



Push-Pull for Single-Ended 211 Amp

This article describes the design and construction of a 25W single-ended 211 amplifier with a transformer-coupled push-pull driver stage.

By Lee Roitberg

Like a moth drawn to a flame, the light given off by a large transmitting triode is alluring. You cannot do anything but admire the glow produced by such a large tube. Then after countless minutes of amazement, the realization of the amp's physical size sets in.

Ever since I began building tube equipment many moons ago, I've had the idea of building a large transmitting triode amp. With no immediate need for such a large amplifier, I have been slowly collecting parts, planning on one day building a large transmitting triode amplifier. Well, the stars finally aligned, and I recently built the large amplifier I had dreamed about (Photo 1).

WHAT TO BUILD

I knew I wanted to build a large amp, but the question of what tube to use had always come up. The options were 211, 845, 813, GM70, or 833. All of the tubes are available as current production, and you can purchase some of them, such as the 211 and 845, for a very low price. My dilemma was simply answered when a friend, Darel Wieman, provided me with four GE VT-4 tubes.

With newly acquired tubes and a pile

DISCLAIMER

This circuit is intended for non-commercial use only. Lee Roitberg is not liable for any damage that may occur from the construction of this amplifier or any of the information provided within this article.

of power-supply parts in hand, I scoured the Internet and old magazines for schematics, ideas, and insight. During my quest, I ran across countless designs; some had tube rectifiers, some had solid-state rectifiers, and some even had a combination of both. I saw amplifiers with two, three, and four driver stages. There were capacitor-coupled, direct-coupled, and transformer-coupled drive stages. Of all the designs I had studied, one thing became evident—a 211 needed a low impedance driver stage in order to achieve full output power in class A2.

THE LIGHT GOES ON

Amorphous core, nickel core, cobalt core—these are the words that many an audio builder lust after. So, what stops most builders? Money!

During the search for nickel core transformers, I came across a little gem from Hammond, the 124B interstage transformer. It had a 49% nickel core, primary impedance rated at 10k, and secondary impedance rated at 90k center tapped. The most important part was that it was available for around

\$12.

So what do you do with a cheap step-up transformer that can't handle unbalanced DC? **You use it backwards as a push-pull plate transformer with a single-ended output.** Please reread the previous sentence, which contains an important concept.

I have been using the 124B configured backwards, on a few preamps, with incredibly good results. With a 3:1 step down, I figured it would be a natural to drive the honoree 211's grid.

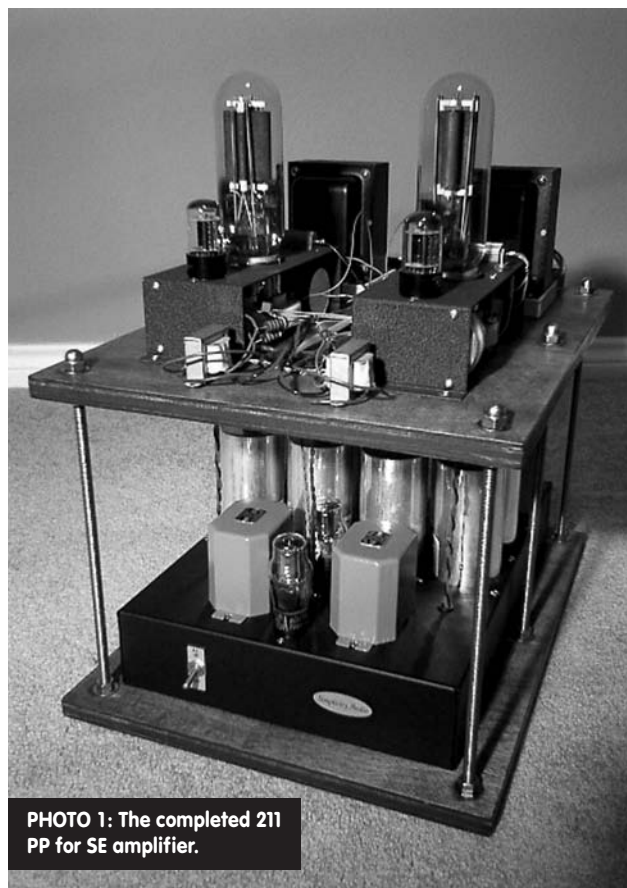


PHOTO 1: The completed 211 PP for SE amplifier.

