The Inverted Triode John L Stewart June 2017

Too many of us 'The Inverted Triode' may sound somewhat odd but does not refer to a triode stood on its head. Nor does it repeal Newton's Laws of Gravity or Darwin's Theory of Evolution. Simply stated, the functions of the plate & grid are reversed.

The plate becomes the controlling electrode while the grid provides a usable output. That is very different from what we are accustomed. FE Terman is referenced as the first to suggest this form of operation in a 1928 paper. On p209 of the 4th Edition of Electronic & Radio Engineering he refers to a useful application wherein a current in the grid circuit can be controlled by a very large voltage on the plate. The influence of the plate on the cathode current is much less than that of the grid, since it is shielded from the cathode by the grid. In general, the mu of the inverted triode is simply 1 / mu, the reciprocal of the triode mu.

mu' = 1 / mu (mu prime)

This kind of operation & information does not seem to be very useful. But applications are often found later.

In an ordinary triode tube, the functions of the grid and plate can be interchanged by making the grid the anode, and by using the plate as the negative control electrode, as shown in Fig. 6-27. In such an *inverted* tube the negative plate affects the electrostatic field in the vicinity of the cathode and hence controls the anode (grid) current. However, since this control electrode is relatively well shielded from the cathode, the amplification factor is low, being approximately $1/\mu$, where μ is the amplification factor of the tube operated as a triode in the normal manner. The inverted tube is a useful laboratory tool where it is necessary to control a current by a very high voltage without at the same time consuming energy from the high potential source.[1]

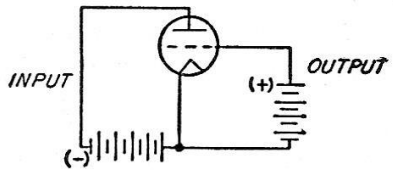
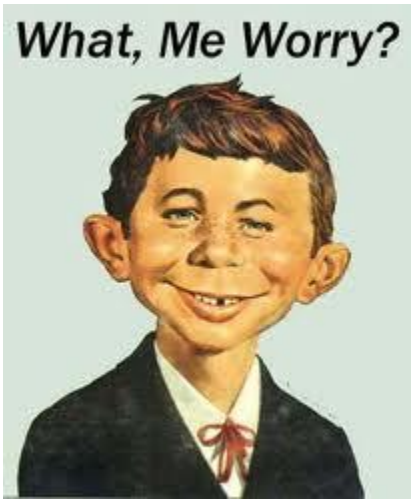


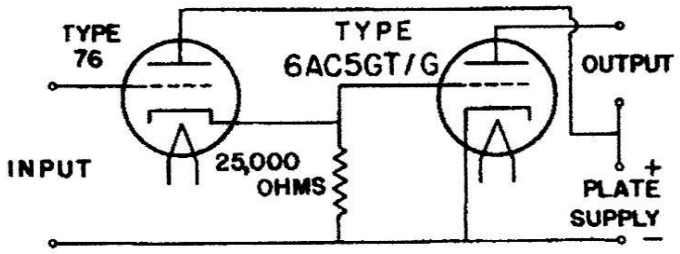
FIG. 6-27. Circuit of inverted tube.

Steve Bench- was a regular contributor to various vacuum tube forums for many years. He is an electrical engineer with many years experience primarily in the telecom field. We can read about him & many of his projects at this link- http://diyaudioprojects.com/mirror/members.aol.com/sbench101/

