Secrets of the phono stage... Allen Wright, Vacuum State Electronics

When it…finally…arrived…*SP #14* was a blast! Three *New York* power amps and an *Italian* phono stage with full details of how, when and why—which in a world overrun with micro poweramps masquerading as preamps takes big time courage—*Bravo Diego!*

I put my ass on the line with the heavily phono biased *TubePreamp CookBook* so I get very interested in seeing what others come up with in this trickiest of audio areas. Any half decent tube poweramp can sound acceptably musical, and line amps in this age of digital cut more than boost—but phono preamps have to handle very dynamic yet incredibly low signal levels—hit them with a wild equalisation curve and all the while (hopefully) maintaining a *very* tight gain/phase relationship between the channels—so as not to corrupt a stereo picture hard won from a diamond to vinyl *mechanical* interface!

Before Diego's opus, a few passive EQ phono stages/preamps appeared in the literature; some balanced, most s/e:

- the legendary *Loesch* in SP#3,
- JC's *Siren Song* in SP#3 + #4
- Joe Curcio's *Daniel* in AA circa '85
- Erno Borbely's hybrid in GA 2/97
- My balanced *RTP's* in the TPCB
- My s/e *FVP* in the TPCB 2nd edition.

Now my intention is not to offend in discussing these designs, but to help make these units *even* better. And I've included my latest s/e effort so you can see where I'm coming from.

VITAL points in phono stages:

1/ No loop feedback! No contest—the sonic advantages of dumping all time dispersive NFB and going *realtime* doesn't have to be preached to too many SP readers!

2/ Use hi gm tubes at hi currents! Arthur Loesch runs those freaky 417A UHF tubes as RIAA inputs, with 6922's to follow—a man with soul! And why use such tubes? Consider this from Prof M. O. Hawksford *(HFN&RR 8/84):*

"…just as the stylus is required to resolve distances compared to the wave length of green light, so the (phono) amplifier is required to resolve charge levels in the order of an electron"

This is a MC cartridge hunting for the *extreme* low level ambience that makes great live recordings shift time and space so wonderfully—and a WE417A with it's 25mA/V (or a 2SK147V with 40mA/V) will have *W-A-Y* more chance of perceiving and acting upon this lone little electron than a 12AX7 with one twentieth the gm. They're also much quieter, and at typically ten times the running current the associated impedances are much lower—which all helps the music roll on through.

3/ Accurate RIAA! The three time constants in the original RIAA spec create four areas in the audio spectrum: under 50Hz, 50Hz to 500Hz, 500 to 2122Hz, and 2122Hz on up. Now normally a 1dB shift is not easy to hear, but such an error in one of these bands can make a whole system become light and bright (or dark and mysterious) because it moves at least two whole *octaves* of music bandwidth around!

Although not a cure-all, split time constant EQ is the way to go (unless you are a devotee of the KISS principle chasing *minimal* stage count) but the key advantage has not been emphasised by our authors: split EQ may or may not sound better—but it is *infinitely* easier to trim to exact RIAA conformance than any "all in one" topology. And trim it you *must* if you want to get real RIAA accuracy!

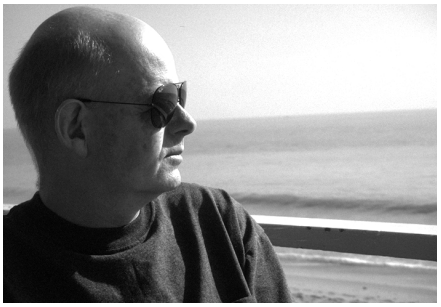
Your wiring capacitances will always be different to the designers unit, and unless you luck onto some 0.2% C's and R's of *exactly* the specified value, you won't be in the ballpark—even assuming the published values were right in the first place!

As detailed in the *TPCB:*

a/ Aquire RIAA caps as close as possible to the spec'ed values. I use *WIMA* FKP2 polyprop and foil. Buy lots…

b/ Match these caps ch to ch to better than 0.1%. N.B. Diego's *Audio Note* paper & oils may sound wonderful, but they don't come in the tolerances needed here—so you may need *quite a few* to find those *matched* pairs…

c/ Input a square wave via a precise reverse RIAA network and then tweak the relevent *resistors* to get the best



possible square wave out. I use 10 turn trimmers to start, and replace them with fixed R's once it's AOK.

Surprisingly, few designers suggest precise caps, and none say to match them *super tight* channel to channel. But Diego splits the network the way I found sounds best: with the 3180 + 318μS first and the 75 μS last…

4/ Add the missing Time Constant!

