# V A L V E

*the magazine of astounding sound*

## The Simplex

**by**
**Ari Polisois** *©2001, 2002*

*The Simplex Single-ended Audio Amplifier*

### The Idea

After having built several audio amplifiers (single-ended and push-pull) and compared, first their theoretical qualities, then the practical side (complexity, matching of the valves and need of adjustments) and, last but not least, the sound, I decided in favor of the single-ended. I was much inspired by the wonderful article written by Scott Frankland on the Dec. 96 and Jan-Feb. 97 issues of Stereophile.

There was another reason for me to choose this layout:

single ended amplifiers are less expensive to build, in terms of cost of components and time spent to assemble them. My plan was to design an amplifier as simple as possible, still keeping the quality high. The latest one I completed a week ago has an incredibly pure sound, by far the best, compared to the others I had so far built, that were considered, until then, by all people who listened to them, of having an impressive good sound.

My wish is that someone else decides to build its twin and share his impressions with me. Surely, with different speaker systems and listening rooms, etc...the comparison will be questionable, but, nevertheless, some character should show up.

I gave the amp the name Simplex, as it is to me: Simple and excellent. At first sight it is not so simple, due to the fact that it contains some novel solutions and, undoubtedly, everything new implies effort to be fully understood. But once you have accepted them, I bet you will use them as an alternative to the traditional and too often repeated circuits, most of which polluted by compromises that reduce the sound quality. I am aware that what I am saying seems quite arrogant. Take it as an invitation to prove the opposite.

I decided to use the bulky but generous 6C33C, driven by the evergreen 6SN7, for the following reasons:

- the 6C33C has a lot of potential as it can deliver a substantial amount of power
- it works at quite a low plate voltage
- it has a wide filament/heater surface
- its price is affordable.

On the other hand, it requires a high driving swing, in the range of 85-100V peak. It took me some time to obtain this swing from a 6SN7, but this beautiful valve succeeded, with an acceptable distortion figure, an unbelievably extended frequency range (from few Hertz to over 150 kHz) and, consequently, with a respectable linearity.

The simulations suggested a biasing voltage of -90 for the 6C33C, a B+ of 270V and an idle plate current of 250 mA. The plate load was set at 800 ohms, with a ratio of 10:1 on an 8 ohm load.

**Raw Power requirements**

At first I will refrain to spend much time and space on

For 110V Mains
F1 - 1A Time Delay
F2 - 3.16A Time Delay
F3 - 3.16A Time Delay

For 220/230V Mains
F1 - 1A Time Delay
F2 - 2A Time Delay
F3 - 2A Time Delay

R1 - 470 - 600 ohms 25W w/heatsink
R2 - 470 ohms 50W w/heatsink
C1 - 100uF 500V
C2 - 470uF 450V
C3 - 470nF 100V MKT
C4 - 220uF 450V
C5 - 1000uF 385V
C6 - 470nF 1000V MKT
C7 - 1000uF 385V
B1 - 4 pairs of 1N4007 shunted by 4700pF 1000V caps
B2 - 4 - 1N5408 shunted by 4700pF 1000V caps
CH1 - 5H 600mA Choke
SW1 - 250V 3A DPST (the second section can be used for a pilot lamp showing that PS2 is powered on)
SW2 - 250V 6A SPST
SW3 - 250V 6A SPST