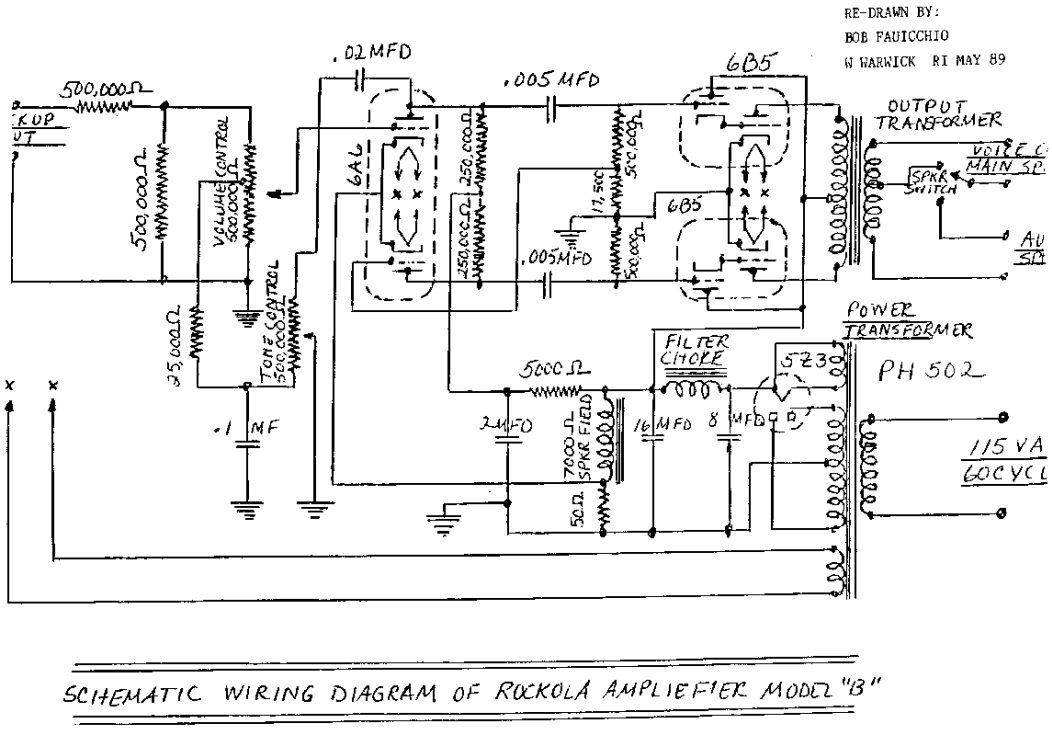
Steve did build several amplifiers using the inverted triode topology. Steve is one of those folks who does think outside the box. Have a look at some of the projects, they are a surprise to many.



About 15 years ago I was looking for a way to simulate pentodes in the Electronic Workbench Software I was using. There appeared to be no easy way to insert a text file containing the information as in SPICE. But there is a connexion of a pair of triodes that looks a lot like a pentode while in circuit. Examples of that shew up in some of the old tube manuals, such as RCA RC-14. Using a very high mu triode 6AC5G (mu = 125) driven into Class A2 by a medium mu triode such as a 76 does that well. A whole group of tubes, including 6B5, 25B5, 6N6G & 25N6G including both the driver & output sections were developed to be pin for pin replacements of similarly rated pentodes. One advantage they have is self biasing, no cathode resister or bypass cap are required. But they did not catch on well.



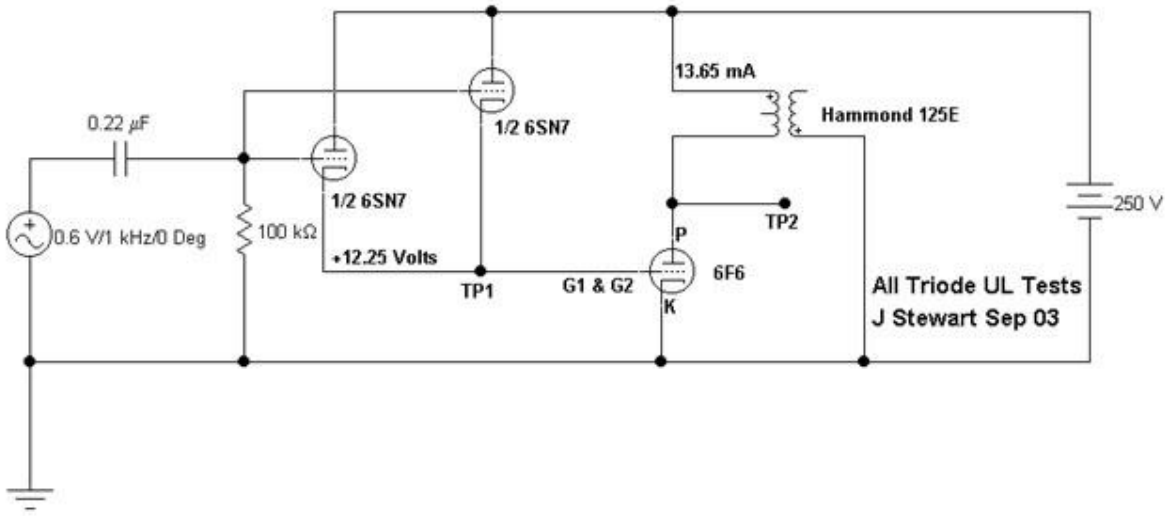
One example where they were used is this PP 6B5 amplifier by Rockolab.



