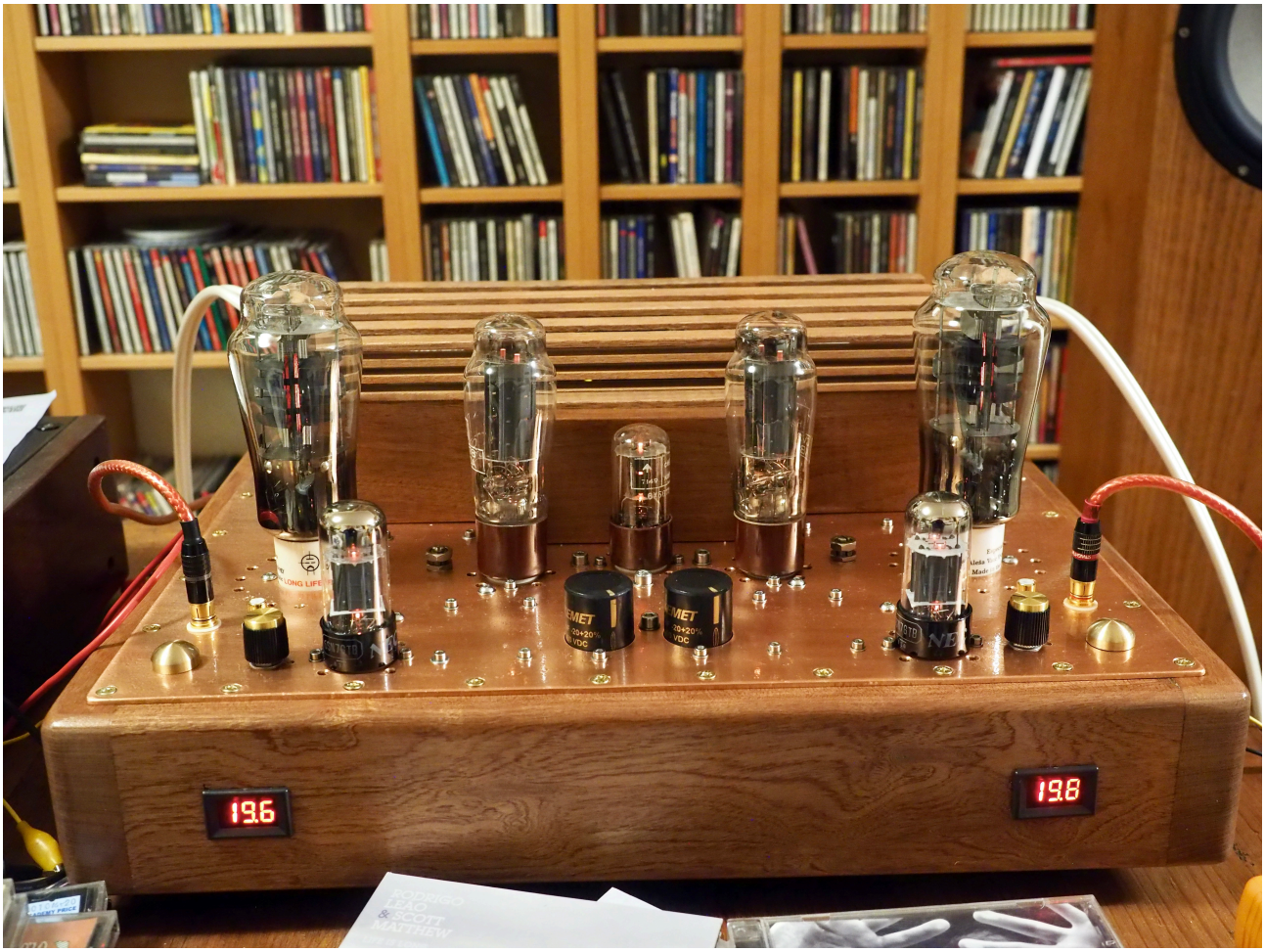
A LONG TERM PROJECT

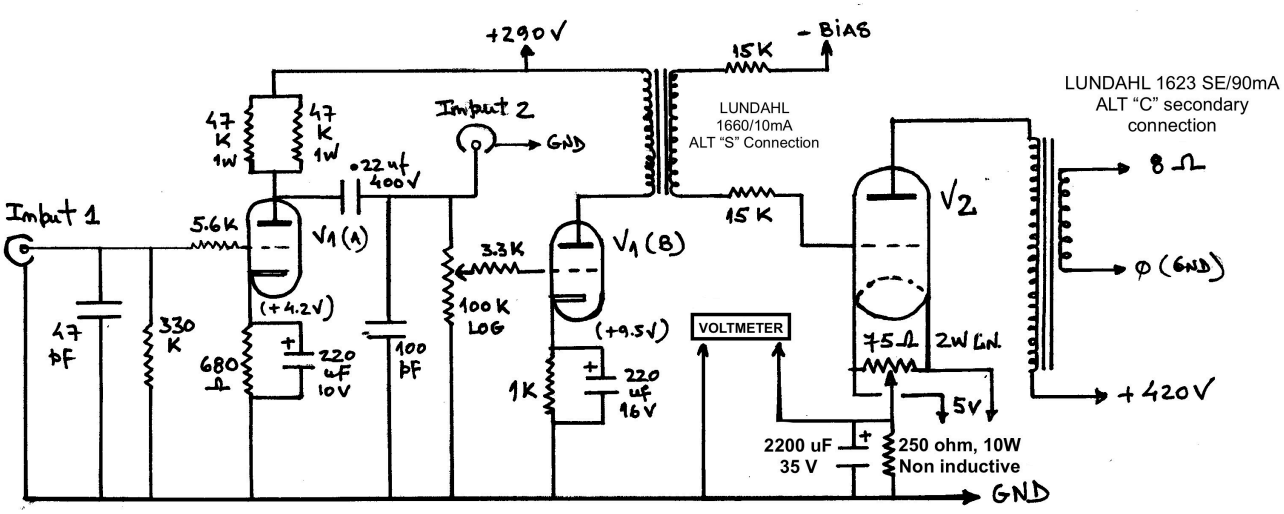


I started to build tube amplifiers in 1994. First from kits, then from scratch. I still have a few of them.
In 1999 I felt confident enough to design a Single Ended Triode (SET) of my own.
I'm neither an engineer nor even an electronics technician. I spent a working life dedicated to aviation, both as an Air Traffic Controller (7 years) and an Airline Pilot (32 years). So I don't have the knowledge to innovate in this field. However, after studying electronic basics from text books, I spent many evenings looking at dozens of different projects, mainly from the forties and fifties.
I also borrowed many ideas from geniuses like Tim de Paravicini (whom I was lucky to have met in person), who were real innovators, unlike me.
Towards the end of last century, a name caught my attention : Alesa Vaic, a young engineer from easter Europe who designed and produced some interesting directly heated triodes. One of them had the specs I was looking for my output stage : the AV 302B, a kind of 300B with steroids (50W of power dissipation vs. 40W) and slightly lower RP (550 vs 700 ohms). I wanted to obtain a power output of about 12W which, given the "poor" ratio of roughly 3 to 1 of triodes, can be attained with circa 36W plate dissipation. Dangerously close to limit for a 300B, but comfortably far with the AV.
The next "obsession" I had was to drive the output tube via an interstage transformer.
So, after some sniffing around on magazines like Glass Audio, Positive Feedback and Sound Practices (remember, internet search sources and resources were scarce 25 years ago…), I took notice of a Swedish brand for the first time, Lundahl.