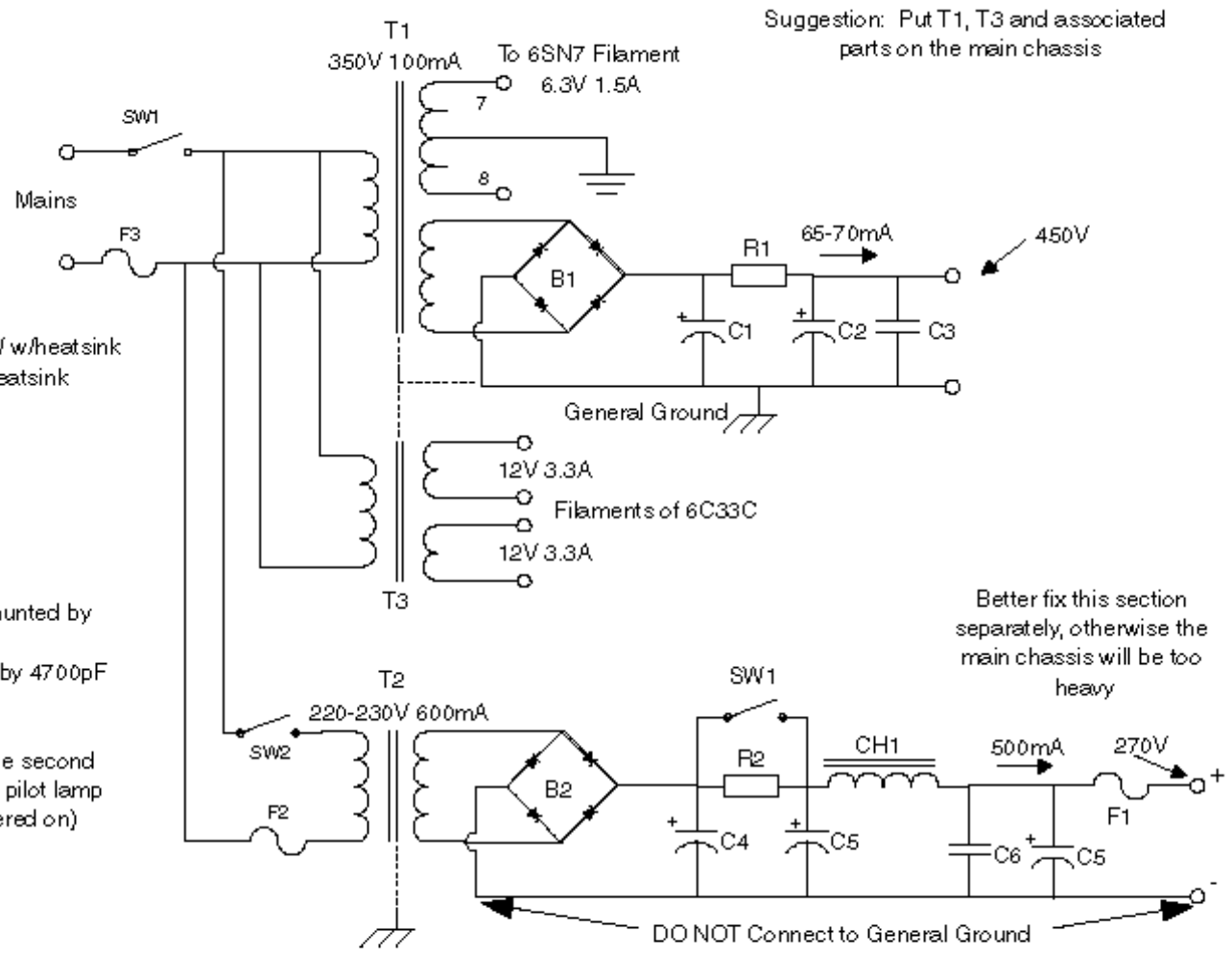
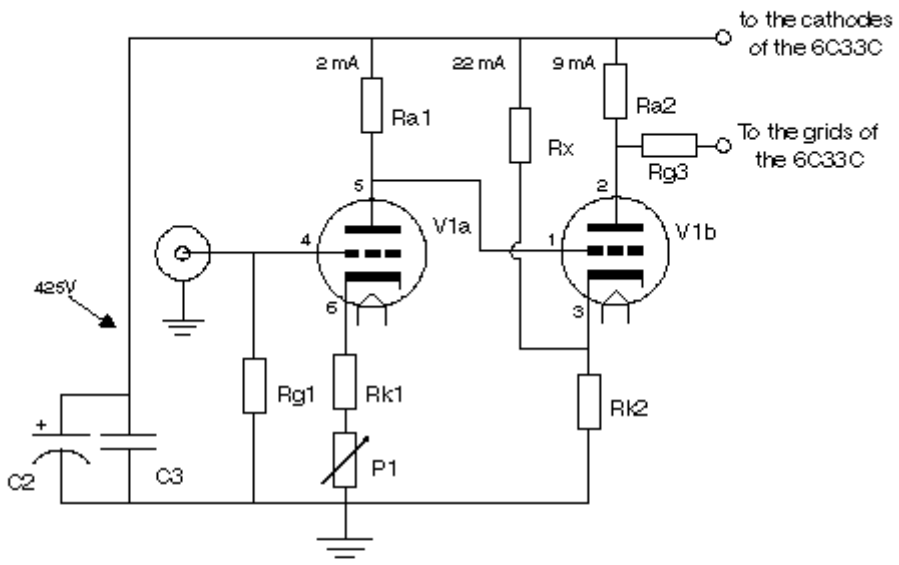



Figure 5. Power Supply Section (both channels)

Figure 1. Driver Stage (one channel)




