is quite simple to calculate the loop bias resistors, two methods is shown in Fig.4 above.

I always insist on a 10 Ohm cathode resistor, that allows us a simple way to monitor the cathode current. That little resistor slightly improves the linearity as well as adding a little extra safety margin.

The last amplifier from the German gang I would like to show you from the period of late 1920's to early 1930's is a Push Pull *power driven* triode amp.

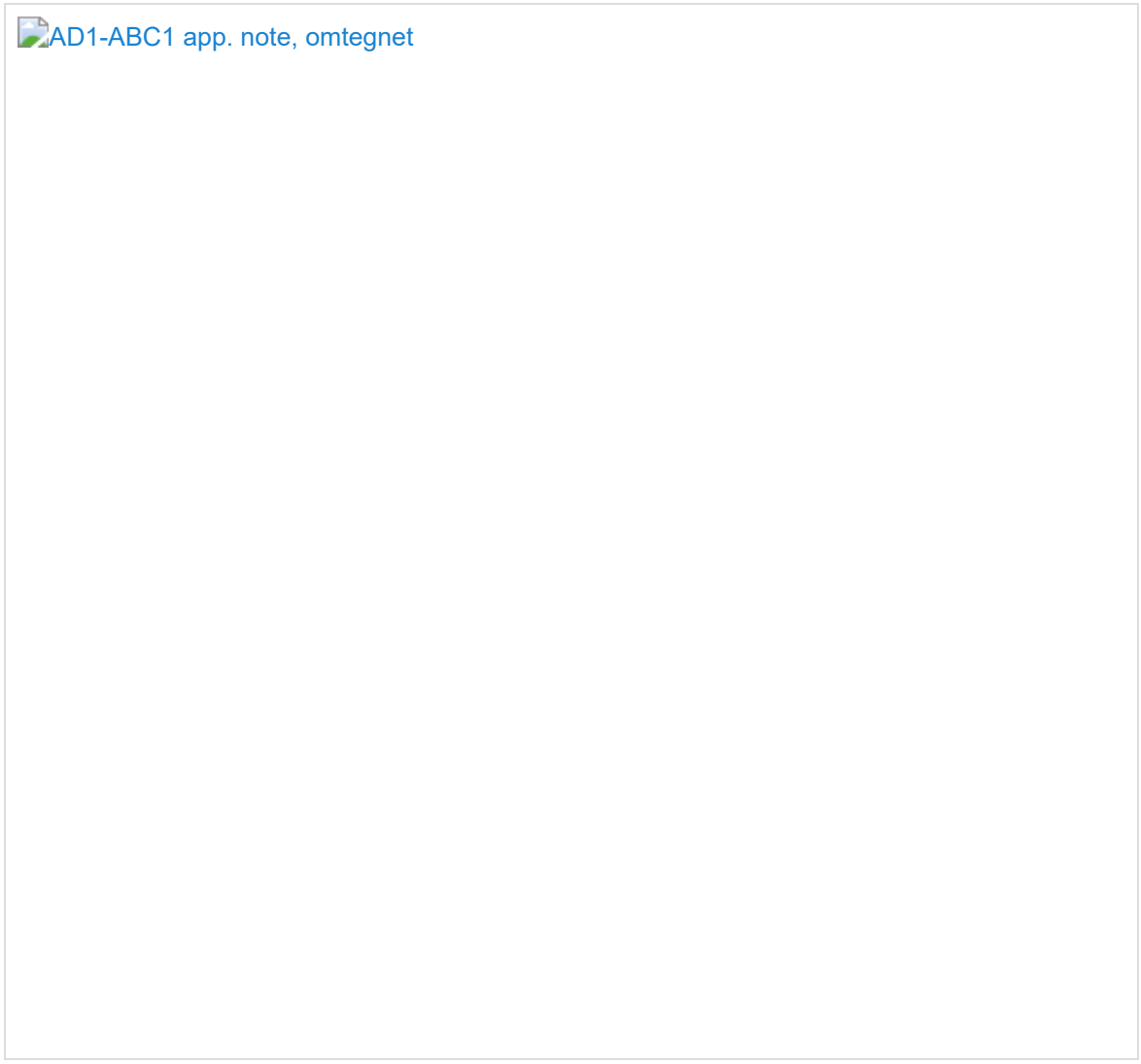


Siemens KV20W , RS241 PP, 1928-1930.

Power triode parafeed phase splitter… This application was a big deal a few years ago and is still a popular circuit among hardcore vacuum audiophiles. (No pond intended) I like the parafeed approach, although I personally prefers a regular interstage. Do note that there is feedback from the second stage RE604 to the first stage REN904, as the cathode of REN904 are returned to ground via the 7,5 Ohm cathode resistor of the RE604. Nice ! Two chokes to smooth – I like that too.

I am a little puzzled about the four diode symbols that shows the rectifier bridge for the negative bias Voltage. What kind of diodes were available back then ? Cats whisker ? I realise that the silicon diode was invented in Germany around 1900 and used in crystal detectors, but I was not aware that they were used as a rectifier 10 years before WW2.

Great design..

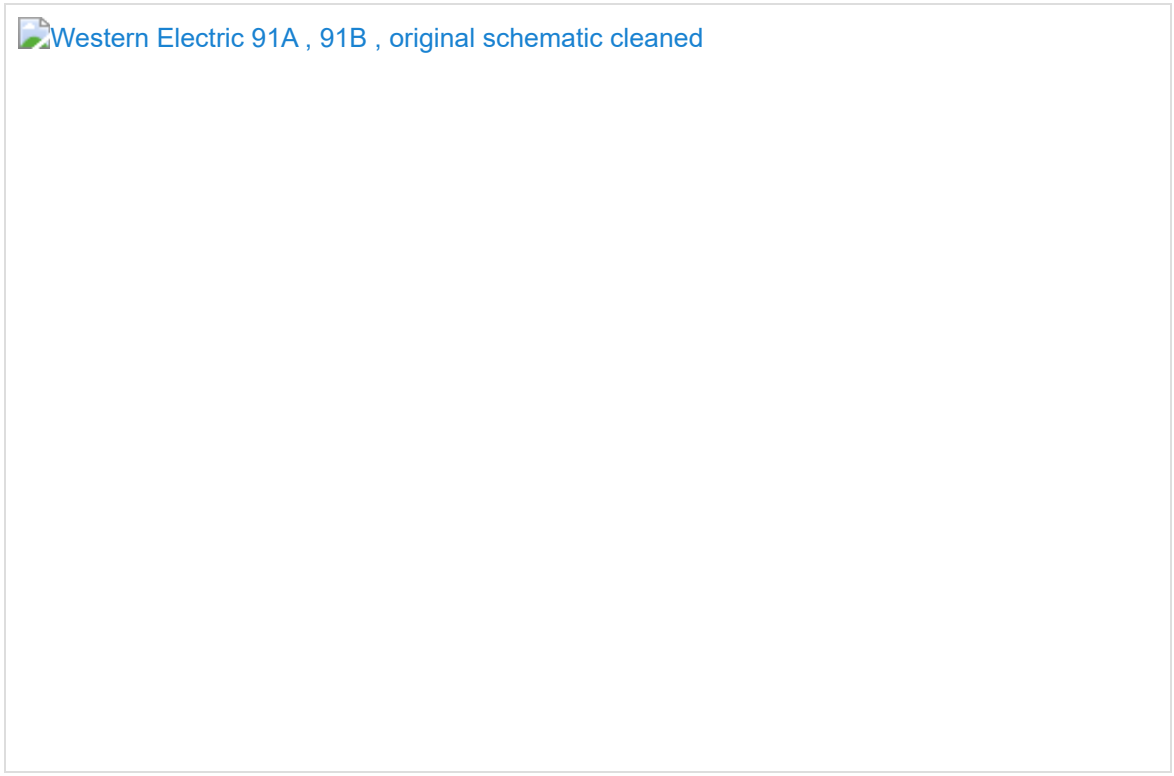


(Suggested by yours truly)

Philips app. Note: SE ABC1+AD1. 1930's

AD1 was introduced in 1936 as an improved version of the common RE604. The circuit above was a typical SE amp of this period. Literally a textbook example. The distortion is remarkable low, despite the absolute lack of feedback..At 1W these two triodes hardly produce a total of 0,25%. Even at 2 Watts it is below 1% ! A 2500 Ohms output transformer and a valve regulated power supply providing some 250 to 300V will make this little circuit a top class audio amplifier. (See my article series about regulators) If you do not like the two diodes in the ABC1, you may swap to AC2. Both of these triodes are very linear and the u is around 28-30. If you do not like the anode caps, you may even swap to a 6J5 or 6SN7 for stereo. For absolute top results use an anode choke or inter-stage trannie for the pre amplifier triode, maintaining the 250V supply. In fact 90% of all class A 15W triodes will fit the output here as long as you adjust the cathode resistor accordingly. (Consult the data sheets)

Nice and simple.



Western Electric 91A/B, 300A, 1936

Iron input, 310A, 310A, 300A OPT.

This little darling amplifier is designed with four amplifying stages !. First the input transformer, then the two 310's and finally a little gain from the 300A. This amounts to a total gain of 92dB's. You may not be familiar with figures about gain, but 92dB is equal to almost 40.000 times ! This amplifier will take a low output MC-pick up directly……I say: "Pump down the Volume"……

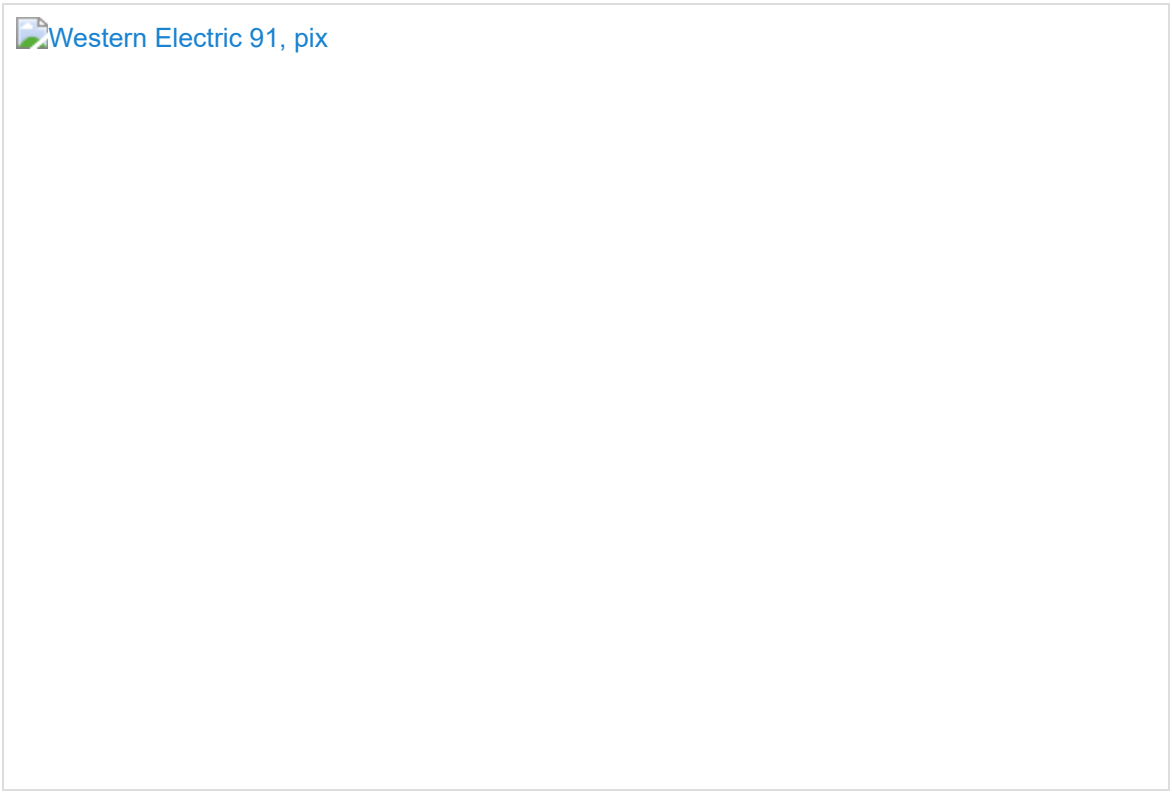
The 91 series are quite conventional and the "grid to cathode trick" is only used at the output stage. This may appear a little odd, but I assume it was made such in order to reduce noise and hum pick up as this particular W.E. trick tends to be rather sensitive to noise – in particular when noise is gained 40.000 times…

There is feedback from the plate of the 300A to the screen grid of the first 310A stage.This is quite mandatory in such a high gain amplifier and it is on purpose that the OPT is not a part of the fb loop , due to phase shift. The freq range of the W.E. (and other) output transformers in the 1930's was not a thing to brag about.