I was also lucky enough to find an enthusiastic seller who helped me several times : Jac Van de Walle, a Germany based Dutch gentleman. From him I purchased the AV 302B pair of triodes and other items.
Now I must confess that I procrastinated so much on this project (in the meantime, I built and/or modified quite a few, mainly push-pull designs) that only after retirement I gathered all the guts to finish it!
On the last pages you will find the schematics of my AV 302B SET. If you don't like text descriptions, you may skip the following and go straight to them! Anyway, it's better to read my notes looking at those…

This design has 2 inputs, both unbalanced: the first one with a sensivity of around 0,4 V for full power, while using the second we'll need about 6 V for the same result. I wanted a specific input, able to drive this amplifier up to speaker connectors without having the signal travelling through any capacitor. The second input bypasses the first half of a 6SN7GT double triode, producing a gain close to the theoretical figure of this beloved tube (20), as its plate is directly coupled to the primary of a Lundahl LL1660 interstage transformer.
So, when using this second input, there are 2 options : either listen at a not to high sound pressure (depending also of the efficiency of the loudspeakers…) if driving it directly from a (CD) player **or** use a pre-amplifier. I can assure you that in a medium sized room (30 square meters) with medium-low sensivity speakers (Harbeth C7's or HL-5's) the volume pot doesn't travel past 3/4 of its whole range, most of the time, when using this input.
Most amplifiers have the volume pot at the very front end of the (single) input, being its main impedance setter. But then using input # 2 would mean denying volume control, unless using a pre-amplifier…
So I borrowed from Audionote (see their Kit 1 design) the idea of locating the pot between stages. When using high gain valves (small pentodes, 12AX7/ECC83, etc) in the front, this will most likely result on unacceptable levels of distortion in this first stage, because those tubes are typically biased 1 volt from grid to cathode, so a 2 volt input will drive them to cutoff! But these 6SN7's are biased at 4.2 V, so a 2 V input cannot upset them…
The Lundahl interstages were ordered with airgaps optimised for a primary current of 10 mA. So, for the second stage, I elected to use a 1 KOhm cathode resistor for bias which, for a plate/cathode voltage of 275V, let 9,5 mA pass through the second half of the 6SN7 (biasing it -9,5V, of course).
The interstages produce a very small gain of 1,125 and Lundahl advises that they are designed for an optimum secondary impedance of 14 KOhm . I empirically used a resistor of 15 Kohm on each side of secondary with good (listening) results.
The low value capacitors (47 and 100 pF) in parallel with both inputs serve as "depurators" of (radio) high frequency, well above audio band.
Most of the amplifiers I built use (cathode) self bias on the power tubes. This has several advantages, but also some disadvantages. The same can be said about (grid) manual bias.
But if we use BOTH we can have the advantages of the 2, counteracting their disadvantages, besides more electric complexity, of course!
In fact, I like the idea of having a "brake" limiting the possibility of overcurrent. But having the extra power manual bias gives is also welcome! And manual bias also gives me the possibility of "playing" with the sound, as more of less current across the AV's can be chosen. With cathode bias alone, that would mean de-soldering and re-soldering resistors of different values, which is not practical!
So these output tubes are biased about 1/4 by means of non inductive 12W Mills 249 Ohm wirewound resistors, bypassed by 2200uF capacitors. The other 3/4 of biasing is obtained by a 20 KOhm linear 1 W multiturn pot for each output tube : an expensive item

(about 25 € each) but previous experience makes me positively advise NOT to use cheaper and smaller units…
These pots trim the converted (negative) DC voltage (130 V) from a pair of 1500 uF caps (!) into a 100 uF one, which act as an "independent stabilizer" for each tube grill. These are therefore connected to the interstage primary (via the previously mentioned 15K resistor). I used three 33 uF instead of one 100 uF because I had stocked several Black Gates of that value and had no other use for them!
The 300B tube has a plate impedance of 700 Ohm. The AV 302B has 550. But these were measured with relatively low plate voltage and high current. When you increase plate voltage and decrease its current, the impedance value increases. I first planned to use OTP transformers from Audionote having 2.3 Kohm primary impedance and optimum 110mA of current (they were designed for parallel SE of 6550 tetrodes). But recently I abandoned this idea and ordered a pair of Lundahl 1623 with air gaps set for 90mA primary current in SE. With their secondaries tied as per "C" alternative, they offer 3KOhm of primary impedance (assuming a 8 Ohm speaker connected to secondary). I chose this value as the optimum one.
All Lundahl transformers I've used were very well built (C-Core) units, at reasonable prices (for these 1923's I paid about 500 € a pair). On the other hand, they look quite "industrial", so if you ever plan to use them either hide them under the chassis or cover them.
Conclusion: if not for self-added complexity (dual inputs, dual bias), the audio circuit is simplicity itself, as usual in a SE.



