8 The super-pentode / super-triode amplifier SPT-70

The SPT-70 arose out of a challenge, as I will explain below. After that, the audio part of this amplifier will be explained in detail. The pre-amplifier/phase splitter and the driving stage are DC-coupled. The first decoupling capacitors are situated just before the power valves. The possible setups for this amplifier vary from ‘normal’ pentode to ‘super’ triode. The idling current of the valves automatically adjusts itselve to the correct value. The power supply will be slightly touched upon, but is largely left to the reader.

8.1 The story of the challenge

The introduction of my Vanderveen-toroidal-transformers in Holland was received with some scepticism and that was not much different in America and Canada… I did receive some invites for demonstrations from manufacturers of valve amplifiers, but when it came to ordering they did not want to know. Not because of technical reasons but more for conservative reasons: after all, the EI transformer dominated the market. Nobody would be surprised that this caused frustrations, and I was searching frantically for ways to break the impasse until...

One evening I was walking in Toronto with the technical director of an amplifier manufacturer plant. We exchanged different views and insights, investigating the limits of what was technically feasible. I love these kinds of discussions and the challenge they form.

Then the director all of a sudden said: ‘All well and good, but in the end the measurements are all decisive. So, if your amplifiers and transformers can deliver better results than the one I make, then I am your man’.
Right! This was the challenge I was looking for, my chance was within reach. Once back in my lab in the Netherlands I decided to accept the challenge. I devoted a full year to the development of a new amplifier. This entailed many trips across the ocean, with various proto types securely packed in the hold of the aer-

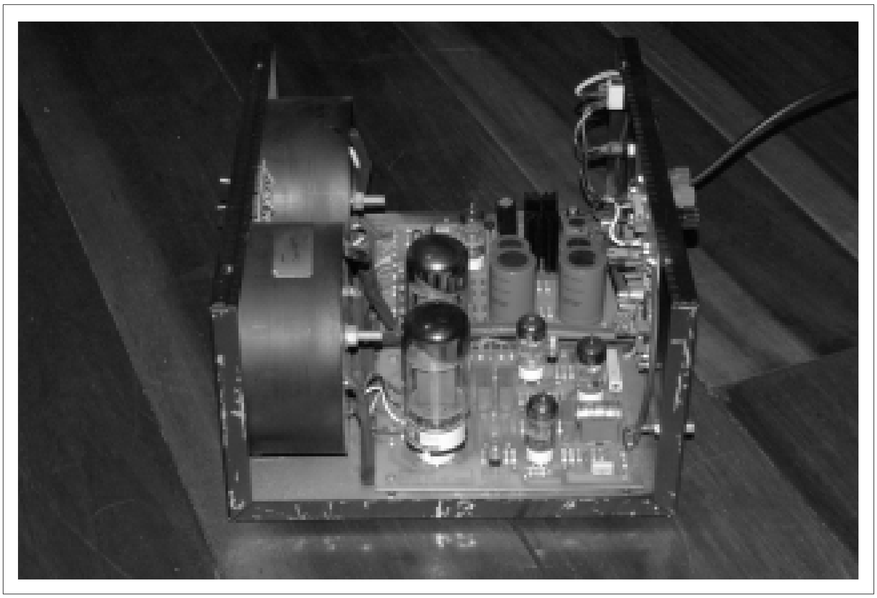
oplane. After a year the development was finished, the amplifier sounded fantastic and the victory was close!

Once in the manufacturer plant, the amplifier ended up on the test bed. The measuring results were indeed fantastic and completely convincing. Later that week there was a delicious dinner, which was finished off with a listening session, whereby both our amplifiers were alternately connected. There was a huge difference: real valves versus transistors.

Both the amplifiers delivered a completely 'clean' signal, both had the same damping factors and a similar frequency range. Yet my amplifier sounded completely different to his transistor amplifier. The next day the moment arrived for the long awaited discussion with the management board. This was surprisingly short and concluded with: 'We are of the opinion that valve amplifiers do not fit into our current production…'.

I had passed, but was rejected. I had the better test results and yet no deal. I withdrew myself from the world for two days in my hotel room and subsequently picked up the thread of my existence.

A half year later, I noticed for myself that I had not let go of the design. I decided for pure enjoyment, without the hope of a take up by a manufacturer and without the push for ever better results, to reconstruct the amplifier one more time. Some details of the design could still be improved upon. It was after I had build the final version of the SPT-70 that I really could let go of this design. It is this final incarnation of this amplifier that I want to discuss in this chapter.



8.2 The input pre-amplifier and the phase splitter B5

Figure 8.2.1 shows the complete schematic of the audio part of the SPT-70. At the far right (the not drawn) output transformer is connected. There are some connection points for the various power supplies, to which I will return later. I start at the far left, the input of the first pre-amplifier valve B5.

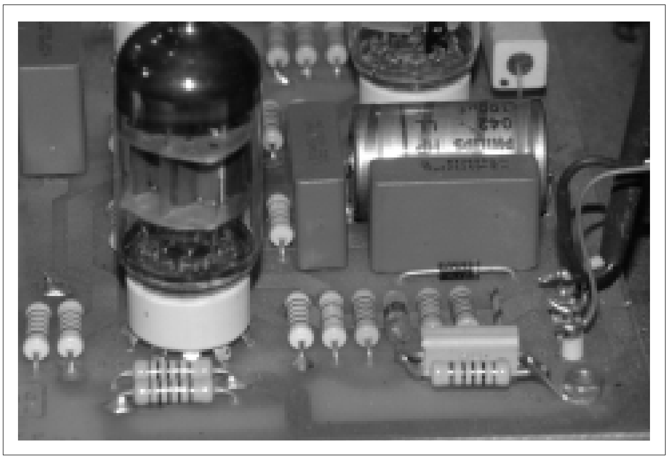
Directly after the audio input you will find C101 blocking any DC voltages of the signal source. In the schematic, in order to void as much degradation of the signal as possible, this capacitor has been bridged.

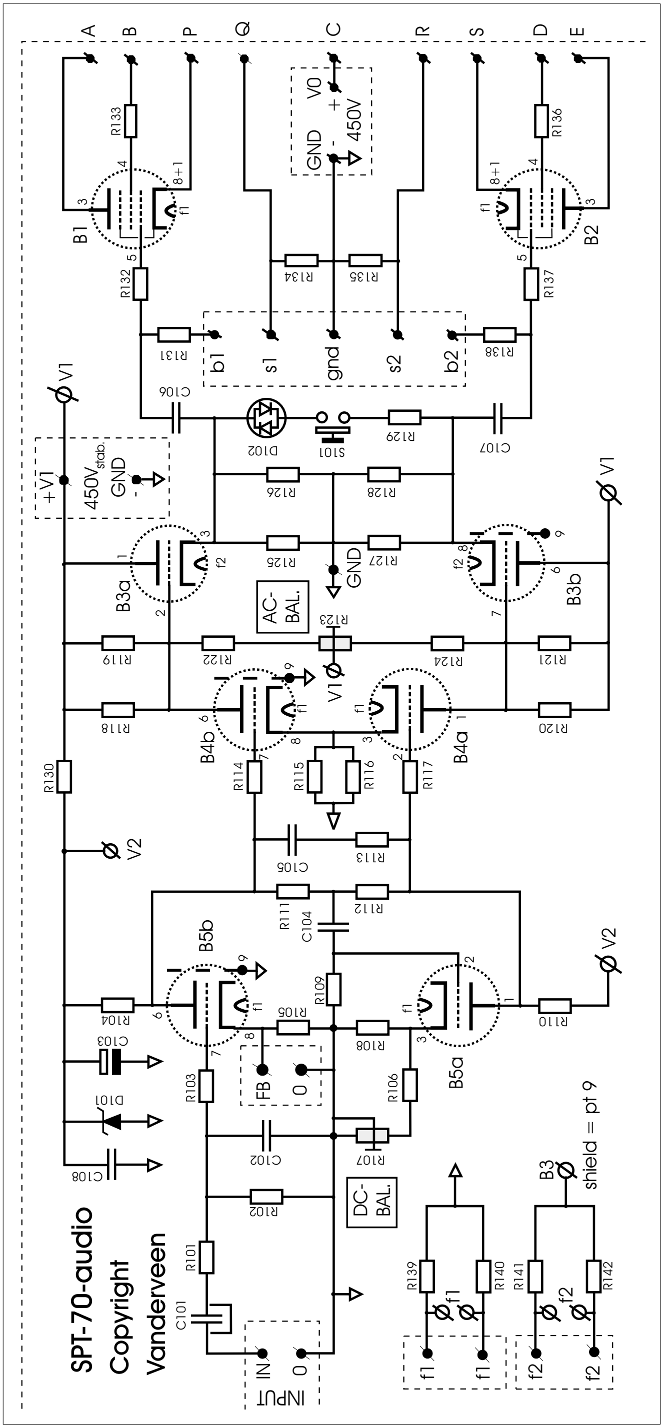
R101 and C102 form a low pass filter (LPF) that blocks high frequency interference from radios, TV, and cell/mobile phones. The –3 dB low pass frequency of this filter is at 160 kHz.