C2 - 470uF 450V (see Fig. 5)
C3 - 470nF 1000V (see Fig. 5)
Rg1 - 330K 1/4W
Ra1 - 180K 2W
Rk1 - 330 or 390 1/4W
P1 - 470 variable
Rx - 16K 20W (2 x 33K 10W in parallel, outside chassis in a well ventilated box)
Ra2 - 10K 2W
Rk2 - 235Ω 4W (2 x 4K7 2W in parallel)
Rg3 - 2K2 - 2K7 1/4W

V1 - 6SN7GTA/GTB

the power supplies, considering that this subject is recurrent in almost every description of an audio amplifier. As per Fig. #5, you need TWO, different ones. Why will be explained later in the text. The first, intended for the driver sections, must be able to deliver 425V at about 100 mA (actually each driver requires approx. 32 mA) and the second, for the 6C33Cs, 270V at 500-600 mA idle (in total, that is, for both power tubes). I decided to use one transformer (T1) just for the driver section, another (T3) for the 6C33C filaments, requiring (each valve) 12.6 V at 3.3 A.

A third, separate transformer of 150-200VA was meant for the B+ supply of the 6C33Cs. A 110-220V to 220V mains insulating transformer would do, because you need to have 220V across the rectifying bridge (I used four 1N5408 diodes, rated 1000V 3 Amps, followed by a 220 µF 350V good quality electrolytic). From my experience, it is better to build, at first, the driver section and its power supply on one chassis, on which you fitted, at the same time, the 6C33C's sockets. No output transformers, for the time being, to have the chassis lighter for tests and measurements.

The dimensions recommended for this chassis (not including the Power supply for the 6C33Cs - see next paragraph) are no less than 12" x 16" (30 x 40 cm.). This accommodates both channels, with their OPTs. Also, an advisable solution is to have the power supply for the Power Tubes physically separated, in a metal box and connected to the main chassis with a three-wire cord (+270V, Null and control wire, if necessary).

**The Driver Section**

One of the classic circuits I admire is the direct coupling used by Williamson in his famous amplifier: the first triode's plate connected directly, that is, without any blocking condenser, to the grid of the second triode. The potential of the cathode must be higher, to ensure the necessary bias (between - 7 and - 9 V, depending on the actual characteristics of the tube used). In the Williamson, the second triode is also a phase inverter. We do not need it here, because of the single-ended topology.

Let us have a look at Fig. #1. V1a is the first section of the 6SN7 (pins 4, 5, 6 preferably). Its plate (pin #5) is connected directly to pin #1 (grid of the second triode). You will notice the usual grid resistor Rg1, connecting the input "i" to ground, as well as Rk1 and P1, both acting to provide the cathode bias to V1a. The purpose of P1 is to vary the bias of V1a as required, within certain limits. We will see

later why, but we can state immediately that the adjustment of P1 also varies the potential level of the anode of V1a (which is directly connected to the grid of V1b), with respect to the cathode (pin #3). The consequence is that also the bias of V1b changes, modifying the plate current. The plate load of V1b, the resistor Ra2, catches a different voltage, depending on the setting of P1. In other words, P1 controls the voltage drop across Ra2.

What is the purpose of Rx? This hi-wattage resistor supplies an extra current to Rk2, adding to V1b's idle anode current. This layout has two main effects:

a) the local negative feed-back, taking place because of the absence of a by-pass condenser across Rk2, improves the performance of V1b (in fact I measured a drop of 75% in THD) at the expense, of course, of a reduction of gain by almost the same proportion;

b) The extra 22 mA current supplied by Rx, reduces the need of a higher value resistor Rk2, still providing for the voltage level to counter-act V1a's plate voltage (remember that the bias of V1b is the difference between the Voltage at pin 5 and pin 3). The advantage is that the ratio Ra2/Rk2 is improved and because the gain of V1b depends on this ratio, the amplification jumps from 1 to 4, approximately.

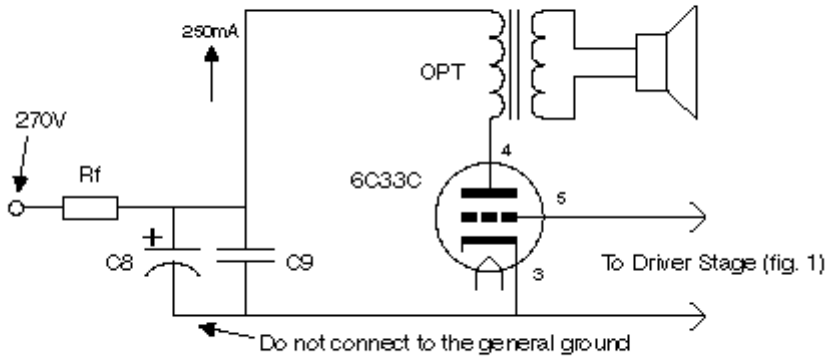
Just a word on Rg3. It has become a habit to fit a small (few kilo-ohms) resistor, before the output tube's grids, to avoid any parasitic oscillation.