CIRCUIT SYNERGY

In the world of audio, there are many claims when it comes to driver stage topologies. One myth is that two stages of amplification are better than three or four. Another myth is that a pentode drive tube driving a triode output tube is better than a triode drive tube driving a triode output tube.

So, what about a triode push-pull stage driving a triode output tube? Is this type of configuration sacrilege? I am proud to say that I am the owner of this odd combination and, most important, it sounds great.

DRIVER STAGE

The Hammond 124B transformer limits the driver tube selection to a tube with a plate resistance no greater than 12k Ω . This offers a large selection of tubes to experiment with. As for the balanced current limitations through the transformer, I have tried keeping them to less than 20mA. This number is just a guess, because there is no information from Hammond on this type of configuration and I have not taken the time to

measure the degenerative effects of DC through the transformer.

I believe transformer-coupled stages—as opposed to capacitor-coupled stages—allow the characteristics of the tube used to come through and not have those characteristics masked by the capacitor's own sonic flavor. Therefore, the tube selected will ultimately affect the sound characteristic of the amplifier. I experimented with three tubes—6J6, 5965, and 6SN7—that had similar characteristics. I know there are many other tubes you can use, and I recommend you give them a try. The differences are not subtle, and you may find a better-sounding combination for your stereo setup.

AND THE WINNER IS...

During my experimentation and listening evaluations, I found the 6SN7 to be my favorite-sounding tube. The flavor of the 6SN7 I chose is a topic for another discussion.

So, the 6SN7 has an ideal μ of 20 per side and the plate transformer steps down the output by 3. Unfortunately, this is not enough voltage gain to drive the

211 to full output. Plus, how do you drive the push-pull grids of the 6SN7? Simple, you use another 124B as a step-up/phase splitter input transformer.

The combination of the input transformer, the 6SN7, and the output transformer provide a total measured gain of 25. If you are using a passive volume control, the amplifier's gain will be too low and full output power will not be achieved with a CD player's direct output. You will definitely need a good preamp with gain. As a more expensive alternative, there are many other transformer manufacturers offering input transformers with a higher step-up ratio.

Look at the simplicity of the Fig. 1 schematic and the low parts count. There is no global feedback. Because of the push-pull driver stage, there is no need for a 6SN7 cathode bypass capacitor. Amplifier stability is very good to the point of not having to use any grid stop resistors.

WARNING

Building an amplifier with a B+ over 500V DC is extremely dangerous.



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Other stuff we're working on: A420 (6600 ohm 30W) and A442 (4300 ohm 60W with tertiary screen winding)..

FIGURE 1: Schematic of the transformer-coupled 211 amplifier. Only one channel is shown.

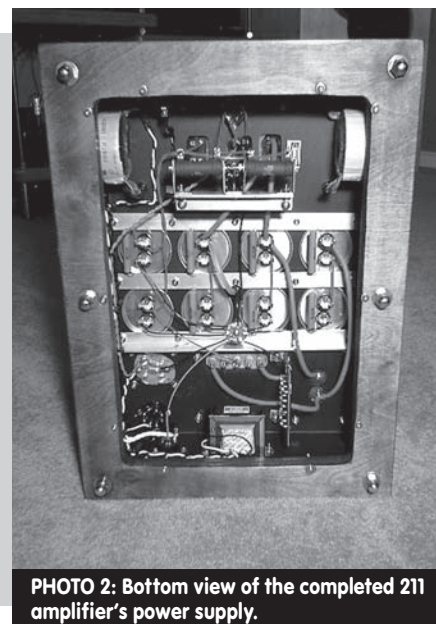
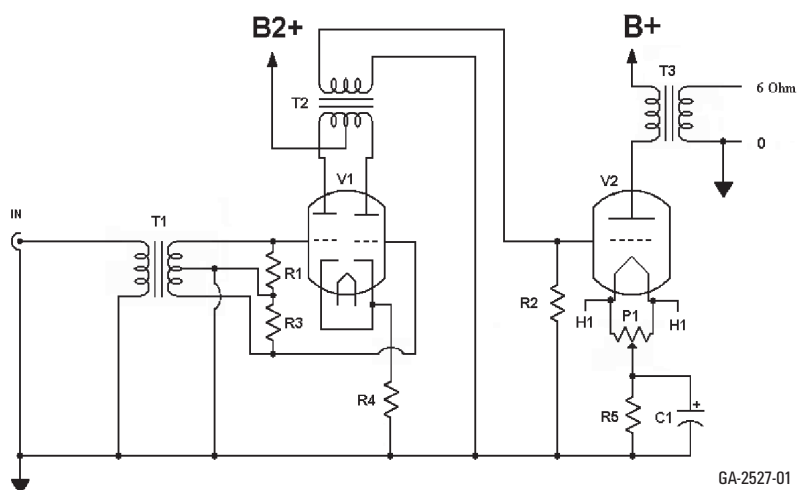