Resistors are 1/2 W unless marked differently

V1 - 6SN7GT

V2 - AV 302B

300B tube can be used. If so, set bias not to exceed 80 mA of plate current (20 V on the voltmeter)

Audio Circuit Schematic (one channel shown).
For Power Supply, please see next page

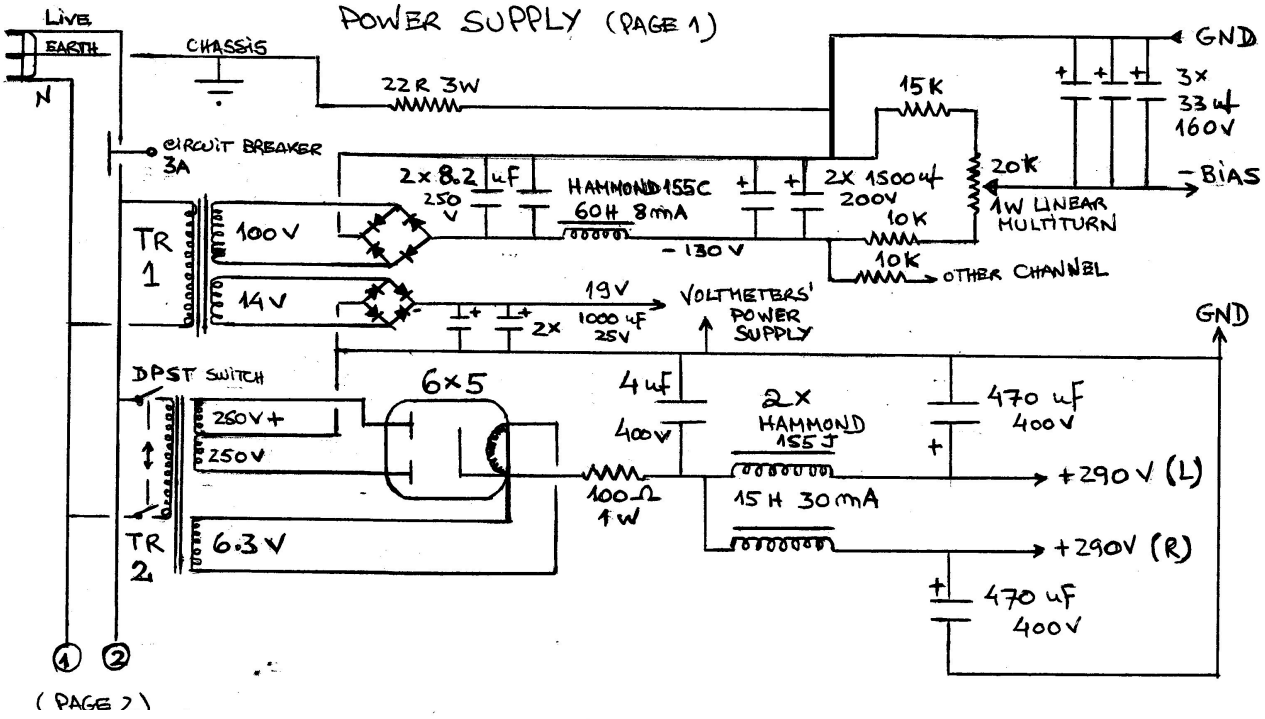
AV302 SET transformer driven amplifier.
Design by Pedro J M L R Cadete, 1999.