**The Output Stage**

Now, how is the driver connected to the power tube? Very simple: plate to grids, because the 6C33 has 2 grids (pin #5), without any blocking condenser (just Rg3, as explained above) and B+ terminal to cathodes (Pin #3). This is made possible by the fact that there are TWO dedicated power supplies, one for the driver and one for the output tubes and they do not have their negative terminals connected together. In fact, the Power stage's B- is, instead, connected to the Driver stage's B+. Fig. #2 illustrates the power section. The polarity of the voltage across Ra2 suits the bias requirement (minus to grid and plus to cathode).

Now, please do not tell me that this is a complication. What difference does it make to have two smaller transformers instead of a single but bulky and heavy one with a lot of outgoing wires? It is true that you need two different filtering sets, and this is quite expensive, but, in

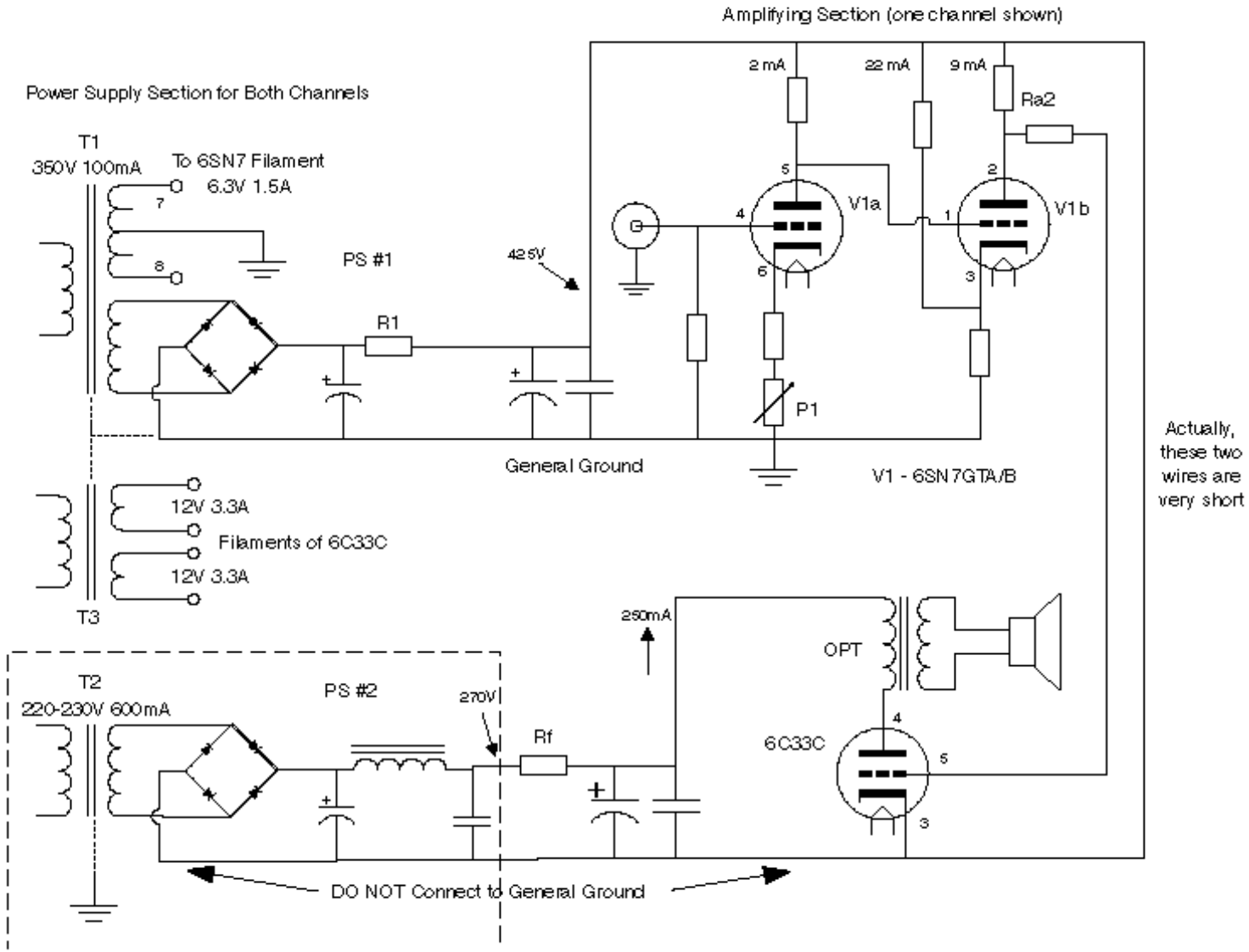
**Figure 2. Power Stage (one channel, simplified)**




