

Matteo: A 10W Integrated Amplifier

This VT power amp design is the right answer for this author's cherished speakers.

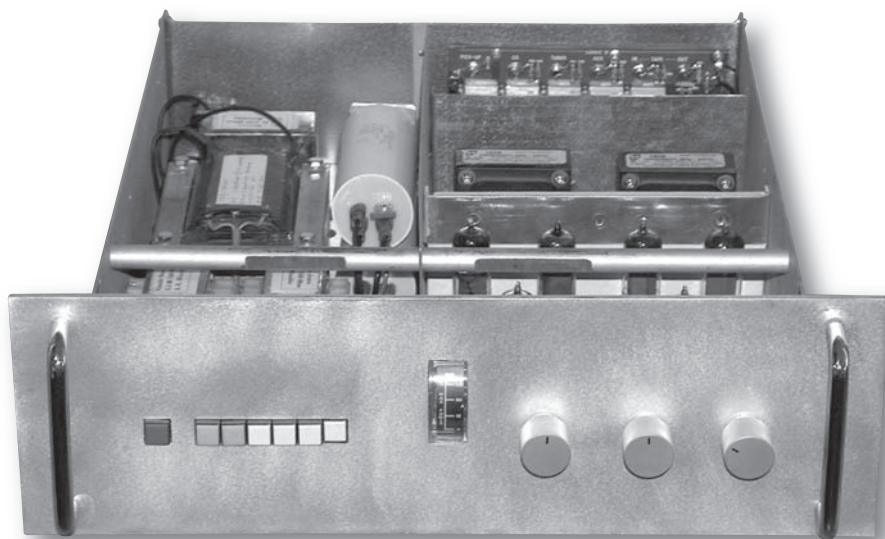


PHOTO 1: Overall view of the amplifier with top cover removed, prior to engraving the front panel.

The idea to build a low-power, high-quality power amp came after I had built the small French towers ("A Simple Audio System, Part 2: Speakers," March '05 *aX*, p. 36, by Aren van Waarde). These two little towers were so good in relation to their cost, dimension, and look that they deserved to be driven by a dedicated hi-fi amp. But, what scheme? Which technology? The answer came rather quickly: A classic 1950s schematic with modern modifications, where justified, and, of course, vacuum tubes.

THE CHOICE

After reviewing several designs with different output power and features, I elected to start, as a base, with the one described in the "RCA receiving tube manual" page 692 (a push-pull capable of 15W). From that base I made the following, substantial modifications:

1. Employment of EL84s as power tubes in an *ultralinear/reduced load* mode, instead of 6973s (lower cost and readily available).
2. No more than 8–10W crisp and clean.
3. A "no compromise" solid-state power supply.

4. Addition of a passive tone control circuit.
5. Selections of inputs through relays as opposed to a rotary switch.
6. Addition of a power indicator meter (just for fun and to give it an esoteric look).