Looking at the PSU , we note the use of series capacitors and resistor network around these. Despite what is often claimed by hardcore WE fans, there is absolutely NO advantage, whatsoever, by doing this. The reason why W.E. did it this way, was due to the poor technology of capacitors back then. In order to obtain a "high" value of capacitance and not to overload these by excessive Voltage, it was very sensible to connect these capacitors in series and in order to balance the Voltage for the "loose" and drifting of capacitors over time a Voltage divider (Bleeder) by means of resistors was made. It is as simple as that. Today we would replace the entire mess

around the first capacitor with a single 20u/600V of good quality. And the one after the choke with a single 10u/600V. Should you want to make a copy of this famous amplifier, I would suggest to a PSU choke of 10H – a choke of 5H will do and 20H would be very good.

Most of the special WE tricks were practical and economic solutions made to practical problems and clever practical solutions to improve stability and to insure safe long term use.

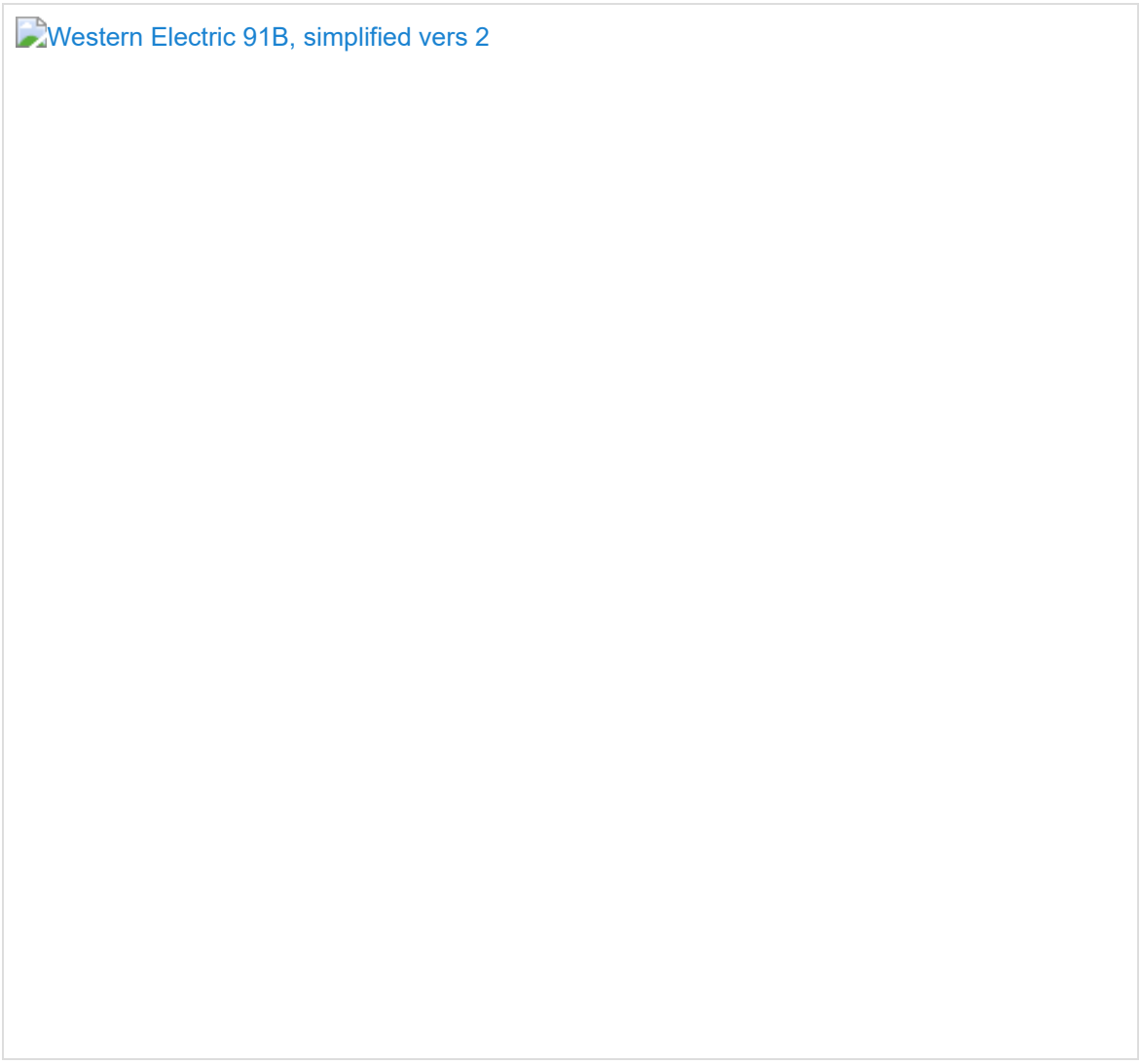


(Pix from “westernlabo.com)

As mentioned most vintage amplifiers has a gain/sensitivity that is way too high for practical use today. Although it made a lot of sense back then when the signals from the cinema soundtracks were very low indeed, these excessive gain levels are the cause of noise and distortion. As we do not need all that gain anymore , we can actually reduce both noise and distortion drastically. The remedy is simple..
Remove a stage or two (Sometimes even three or four) and we are there.

In this case it is relatively easy for a single 310A to serve as the Voltage amplifying stage as well as the driver for a 300A, the 300A being auto biased with a grid resistor of 500k Ohm. I would place an input volume pot before the 310A and it is worth trying to triode couple it. (Two stages might be necessary in particular if you would want to use feedback)

Apart from the mentioned it is indeed still a nice amplifier….80 years on the back…and still rocking…



Western Electric 91B, 1936

Above the W.E. 91-B drawn with the PSU and amplifier separated from one another. Parallel components are considered as single components, just as W.E. would have used – had they had access to modern components.





, **Western Electric 92B, 1936**

Pretty much the same as WE 86B, except for one significant difference: The cross coupled feedback at the output stage. I will briefly explain the cross coupled circuit here as for the rest of the 92-B amplifier, please, read the 86-B vignette.

The Western Electric “cross coupled feedback” explained.

This W.E. trick is often referred to as a cancellation circuit.It is also considered in some circles as an anti distortion feedback. None of this is the case, in fact the circuit performs the opposite in both cases.

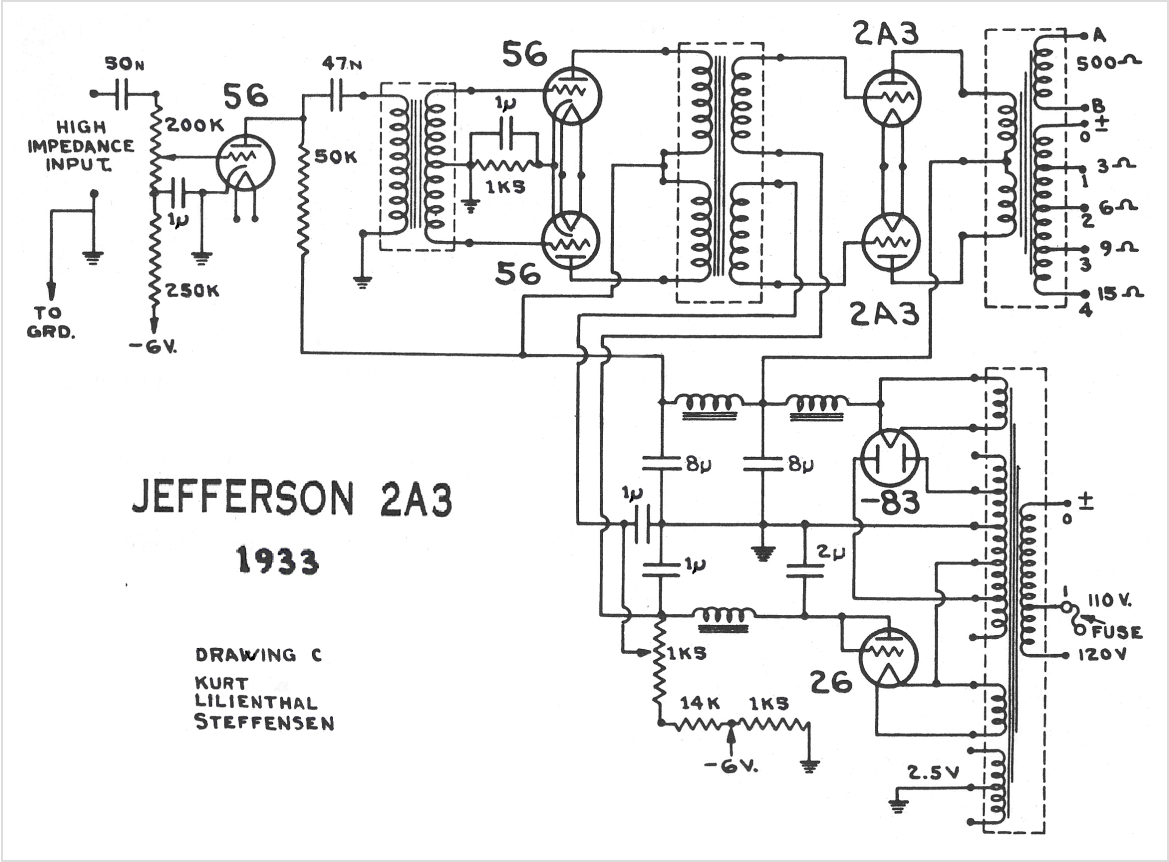


As can be seen, the signal at the plates of the 300B’s is feed back to the grids of the opposite tubes via the two capacitors. As the grid of a tube goes positive, the plate goes negative and vice versa. This means that the circuit here shall be considered as *positive* feedback. Such feedback can never cancel oscillation or distortion, it does however introduce overshoot, signal ripples and harmonic distortion – in particular high orders of such. It may not appear so, when visually inspecting sine waves at the oscilloscope and it may to a certain degree be hidden inside a negative overall feedback loop, but never the less this is exactly what this circuit does to the performance. Positive feedback ruins the transients by means of overshoot and following ripples. This can be seen clearly at the pulse response or in lack of a pulse generator by means of square waves in form of ringing. The exact nature of this ringing or signal ripples depends upon the size of the capacitors. In the case of the W.E. 92-B, the capacitors are small, hence the ringing and oscillations will die out fast. The purpose of the feedback scheme in the 92-B, may have been to improve the freq response as positive feedback at high freq will lift the upper roll off pole. But it is indeed bad engineering from a qualitative sonic point of view.

McIntosh used a similar practice in some of his unity coupled amplifiers in order to please the drivers – easier drive, due to higher gain by the positive feedback. Nasty , I say , nasty indeed.

It is a mystery to me that this W.E. trick is considered as the holy grail by many hard core WE fans. It is plain and simply rubbish.(Pardon my French)

Shortly after this amplifier was released, WE changed the orientation of the small pin at the side of the socket at the 300A, in order to make it fit the old 205D sockets. The new other vice *100% identical* tube was called 300B. (1938)



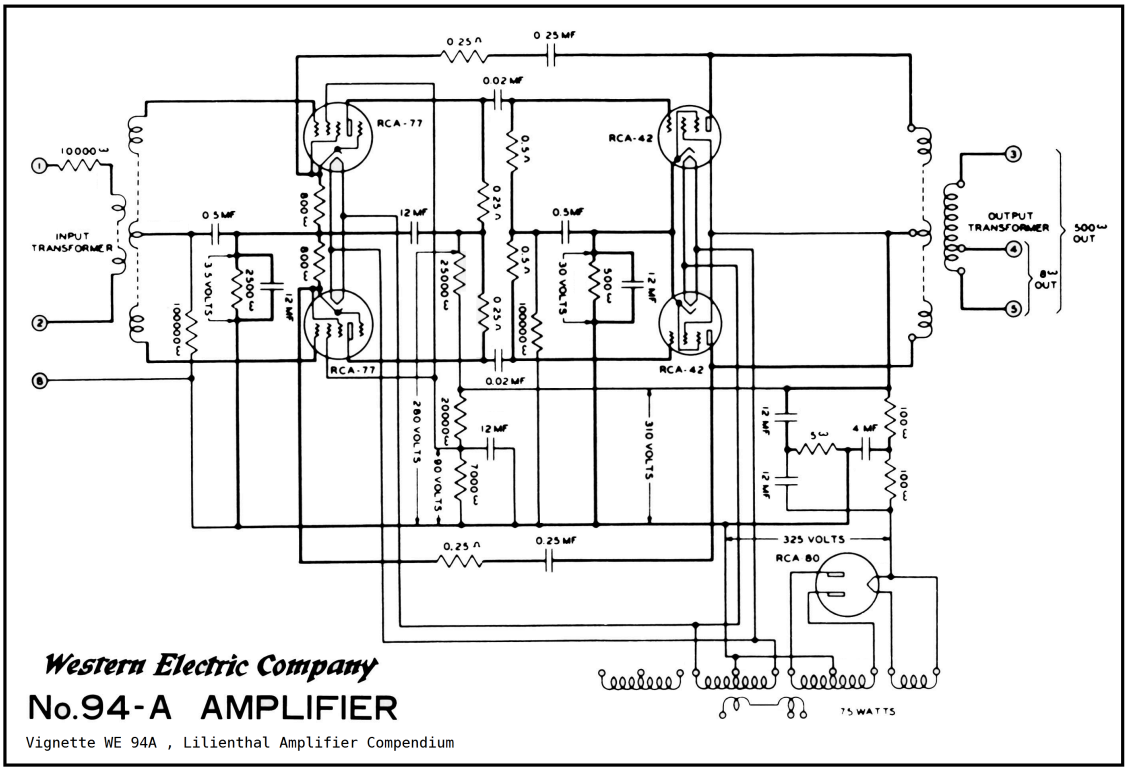
(Suggested by yours truly)
Jefferson, 2A3 PP. 1933

I could just as well have chosen yet another WE design, but WE never used the 2A3 workinghorse.
Jefferson uses an active biased 56 triode to drive the transformer phase splitter, then two 56's coupled in balanced PP to transformer drive the 2A3's PP output stage. I do think that the active bias of the input 56 is slightly overkill. I would probably change it to autobias, reduce the gain and at the same time get rid of the input cap. A cathode resistor of about 1k2 – 1k8 will do fine. The 56 triode is an extremely linear and good sounding triode, very close in data and performance to 6J5 and 6SN7. The u of 56 is a low 12-14, but that is plenty in this fine circuit. Note that the secondary of the driver transformer are divided into two windings. This allows individual bias for the two 2A3's. Jefferson has one fixed and the other adjustable for DC balance.