After that the signal flows through R103, which in combination with the internal Miller capacitance of valve section B5b, forms an additional low pass filter. This double filtering ensures that the input stage of this amplifier has been protected enough against the above-mentioned interferences.

Resistor R102 determines the input impedance of the amplifier. The value is not very important; 47 kΩ (instead of the 100 kΩ mentioned in the parts list) is also very acceptable. What is important is that the source of the signal is not too heavily loaded, therefore choose the value of R102 not too low. If you choose, for instance, R102 to be 470 kΩ, then the amplifier becomes very susceptible to hum when no signal has been connected to the input.

The first pre-amplification happens in valve section B5b (ECC88). The supply voltage is low: V2 = 100 V. This voltage over zener diode D101 and any noise generated by the diode will be made harmless by the capacitors C103 and C108.





⇧ ***Figure 8.2.1*** *The audio part of the SPT-70.*

The cathode resistor R105 has not been bypassed with an electrolytic capacitor. An advantage of such a capacitor was that the effective internal resistance of valve B5b would have been reduced, which would have given an extra large frequency range. The total concept of this amplifier is to apply at the first stages DC-coupling only and then the use of an electrolytic capacitor has been ruled out. In this case, it is also important that possible negative feedback (which I decided not to do in the end) can be connected directly to R105, without the possibility that a possible capacitor would make the negative feedback frequency dependent.

The value of the anode resistor is 10 kΩ; we may call this remarkably low. The reasons for this low value are: a proportionally large current (4 mA) through valve section B5b for a good linearity, plus a low impedance in order to effect the highest possible frequency range. The anode of valve section B5b has been set to 60 (±2) V. The exact value of this voltage is important in order to accomplish a good functioning of the next DC-coupled amplifier stage.

The effective output impedance at the anode of B5b is $(R_a + \mu \cdot R105)//R104$. Here R_a, is the effective internal resistance (4k7) of the ECC88, while μ is 30. The effective output impedance equals 5.6 kΩ. This value, in order to calculate the values of R113 and C105 later on, is needed if one wishes apply negative feedback. The signal amplification is ten times, calculated from the input to the anode of B5b.

Valve section B5a has been set up in the same way as valve section B5b, but here the amplification is determined by the ratio of the resistors R112 and R111. The total amplification factor should be exactly –1 times, so one would expect both the resistors R111 and R112 to be of equal value. This, however, is not the case (R112 is thus somewhat larger), and the reason for this is that the amplification of valve B5a is not infinite but is only ten times. The formulae of this 'ideal' si-

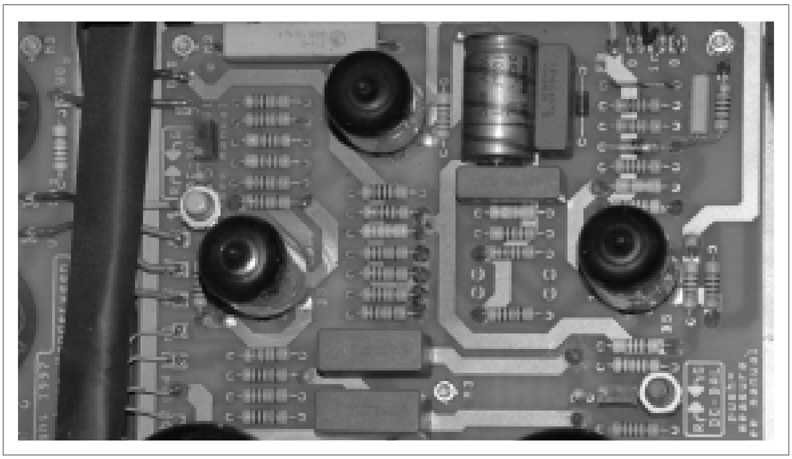
tuation should therefore be adjusted, with the result that R112 is slightly larger than R111.

At the valve B5's cathodes, something special happens. The cathode resistor of valve section B5b is R105, while the cathode resistor of valve section B5a has been made up of resistor R108, paralleled by the series resistors R106 and the ten-turn trim pot R107. Through this, the value of the cathode resistor of valve section B5a can be altered to some degree, ensuring that the DC anode voltages of B5b and B5a can be made equal by adjusting R107. Surely, the whole of the driving stage is DC-coupled, thus any differences in the anode DC voltages will also be amplified, and, that is not really desired.

If we look at the output of the driving stage (the cathodes B3a and B3b), we find there a two coloured LED D102 in series with resistor R129 and pushbutton switch S101. Suppose the anodes of B5a and B5b are not receiving an equal DC-voltage, then both the cathodes of B3 will have a different DC-voltage. Press the push-button and the LED lights up. Only if R107 has been adjusted properly will the LED not come on (red or green), and thus the DC-setup of the whole of the driving stage is symmetrical.

The DC equalisation can be easily made automatic by measuring the cathode voltages of B3 with the aid of an IC (switched as a differential amplifier). I did try this and it worked fine, but such a setup always has a certain reaction/delay time, whereby the DC-character of the circuit is negatively influenced. It is easier to adjust with R107 and it therefore works better.

But, C104 then? Is that not DC coupling? Indeed it is, but the corner frequency of this network formed by R109 (470 kΩ) and C104 (220 nF) is 1.5 Hz. If you then consider the feedback caused by R111 and R112 then the corner frequency will reduce even further to 0.15 Hz. It is only then, with this extremely low frequency, that an asymmetry can occur at the output of the phase splitter. This asymmetry, however, is disposed of in B4 by means of a common cathode resistor.



C105 and R113 limit the frequency range of both the pre-amplifier and the phase splitter. This is only needed if negative feedback has been applied from the output to R105. If no negative feedback has been applied both C105 and R113 should be left out.

How should C105 and R113 be dimensioned if negative feedback has been applied? In that case the frequency range of B5 should be limited because the output transformer will, at very high frequency, shift the phase to (finally) 180°. Then negative feedback changes into positive feedback and the amplifier turns into a high frequency oscillator. This problem is resolved with the aid of C105 by reducing the high frequency amplification of B5; the overall amplification from the input to the output becomes less than one. Chapter 5 of this book deals with the relevant background theory. I will limit myself to just one example. Suppose you wish to reduce the bandwidth of B5 to 20 kHz (lower, however, I do not recommend). Then C105, together with the internal resistances of B5a and B5b, form a first order filter. The internal resistance for B5b is 5k6 and for B5a is 700 Ω. These resistors are in series, which in their turn are paralleled by R111 and R112, so that the total output impedance of the amplification section around B5 becomes, 5k9. This 5k9 plus C105 should give a –3 dB frequency of 20 kHz. C105 should therefore be equal to 1n35 (use 1n2 or 1n5). The output transformer reaches its –3 dB point only at 200 kHz and then the influence of C105 must be disposed of in order to avoid the phase shift happening. This 200 kHz, plus the 1n34 gives then: R113 = 594 Ω (fit either 560 or 680 Ω).