PHOTO 2: Bottom view of the completed 211 amplifier's power supply.

Parts selection is critical because resistors, capacitors, transformers, and wire are not normally rated to such high voltages. Most off-the-shelf components will fail with possible lethal consequences. Please, if you do not know what you are doing, do not attempt to build this amp. Do not risk your life or

the life of someone else.

CONSTRUCTION

As with any amplifier, there are trade-offs and compromises. My biggest constraint was that I needed to be able to lift the amp, by myself, onto my workbench. After debating about the amplifier's size and layout, I settled on a two-tiered amplifier with the power supply on the bottom and the audio section on the top.

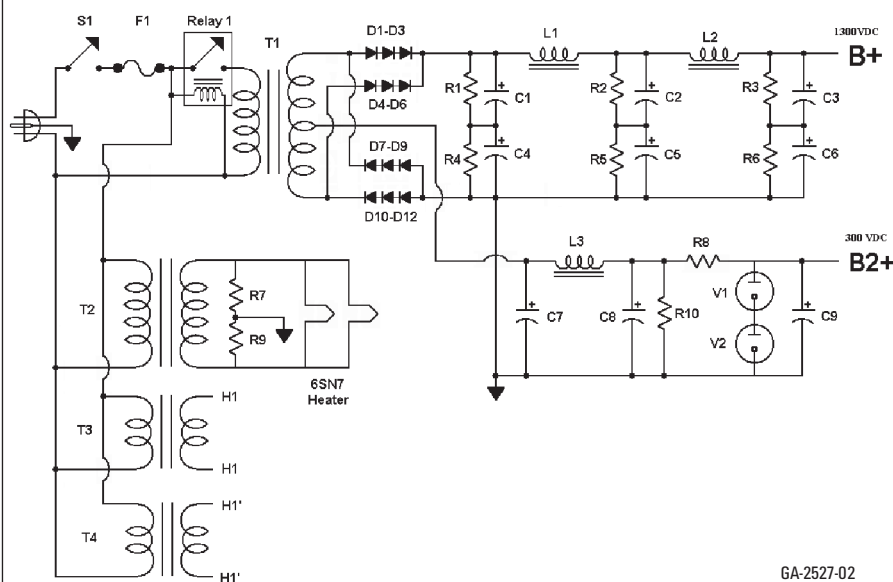
This amp was to be a cross between a breadboard amp and a finished product. I knew I could design and build the power supply so that it would not need

any modifications, but the audio section still posed many questions that needed to be answered.

THE POWER SUPPLY

I built the power supply (**Fig. 2**) on a very large Hammond steel chassis (**Photo 2**). It is 12" wide, 17" deep, and 3" tall. Weight and chassis limitations dictated I use a solid-state rectifier. Instead of choosing the standard 1N4007 diodes, I ended up using the NTE571 diode from Mouser Electronics, which is a 1000V PIV 1A diode that is listed as a fast switching/soft recovery diode. I placed three in se-

FIGURE 2: The power supply of the 211 amplifier.



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The B+ voltage is generated by a dedicated plate transformer rated at 1200Vct at 400mA. This one transformer provides both the high voltage for the 211 plate and half of the B+ voltage to a shunt regulator for the driver stage. For delaying the B+ voltage, I chose a delay-on relay, available from Potter & Brumfield, connected to the primary winding of the plate transformer.