The 75μS networks in all these designs (except mine) fall at 6 dB/oct *forever…* OK, this may be the RIAA spec but if you think of the record cutting process—can they really boost at 6dB/Oct. from 2122Hz on up *forever*?

Back in the 70's we called some cutting equipment service departments and found they do roll off this boost with a chicane at around 50kHz (3.18μS)—so as to keep cutter head warranty claims to a minimum or whatever. And when this is done (in reverse) in a preamp, it flattens out that 75μS drop to hell and restores much of the air and naturalness that's on the master tape.

This is the purpose of R3 on the *FVP5* map, and it's pretty easy to try yourself:

a/ Find the cap used for the 75μS roll off (i.e. 820 or 1000 pF in Diego's)

b/ Calculate what R you will need to get 3.18μS in conjunction with this cap (= 3K87 or 3K18 in Diego's)

c/ Fit it in *series* with the cap—and tweak for sonic satisfaction and *exact* upper octave ch to ch balance. N.B. It's phase accuracy across all four bands that gives you that *real life* image the bottom feeders say don't exist!

5/ Starwire Everything! I always *star wire* my modular stages to just one point each for B+ and gnd, and further *starwire* each of these modules to the power supply reference points—all with low impedance 3mm silver foil.

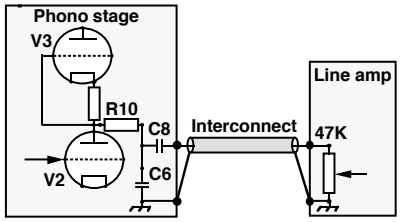
6/ No redundant stages! This generally means high gain per stage. Most of the listed units need two stages in the phono for MM and three for MC—but the *FVP5* does MC with two and the *RTP3/5* does MC with just one!

And Joe & Diego, please…*NO* cathode followers, nowhere! In the *TPCB* I call them *Miss Piggy* as they sound just horrible, yet with some innovative thinking it's off to market for her…

For example; Diego's 75μS network is driven from the second tube, and followed by a CF. Yet he says this CF has to be very lightly loaded or it sounds *tired,* which is a very good description of the *Miss Piggy* sound. But if she can't perform, why use her at all? As the subsequent v/control is 50K, her only purpose is to isolate the 75μS network from the outside world—and that's a small job for a very big girl…

If the phono stage is in the same box as the line amp, this problem's minimal anyway and *Miss Piggy's* redundant.

But if they are separate, and if you're prepared to always use the same I/C between the boxes (perhaps a superb silver foil/teflon construction from the *SCCB?*) why not turn this bug into a benefit by using the high quality capacitance of the I/C as part of the 75μS?

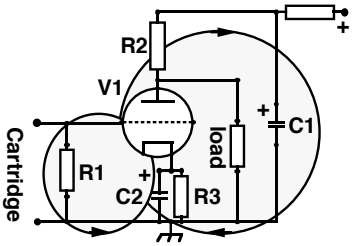


The *"Give Miss Piggy a Miss"* mod

Miss P is again redundant and should perhaps look to a career in the movies!

7/ Circuit before components! Diego identifies the places where you need to spend money, and where it doesn't matter so much—but I say focus on these vital points and *first* get the circuit right to ensure you keep *all* the dynamics and information—*then* find the sonic flavour you like by playing with components to your hearts content.

8/ No Electrolytic Caps in the signal path! No SP reader would ever e/cap one stage to the next, but do realise this also means no e/cap cathode bypasses and no e/cap B+ rail bypasses? I'm sure there are some real scientific terms for the "input" and "output loops" that exist in every stage, but these are good enough for a country boy to make his point with someone else's amp…so let's look at Diego's input stage:



Input and Output Loops

Here the input loop contains C2, and the output loop contains C1 plus C2! Look, I know everybody uses these things—but does that make it right?

Every time I pull a cathode e/cap, things get cleaner, more dynamic and transparent, and when I also do the B+ rail correctly—magic occurs!

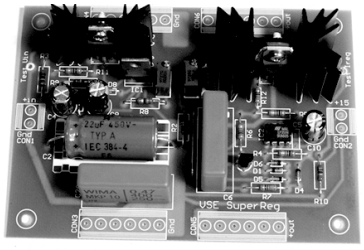
9/ Use Shunt Regs! I agree that series regulators are a waste of time and do more harm than good, but a full house, fast and *current sourced* shunt reg will change your views on B+ bypassing and regulation—forever!