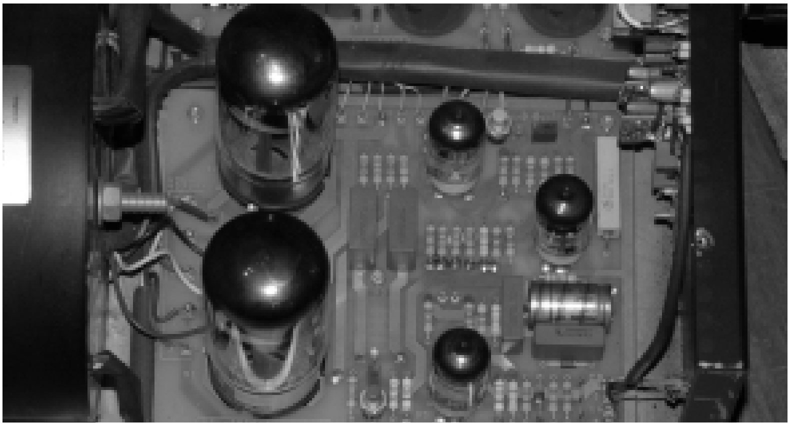
8.3 The pre-amplifier B4 and the cathode follower B3

It is of great importance that the supply voltage V1 is stabilised at 450 V for this part of the driving stage. Because the whole of the circuit is DC-coupled, the driving stage is very sensitive for fluctuation in the supply voltage. In paragraph 8.8, I will explain how I stabilised V1 in a practical way.

Both the valve sections B4a and B4b form a differential amplifier with a common cathode resistor (R115 parallel with R116). The voltage on the cathodes (pins 3 and 8) is 64 V (anode voltage B5a/b plus 4 V). This means that per valve section in B4a and B4b the anode current equals 64 V divided by R115/R116 divided by two: $I_a = 5.87$ mA.

The anode resistors of B4a/b are made out of different resistors. If we look at the top valve B4b, the anode resistor is formed by R118/R119//(R122 plus half R123). The effective anode resistor R_a is then 29k5. For the anode voltages for B4a and B4b, $V_a = 450 - I_a \cdot R_a = 277$ V.

Do not under estimate the importance of these calculations and setup points, because these are determined for the maximum alternating voltage that can be



delivered by the driving stage; these voltages should be sufficiently large in connection with the special setup of the power valves.

In order to avoid the printed circuit below the resistors becoming too hot I deliberately spread the heat of the resistors by creating series and parallel setups. In addition, I did want to limit the current through R123 as much as possible; trim potentiometers do not like current all that much.

With the aid of R123 the amplification factor of B4a and B4b can be made equal, so that both the anodes deliver an equally large alternating voltage (although in opposite phase). R123 (a ten turn trim pot) does influence the DC-adjustment of B4a and B4b. When first tuning the amplifier R107 must be set as correctly as possible first, and then R123 must be adjusted in order to fine-tune the AC-balance.

For this a 100 Hz square wave signal can be used, or one can use a distortion meter by setting the harmonic distortion to the least amount, or one can add the signals of the cathode resistor together, listen and adjust to the minimum difference signal, or… Once the setup has been completed, one should re-adjust R107 once again so that the voltages on the cathodes of B3a and B3b are exactly equal.

In the schematic, after B4a/b you will find the cathode follower B3. This is done because the low ohmic driving of the power valves delivers a large frequency range. As before, in order to spread the heat production, the effective cathode resistance has been split over several resistors. The voltage over the cathodes is $277 + 4 = 281 \pm 5$ V.

A remark should be made about this last value. The cathodes of B3 are set on 281 V and thus the filament of B3 should therefore be set at the same voltage potential. Valve B3, therefore, has a separate filament voltage f2. In the schematic of the power supply you can refer back to this part, whereby R225 (100k) and R226 (220k) divert a voltage of 309 V out of V1. The filament of B3, therefore, has a voltage potential of 309 V, which is slightly higher than the cathode voltage of 281 V. It is favourable to give the filament a slightly higher voltage than the cathode, as possible interference between the cathode and the filament will be reduced.

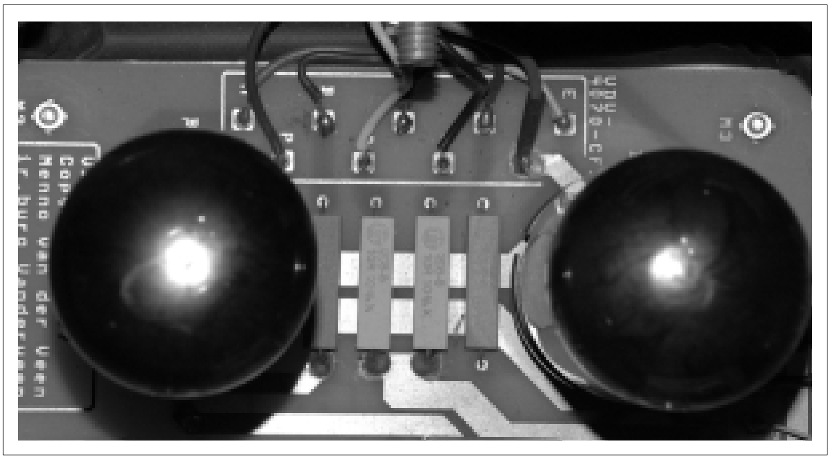
In valve B3 there is also a shield present which is connected to pin 9. Via R141 and R142, the potential of this screen is also set to 309 V in order to avoid any voltage transfer within the valve. The filaments of the other valves receive their voltage supply out of f1 and the filaments are grounded via R139 and R140 (see left below in figure 8.2.1).

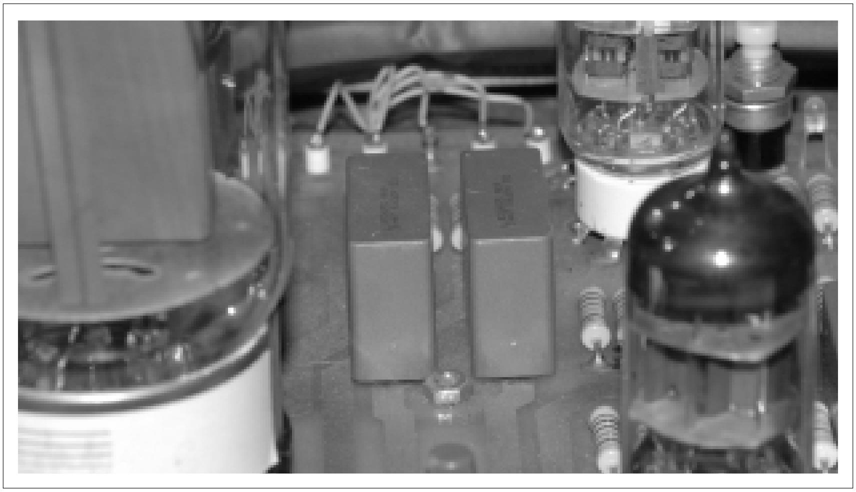
8.4 The measurement values of the driving stage

From the input (the control grid of valve section B5b) to the unloaded output (B1 and B2 are not connected) of the driving stage (the cathodes of B3) a couple of important measurement values have been determined. The amplification factor A from the control grid of B5b (the input filter R101, plus C102 are thus circumvented) to one of the cathodes of B3 is 345.