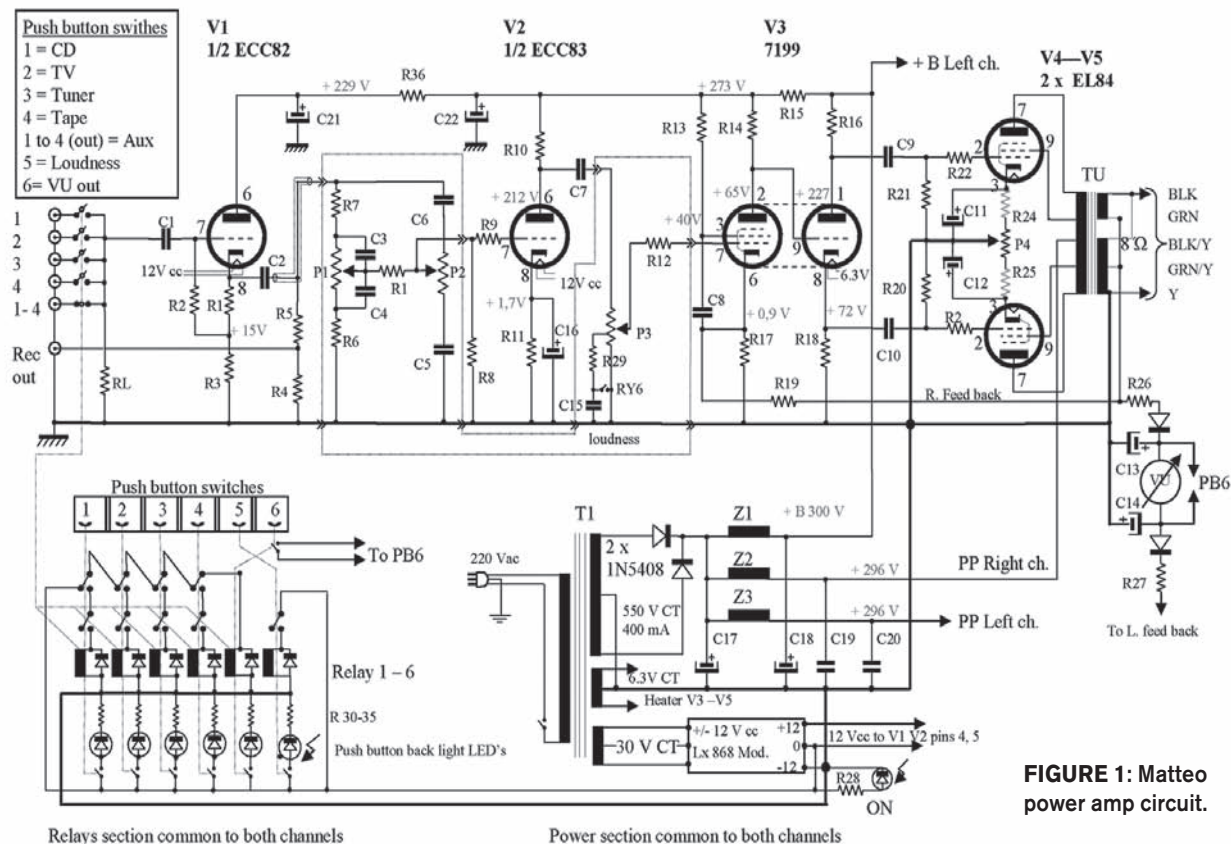
The end result is shown in **Photo 1**.

THE SCHEMATIC

The final version of the schematic is shown in **Fig. 1**. The input stage is a V1 cathode follower (CF) with no gain. It is located close to the input relay board on the back of the chassis and transfers selected signal to the treble and bass controls located at the front panel. This arrangement allows the signal to travel across the whole amplifier in a low impedance line, reducing potential hum pickup and high-frequency loss. In addition, the CF feeds the rec-out sockets without significant load to the circuit.

The input selection arrangement uses a four-position pushbutton switch to drive the proper relay. Selected input is loaded by the value of RL, which I chose to be 100kΩ. From the tone controls, the signal goes to a V2 amplifier stage, which is necessary to restore the loss of the tone control circuits. These two stages, including attenuation introduced by the tone controls, have an overall gain of about 2.5.

The driver stage is a pentode/triode V3, 7199 and provides proper amplification and phase inversion to drive the push-pull stage with an undistorted



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22Vpp signal. A 100kΩ pot with a 10k loudness tap provides the volume control. The loudness can be inserted by means of a push-button switch which, in turn, activates a relay.

The cathode of the 7199 pentode section receives a 15dB negative feedback from the output transformer secondary winding. The amplifier has proven to be very stable without adding a capacitor in parallel to R19. I made a considerable variation (with respect to the RCA manual schematic) in the final stage.