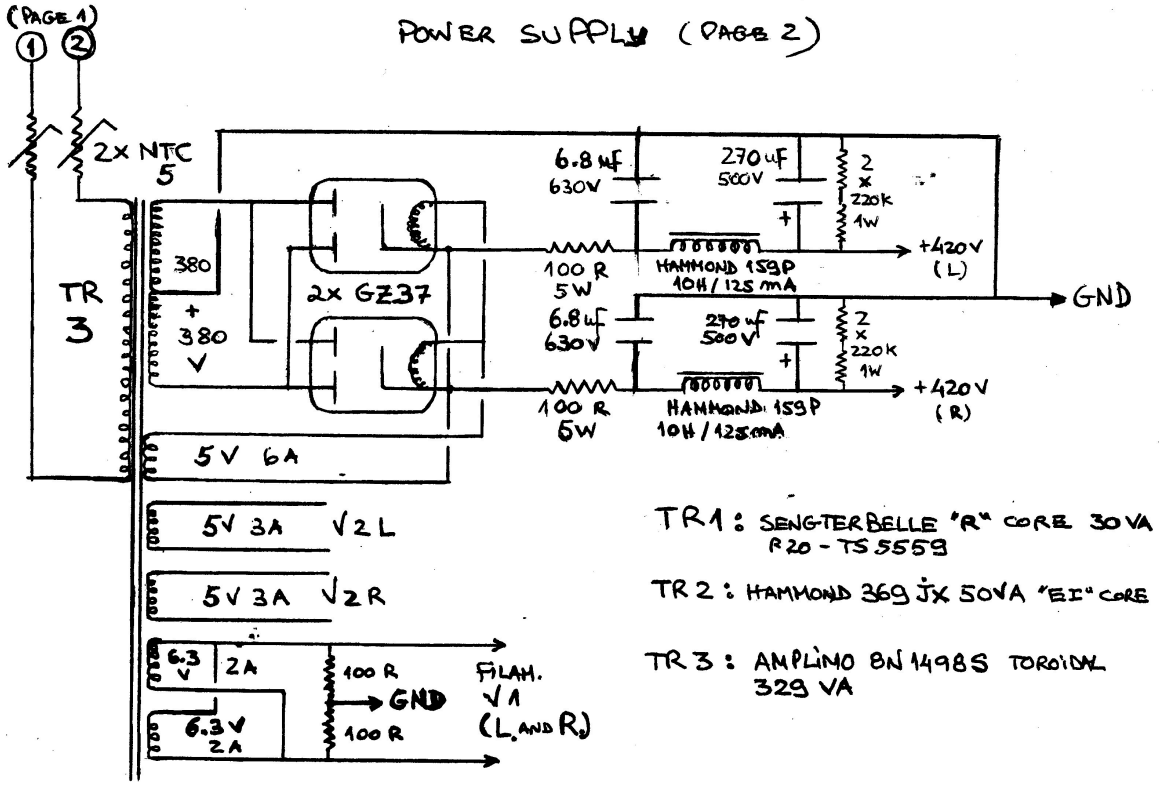
The Power Supply (PS), however, is more elaborate!
I must confess I'm a PS freak! I truly believe an amplifier is as good as its PS…
Almost all amplifiers I built which were not my designs had their PS heavily modified, for the sake of (less distorted) power. May they have 1 or 100 Watts, they must sound effortless at various listening levels. I have a SE producing 3 Watts per channel (from 2A3 tubes) which drives my Harbeths faultlessly!
As you probably know, the most easy load for a given PS is a Class A push-pull output stage, because the current drawn is nearly constant. This is NOT the case with a Single Ended.
On the other hand, I have some beautiful (in looks and function) GZ 37 rectifier tubes I wanted to use in this project. The GZ37, besides its toughness and reliability, was designed for low values of capacitance (the specs mention 4 mF!!), so I had to find a combination which could fulfil my needs, such as a) low ripple, b) correct voltage, and c) adequate power bank.
So, the secondary (380 + 380 VAC) is directly tied in parallel to the 4 plates of 2 GZ37's. The resulting undulating DC from each cathode is then connected to a 6.8 mF/630V Polypropylene capacitor through a 100 Ohm 7W resistor (which acts both as current limiter and voltage adjuster) . It then travels through a 10 Henry Choke before "meeting" a 270 mF /500 V electrolytic capacitor and, next, the PS side of each OTP primary. A bleeder resistor of 440 KOhm (twin in-series 220K, to be more precise) across this later cap allows the resulting 420V to discharge in 5 minutes (instead of 20, if no bleeders are installed) after switch-off.
At this point, let me make a pause for the usual warning: these amplifiers use LETHAL voltages. Don't try to build any unless you know how to avoid to be killed by them! When measuring voltages inside any (valve) amplifier, I previously clip the black probe of my multimeters to ground so I can measure with a single (red) probe (on gloved hand), keeping the other hand inside one of my trouser's back pocket. And don't forget to ensure yourself that ALL HT capacitors have discharged to safe levels (less than 20 V) before attempting to work inside the amplifier!
And please also remember: no matter how anxious you are to check and play your new "toy", after many hours of work, don't rush. Excellence and hurry do NOT mix!