The PSU is made of a strong 83 mercury rectifier choke input and another choke to smooth the DC, yet a diode coupled 26 triode to rectify and another choke to smooth the bias Voltage. Very nice indeed. Today we can swap the 6u paper capacitors to something a little larger. 22-47u would not hurt. The two interstage transformers could be about 1:1 or 1:3. The output transformer is 4-6 kOhm. 250-300VDC will drive the whole thing in a nice and proper manner.



This is a pretty advanced design for the time, guys, a 80 year old circuit that would be considered as extravagant High End today. (with the input modified that is)
Hats off to ***Jefferson***, Gentlemen…..



Western Electric 94-A , 42 PP

This is a typical W.E. circuit, but it is unique in the sense that it does not use tubes of Western Electric origin. The tubes used was made by RCA. I wonder why W.E. did that ? I know of only 3-4 amplifiers designed by Bell Lab/W.E. that uses tubes other than W.E. design. The 94-A is not well known among the tube enthusiast or WE collectors, but I hope it will be in the future. I have cleaned the schematic somewhat and I trust it is possible to read it without to much trouble. (The 42 tube is similar to 6F6)

Enjoy….



Tannoy , PX4 SE, 1932

This schematic is redrawn from Jean Hiraga's good book. Nice straight forward design. Note the parafeed driver and the 1:4 step up ratio at the tapped autotransformer.

Roger Modjeski,(Music Reference), kindly points out that It is also worth to note the metal selenium rectifiers.Such was made of a series of anode and cathode cells, separated by a thin layer of Selenium. These rectifiers were rarely used in audio amplifiers* , possible due to relatively high costs, a limit of 25V per cell, large size and highly toxic fumes in case of failure. The HT Voltage doubler that Tannoy uses here are possible due to the metal rectifiers.

(The Siemens Klangfilm KV20W, 1928-30 had metal rectifiers installed too.)

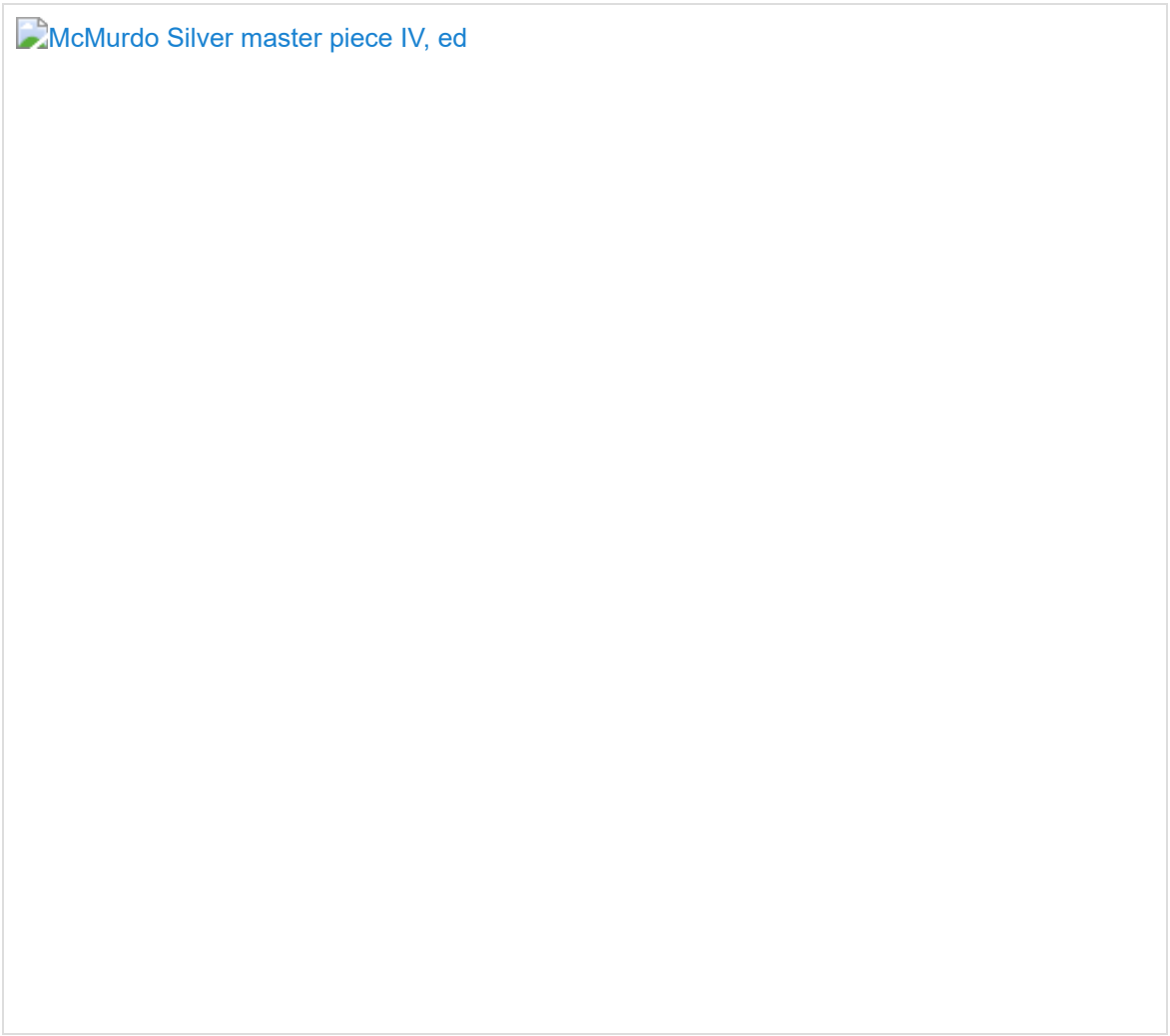
Anyway it is a good example of the typical English Single End amplifier as they were used in the domestic radios. This one obviously had a "gramophone" as well.



His Masters Voice, ”De Luxe radiogram” PX25 PP, 1930s

A very good typical English prewar Push Pull type. There was a lot of fine made English amplifiers during the 1930’s. PX4, PX5, PX25, DA30, DO30 just to mention a few of the common British 1930’s power triodes. The circuit is pretty conventional, but it is worth to note the simple choke phase-splitter and the use of the two field coil speakers to smooth the DC. Certainly a circuit to consider when building your triode push pull. The components marked with yellow should just be deleted for modern hifi use.

Note that the bass and treble speaker are connected to two individual windings at the OPT. This is certainly my cup of tea, – I’d say…



Mcmurdo Silver Masterpiece IV, 4 x 42 PP, 1935

It is probably not the most modest attitude when you yourself call the product a masterpiece, but here it is indeed the case in every sense of the word.The diagram is a master stroke, the building

quality too and the design of the whole thing is masterful as well. Unfortuneately is the quality of the schematic I have too poor in order to read the values of the components, neither was it possible for me to read the bias circuit with any significant certainty. But it matters little as we can clearly see what is going on.

This is a *power driven* amplifier. Two 42's PP drives the parallel 42's PP output stage. They are all triode connected. It is actually remarkable how often vintage amplifiers are strapped as triodes, despite the discontinuity of power triodes. Another thing that we note is the two output transformers. The OPT for the bass is connected the conventional way, but the transformer for the high end of the freq range are AC connected via a single capacitor. There is several advantages to this neat trick. First of all it makes it possible to wind better OPT than usual, as none of them needs to cover the opposite extreme of the freq range. Thus the distortion is lower as well and the passive crossover are less critical.

It is also worth to notice the use of two parallel rectifiers and not less than three smoothing chokes. Two of these are the field coils for the loudspeakers. Do also not that the power supply connection are only taken after the third choke. This most certainly insures the lowest possible ripple, but I am not quite sure that it is indeed such a good idea. Although the gain of the entire power amplifier is relatively low, the single current loop may lead to motor boating alike oscillations at transient or high power soak.

As I can not read the text at the copy I have of the original schematic, I do not know the Voltage supplied to the 42's. But a qualified guesstimate would be around 300 to 350 Volts. This will put out a comfortable 20-25 Watts of class AB – more than plenty for the massive 18″ Jensen speaker that came with this amazing radio set.

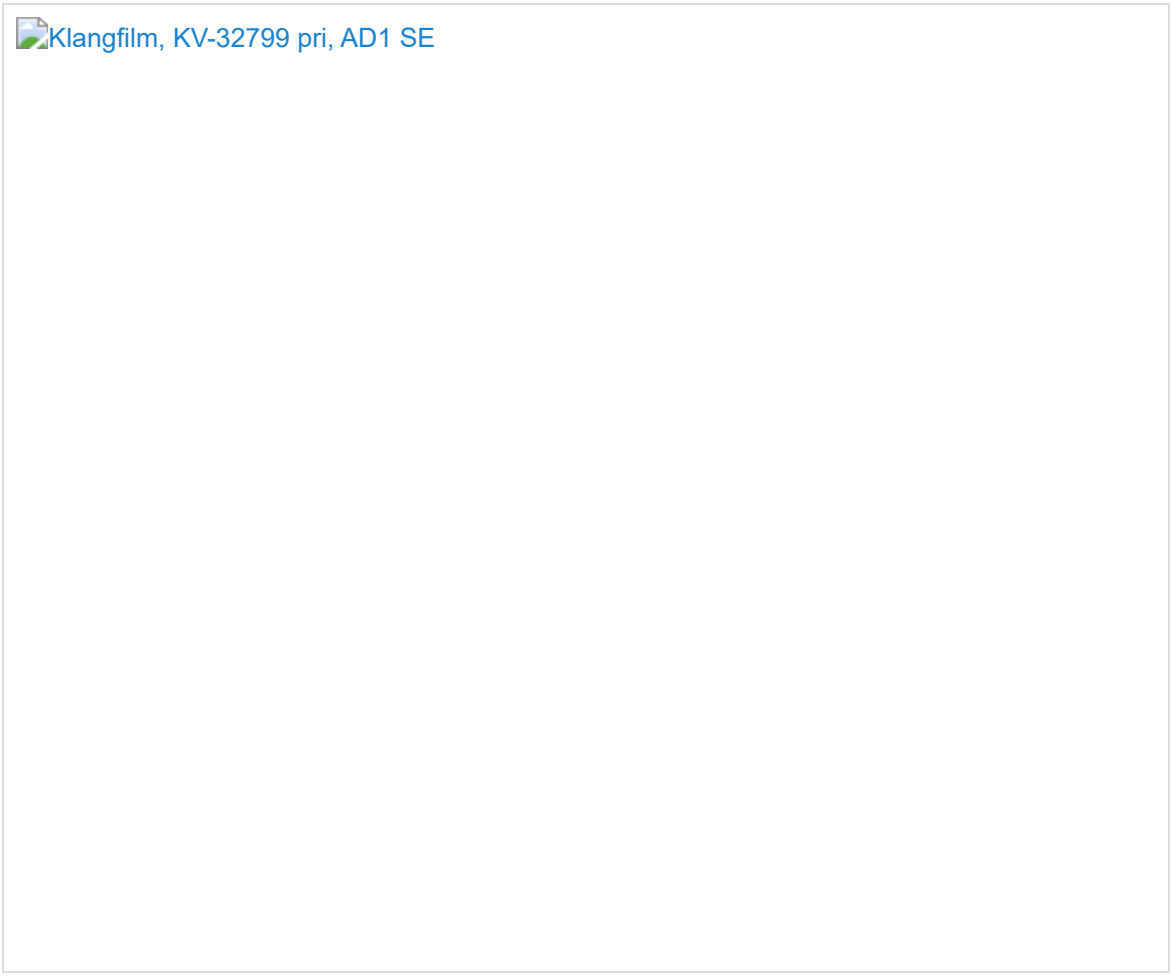
The 42 pentode is equal to 6F6 and 2A5 , except for socket and heater Voltage.