At an output voltage of 8 V_{pp} on both the cathodes of B3, the –3 dB frequency range is 248 kHz, while at 80 V_{pp} this is 240 kHz. Thusthe driver signal to the power valves has hardly any influence on the frequency range.

The maximum alternating voltage on both the cathodes of B3 is 280 V_{pp} to the limit when clipping occurs. This is a large voltage, which is certainly needed: in the super-triode and super-pentode configurations, extra large voltages are needed on the control grids of the power valves. Besides that, during the development of the driver stage, I built in a margin of 6 dB (a factor of 2) so that with any





possible overdrive, the power valves first are overdriven and after that, the driving stage starts to clip. This 6 dB margin is applied in many valve amplifiers and is seen as one of the reasons why, in overdrive, valve amplifiers still sound friendly (*soft clipping*, only of the power valves).

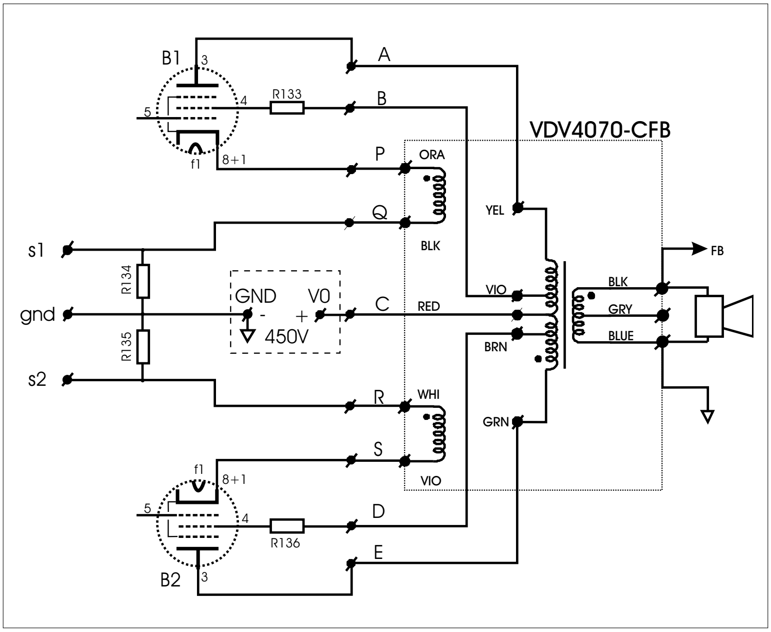
8.5 The power valves and the output transformer

For the power valves B1 and B2, very sturdy and reliable valves of the type 6550WA have been used. This is where you see, for the first time in this amplifier, two capacitors (C106 and C107) in the signal path. Only use high quality capacitors for this like, for instance, polypropylene or silver-oil capacitors. You can see on the photo that I fitted polypropylene capacitors.

Via R131 and R135, the control grids receive from the connection points b1 and b2 the negative pre-voltage that determines the operating points of the power valves (see later for a bit more about this). After that the 'famous' oscillation stoppers R132 and R137 in combination with the internal Miller capacitances limit the bandwidth somewhat.

R134 and R135 are the cathode resistors. The idling current through the power valves drop a voltage over these resistors that via the contact points s1 and s2 (the s stand for sensing) can be measured; with the aid of these voltages the negative voltage (b1 and b2) can be adjusted. R133 and R136 are connected to the screen grids to avoid that the screen grid currents become too large. These contact points are, in fact, the connection points for the output transformer. This output transformer can be connected in different ways to the power valves. See chapter 3 and 9 for the details and the underlying theory.

I want to shed some additional light on one of the connections possible, the variant I personally found to sound best: the super-triode connection. Figure 8.5.1 shows the details. As output transformer, I used the VDV4070-CFB. The anodes are connected to the points A and E the ends of the primary winding of the output transformer. The middle of the primary (connection C) gets the not stabilised, but heavily buffered, voltage of 450 V. The screen grids are connected to points B and D to the 'ultralinear' tap of the primary winding. The feedback windings for the cathodes can be found between the points P and Q (for B1), and, S and R (for B2). The schematic also gives the colour code for the connection wires of the transformer. Because the why's and the how's have been discussed in detail in chapter 3 of this book, I will refrain from delving into this matter again.



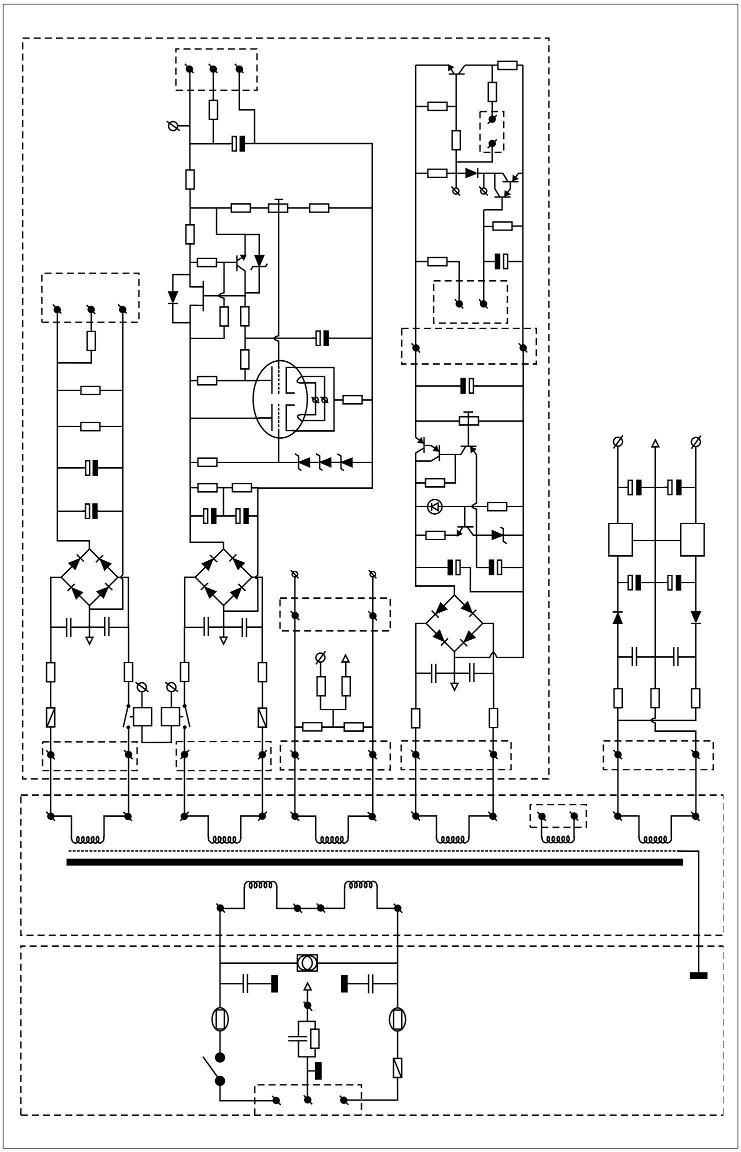
⇧ ***Figure 8.5.1*** *The super-triode connection of the output transformer.*