Rf - 10 - 15 2W (filtering and measuring resistor)
C8 - 1000uF 385V
C9 - 470nF 1000V MKT
OPT - Must be the following:

Z = 800 ohms
Turns Ratio 10:1
Nominal Power > 20W
Max. Current 500mA
Frequency Range 20Hz to 40KHz
Primary Resistance < 80 ohms

# Figure 3. General Layout



any case, you always have to separate the output stage power positive voltage source and the driver source with some kind of resistor/choke plus condenser combinations.

You can now examine the general architecture of the amplifier in Fig. #3. Note how few are the components of the amplifying/power stages. The root "simple", of the word SIMPLEX is thus explained.

With regard to the power supplies, unfortunately there is nothing I can do to reduce their size nor the number of components. The more they are generously furnished, the better the amplifier's performance, within certain limits, of course. Just one additional word on the subject: T3 (Fig. #3) is better located on the main chassis, not too far from the 6C33C sockets, because of the high current flowing in the wires. Fig. #4 shows the area reserved for the driver section as well as for T3 (approx. 8 x 16 inches). The output transformers find their place on the back corners, thus requiring an extension of the above basic area to 12 x 16" ; however, in the topology I have chosen, the 6C33Cs are in the front row and the OPTs on the sides. If the amplifier is at reach of inexperienced persons, make a provision to surround at least the output tubes with a protection against burns.

**Testing the Driver Section**

Going back to Fig. 1, you will notice the expected currents in the three branches (V1a anode, V1b anode and through Rx), but this is just orientative. Assuming the PS voltage is close to 425 Volts (if not, you can replace R1 - Fig. 5, by a suitable resistor), you should measure about 65V at pin 5 (same as pin 1) of the 6SN7, with respect to ground.

The opponent voltage present at pin 3 should be higher, but by less than 10 Volts (say 73V to 74V with respect to ground. Any difference is due to the tolerances of the components, including tubes. What matters is the anode current of V1b. By adjusting P1 you should be able to have a drop of 90V across Ra2 (Fig. 1). If the drop is lower even at P1's limit, set P1 in the middle position and find a suitable shunting resistor (normally 33K 2W should do) to reduce Rk2's value. The plate current of V1b should increase and so the drop across Ra2. When both 6SN7 are checked, your driver's channels are ready.