The Silver Masterpiece radio series all came in full chrome and the most beautiful wooden case that held the 18″ Jensen field coil bass and a field coil treble speaker. Please, make a google search for this and select pictures. You will probably become as amazed by the stunning look as I did.

Here is a link to some pictures by Jeremy F. Hopkin:https://www.flickr.com/photos/jeremyhopkin/sets/72157601741849767/

I will try to contact Jeremy and ask if we may have some of the pix here, allowing more people to see this beautiful piece of art.

Indeed a silver masterpiece.



Klangfilm KV32700 , AD1 , 1936-38

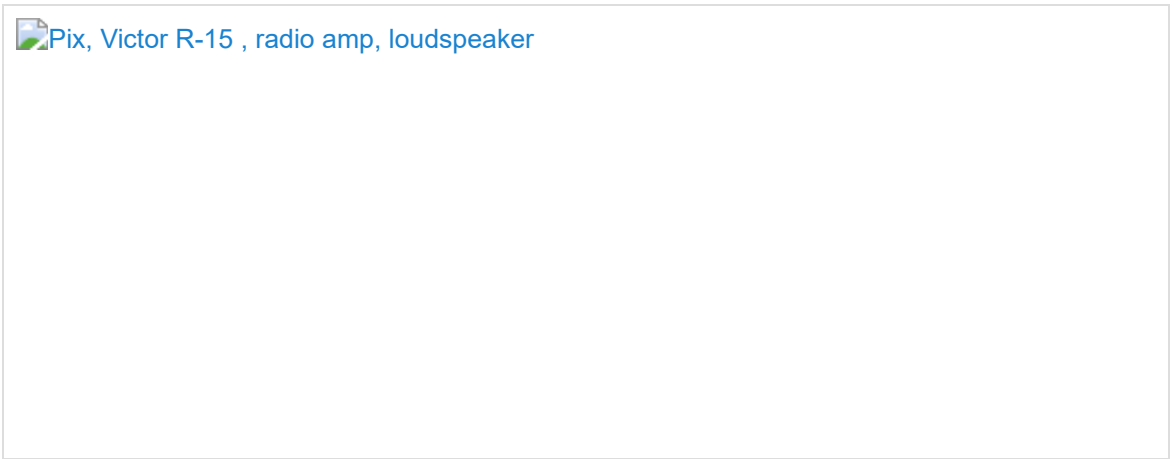
The famous AD1 triode replaced the older RE604 in the midst of the 1930's. AD1 was to become the most common used power triode on continent Europe for the following 7-8 years. It was placed in countless radio's and small class A or AB power amplifiers. Although this "pro-use" Klangfilm amplifier is not as straightforward as it may seem at glance, it is a good example of such application. Note the grounded cathodes, the Voltage divider (45R and 670R) in the current loop of the PSU and the clever use of the lamp as ballast. It deserves a deeper analyse and I will probably get back to this fascinating design later. In the meantime it is here for you to admire.



(Suggested by Joe Roberts)

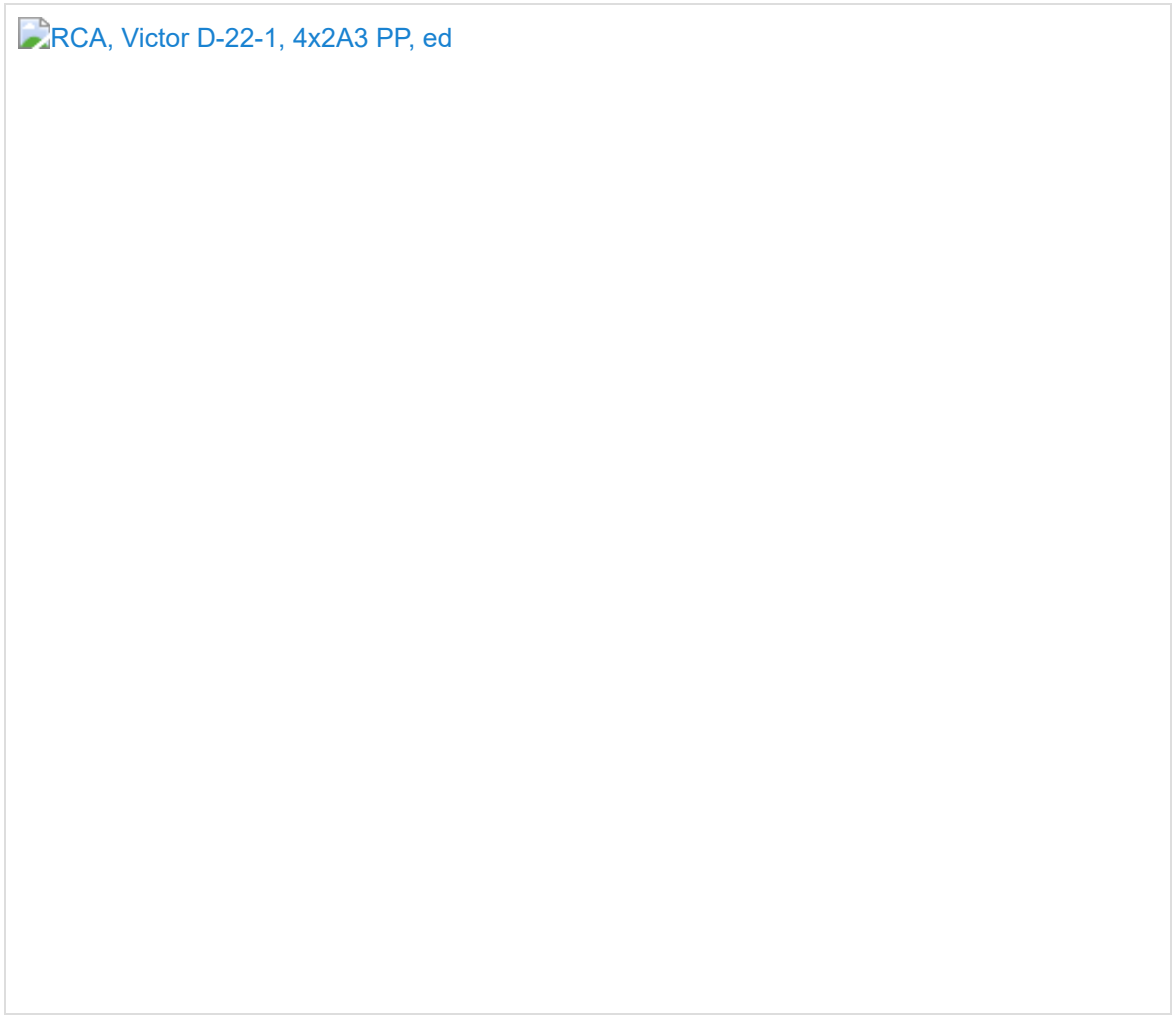
Victor R-15 , UX-245 , PP , 1930-31

Thanks a lot to Kris Walter for finding this schematic for me. I have not cleaned the schematic that shows the entire radio. The audio stage is very similar to the three radio sets below – in particular the Victor type 245. But before you scroll down, gaze over the guts of the R-15:



Chassis and loudspeaker , Victor R-15. Photo , courtesy of **Kris Walte**r. (See entire beautiful radio in detail at:http://www.greenhillsgf.com/IndexOwn_Victor_R-15.htm

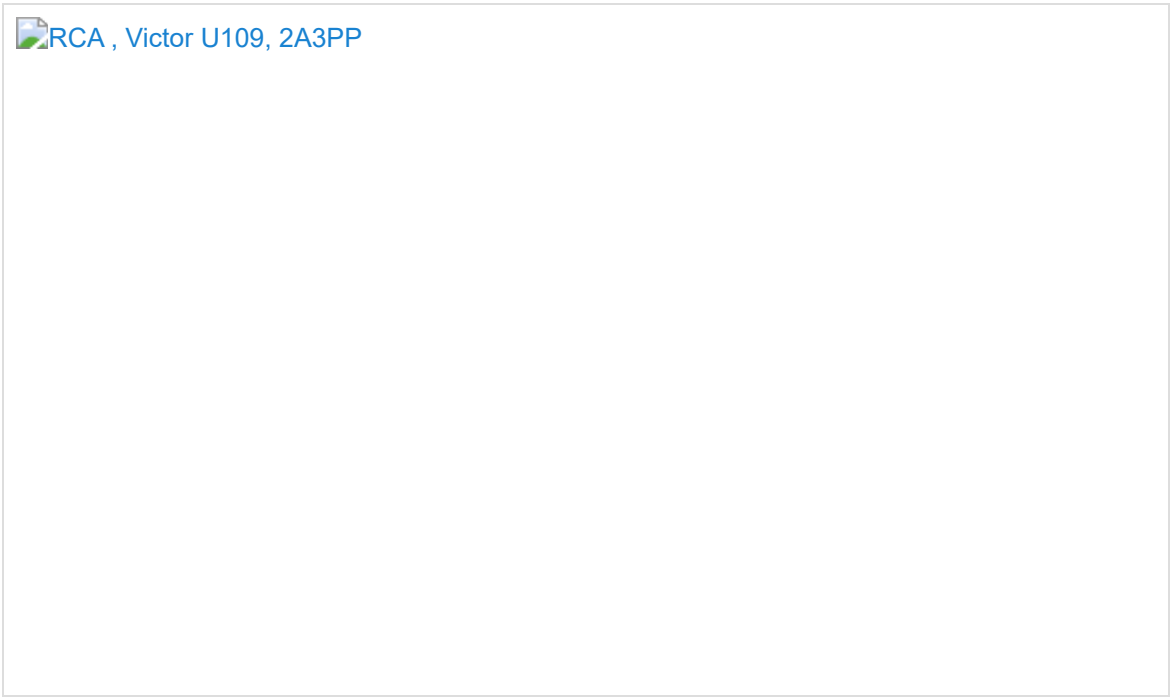
Note the leather suspension of the loudspeaker. A quite common practice back then.



Victor RCA D-22-1 , 245 PP, 1930-31

The D-22 is a straightforward design – nice auto bias via the current through the 48 Ohms resistor. (Loop Bias)

Two electrodynamic field coil speakers of which the coils are NOT used for smoothing. I wonder why. The OPT should be about 2500 Ohms.



RCA Victor U-109, 2A3 PP

The U-109 is pretty similar to the D-22. If you ignore the radio and preamplifier section, it is nothing but a 6C5 triode driving an interstage phase-splitter – just the way we like it. The volume expander was not a bad idea, considering the poor quality of signal sources at the time.



VICTOR Type 245 , 245 PP , Model R-34 , 1929. Pictures courtesy of **Kris Walter, www.radio-antiks.com** (Lots of beautiful pictures. Kris sells vintage restored radio's)

This amplifier is very similar to the two later RCA models. (Victor was taken over by RCA in 1929) The output stage runs in class AB, which in this case presents some 12-15 Watts out. As can be seen from the pictures the amplifier was installed in a large AM radio set intended for domestic use.The larger model RE-46 came with a gramophone. The 26 and 245 (45) tubes are of the indirectly heated types. They are both very linear and even with the relatively poor transformers made in the 1930's, the amplifier above will still to this day, provide high quality audio. A modern copy, with the high quality transformers and capacitors possible today will insure audio quality far

above the mediocre modern plastic amplifiers. You would need two, though, of this beautiful crafted radio's.



Here above is some more pictures from the hand of Kris Walter of "radio-antiks", showing the Victor R-34 radio with the type 245 amplifier. The woodwork is stunning. Note the large field coil speaker and the decorative tuning adjustment. Below you have the cosy night vision….



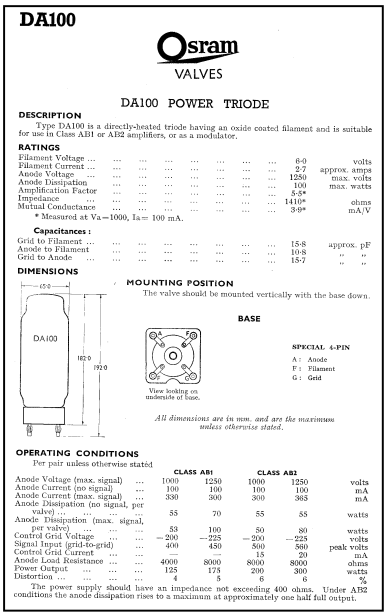
Photo by Kris Walter.