8.6 The power supply

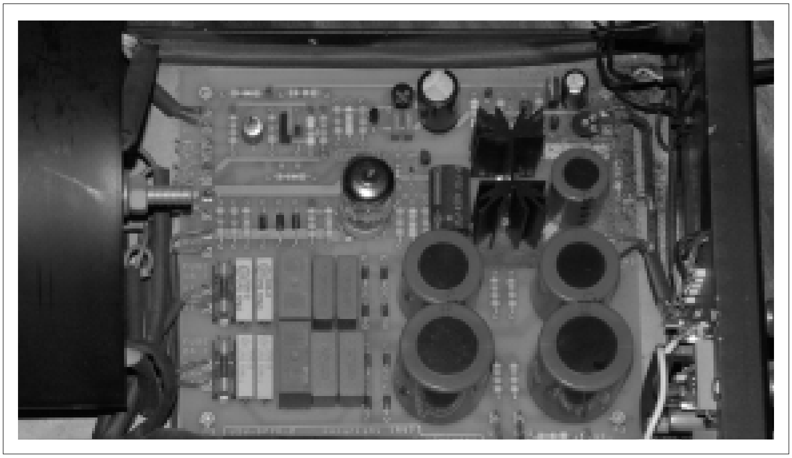
There are quite a few different supply voltages needed in this amplifier. In the first place a power supply of 450 V: this is the high voltage for the power valves. Then a stabilised power supply of 450 V for the driving stage. The negative grid voltages for the power valves will also need to come from a stabilised power supply. The filament voltages f1 and f2 (lifted to a potential voltage of 309 V) stoke the valves warm. For the control electronics (guarding and safeguarding, and so also the automatic bias of the idling current of the power valves) yet another (double) voltage supply of ±9 V is needed.

Taking all this into account a voltage supply of this calibre will be just as large and complex as the amplifier itself, as shown in the photographs where the power PCB is as large as the audio PCB of the SPT-70. This, however, cannot be avoided, as a good amplifier delivering top performance needs a top quality power supply.

The power transformer that can deliver all of these voltages is the type 7N994SPP. Figure 8.6.1 gives an overview of the power supply.



⇧ ***Figure 8.6.1*** *A bird's eye view of the power supply.*



Left, you see the primary winding (230 V or 115 V) together with the NTC's for a gentle start of the power supply, the HF decoupling capacitors, overvoltage protection and fuse, HF-decoupled ground plus the on and off switch. Not drawn is a *DC blocker* that blocks DC voltages from the mains; I assume that this is already well known and that the reader can fit this into the primary circuit.

In figure 8.6.1 the top secondary winding delivers the power for the power stage. The second winding is for the stabilised 450 V power supply. The third winding is the 6.3 V winding for f2. The fourth is the winding for the negative grid voltage. The fifth delivers the filament voltage f1. Lastly, the sixth gives the ±9V for the additional control related electronics.

All the secondary voltages come on at once when the mains switch has been turned on, except for both the high voltages. The amplifier starts in a *standby* modus; the negative grid voltage is present, the filaments have their respective voltages and the power for the additional control electronics is present too.

Only when the small standby switch has been turned on (fitted within the supply of the negative voltage), will the 450 V high voltage be turned on with the aid of relays. The manner of switching on is of great importance. The amplifier can only be switched on if the negative control grid voltage is present. This prevents the power valves from blowing themselves should the negative voltage supply somehow be defective or not present.

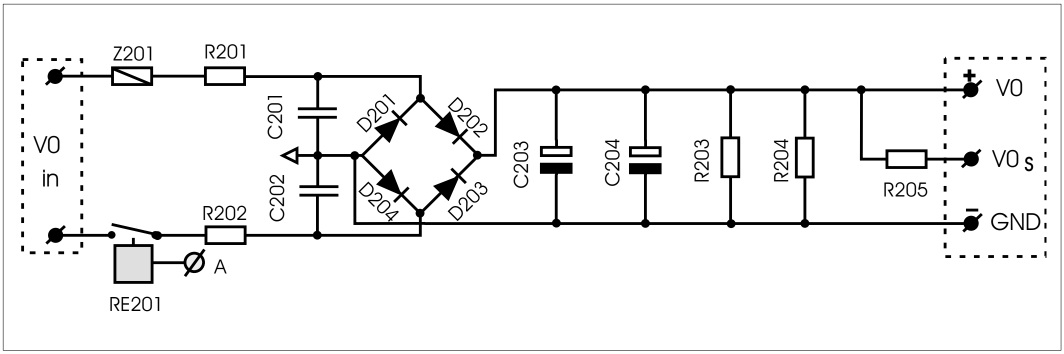
A second important condition is that the stabilised 450 V power supply for the driver stage comes up slowly, so that the driving stage can settle gently. The total start up delay is about one minute. In addition, the automatic idling current adjustment ensures that the power valves only reach their operating point after

three minutes, provided that the 450 V power supplies (and also the negative grid voltage) are present.

In conclusion, the start up procedure of this amplifier is completely automated and in every respect made to be secure. If, for instance, somewhere in the amplifier a fuse has blown, then the power supply will not start up and the failure is indicated by a red LED in the front panel. In the next paragraphs, the various power supplies will be briefly explained.

8.7 The main power supply V0 = 450 V

Figure 8.7.1 shows the main power supply for the power valves. This has a fuse Z201 and is high frequency decoupled by R201, R202, C201, and C202. Following on from that the rectification takes place, buffered by C203 and C204 with parallel bleeder resistors R203 and R204. Resistor R205 diverts a part of the high voltage ($V0_S$) to the control electronics that checks if the voltage V0 is present.



⇧ ***Figure 8.7.1*** *The main power supply in detail.*

The high voltage is switched on with relay RE201, that is in series with the relay RE202 of the stabilised power supply.

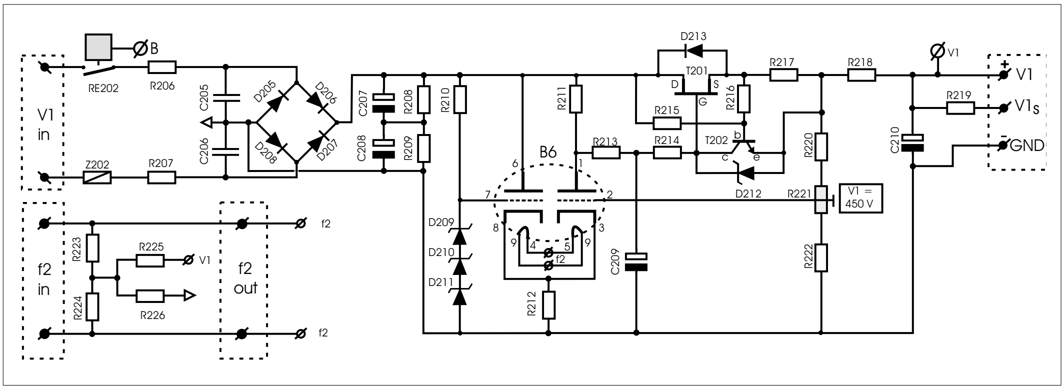
8.8 The stabilised power supply V1 and f2

The second circuit, drawn in detail in figure 8.8.1, gives the power supply V1. To the left we once again find a fuse, the relay RE202, the high frequency de-coupling, and the rectification. The buffer capacitors C207 and C208 receive a total voltage of 490 V. The stabilisation circuit uses valve B6, an ECC83, which is switched as a differential amplifier. A stabilised reference voltage of 300 V is presented to the left control grid (received via the zener diodes D209, D210, and D211), a part of the supply voltage V1 is presented to the right control for comparison (via trim pot R221). The cathode of the ECC83 is adjusted to be around 300 V, the filament voltage for this valve must be delivered by f2 (which is lifted up to 309 V).