The concept of this modification (as described in the 1959 Philips manual) is based on the fact that the average signal value of music and speech is considerably lower than the maximum output signal measured with a constant sine-

wave. Therefore, when the output stage is polarized via a high cathode resistor bypassed by a capacitor, the bias voltage remains relatively constant even if the signal peaks to its maximum level, thus emulating a fixed grid bias condition. The advantage of this solution, however, is that the cathode polarization produces a lower distortion with respect to a fixed bias scheme (Table 1), when the stage is driven toward high power level by peak of music or speech signals.

The stage employs a push-pull EL84 with 440Ω R24, R25, ½ P4 cathode resistors (390 + 50) per tube bypassed by a 100μF capacitor. This solution allows the tubes to work with a *reduced load*. The EL84 total idle current is, in fact, 25/27mA per tube instead of the usual 40mA, dissipating 30% less power and

increasing the tube's life considerably. The disadvantage, however (theoretically), is that the stage cannot be driven to full power using a continuous sine wave signal, the distortion will be excessive because it is designed to handle peaks of power.

A 100Ω pot on the cathode circuit allows for a DC balance of EL84 tubes. Should you desire to establish *standard* operating conditions, replace the R24–25, 390Ω resistors with 2 × 220Ω. You may prefer to leave the bypass cap or take them off to add some sort of feedback.

From the 16Ω tap, the signal through R26, R27 feeds a meter to monitor the output power. The resistor value is chosen to obtain a full scale reading at maximum output.

Table 1

OUTPUT POWER (W. PEAK)	2	4	6	8	10	12
FIXED BIAS CONDITION. DISTORTION	0.4	0.9	1.4	2	2.6	3.4
CATHODE BIAS (REDUCED LOAD). DISTORTION	0.4	0.9	1.1	1.2	1.3	1.4

Distortion measurements under different bias conditions

POWER SUPPLY

As I stated, the power supply (Photo 3) is a no-compromise circuit with CLC filters all over. There is absolutely no hum at the speakers even if you put your ear inside them. The power stages get their voltage through two separate CLC cells (Z2, Z3), while the input stage and driver sections get their power through a third CLC cell (Z1). A ±12V fixed regulator feeds the heater of the first two stages and the various LEDs used to backlight the pushbutton switches. There appears to be a lot of redundancy in this circuit, and in fact there is. However, this is so the final stage has plenty of current when needed.

ASSEMBLY

The whole amp is built with point-to-point wiring with the exception of the relays input board and 12V cc filament supply, which were made from commercial kits. Photos 2 and 4 show the component layout and all the related wiring. Even if this is to be considered a small and relatively simple power amp, it must be built with great care. Good components throughout are essential to achieve quality results.

MECHANICS AND CONTROLS

The chassis is an old Wavetek Sweep-Marker no longer in use, modified as required to fit the new mechanics. The front panel accommodates the tone and volume controls, a pushbutton

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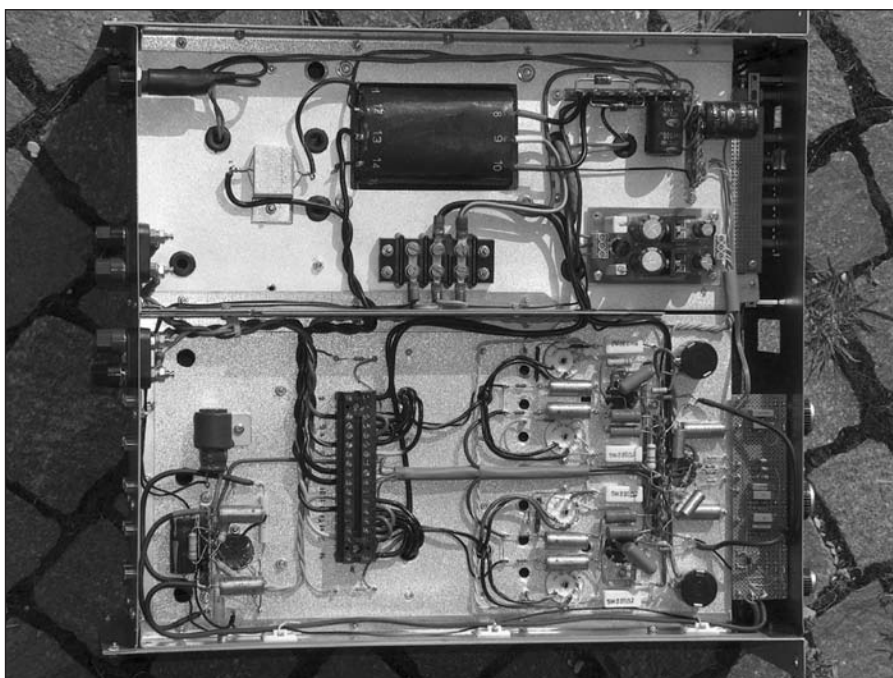