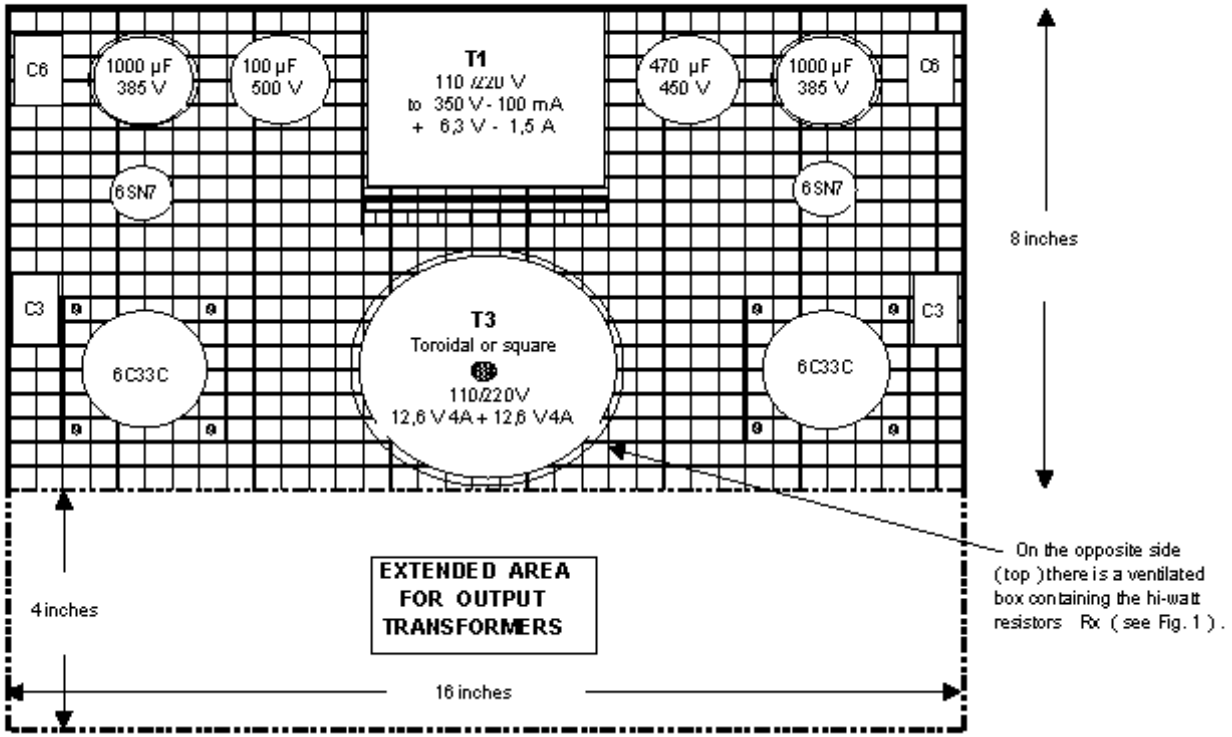
**Testing the Power Section**

The DC power is supplied to the output tubes through a

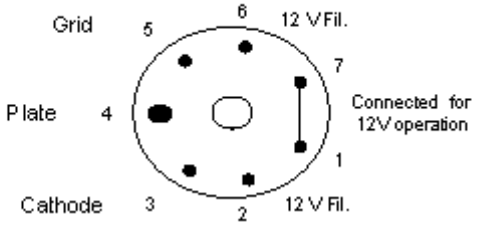
4

# THE MAIN CHASSIS

**( View from inside ).**

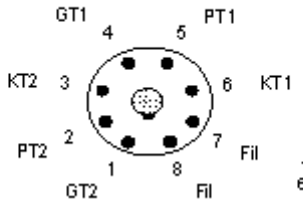



## 6C33C




| MAX. RATINGS | 6C33 | 6SN7GTA/B | |
|---|---|---|---|
| Plate voltage | 400 | 450 | V |
| Cathode current | 600 | 20 | mA |
| Plate dissipation | 60 | 3.75 | W |
| Filaments | 2 x 6.3 | 6.3 | V |
| Current | 2 x 3.3 | 0.6 | A |

## 6SN7




Art Poltrot - the SIMPLEX 6C33 Chassis

low ohm resistor (10 to 15 Ohms 2W). I have fitted two 13 ohm 3W resistors (available), one in each channel path. This addition serves three purposes:

- it allows measuring the anode currents of each power tube (these should be 250 mA each but, actually can be substantially different, even with the same bias level)
- it adds another filtering section to the common one included in the 270V power supply box (as mentioned, this power supply is kept far from the main chassis and OPTs)
- It reduces the interference of one channel with respect to the other.