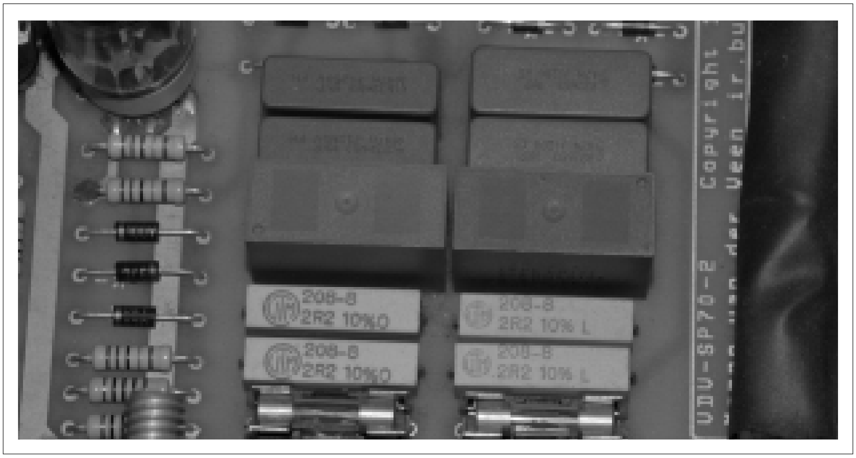
The heart of the series regulator circuit is formed by the MOSFET T201, whereby R201 prevents oscillation. There is an extra security feature present in the form of transistor T202 should there be an unexpected short-circuit of V1. The combination of R213 and C209 is remarkable, as they will cause a ‘slow start’ of the voltage V1. C209 a very low leakage current type. Any output noise will be removed by R218 and C210.

R219 is again a sensor resistor for the control electronics, measuring if V1 is present or not. V1 is set to 450 V by trim pot R221. You should apply patience when adjusting this voltage as the circuit will react slowly.

The third secondary winding gives an alternating voltage of 6.3 V, which, in its entirety, needs to be lifted up to the 309 V potential. R225 and R226 are responsible for this, once again see figure 8.8.1.



⇧ ***Figure 8.8.1*** *The stabilised power supply V1 with f2 at 309 V potential.*

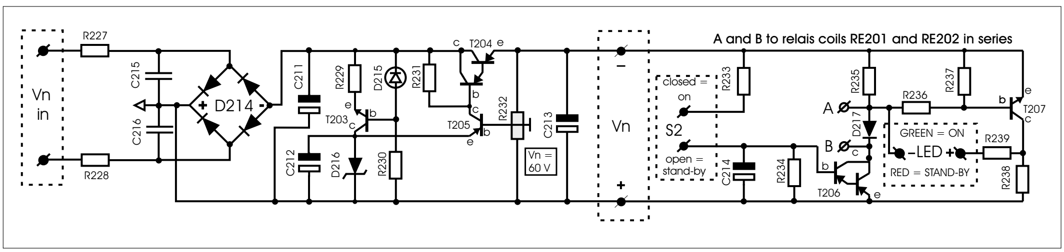


Please note that the lifting up of the filament voltage runs synchronous with the slow start of V1. This will prevent a too large voltage difference between the filament and the cathode of valve B3 of the driving stage when the amplifier is started up.

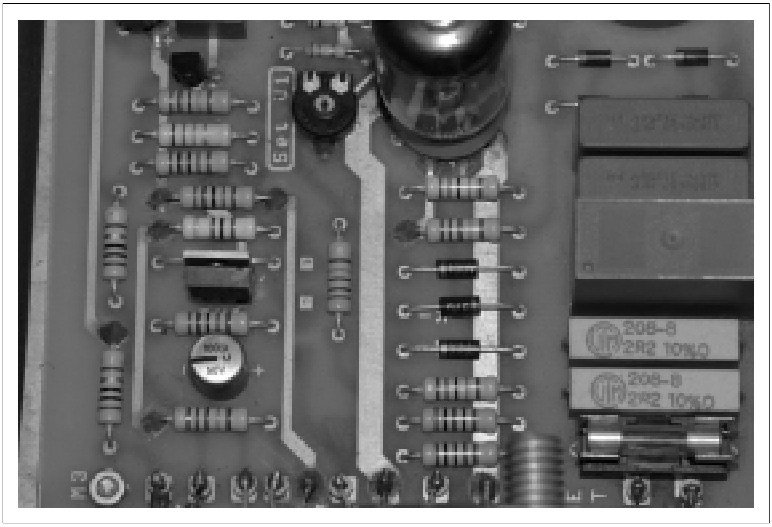
8.9 The stabilised negative power supply Vn

The fourth secondary winding is also HF-decoupled, rectified, buffered by C211 followed by a standard stabilisation circuit that does not require any further explanation. Shown in the far right of the schematic of figure 8.9.1 is the control relay circuit. If S2 (the standby switch) is closed, then C214 will be charged and T206 will start to conduct. The 24 V coils of both the high voltage relays (RE201 and RE202) are in series with each other and connected to points A and B. Diode D217, as a no-load diode, prevents damage when the relay is switched off.

T207 drives a two-coloured LED (in fact a red and a green LED, placed anti-parallel in one unit). If S2 is closed, the green LED will burn and if open, the red LED will burn.



⇧ ***Figure 8.9.1*** *The stabilised negative power supply Vn; the driving circuit of the relays RE201 and RE202.*



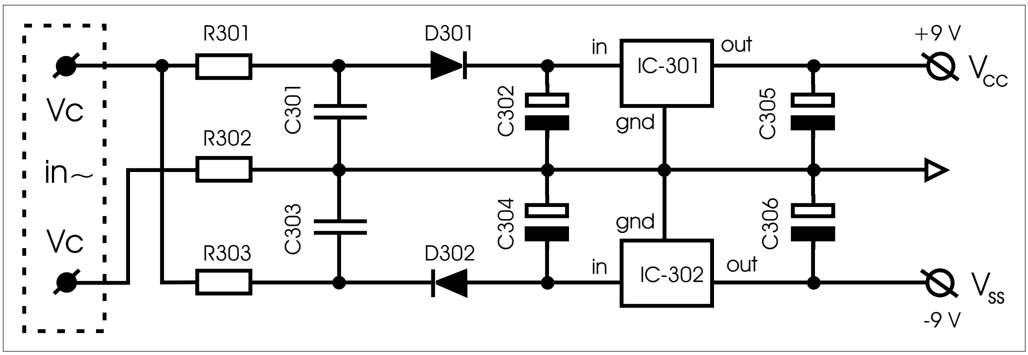
This setup forms the core of the safety precaution: the high voltage will only be switched on if the negative power supply Vn is present.

8.10 The power supply for the safety circuits

The fifth secondary winding delivers the filament voltage f1 for the valves B1, B2, B4, and B5. No additional schematic is needed as the filaments are directly connected with the power transformer.

Please note that the audio schematic (figure 8.2.1) indicates that in order to avoid hum the filament voltages are connected to earth via the resistors R139 and R140.

The sixth and final winding is double sided HF-decoupled, single phase rectified, and with the aid of standard stabilisation IC's set to plus and minus 9 V.

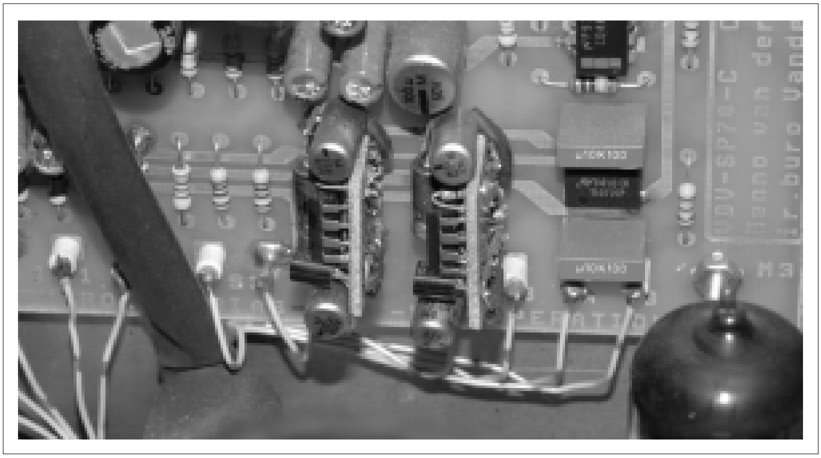


⇧ ***Figure 8.10.1*** *The circuit for the ±9 V power supply.*

8.11 The idling current of the power valves

The prototype of the SPT-70 is fitted with the circuit VDV-NRS2610, later to be discussed in the book, whose purpose is to automatically set and adjust and maintain the idling current even when the music is playing. The design of the SPT-70 is already completely prepared for the application for the NRS2610.