SCHEMATIC WIRING DIAGRAM OF ROCKOLA AMPLIEFIER MODEL "13"

I did not have any 6AC5G high mu triodes in my stash. And the price is often rather high, the market is driven by collectors & those restoring old receivers. For the tests of circuit feasibility I chose the 6F6 to act as the high mu part of this strange combination. When the screen & control grids are connected together & the drive is applied at that point the mu is about 50. This is a property of most common power pentodes.

I used the paralleled sections of a 6SN7GT (mu = 20) as the driver. All of that driving into a Hammond 125E, a PP output transformer. By connecting the plates of the 6SN7 first to the supply, then the Hammond OPT CT & finally to the 6F6 a table of operating results was obtained.



6SN7 6F6 Direct Coupled Composite Amplifier Test Results

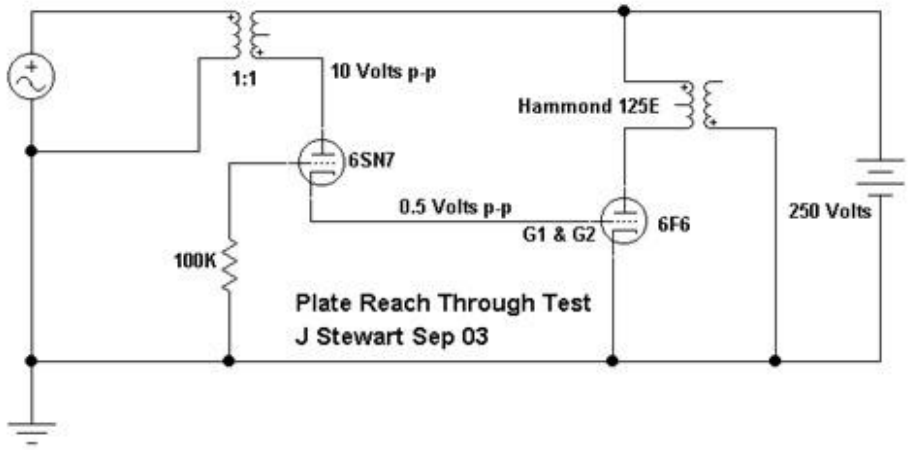
Both sections of 6SN7 cathode follower direct coupled to a 6F6 whose G1 & G2 are strapped together.

Input test signal is 6 volts p-p. All measurements as seen through a X10 Scope Probe.

Rp determined by what resistance in parallel with the unloaded output transformer will reduce the output signal by 50%.

Test	6SN7 Plate Connexion	Signal at 6SN7 K volts p-p TP1	Signal at 6F6 Plate volts p-p TP2	Composite Mu	6F6 Mu	Measured Rp
1	+ve Rail	0.48	21.5	35.83	44.79	51K
2	50% Tap	0.25	11.8	19.67	47.20	27K
3	6F6 Plate	0.16	7.9	13.17	49.38	15K

I wondered about the influence of the various signals driving the plates of the 6SN7. A test was setup so that an interfering signal could be applied to the plate while the circuit had no other input.



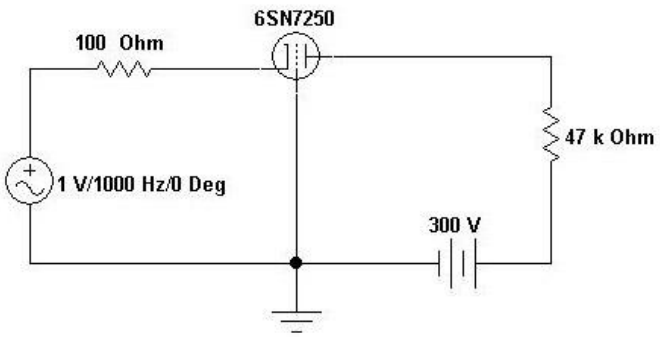
As it turns out, the reach thru to the 6SN7 cathode is 1/20th of the signal on the plates. That is just as Terman tells us, the plate in this case has 1/20th the influence of the grid. And the inverted mu is

mu' = 1 / mu

The Grounded Grid Amplifier

The cathode of a triode (or pentode) can also be driven so that gain is possible at the plate. In this case the mu of the configuration is (mu + 1). So the influence of the plate in that connexion becomes

mu' = 1 / (mu + 1)



In calculations where the tube has an ordinary triode mu of 20 or more, this makes little difference in the final result. However, input impedance is quite low. For this example, using

the published data, the input looks like 2.6K. The source impedance needs to be included in any calculations.