Filtering is provided by ASC oil caps and some vintage UTC chokes. Note that the capacitors are in series in order to meet the B+ voltage requirements. This configuration requires a balancing resistor across the capacitors. The resistors should be rated at 1000V DC or greater.

Wasting energy, as resistor heat, goes against my better judgment. I have never been fond of DC heaters or regulated heaters, mainly due to their inefficiency and the large amount of heat dissipated by their resistors. I find the only answer is to use AC heating for the filaments.

Please no comments on hum due to AC filament supplies. If you carefully select the filament components, hum will be very low. At present, my amplifier is running AC filaments on both the driver stage and output tubes. Measured hum, into an 8Ω load, is only 2.6mV for one channel and 4mV for the second.

THE AUDIO SECTION

Because the audio section is meant for experimentation and therefore will not be contained in a closed chassis, I took extra precautions in order to limit exposure to the B+ voltages. I rotated the 211 sockets 90° to each other so that the plate connections are towards the middle of the amplifier. Also, I rated all exposed B+ wire for 15,000V DC.

Along with price and quality, there were many considerations in choosing the output transformer. After narrowing my choices, I contacted Jack at Electra-Print. A short 30-minute phone conversation sealed the deal. The

TABLE 1.

Audio Section

T1, T1', T2, T2'	Hammond 124B nickel interstage transformer
T3, T3'	Electra-Print 10k to 6Ω 211 output transformer
R1, R1', R3, R3'	33kΩ 2W
R2, R2'	10kΩ 2W
R4, R4'	500Ω 2W
R5, R5'	1.3kΩ 25W
P1, P1'	100Ω 2W
C1, C1'	100μF 250V DC
V1, V1'	6SN7
V2, V2'	VT-4 or 211

' Denotes second channel

transformer had a 10kΩ primary impedance and a 6Ω secondary impedance. It was designed to handle the high B+ voltages along with the 100mA of current. After hearing the final amplifier, I was very happy with my decision to go with the Electra-Print transformer.

RING. RING. RING!

I finished building the amp and began testing it. The waveforms at both 100Hz and 1kHz were clean and linear all the way out to 25W. The bass output was around 1dB down at 20Hz. Everything was looking good until I decided to sweep the entire frequency range at a constant 8W output. I was expecting a ruler-flat frequency response, but what I got was slightly different. Everything looked good until 5kHz. The output began to climb until it peaked +4dB at 14.8kHz, then dropped like a rock.

You get what you pay for. Nothing in life is free. Every cliché I knew came to mind along with a plethora of four-letter words. I knew the \$12 nickel interstage transformer had been too good a deal. Experimentation led me to the conclusion that the ringing was being gener-

TABLE 2. POWER SUPPLY

T1	Plate transformer	1200VCT	400mA
T2	6SN7 filament transformer	6.3V AC	3A
T3, T4	211 filament transformer	10V AC	4A
S1	SPST switch		
F1	4A fuse		
D1-D12	solid-state rectifier	1A 1000V PIV	
R1-R6, R10	300kΩ 10W		
R7, R9	160Ω 3W		
R8	6kΩ 25W		
C1-C8	45μF 600V AC		
C9	0.01μF 1600V DC		
V1, V2	OD3		
L1	filter choke	6H 175mA	2500WV DC
L2, L3	filter choke	6H 175mA	1500WV DC
Relay 1	Delay-ON relay adjustable to 180sec		

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PHOTO 3: The 211 amplifier in front of the author's stereo setup.

ated by the input transformer.

The hook of a \$12 nickel transformer was too good a deal to abandon now. There had to be a solution to the ringing. I went back to the Internet for a little research and the hope that this issue had been tackled before. I stumbled across some information, on the Audio Asylum, regarding a similar interstage

transformer sold by Allied Electronics.