PHOTO 2: Bottom view of the two sections. On the top the power supply section and, at the bottom, the point-to-point wiring of the entire amplifier.

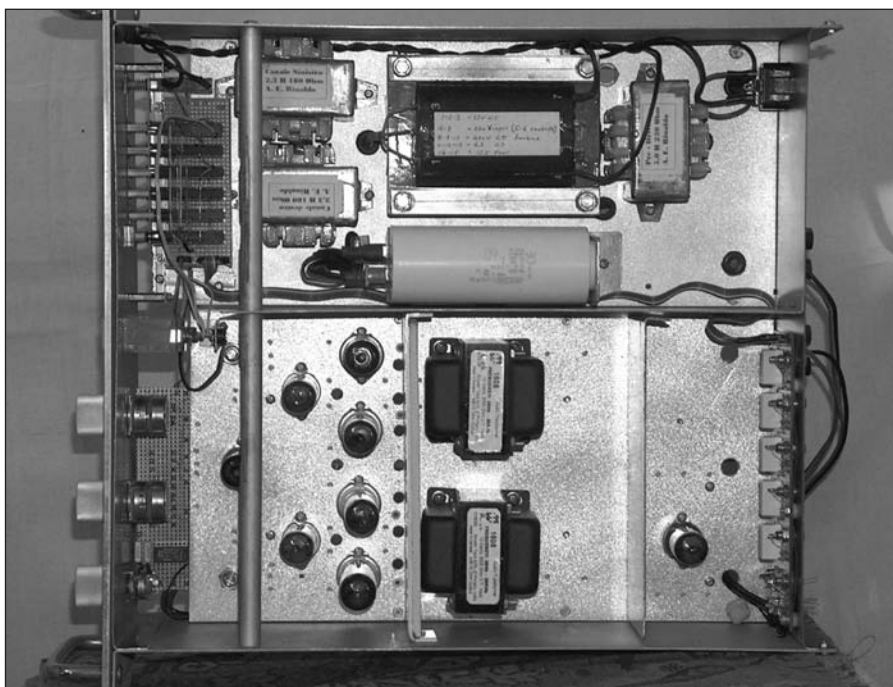


PHOTO 3: Top view. The power supply section shows the oversized power transformer, the three chokes, and paper/oil filter capacitors. Below, the tube layout, the relay board at the back end, and all the controls in the front panel.

input selection, and the on-off switch. I've also added a power meter for reference; it provides an indication of relative power in use. The back panel (**Photo 5**) contains the power cord, fuse, speaker output, and all the RCA

type input/output sockets.

RESULTS

I've already commented on the performance of the French speakers ("Xpress Mail," Dec.'05 *aX*, p. 54), but the results,

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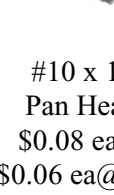
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HP 350D attenuator set	(for gain and F/B measurement)
HP 403B and Fluke 8050 A voltmeters	(Voltage monitor)

when driven with this little 10W Mat-teo, are remarkable (**Photo 6**). The employment of the tone controls allows you to tailor the sound to your pleasure—and that is exactly how you should enjoy reproduced music.