Photo’s by Kris Walter.

This was indeed times of which the logo and name tags meant a great deal. The logos was punched into the transformer capsule and the chassis of the tuner and printed on to the metal sheet.

Very nice indeed.



DA100

Osram
VALVES

DA100 POWER TRIODE

DESCRIPTION

Type DA100 is a directly-heated triode having an oxide coated filament and is suitable for use in Class AB1 or AB2 amplifiers, or as a modulator.

RATINGS

Filament Voltage	6·0	volts
Filament Current	2·7	approx. amps
Anode Voltage	1250	max. volts
Anode Dissipation	100	max. watts
Amplification Factor	5·5*	
Impedance	1410*	ohms
Mutual Conductance	3·9*	mA/V

* Measured at Va=1000, Ia= 100 mA.

Capacitances :

Grid to Filament	15·8	approx. pF
Anode to Filament	10·8	" "
Grid to Anode	15·7	" "

DIMENSIONS

MOUNTING POSITION

The valve should be mounted vertically with the base down.

BASE

View looking on underside of base.

SPECIAL 4-PIN

A : Anode
F : Filament
G : Grid

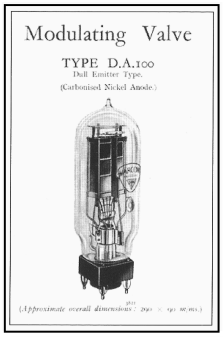
All dimensions are in mm. and are the maximum unless otherwise stated.

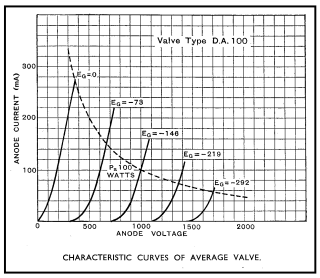
OPERATING CONDITIONS

Per pair unless otherwise stated

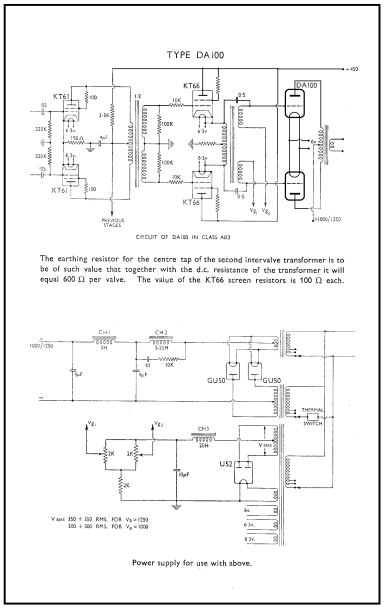
	CLASS AB1		CLASS AB2		
Anode Voltage (max. signal)	1000	1250	1000	1250	volts
Anode Current (no signal)	100	100	100	100	mA
Anode Current (max. signal)	330	300	300	363	mA
Anode Dissipation (no signal, per valve)	55	70	55	55	watts
Anode Dissipation (max. signal, per valve)	53	100	50	80	watts
Control Grid Voltage	−200	−225	−200	−225	volts
Signal Input (grid-to-grid)	400	450	500	580	peak volts
Control Grid Current	—	—	15	20	mA
Anode Load Resistance	4000	8000	8000	8000	ohms
Power Output	125	175	200	300	watts
Distortion	4	5	6	6	%

The power supply should have an impedance not exceeding 400 ohms. Under AB2 conditions the anode dissipation rises to a maximum at approximately one half full output.





CHARACTERISTIC CURVES OF AVERAGE VALVE.



The earthing resistor for the centre tap of the second intervalve transformer is to be of such value that together with the d.c. resistance of the transformer it will equal 600 Ω per valve. The value of the KT66 screen resistors is 100 Ω each.

Power supply for use with above.

Osram DA100 PP , ca 1936

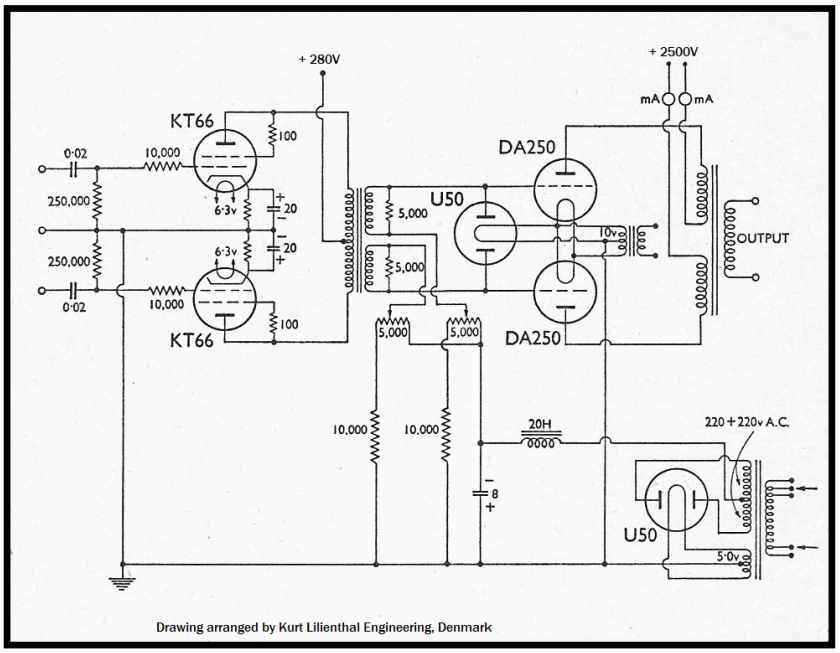
(The schematic above is from the 1951 Osram valve manual part 1, but it was published as a PA/cinema amplifier in the pre WW2 Osram manuals)

This an Osram *power driven* amplifier. The DA100 was introduced in 1936 as type number NT36. In the schematic shown the DA100's runs in class AB and will produce between 100 and 300 W, depending on load and plate Voltage. It is a fascinating design, but I doubt that this circuit will ever be built again in its original form. 4 pcs of DA100's are very hard to fetch, yet another quartet of KT66's. Still it is good to learn from and we may build it from more commonly available valves. The DA100 compares very well to the 845 or the Russian GM70. New production KT66, 6L6G, EL34 or EL37 is indeed available. The KT61 is not that hard to find, but any of the similar pentodes/tetrodes will do, just as long as you remember to adjust the cathode resistors.

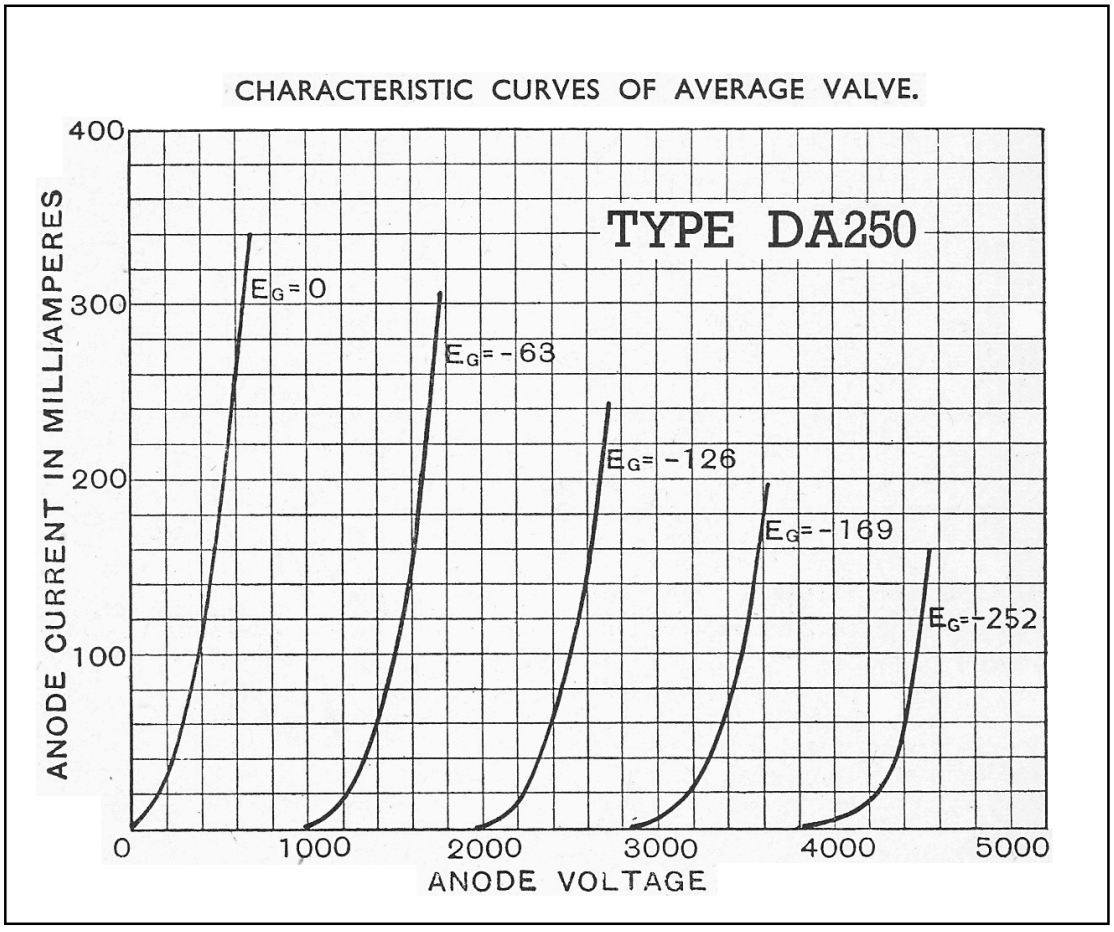
The operation conditions shows it is possible to dial in more than 100 W with a load of 4000 Ω and an impressive THD at only 4%. Keep in mind that this is without feedback !

Should you happen to need 300 Watts of class AB, all you need is a massive 3-500 Watt OPT of 8000Ω and some 1250 Volts for the plates. Now this calls for an almost sacred respect. But we can triumph that. How about a DA250 push pull ?

TYPE DA250



Typical circuit for Class AB1 push pull with DA250 valves. The U50 is included in order to prevent the "trigger effect" due to the reversal of grid current during periods of excess input Voltage.



Osram DA250 PP, 1930´s

This is indeed a monster amplifier. The British DA250 triode is similar to the Western Electric 212. Transformer power driven valve amplifiers has become quite popular again. These amplifiers are considered as the top of the best possible audio amplifiers amongst the hardcore valve amplifier audiophiles. Ken Kessler from the UK, HiFi News Magazine had the Marantz T1 in for a listen in 1997. According to K.K. it was a bombshell and made the best HiFi system he had ever experienced. Ken Kessler went so far as to rate this amplifier as the best ever made. The “secret” behind these power driven amplifiers are the transformers. I will reveal all about it in an article series about power driven amplifiers, that I am still working on.

Now, this DA250 amplifiers is an extremist amongst the extreme. As a single end triode the DA250 will deliver up to 90 Watts ! (Plate Voltage: 2500 Volts, cathode current: 100mA, load: 17-18kΩ !) In the application schematic above the plate Voltage is supposed to be 2500 Volts and the OPT should present a load of 12000 Ω. If we adjust the bias to a total of 100mA, we may obtain 400 Watt’s Class AB with a driver Voltage swing of ca 160 V peak. Grid current will be negligible and the THD will be below 5% ! If the driver accepts up to 20 mA of grid current, we can drive the DA250 pair into an unbelievable 800 Watt’s of massive power. A Voltage swing of up to 220 V peak is necessary and the output ask the PSU to deliver a current of 500mA. (1250 Watt’s) Yet, the THD according to Osram is less than 6%. I do not personally support the THD scheme, but in an amplifier without any feedback, THD figures witness about linearity.

I say hats off to the jumbo triodes from the golden age and we better bend to the engineers from Marconi Osram, better known as MO-valve and Gold Lion the team behind a number of famous valves. MO-valve was associated with G.E.C. England.



Western Electric 100-A , 308-B PPP , 1937

I have been looking forward to show this long forgotten high power W.E. Amplifier. Now, THIS is a monster amplifier: 600 lbs/272 kg – two of such for stereo.