In my opinion the two most important articles ever to appear in SP rocketed right over most people's heads—but they contain vital info for all music lovers, so dig out SP#4 and #6 and read the Boyle/Camille articles. Their 211 amp is amazing but that's not the point—get into their shunt reg revelations. And if you don't get a growing feeling of excitement, then read them again and again until you do—and then study the *SuperReg* chapter in the *TPCB* for even more info.

We've been using shunt regs for 20 years and B & C's discoveries exactly parallel ours. The circuits are conceptually similar—so build up one of the designs (and one is enough even for stereo), pull all your B+ ecap bypasses, starwire the shunter into your box with *low z* wiring—and be prepared to be blissed. I'll spare you the superlatives!

The *FVP5*

Up untill 1980 I was making *Audio Research* style preamps, but they soon became a dead end, with huge work needed to bring minor improvements.



The plug & play *SuperReg*

Luckily, lateral thinking mode kicked in and I tried what was essentially a *Tek/HP* 'scope gain block (balanced cascoded 6922's, no feedback) for phono and line stages. A complete shot in the dark, it was sonically wonderful and became our first (limited) production *Realtime Preamp (RTP).*

This concept is still the best I know and has evolved into the current *RTP3/5's.* This eighteen year long development path is fully documented in the *TPCB*, with (now) all the schematics.

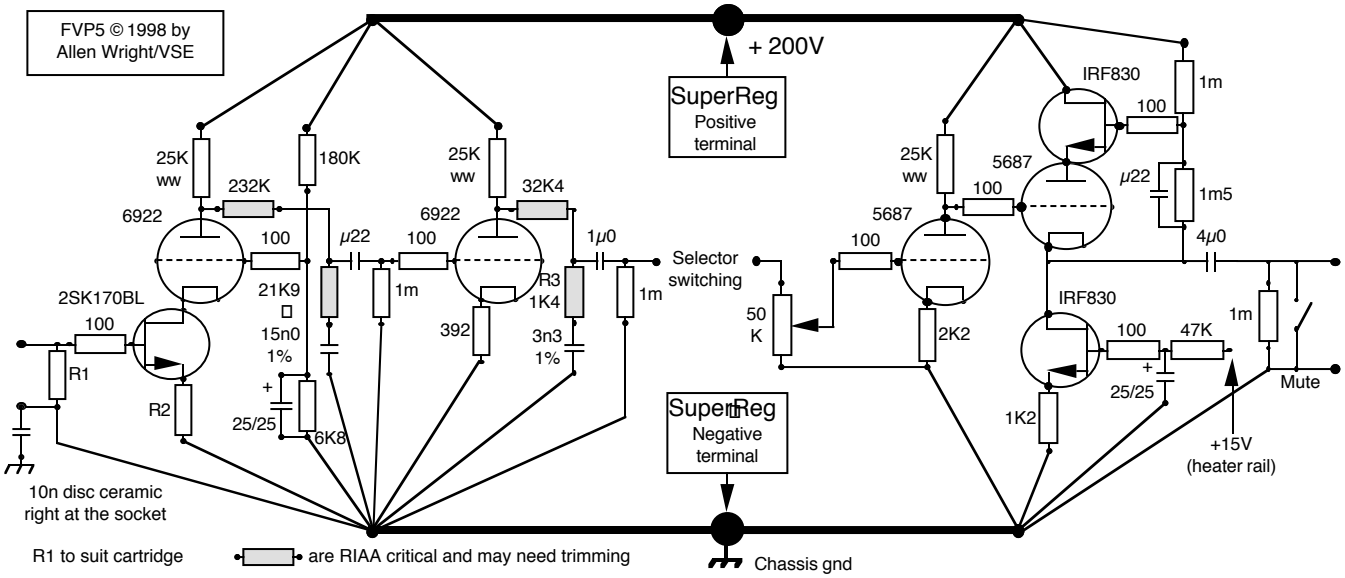
But no matter how perfect a design you come up with *(has he got an ego or what?),* there are always &^$#@! minimalists hanging around waving their *"Bucky sez: Do more with less!"* placards and shouting their downbeat riff: *"KISS! KISS! KISS!"* But one day back in '85 or so, one of them actually put some $$ on the table and said:

"I want a single ended Realtime…"

Cool idea, it sounded as dynamic as a *RTP*—just less refined and missing the super bass tonality. Forgotten for years, the concept was resurrected recently—and using the *SuperReg* and a few other tricks it finally became a serious device that—in hard wired form—was the first preamp I've ever heard that bettered my own—but on a PCB—*RTP3!*

Sure, there were a few false starts with SRPP line stages—not obviously ugly like poor *Miss Piggy* but they gross you out over time—and rest assured, a hard wired *RTP3/5* is another story…

Phono Stage. Enough back patting—I can already hear most of you muttering: *"Yukko—FETs"*. But hear me out—I've built it all tube and this is simpler, cheaper and sounds even (slightly) better. The FET allows a *consistant* low noise figure that handles all but those *nanovolt* output MC's, and without the blurring (and horrific cost) that I find comes with step-up transformers. And used in this way (but only this way) as



the bottom half of a cascode, this FET is *completely sonically invisible!*

Please, try it *before* you sneer, OK?