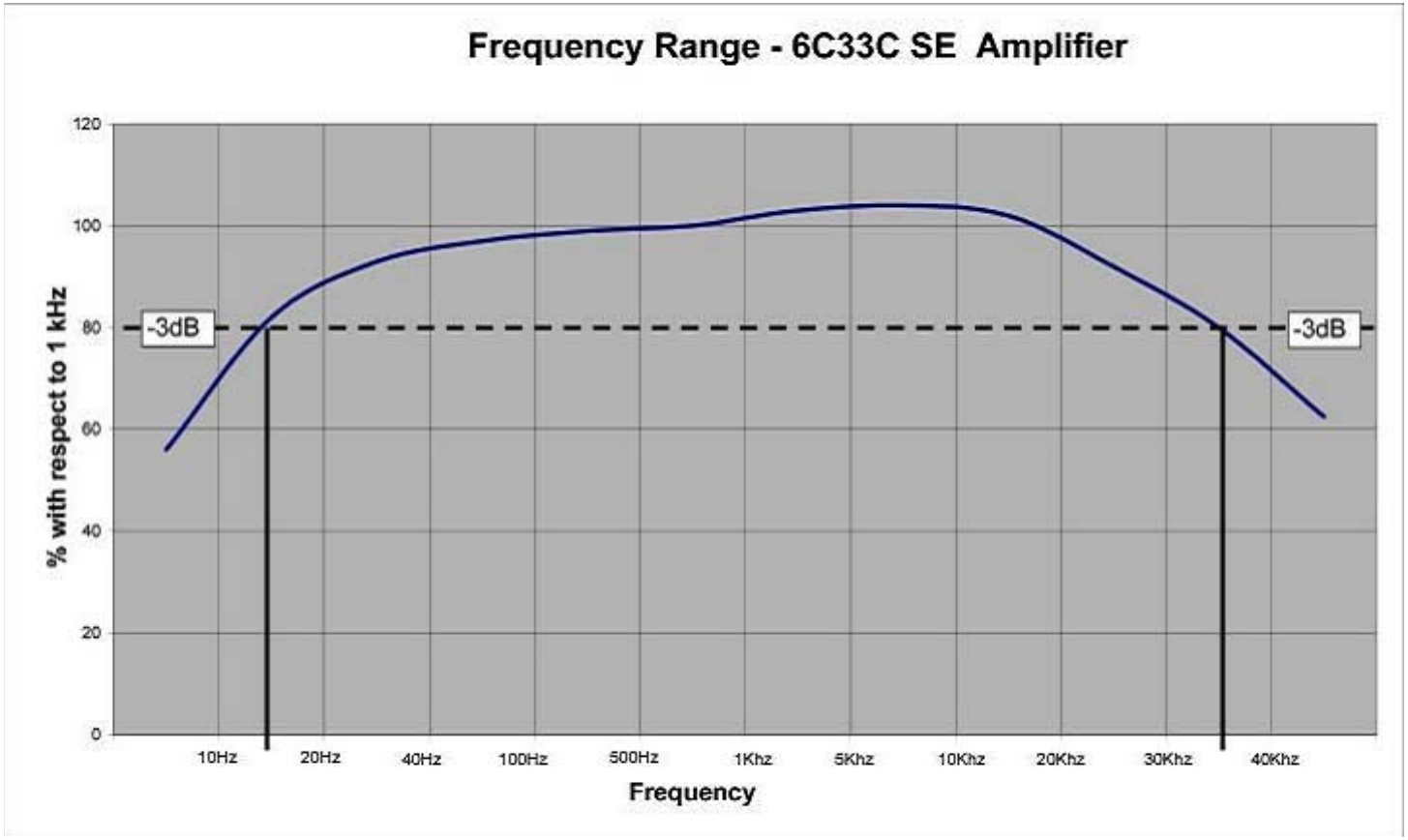
Now here comes a good question, with regard to A. What if, having adjusted the bias of the 6C33C at -90V, we find a higher or lower plate current? Well, if it is lower, we can try first another 6C33C, to replace the "weak" one or, we can reduce the bias, say to -85V, until we get a plate current of about 250 mA. But if it is higher, we better not exceed 270-280 mA (playing with the bias level) or we might damage the OPT (not the 6C33C, because it withstands higher currents). In any case, we must watch not to exceed the rated admissible power dissipation, of 60W, by more than 10%. Usually, with a regular tube, this case remains theoretical.