However, it can also be done differently namely the ‘old fashioned’ way i.e. done by hand. For this take two (ten turn) trim potentiometers of 100 kΩ and connect the ends to the plus and the minus of Vn (60 V). Adjust both the trim pots until both of the sliders measure –60 V in respect to ground and subsequently connect these to connection points b1 and b2 (see figure 8.2.1). Measure the voltage over R134 when you are adjusting the slider to a lower voltage. If one, for instance, measures 0.4 V between s1 and GND, then the idling current through B1 is equal to 40 mA. If one, for instance, measures 0.8 V, then the idling current is 80 mA. The same goes for B2, but then with R135 and measuring point s2.



The 40 mA setup is good if one wants to use the amplifier for background music. An idling current of 80 mA will result in a refined and extremely high sound quality which is meant for a situation in which one wants to hear the very last detail of the music (see chapter 3, where it is discussed that the increase of the idling current will cause the effective internal resistance of the power valves remaining largely constant over the whole of the driving range). Because of that, the dynamic damping factor distortion (DDFD) will be avoided and that is very audible.

The maximum anode dissipation of the 6550WA power valves is 35 W. With an idling current of 40 mA at 450 V, the heat dissipation per valve is $0.04 \cdot 450 = 18$ W. Both B1 and B2 are set well below their maximum, resulting in a long life span. With an idling current of 80 mA the total dissipation is, however, 36 W. The sound is fantastic, but the life span of the valve will be drastically shortened (a maximum of 1000 hrs instead of 6000 hrs). With the aid of the NRS2610, I made the idling current of my SPT-70 adjustable between 40 mA and 80 mA. During day time the amplifier is set to 40 mA but if I want to listen intensly then I set the switch to '80 mA' position for my daily hour of intense music pleasure!

8.12 A warning for the self-builder

In this chapter, I limited my explanations on purpose. I give hints and suggestions, but I refrain from giving the detail. Why do I not describe each wire, resistor, and copper pour on the print? Would this not make it easier for the self-builder?

Of course that would be the case, but this amplifier is extremely complex and all the parts are interdependent. If a part of the power supply does not work properly then you have problems. If one of the security features does not work as it should then you will have problems too. If you do not set up the VDV-NRS2610 properly then the power valves will blow themselves up. If you want to apply negative feedback (which I do not use myself) then you run the risk that, instead of an amplifier, you will end up with a medium wave transmitter.

With this, I am not saying that you should not attempt to self-build this amplifier but a very important pre-condition for building this design should be that you have much experience in measuring, applying the maths and a decent amount of experience with self-build projects. You will need good quality measuring equipment (oscilloscope, oscillator, dummy-loads, distortion-meters, etc). Each stage of this amplifier must be checked with extreme care.

If you do not have the required experience, then you will be wise to use the schematic of the STP-70 for study purposes only and to use it as a source of tips and ideas.

8.13 Measurements and conclusion

To end this chapter, some remarks on the measurement results and the subjective impression this amplifier makes.

The most important measurement results are mentioned in table 8.13.1. 'SP' stands for the Super Pentode setup and 'ST' stands, of course, for the Super Triode setup while the idling current through each of the valves is mentioned after the dash. The relationship between f_{-3} at high frequencies and the output impedance Z_{out} on the loudspeaker connections is remarkable. The smaller Z_{out} is (because of a higher idling current or the transition from SP to ST) the larger f_{-3} will be.

Table 8.13.1: Measurements of the SPT-70				
	SP-40mA	*SP-80mA*	*ST-40mA*	*ST-80mA*
P [W]	61	61	55	58
f_{-3} [kHz]	69	85	101	113
Z_{out} [Ω]	15,4	9,3	4,4	3,3
Gain [-]	108	143	71	87

This relationship is clearly set by the L_{sp} and the C_{ip} values of the output transformer and the effective R_{ib} of the valves B1 and B2. At low frequencies the –3 dB frequency for all setups is 3 Hz. The lowest frequency at which 60 W can be delivered is 16 Hz; this frequency is determined by the maximum magnetisation of the core of the VDV4070-CFB. The gain is measured from the input to the output, which is loaded with 4 Ω.

If, on top, overall-negative feedback is applied, then a THD-value of 0.03 % over the whole of the frequency range is possible. The IMD-value is more or less the same. Hum and noise: not audible (–103 dB measured referred to the nominal output power) and I could continue like that…

Subjectively speaking I can make this remark: this amplifier, set to an idling current of 80 mA in the Super-Triode setting without negative feedback applied, sounds so 'very clean', pure, clear, and spatial and yet so 'valve' like, that I was left to conclude that I had reached my goal and that this amplifier had reached the maximum sound quality obtainable.

8.14 Part lists

Table 8.14.1

No	*R*	*W*	*Ma*	*Colour Code*
101	1k	1	Ph	bn, bk, bk, bn
102	100k	1	Ph	bn, bk, bk, og
103	2k2	1	Ph	rd, rd, bk, bn
104	10k	1	Ph	bn, bk, bk, rd
105	270	1	Ph	rd, vt, bk, bk
106	270	1	Ph	rd, vt, bk, bk
107	1k		Bu	10-turn
108	470	1	Ph	ye, vt, bk, bk
109	470k	1	Ph	ye, vt, bk, og
110	10k	1	Ph	bn, bk, bk, rd
111	39k	1	Ph	og, wh, bk, rd
112	47k	1	Ph	ye, vt, bk, rd
113	xx	1	Ph	see text
114	100	1	Ph	bn, bk, bk, bk

Table 8.14.1 (continued)

No	*R*	*W*	*Ma*	*Colour Code*
115	10k	1	Ph	bn, bk, bk, rd
116	12k	1	Ph	bn, rd, bk, rd
117	100	1	Ph	bn, bk, bk, bk
118	100k	1	Ph	bn, bk, bk, og
119	100k	1	Ph	bn, bk, bk, og
120	100k	1	Ph	bn, bk, bk, og
121	100k	1	Ph	bn, bk, bk, og
122	47k	1	Ph	ye, vt, bk, rd
123	50k		Bu	10-turn
124	47k	1	Ph	ye, vt, bk, rd
125	100k	1	Ph	bn, bk, bk, og
126	100k	1	Ph	bn, bk, bk, og
127	100k	1	Ph	bn, bk, bk, og
128	100k	1	Ph	bn, bk, bk, og
129	2k2	1	Ph	rd, rd, bk, bn
130	33k	5		
131	100k	1	Ph	bn, bk, bk, og
132	1k	1	Ph	bn, bk, bk, bn
133	150	5	Ph	bn, gn, bk, bk
134	10	5	Ph	bn, bk
135	10	5	Ph	bn, bk
136	150	5	Ph	bn, gn, bk, bk
137	1k	1	Ph	bn, bk, bk, bn
138	100k	1	Ph	bn, bk, bk, og
139	100	1	Ph	bn, bk, bk, bk
140	100	1	Ph	bn, bk, bk, bk
141	100	1	Ph	bn, bk, bk, bk
142	100	1	Ph	bn, bk, bk, bk

Tabel 8.14.2

No	*C*	*V*	*Ma*	*Code*
101	1 μF	?	?	wire bridge
102	100 pF			Styroflex 120; 105-060
103	100 μ	100 V	Mu	F 913-327
104	μ22	600 V	S	B 32650
105	?			see text
106	μ47	630 V	S	B 32650
107	μ47	630 V	S	B 32650
108	μ22	630 V	S	B 32650