The 2SK147 is now out of production and almost impossible to get—but the readily available 2SK170 and '369 seem pin and chip identical. The only change is the TO92 package which limits its dissipation to 400mW—but they're cheaper and the '170 is even quieter!

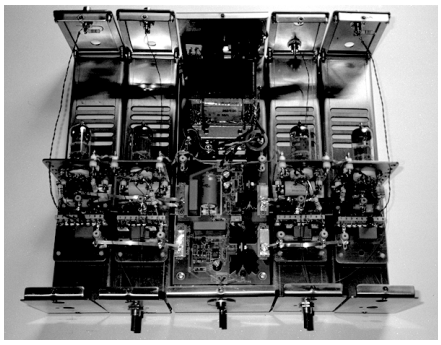
Schematic Details—Phono: A cascode 1st stage brings several advantages:

1/ R2 can range from 150Ω down to 15Ω, which adjusts the phono gain from 40 to 60dB—with no side effects.

2/ The high output Z means tube selection and/or aging doesn't affect the 1st part of the RIAA network—and with both the 3180 and 318μS points there you don't want too many changes…

3/ It is inherently quiet, linear and very fast—which is why *Tek* & *HP* used it.

The stuff on the 1st grid ensures the FET operates at it's best point—it will work with the grid grounded (via the stopper!) but not at all gain settings.



The prototype modular "kit" *FVP5*

This stage feeds through the RIAA into the second tube, a common cathode (CC) stage with (an unbypassed) cathode R—a topology that should *never* be called an *anode follower* because that's something *very* different: a tube "op–amp" with –1 gain from 100% NFB.

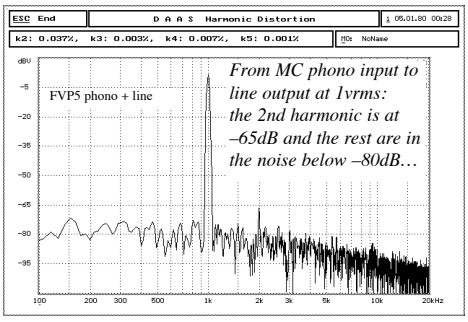
The cathode degeneration makes this stage more linear and again helps to keep things stable long term with differing tubes and the effects of aging.

It feeds into the 75μS network—where the trick 3.18μS time constant is formed by R3. Now if you can't figure anything like 75μS from these values—add in the 50K pot and the Ra of the tube as they're very much part of this network. The RIAA values given are those from the prototype "kit" *FVP5* (as pictured) and should be close—but tweek you must if you want it to *really* focus…

The Line Amp runs a hi gm low μ triode for a stage gain of 15dB—the lowest I could get while still having lots of current to keep it fast and clean. And even then it's more than digital needs. A 12AU7 works fine and octalists could try a 6SN7. First tube is a CC amp and then a very special output stage we call the *Super Linear Cathode Follower.* .

I guess with all my dissing of *Miss P* I'll have to explain the SLCF a little: It is the only cable driving stage we have found that's (almost) transparent—and came about after some serious study of *Valley & Wallman* back in '84.

They say a CF is helped by a current



source in it's tail—sure, but it's not enough—so we added an *active* bootstrap to force the CF to also operate under constant *voltage* conditions, which is how they're supposed to like to work—and miracles of miracles—*Miss P* blossomed into *Rebecca Rabbit* and I fell deeply and seriously in love!

MOSFETs, which are fine in (but *only* in) "secondary" signal paths make this stage tighter than if it were all tube—and this SLCF topology sonically *kills* the SRPP, the μF and *everything* else we have tried that has any muscle…

Enough *FVP5's* have been built to ensure the bugs are flushed, so you can build it with every confidence of having a real stunner. And it is—because it's fast, detailed and ultra dynamic, yet it *really* honours the music…

I still prefer a hardwired *RTP3/5* if only for it's inherent ease of *absolute polarity* switching—but this *FVP5* has been in my system for six months now and it still impresses me, and my visitors.

Whatever…let's not forget why we do all this fooling around—and as the way cool Steven R sez:

Enjoy the music, dudes...