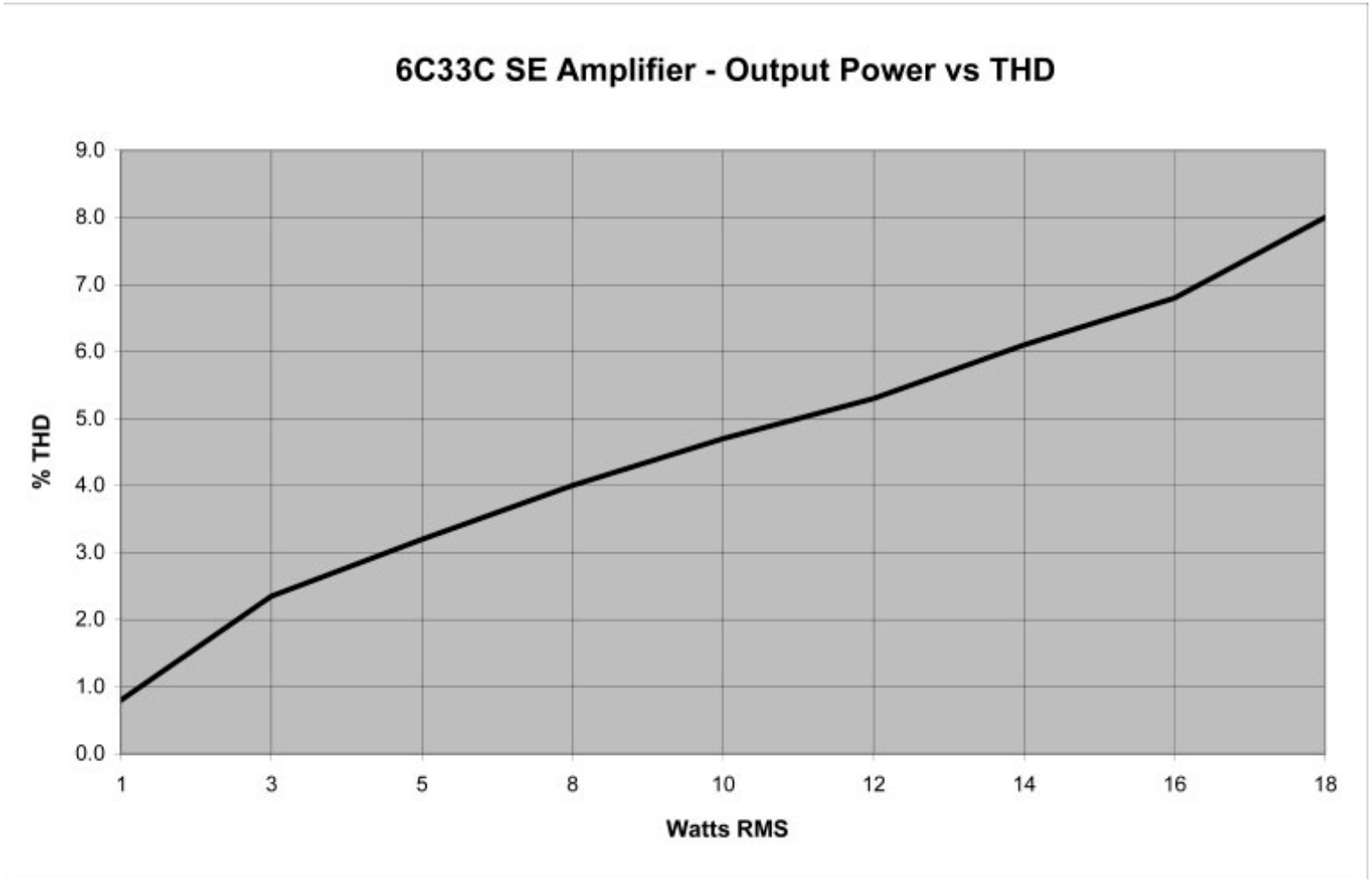
Lowering or increasing the bias level, I found, does not change noticeably the overall performance of the amplifier. I tried with a bias of -85 V up to -100 V. The anode current consumption varied a lot and probably, with the lower bias tests, the life of the 6C33C was somewhat shortened, but I cannot tell, at present, by how much.

The presence of high capacity filtering condensers has suggested to insert R2 after the reservoir capacitor C4. This relatively high value (and wattage) resistor allows a slower charge of C5 and C7. Within a minute or so, SW1 can be manually operated to short-circuit R2 and allow the full amount of current to flow. This could also be done with a relay, operated from the main chassis, using the third wire connecting the latter to the PS Box.

**The Output Transformers**

Fig. 2 gives a general indication of their characteristics. The OPTs I used are custom made and work fine, as can be seen in the graph of frequency range and output power vs. THD. No other measurements have been made


Frequency Range - 6C33C SE Amplifier
% with respect to 1 kHz
120
100
80
60
40
20
0
-3dB
-3dB
10Hz
20Hz
40Hz
100Hz
500Hz
1Khz
5Khz
10Khz
20Khz
30Khz
40Khz
Frequency


6C33C SE Amplifier - Output Power vs THD
% THD
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1
3
5
8
10
12
14
16
18
Watts RMS

so far. If you can find a suitable transformer from a commercial source, make sure its primary can withstand at least 400 mA. The ratio 10:1 allows a good power transfer. 7:1 can give more power but also more distortion. I hope to be able to give more details on this subject in a coming article.

WARNING: the amplifier is super up to the OPT connection. If you use a low grade output transformer, you loose a lot of brilliancy.

**Questions**

This chapter, I presume, should have been located at the beginning and not at the end of the text. I refer to the main question many of you have in mind: "Why not use a regular blocking condenser, instead of a direct coupling between the driver and the output tube, requiring two power supplies?"

Let me ask you: Are you aware of the damages to the sound, made by this cap? And also: Only if you listen to the SimplEX you will be fully convinced, because of its Excellent sound. If you don't believe what I say, you have two main choices: forget this amplifier or build it and check.

Should you have other questions, I suggest to contact me by e-mail and I'll do my best to answer.

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# VALVE

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