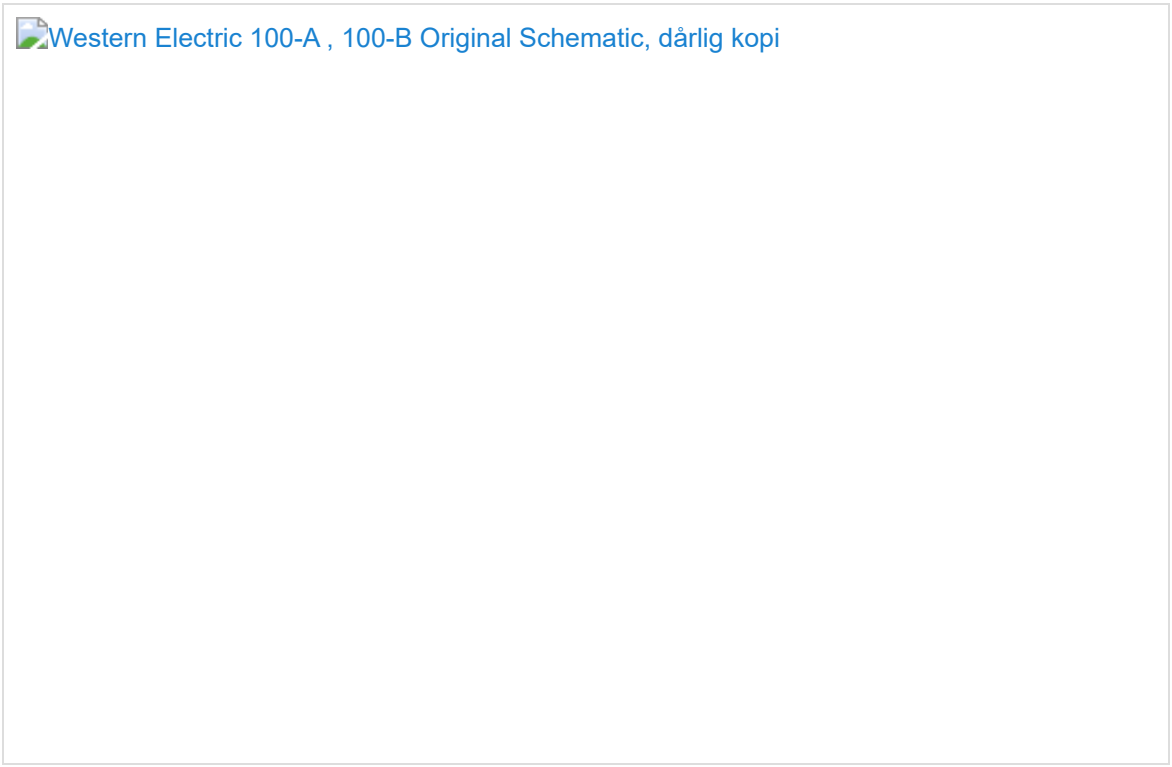
The 308B triode is quite similar to the 212's. The u of 308B is 8 and the u of 212 is 16, this affects the characteristics by making the 308B slightly more linear that 212 and making the bias Voltage for 308B higher.(More Voltage swing is needed)

Western Electric produced a similar amplifier called 6-B, used mainly for transmitting/ power amplifier. It was a 212-D PP driven by a pair of 211-E's. An earlier similar model used exclusively for radio transmitting was model No. 1-A. (1929)



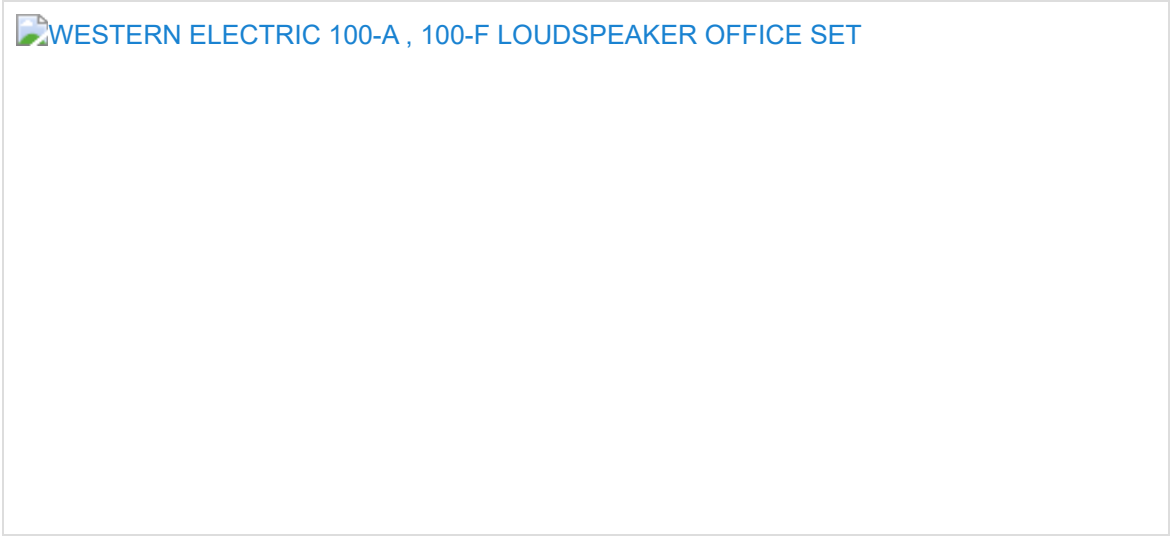
Western Electric 100A & 100B amplifier. Left: front view, right: backside with cover removed. (I regret the poor quality of these old pictures.)

Below is the only copy I have of the original schematic for this old amplifier. As you can see the quality is very poor and it is impossible to read most of the component values.I have removed the relays and connections for the meters in my drawing. I have also simplified the resistor network at the input and output – these have nothing to do with the actual amplifier. The input resistors was used to attenuate – if wanted and the resistors at the output is used for the meter and to maintain loading and to ground the secondary winding. The difference between the A and B model, was the input attenuator.

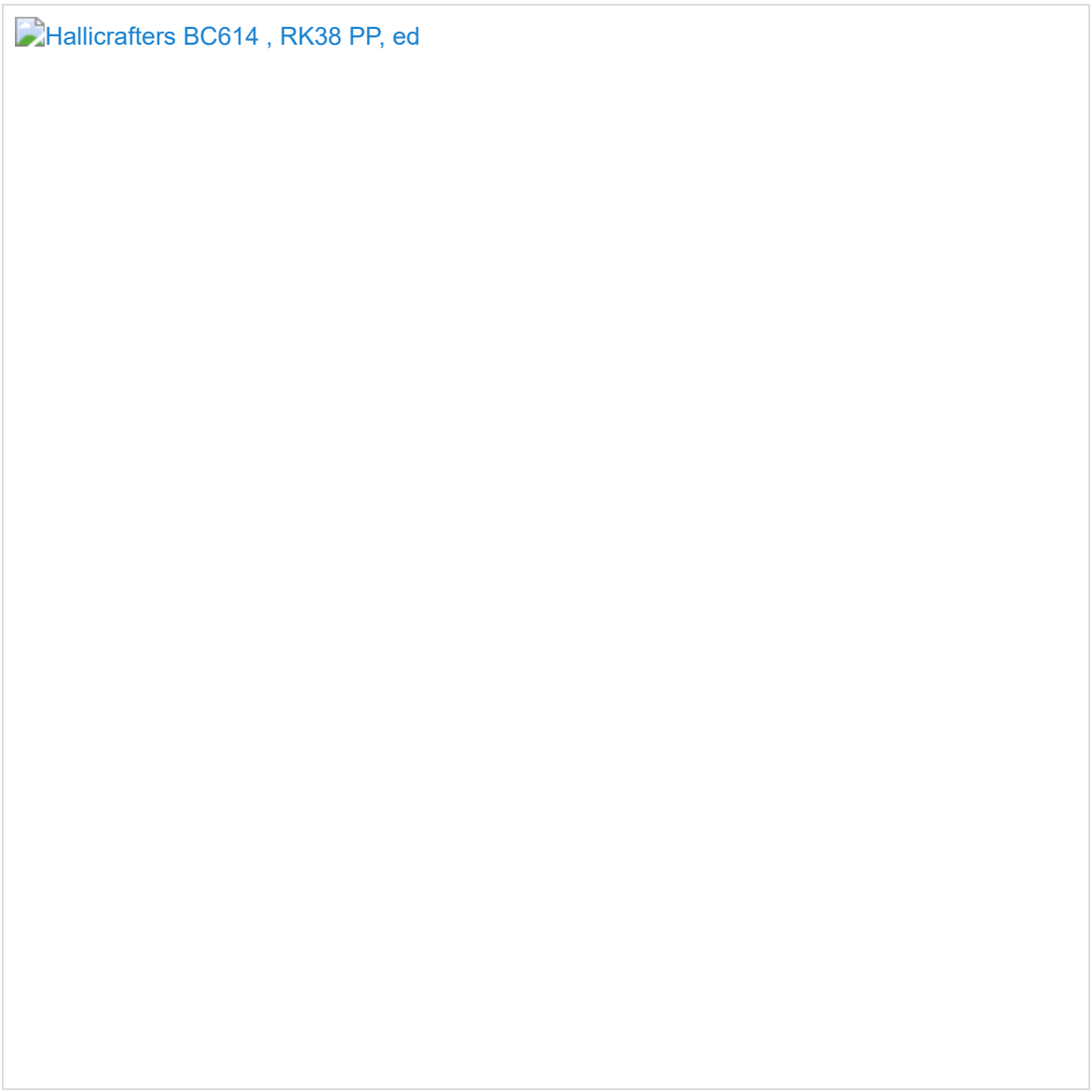


Western Electric 100-A/B , original schematic.

Western Electric produced another amplifier called 100-A at the time. It was quite a different animal intended for telephone monitor amplifier at the office or similar. It was a set that came with a loudspeaker and amplifier. This model was produced from the beginning of the 1930's and up to the end of the 1950's. I guess this means that we need to see a picture, before we bid on a W.E. 100-A or 100-B amplifier. ;-) The models of the telephone amplifiers was called 100-A, 100-B, 100-C , 100-D, 100-E and finally 100-F. The changes between these models was mainly the tubes. For some odd reasons W.E. never used their own tubes in these amplifiers ? I guess it could have been due to the government regulation against monopoly on the free market, that was practiced back then. The freq range of this little PA-set was 300Hz to 3kHz +5dB. Not a thing that ignites this ol' viking, I have to say.



Hallicrafters BC614 , RK38 PP, ed



(Suggested by Joe Roberts)
Hallicrafters HT- 5 and
Hallicrafters BC-614 speech amplifier, WW2,

After a long search I found some info about these two amplifiers. HT-5 was an audio mixer amplifier made to drive the PA speech (Or modulator ?) for the BC-614/HT-4 system. BC-614 was a combined transmitter and PA-amplifier/modulator.

Very interesting (and exotic) pick, Joe…This set will bring you more than 300 Watt's class B. That ought to do it I guess. It is interesting that the 2A3 power amplifier are configured with negative Voltage compared to ground. Before you jump to any conclusions about the advantages or disadvantages about this, keep in mind that the tubes do not know the difference. The cathodes are the absolute references and therefor it works exactly as normal. The reason why Hallicrafters performed this little trick was that they needed a good power supply for the negative bias to the RK38 grids. And simply in order to spare resources they wicely chose to use this PSU for the 2A3

power amplifier as well. Nothing more, nothing less. After all this amplifier are pretty conventional – except for the high power. We can actually “back engineer” the whole mess. RK38 is a Thoriated Tungsten filament, Tantalum plate high u triode capable of 100 Watts of plate dissipation. The maximum plate Volts are given as 3000 Volts. Heaters are hungry 8 Amperes at 5 Volts. A typical class B audio freq set up is as follows:

Plate Voltage : 2000 Volts
Bias: – 52 Volts
Idle current: 35mA
Plate to plate load:16000 Ohms
Peak to peak drive:360 Volts
Power max drive: 6 Watts/40mA grid current
Power out: 330 Watts

I will bet my favorite triodes that this is exactly what Halli’s are doing. (+/- 20%)

The 2A3 stage would be a regular class A – some 300 Volts and 5k Ohms load. It only needs to deliver 6 Watts, so you can run it pretty much how you like.

“Why” – you may ask, “why the heck does Joe like an old dusty class B, WW2 military speech amplifier” ? (Good question, thank you) Well, I can not speak for Joe, but I believe I know why (Or maybe it is that Joe merely likes it because it is so freaking rare) First of all, despite being a class B amplifier the first few Watts from this monster are actually genuine direct heated triode class A. Secondly, there is not a single capacitor in the signal path and that can be heard. The power supplies are well regulated; choke input plus another smoothing choke for the 2A3 stage and mercury double choke smoothed for the RK38 power amp. Finally inductors (transformers) are in practice the optimal load for any tube as it forces the distortion down (compared to a resistor load) and the transformer responds to the current by “kicking back” as much Voltage as the tube could ever ask for. On top on that the DC idle Voltage losses in a transformer/choke load are only what amounts to the copper resistance of the winding wire. Of course a class A output would be better and I am pretty sure that either extreme end of the audio band are ignored in the speech amplifier. After all it was meant as a tool of spitting angry orders to your men at safe distance during WW2 – or something like that.