There is a second HT, dedicated to the 6SN7's : another transformer feeds a 6X5 rectifier with 250 + 250 VAC (and 6.3VAC for its filament, of course…). Then another "Pi" filter follows (through another 100 Ohm 7W resistor) : 4 mF/400V cap and, for each channel, a 15 Henry choke and a 470 mF/ 400 V capacitor. As you may guess, the principle is the same : low capacitance/ choke / massive capacitance. It has always worked very well in many of my projects…

There is a third ("R core") transformer I purchased from AliExpress, an inexpensive 30 VA unit which works very well, so far. It gives me 100 VAC for the bias (negative) voltage and 14 V which, after rectified and smoothed, turn into about -130 and +19 VDC, respectively, the later used to power both voltmeters.
These 2 indicators which can be seen shining on the front wooden chassis panel, show a value which is actually 1/4 of the current across each output tube, as they are connected to both ends of the 250 Ohm (cathode) resistors. So, the voltage shown is, quite accurately (as these voltmeters are high resistance ones), 1/4 of the plate current in miliamperes. Ex: 20 V means 80 mA of plate current. I just have to turn the bias pots to set this value.

By the way, these voltmeters **must** be of high impedance as they work in parallel with the power tubes' cathode resistors. Most ancient, passive types, fail to meet this requirement…
I tried several settings (each time current increases, plate voltage decreases slightly, which is normal) and ended up with 420V and 80 mA, which I found to be a good compromise between sound quality and tube lifetime (triodes tend to sound better with more current across them but, of course, their lifetime will be shorter…). We must subtract the 20 cathode positive volts from those 420 to obtain a true plate-cathode voltage of 400 VDC. So each output valve is dissipating 80 mA times 400 V = 32 Watts.
This will allow it to output about 10 Watts of musical heaven (I don't have any distortion measuring equipment, I judge my amplifiers by ear…).





Do they sound “soft”? I don’t think (ear) so.
They sound soft when the music is soft, but can play “hard” too.
One of the tracks I use to check if a PSU is feeding (mainly the output stage) adequately is the “Liberty Fanfare” (which, by the way, was composed for the Statue of Liberty 100th birthday, in 1984), from the CD “Winds of War and Peace” (Wilson Audio WCD-8823). The dynamics of this recording can leave you breathless (and damage your loudspeakers if playing too loud…). The AV302B SE passed this test faultless! The only feature, I confess, which scored less than expected was image height: I was expecting more standing and less sitting performers in my recordings…
But I still have to try them with sensitive speakers to form a definite conclusion…
All the metal and woodwork was done by me: the chassis is from solid, 35mm thick mahogany, and the top plate is solid 2 mm thick copper, polished and coated twice with clear 2 component poly varnish on top side.
I avoid ground loops at all cost. The “return” paths converge into a point, located near the mains earth connection tothe chassis, and “drops” into it via a 22 ohm resistor.
The 302B’s filaments are fed via AC. A 75 ohm WW 2W linear pot balances current on both sides of the filament. The result of careful ground connections and these balancing pots is an almost absolute absence of hum. I have to take my head about 10 cm from the speakers, in total silence, to hear any…
The last photo shows a messy, far from finished circuit, still under construction!…