Table 8.14.3

D	*V*	*W*	*Ma*	*Type*
101	100	1,3		Zener diode
102				Bi-colour LED 858; 637-180
103				Bi-colour LED 858; 637-180

Table 8.14.4

B	*Type*	*Manufacturer*
B1	6550 WA	Sovtek/Svetlana
B2	6550 WA	Sovtek/Svetlana
B3	6922	Sovtek
B4	6922	Sovtek
B5	E88CC-01	Golden Dragon

Table 8.14.5

No	*R*	*W*	*Ma*	*Colour Code*
201	2,2	5	Ph	
202	2,2	5	Ph	
203	220k	1	Ph	rd, rd, bk, og
204	220k	1	Ph	rd, rd, bk, og
205	680k	1	Ph	bu, gy, bk, og
206	2,2	5	Ph	
207	2,2	5	Ph	
208	220k	1	Ph	rd, rd, bk, og
209	220k	1	Ph	rd, rd, bk, og
210	220k	1	Ph	rd, rd, bk, og
211	100k	1	Ph	bn, bk, bk, og
212	220k	1	Ph	rd, rd, bk, og
213	220k	1	Ph	rd, rd, bk, og
214	100k	1	Ph	bn, bk, bk, og
215	1M	1/4	M	bn, bk, gn
216	1k	1/4	M	bn, bk, rd
217	1,2	1/4	M	bn, rd, gd, gd
218	1,0	5	Ph	
219	680k	1	Ph	bu, gy, bk, og
220	100k	1/4	M	bn, bk, bk, og
221	100k		Pi	PT10; hor. mount
222	270k	1/4	M	rd, vt, ye
223	100	1	Ph	bn, bk, bk, bk
224	100	1	Ph	bn, bk, bk, bk
225	100k	1	Ph	bn, bk, bk, og

Table 8.14.5 (continued)

No	*R*	*W*	*Ma*	*Colour Code*
226	220k	1	Ph	rd, rd, bk, og
227	10	1	Ph	bn, bk, bk
228	10	1	Ph	bn, bk, bk
229	390	1	Ph	og, wh, bk, bk
230	47k	1	Ph	ye, vt, bk, rd
231	10k	1	Ph	bn, bk, bk, rd
232	50k		Pi	PT10; hor. mount
233	220k	1	Ph	rd, rd, bk, og
234	10k	1	Ph	bn, bk, bk, rd
235	390	1	Ph	og, wh, bk, bk
236	68k	1	Ph	bu, gy, bk, rd
237	22k	1	Ph	rd, rd, bk, rd
238	10k	1	Ph	bn, bk, bk, rd
239	1k	1	Ph	bn, bk, bk, bn
xxx	33k	10	Ph	test resistor, see text

Table 8.14.6

No	*C*	*V*	*Ma*	*Code*
201	47n	1250	S	B 32 653
202	47n	1250	S	B 32 653
203	470μ	450	Ph	157 57 471, p. 153; 868-371
204	470μ	450	Ph	157 57 471, p. 153; 868-371
205	47n	1250	S	B 32 653
206	47n	1250	S	B 32 653
207	330μ	400	Ph	157 56 331, p. 153; 868 292
208	330μ	400	Ph	157 56 551, p. 153; 868 292
209	10μ	450	Pa	ECEB2WU100, p. 146; 446-385
210	100μ	450	Ph	157 37 101, p. 153; 868-334
211	470μ	100	Pa	ECEA2AGE471, p. 140; 698-945
212	10μ	63	Ph	Sp 2222-036-58109
213	220μ	63	Pa	ECEA1JGE221, p. 140; 698-787
214	100μ	25	Ph	SP 2222-036-56101
215	100n	100	S	MKH shielded
216	100n	100	S	MKH Shielded

Table 8.14.7

D	*Number*	*W*	*Ma*	*Function*
201	1N4007			rectification
202	1N4007			,,
203	1N4007			,,

Table 8.14.7 (vervolg)

D	*Number*	*W*	*Ma*	*Fu*
204	1N4007			rectification
205	1N4007			,,
206	1N4007			,,
207	1N4007			,,
208	1N4007			,,
209	Z100V	1,3	Ph	BZY976-100V
210	Z100V	1,3	Ph	BZY976-100V
211	Z100V	1,3	Ph	BZY976-100V
212	Z12V	0,4		safety
213	1N4007			safety
214	B200C2			bridge rectifier 200V/2A
215	LED			red, 3mm, reference
216	Z24V	0,4		stabilisation
217	1N4007			spike-suppress

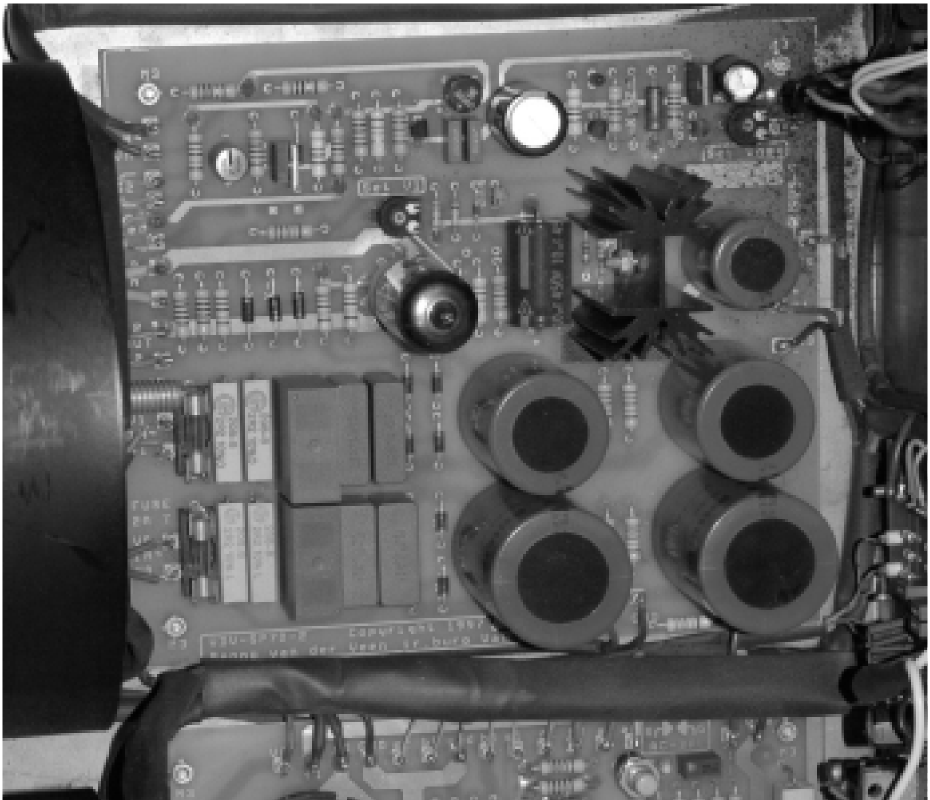
Table 8.14.8

T & B	*Type*	*Ma ++*
201	BUZ80	
202	BC639	
203	BC639	
204	BDT64C	
205	BC640	
206	BDT64C	
207	BC639	
B6	ECC83	

Abbreviations used

M : metal film 1/4W
Bu : Bourns
Ph : Philips or Beyschlag
Pi : Piher
S : Siemens
Pa : Panasonic
SP : Spoerle, Diode
Mu : Multicomp
Ma : Manufacturer

Note: The page number and the 6 figure order number is from the Farnell catalogue October 1997; RE201 and RE202 are loudspeaker relays available from Amplimo BV, Holland



⇧ ***Photo*** *A birds eye overview of the SP-70.*