Anyway – damn interesting design, thank you for drawing our attention to that odd amplifier, Joe

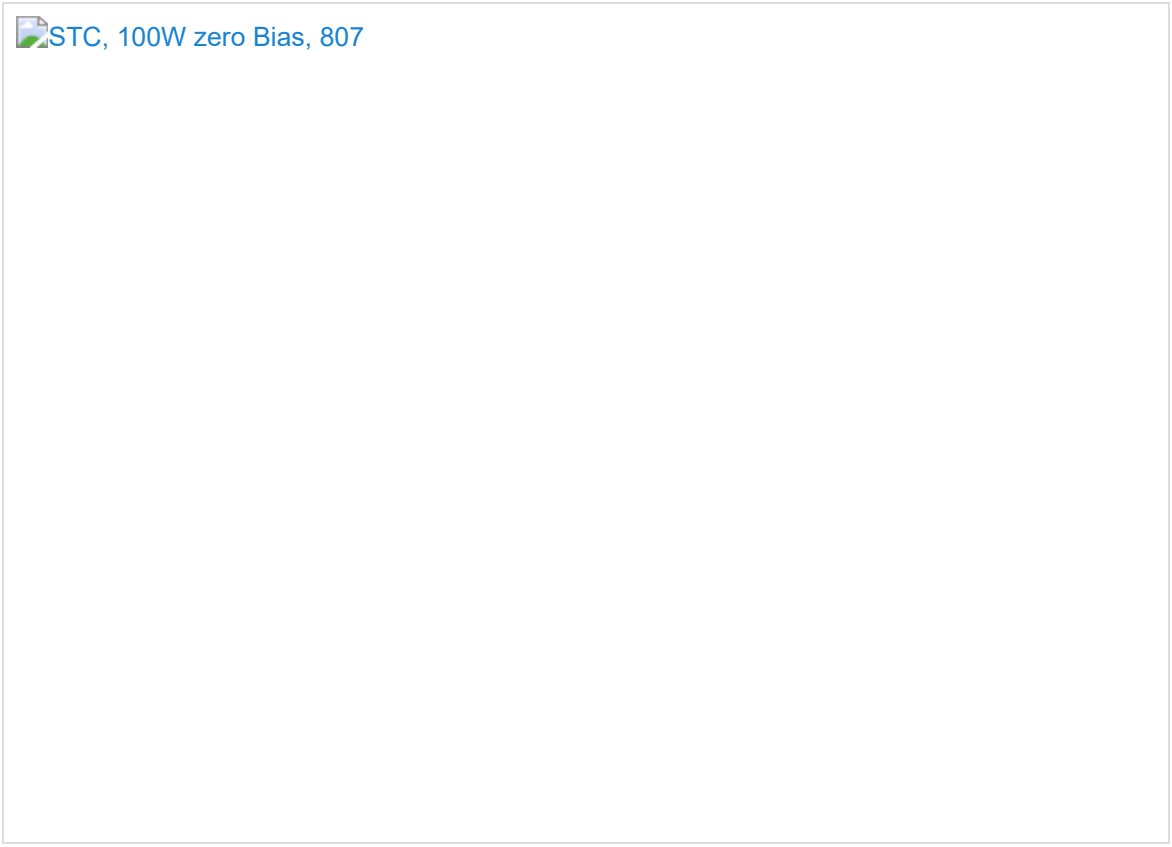
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Osram DA41, class B amplifier. 1940

The illustration above, pretty much says it all. It is a genuine 0 Volt bias output stage. It probably draws some 25mA idle per DA41. (25 Watts plate dissipation) It will work with a 5000 Ω OPT , probably even add a few Watts of power, but Osram recommends 7000 Ω. I am quite impressed by the relative low distortion despite the lack of feedback. It is relatively easy to convert the circuit to a 805, 211 or 845. All you need to do is to adapt the filament Voltage and use a suitable cathode resistor. KT61 may be replaced by a similar power valve, say a 6V6G, 6F6G or 6Y6G. The KTZ63's may be swapped to same or EL84, even a pair of triodes with a medium u will do the job. (ECC85 may be a good candidate).

DA41's are available at reasonable prices. There is no real equivalent to DA41/CV1076, but the TZ40 and VT76 are pretty close and readable changeable. A better triode would be the Brown Boveri T50-1, but these are quite rare.

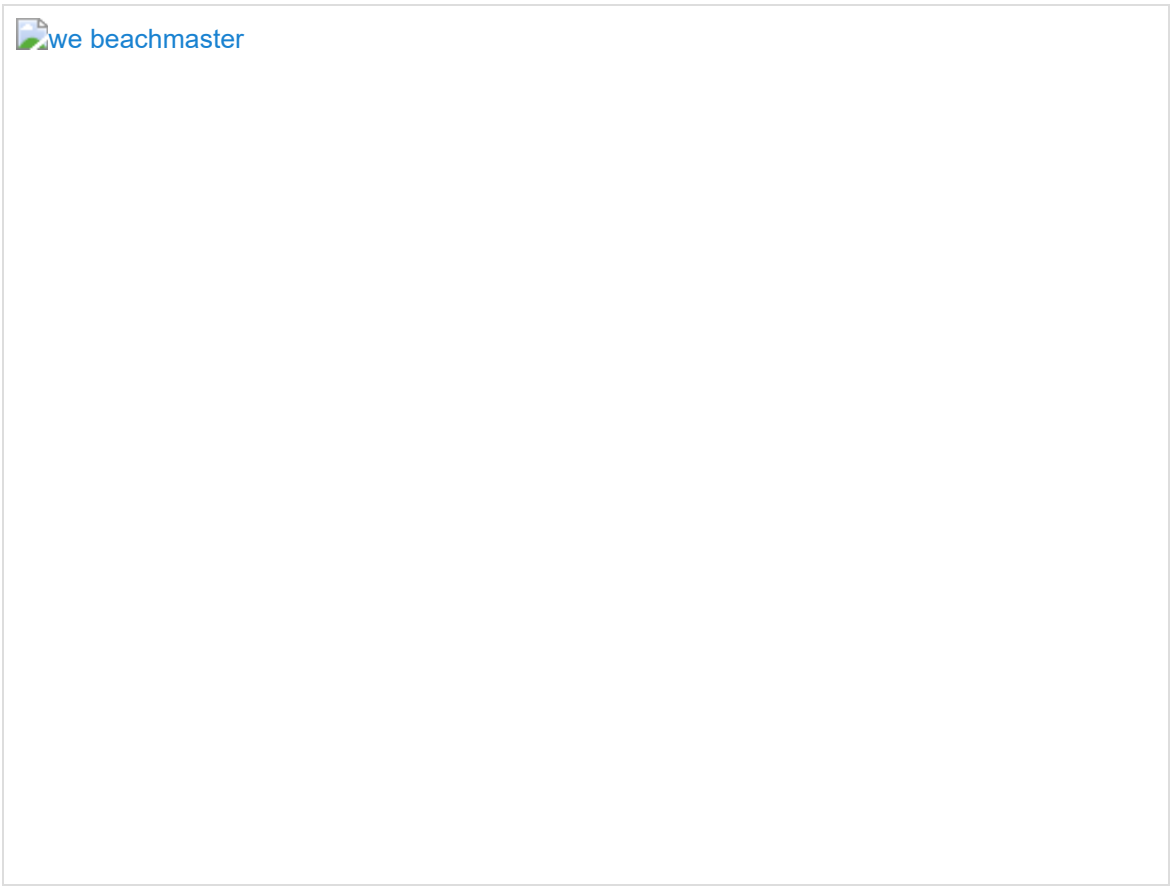


STC, Zero Bias, 807 PP.

A number of years ago the zero bias circuit was reinvented. It was quite popular to play with valves such as 811, 812 and other class B triodes. The circuit above is made by STC, the English division of ITT and Western Electric. It probably dates back to around WW2, but it could be early 1950's. It is remarkable that it is made without feedback, not a thing I would recommend for a class B amplifier. Class B output demands a lot from the output transformer. The leakage and the capacities of this must be as low as possible, not and easy task. It is also difficult to drive a class B output stage, as it requires a high Voltage swing as well as current for the grids. STC solved this by

means of a 6L6G beam power tube and lots of Voltage at the plate. 600 Volts is a lot, even for a working horse such as the 6L6G. Note the unusual way the 807's are strapped. The input grid is made of the parallel coupling of grid 1 and grid 2. This little trick makes it quite a different animal. It becomes a triode alright, but a rather different one. It wont draw much current even though these grids are at ground, the same potential as the cathode. But as the grids enter the positive area, the 807's will gradually open for current to pass between the cathode and plate. The efficiency of this circuit is high and you should expect some 50 Watt's of output power. I have added the L63 input amplifier as the original schematic I have at hand, does not suggest any pre-amplifier.

I doubt the quality of this circuit, but it is very interesting, both from the point of view of the zero bias approach, but also due to the odd strapping of the 807. 807 is more or less a low stray capacitance version of the 6L6G, intended for high frequencies. It makes good sense to do ones best to reduce any possible capacitance in a class B circuit as these loads the driver hard, in particularly at high frequencies. (Say above 2-5 kHz)



WW PAB-1. Photo from US Militaria forum.

(Suggested by Joe Roberts)

WE beachmaster PAB-1, WW2

Gee – here we go again with an amplifier to fight nazi's…
Very large amplifier used by US army at D-day…Hence the nickname, as I understand it.

The tubes seems to be: 1 x 6E5, 2 x 805, 2 x 836, 2 x 6V6GT, 1 x 6L7GT, 1 x 5Y3GT

That is all I know about this amplifier….it is rare as rocking horse shit. Don't expect to fall over one of these at the local fleamarket – less two of them…



Bjørn Kolbrek suggests this amp, also one of Joe Roberts long time favorites:

Western Electric 124A, 350B PP, (1941 ?)

Yes, this is good engineering….Excellent simple design. Only thing I regret is that they do not use the input trannie to split the phase. This is such an obvious solution, that I struggle to comprehend why they didn't do it. These amps fetch golden prices nowadays.

Nice indeed.

The end of the terrible and absurd World War II, sadly also marked the end of class A power triodes.The need for efficiency, low cost and small sizes made pentodes/tetrodes take over. Nothing wrong with the new valve technology, but the sonic qualities offered by triodes got lost as well.

The most commonly used power triodes for audio ca.1926 to 1939 was (In no particular order):

2A3
45
50
300B
RE604
RS241
AD1
PX4



PX25/DA30

High power triodes was mainly used for public address purposes, such as cinema, speech and broadcast.
211
845