The solution discovered—on the Internet—was to use a small capacitor across the transformer from the primary winding to the secondary winding. I gave the proposed solution a try and sure enough the results were very promising on the bench. As I increased the transformer bypass capacitor from

MEASUREMENTS

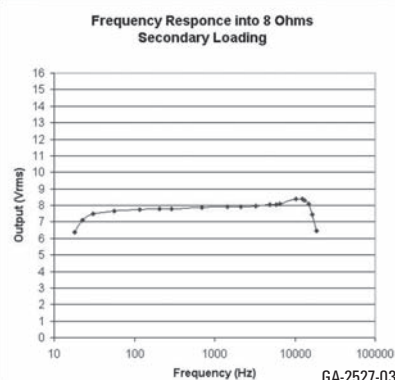
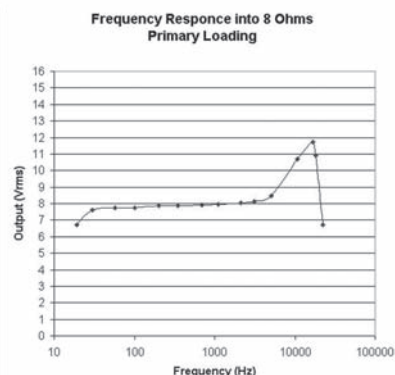
211 plate voltage = 1260V DC
 211 plate current = 58mA
 6SN7 plate voltage = 292V DC
 6SN7 plate current = 9.2mA p/s
 Maximum output power 8Ω
 load at 1kHz = 24.9W
 Input sensitivity = 4.2V RMS
 total weight = 86 lbs

10nF to 100nF, the high-frequency peak smoothed out. Unfortunately, listening to the amplifier with the input bypass capacitor made the amp sound lifeless and dull.

My friend, Dr. John Day, mentioned loading the secondary winding of the input transformer as opposed to the primary winding. I replaced the 10kΩ input resistor and transformer bypass capacitor with two 33kΩ resistors across the secondary winding. The high-frequency response peak smoothed out considerably, and the best part was that the sound was effortless and detailed.

Figure 3 shows the initial frequency re-

FIGURE 3: The frequency response of the 211 amplifier comparing different input transformer loading possibilities.



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ACKNOWLEDGEMENTS

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sponse of the 211 amplifier with a 10k loading resistor across the primary winding and the final frequency response with the input transformer loaded across the secondary.

The idea of being able to tune the frequency response of the amplifier by selectively loading the input transformer was an interesting trick. If your speakers are lacking a little top end sparkle, place a 10k resistor across the primary winding of the input transformer and give it a listen. It may be the perfect little boost for Lowthers or single driver speaker owners.

SOUND

What can I say? I have a grin from ear to ear every time I hear or see the amplifier. The sound is exquisite and effortless (**Photo 3**). *ax*

Lee Roitberg received his BS in Electrical Engineering in 1997. Working in the high-tech industry since then, he has worked for Intel, Motorola, Dell, Foxconn, and most recently ModusLink. The last four years of his professional career have been in the area of root cause failure analysis. He recently joined ModusLink as a Senior Engineer managing Engineering Services.

In his spare time, he enjoys remodeling his 1959 house along with building audio equipment. Most recently, he completed a dedicated listening room in an effort to maintain marital bliss with his very understanding and patient wife.

SOURCES

Angela Instruments
10830 Guilford Rd. Ste 309
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www.angela.com

Electra-Print Audio
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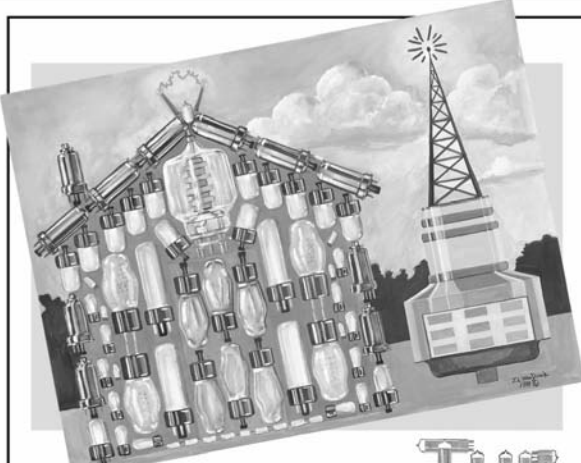
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