I made performance measurements using a lower cathode resistor ($220 + 50\Omega$) with a continuous sine wave signal. At 8W, 1kHz, THD is well below 1%, while the HP 3585A spectrum analyzer shows a rapid monotonic decrease of harmonic. Below 100Hz distortion in-

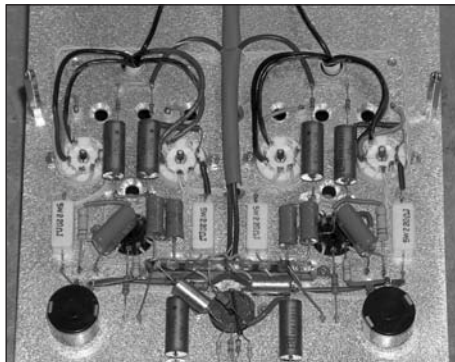


PHOTO 4: Closeup view of the amplifier wiring.

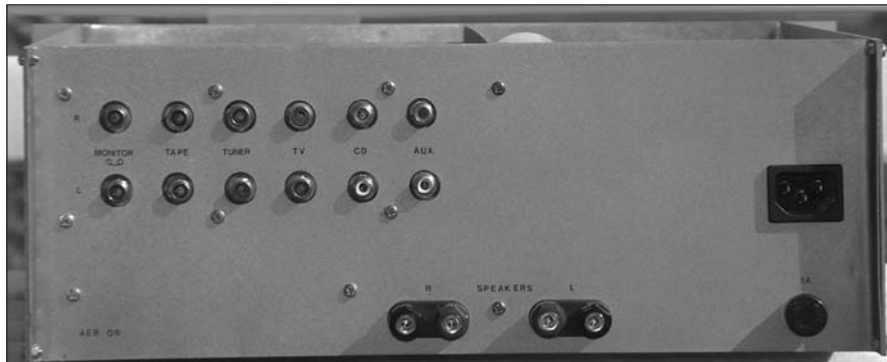


PHOTO 5: The back panel with all the input and output terminals, power plug, and speaker output.

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PHOTO 6: Matteo driving the small French speakers while still in my lab.

creases slightly.

Under reduced load conditions, overall performance should be even better. You'll like it. *ax*

[Author Rinaldo informs us that this amp design is named for his nephew, Matteo.--Eds.]

PARTS LIST

RESISTORS	VALUE	NOTE
R1	1.5K	½W
R2	470K	½W
R3, R19	15K	½W
R4, R7	100K	½W
R5, R6	10K	½W
R8	1M	½W
R9, 12, 22, 23	4.7K	½W
R10	100K	½W
R11, 29	3.3K	½W
R13	820K	½W
R14	220K	1W
R15	4.7K	2W
R16, 18	15K	2W
R17, 28	820Ω	½W
R20, 21	220K	½W
R24, 25	390Ω	3W SEE TEXT
R26, 27		SEE TEXT
R30-35	1K	½W
R36	22K	½W
RL	100K	SEE TEXT
P1 BASS CONTROL	2 × 500K	LOG TYPE
P2 TREBLE CONTROL	2 × 1M	LOG TYPE
P3 VOLUME CONTROL	2 × 100K	LOG WITH LOUD TAP
P4 DC BALANCE	100Ω	WIRE-WOUND

CAPACITORS

C1	100K	400V
C2, 7, 9, 10	470K	400V

PARTS LIST cont.

C3, 5	2.2K	400V
C4	22K	400V
C6	220P	400V
C8	250K	400V
C11-14, 16	100MF	50V
C15	68K	100V
C17, 18	100MF	450V
C19, 20	60MF	450V PAPER/OIL
C21	10MF	450V
C22	47MF	450V

MISCELLANEOUS

T1 POWER TRANSFORMER	CUSTOM	SEE SCHEMATIC
TU OUTPUT TRANSFORMER	10W PP	HAMMOND 1608
Z1 IMPEDANCE	5H	100MA
Z2, Z3 IMPEDANCE	2.3H	200MA
RELAY BOARD	12V	FEME-MINI
LEDS	GREEN	7
METER	1MA	SEE TEX
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