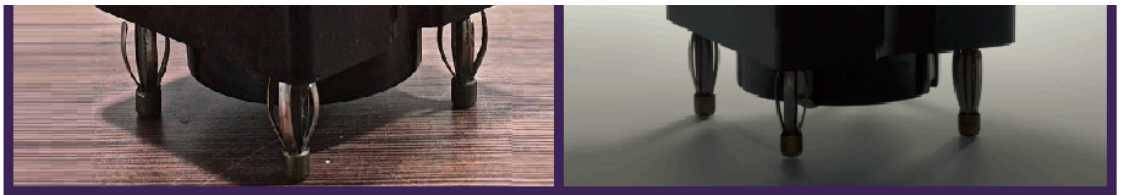




CV1025	DA 60







DA 60	DO 60

DA60

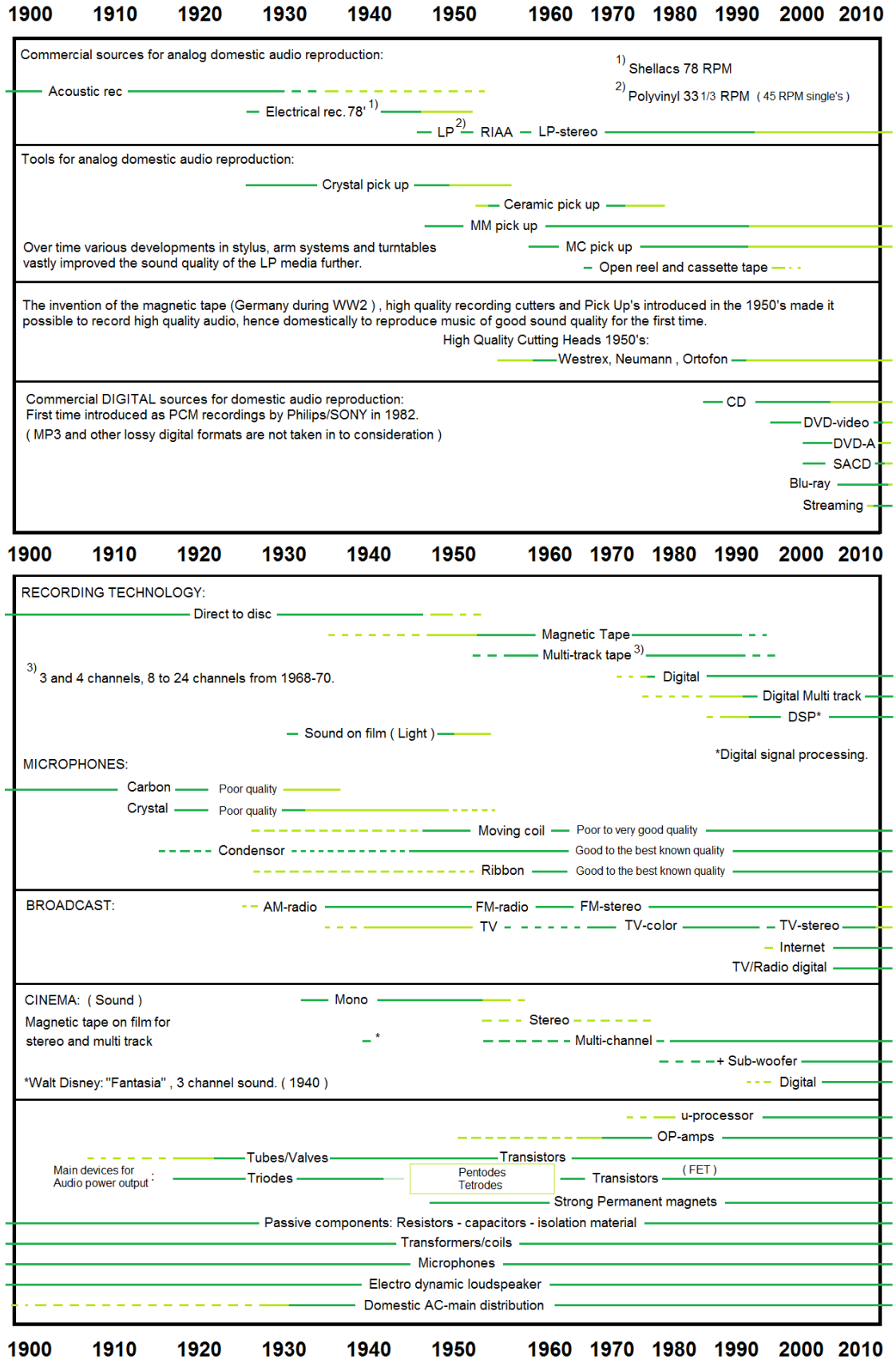

ADM PATT
3830
NT36
SER. No.
ADM PATT
3830
NT36
SER. No.
F 258 5
CV 12
B17
Sraln
Valve



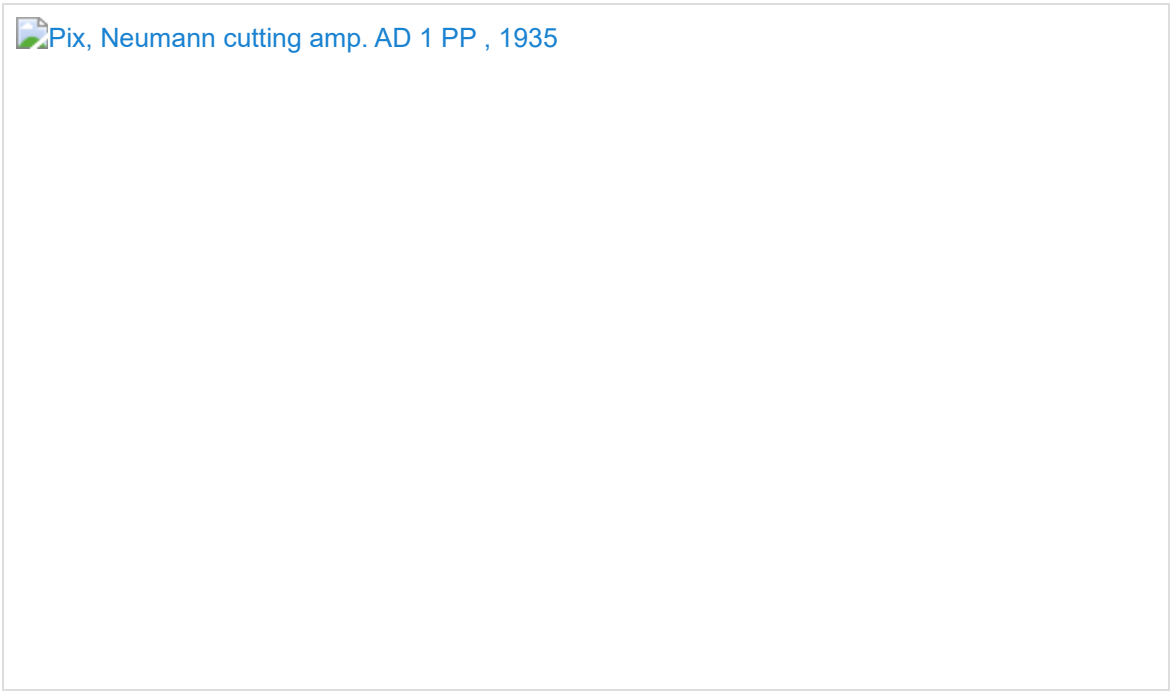
DA100
DA250
RS237

Philips held the patent for pentodes and these were widely used in Europe from the early 1930's. Most valve manufacturers in Europe produced pentodes on a license basis from Philips.
AL4, CL4, EL3, PT625 just to mention a few.

In the early 1930's Marconi Osram, UK and RCA, USA met with a plan to break the popular demand for the Philip's pentodes. Tetrodes were well known for their tendency to "kink" and other instabilities. In a close collaboration MO-valve and RCA developed a power tetrode, that compared well to the qualities of a pentode. Hence in 1936, RCA introduced the 6L6 metal and MO introduced their version the KT66. These were to become some of the most successful power tubes ever for audio. In particular the improved glass version of 6L6. 6L6G's is to this day the most commonly used power tube in electric guitar amplifiers. (seconded by the later EL34.)


1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010
Commercial sources for analog domestic audio reproduction:
1) Shellacs 78 RPM
2) Polyvinyl 33 1/3 RPM (45 RPM single's)
Acoustic rec
Electrical rec. 78' 1)
LP 2)
RIAA
LP-stereo
Tools for analog domestic audio reproduction:
Crystal pick up
Ceramic pick up
MM pick up
MC pick up
Open reel and cassette tape
Over time various developments in stylus, arm systems and turntables vastly improved the sound quality of the LP media further.
The invention of the magnetic tape (Germany during WW2) , high quality recording cutters and Pick Up's introduced in the 1950's made it possible to record high quality audio, hence domestically to reproduce music of good sound quality for the first time.
High Quality Cutting Heads 1950's:
Westrex, Neumann , Ortofon
Commercial DIGITAL sources for domestic audio reproduction:
First time introduced as PCM recordings by Philips/SONY in 1982.
(MP3 and other lossy digital formats are not taken in to consideration)
CD
DVD-video
DVD-A
SACD
Blu-ray
Streaming
1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010
RECORDING TECHNOLOGY:
Direct to disc
Magnetic Tape
Multi-track tape 3)
Digital
Digital Multi track
DSP*
Sound on film (Light)
3) 3 and 4 channels, 8 to 24 channels from 1968-70.
*Digital signal processing.
MICROPHONES:
Carbon
Crystal
Poor quality
Moving coil
Poor to very good quality
Condensor
Ribbon
Good to the best known quality
BROADCAST:
AM-radio
FM-radio
FM-stereo
TV
TV-color
TV-stereo
Internet
TV/Radio digital
CINEMA: (Sound)
Magnetic tape on film for stereo and multi track
Mono
Stereo
Multi-channel
+ Sub-woofer
Digital
*Walt Disney: "Fantasia" , 3 channel sound. (1940)
u-processor
OP-amps
Tubes/Valves
Transistors
Main devices for Audio power output :
Triodes
Pentodes Tetrodes
Transistors (FET)
Strong Permanent magnets
Passive components: Resistors - capacitors - isolation material
Transformers/coils
Microphones
Electro dynamic loudspeaker
Domestic AC-main distribution
1900 1910 1920 1930 1940 1950 1960 1970 1980 1990 2000 2010

In the times before the 1950's there was no high quality sources available to the public for domestic use. The only recorded media for home reproduction of music was mono shellac 78's. The turntables and arm-systems were poor and the only available Pick Ups were crystal and later ceramic. None of these were good. Direct AM radio transmissions was the best chance to listen to acceptable quality, but noise, annoying distortion and a very limited freq response was the standard.



1930's Neumann , mono cutting system.

The audio quality of TV-transmissions was said to outperform the conventional AM radio.The highest quality of audio had to be experienced in the cinemas. Early audio enthusiast kept sticking to acoustic recordings way up in the 1950's. I have had the pleasure to hear a well tuned acoustic gramophone playing first generation copies of acoustic recordings and it was mind blowing. The serious downside of acoustic recordings was that only the original and first generation copies were good. Below here is a photo of the largest acoustic gramophone ever made. Unfortuneately I have never been able to hear this masterpiece in real life.



E.M. Ginn , Acoustic gramophone, 1933. Kris Walter enjoying the monster gramophone. Photo Kris Walter.

Just as many audiophiles today stick to vinyl and/or tubes, so did serious audiophiles stick to acoustic reproduction all the way up to the 1950's. Have a closer look at this "amplifierless" wonder here: http://www.radio-antiks.com/IndexRadio-Antiks_EMGinn_Expert.htm

The explosive progress in audio (And most everything else) during the 1950's was a lucky conjunction of many circumstances. The basic building blocks and technology was already at hand (Active and passive components etc.), but a major leap was necessary to develop and bring these into a condition that would allow the public to make use of these extreme expensive items and materials. High quality loudspeakers and amplifiers were developed, due to the popular cinema technology.

NOTE: I am still writing on this chapter. Here is what I have got so far:

We have to recognise that literally a "million" things had to be in place in order for this part of our culture to evolve into what it became and what it is today.

1) The distribution of power had become widespread and common in the 1950's western societies.

2) Magnetic tape.

3) High quality microphones.



The Neumann U47 microphone was developed in the late 1940's after WW2 and it was a clever result of simply using the materials "at hand". The VF14 was *not* designed for this microphone, neither was it designed specially to Neumann. It was a pentode designed for HF and was mainly used by the German military in the 1930's. The innovative little detail, apart from the brilliant condenser capsule, that made the U47 one of the best (if not *the* best) microphone at the time and for the following 20 years, was to use of the filament current to set the bias. As can be seen from the original schematic – that I have carefully restored – the current that supplies the plate/cathode circuits, also supplies the filament. In fact they are coupled in series. There is several advantages of this arrangement. Noise are highly rejected due to the common mode series

application and the higher filament current means that a resistor as low as 29Ω can be used to set the cathode bias. Such low resistor means that high gain is possible. On the other hand is this same current very low for a heater and may easily be supplied from a low noise phantom alike PSU. The VF 14 is triode coupled and the metal housing insures low EMI pick up. It is certain that Neumann would have prefered a triode with fewer elements, in order to reduce noise and “microphonics” within this valve, but no such one was available in the starvation time in the WW2 aftermath. In the 1960’s , Neumann developed a new version of the U47, this time with a modern nuvistor triode.

The U47 was one of the most used microphones for musical sound recording for many years. It was the favorite microphone of George Martin, EMI Abbey Road Studio and it was regularly used on all the Beatles recordings.

4) LP.

5) High quality cutter heads.

6) Permanent strong magnetic materials.

7) FM.

8) Vast improvements in passive components during WW2 and the following decade.

9) RIAA.

10) Stereo.

11) MM and MC pick ups.

12) Exchange of knowledge. (German patents cancelled),

New political and economical strategies:

13) Mass-production. Unions succeeded in Minimum pay agreements meaning that the public had money to spend, hence marked demand expanded, hence mass-production, hence lower prices – hence the perpetual wheel.

14) Increased consumer market due to high employment. Fiscal stimuli (“New deal” , Keynesian practice and more, not least the war itself created millions of jobs in the USA) in most western societies created new jobs(Health care, schools , enhanced infrastructure, etc.) , higher education and more money into the system. Progressive tax systems kept this circle going. (Rolled back again from the 1980’s)

15) Stable economy. Regulation of the financial sector (Glass Steagall, Bretton Wood agreements) meant reasonable stable economies for the first time in history.(Has since been

deregulated again in the 1980's)

The period after WW2 and up to the late 1950's was nevertheless very exciting because of the intelligent ingenuity and imagination. Wonderful amplifiers were made during this period and high quality reliable passive components were developed. Relatively few power tubes/valves were developed in the 1950's for audio. EL34, EL37, EL84, KT77, KT88, 6550, 7027, 8417 comes to mind. The technology of electron tubes peaked from 1958 to 1962. Nuvistors and Ceramic planar tubes were the receiving tube technology at its highest. Everybody knew, however, that it was only a matter of time before transistors would take over. Further development of electron tubes was cancelled. G.E., USA designed some ceramic tubes and Tung-Sol, USA designed a series of high current triodes in the 1960's. In Europe a few similar extremes was developed, but in time silicon solid state took over entirely.