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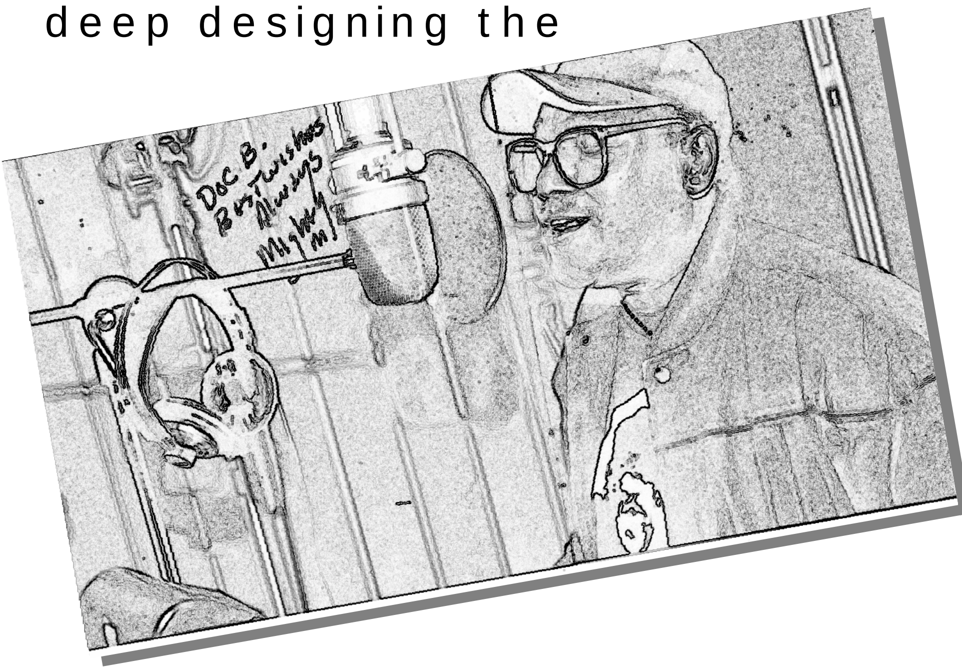
ElectronicTonalities

V A L V E

SPECIAL ISSUE

deep designing the



Blues Master

part 1

volume 5 number 1 1998

VALVE

the monthly magazine
of eXtreme audio

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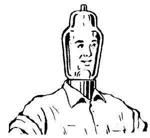


editor's thing

Yes, that really was Baby Katlyn's bottom on the inside cover last month, not mine.

OK, that's out of the way.

Now, it gives me great pleasure to present one of the most challenging issues I've ever put together.

In an effort to demonstrate the point that the sharing of knowledge by the tube audio community is as important as the finished products we build, I present to you this month something which I have tagged a deep design. Deep design is my effort to explain in some depth the logic behind the selection of each component in a circuit design.

Too many circuits shown in this mag and others gloss over the small points in an effort to explain one element of a design, or they just plain throw up a schematic with no explanation at all.

This design, which I call the Blues Master, attempts to address to the logic behind the topology chosen for each stage, the math required to derive component values, and part numbers and sources for each component.

You should be able to throw all these parts together and have a beautiful sounding project. But don't blow this issue off just because you don't want a SE 300B amp!

Many of the ideas, the math, that basic theory, can be applied to any design you wish to tackle.

One thing I may take some heat for is the fact that this is not the simplest design to derive, it is direct coupled, uses a very special active load on the driver stage, and has a parallel feed output stage.

But I have included these concepts because I feel they are the way of the future in competent SE design, and are worth learning.

So let me know what you think. I know that one article filling the whole issue will turn some folks off, but I suggest that you consider the quality of the subject matter before the format. I know that VALVE seems to be filling up with ads, too. Without delving into the economics of paper and postage, I want you to know that are working on this situation, and hope to have some solution soon.

What are you waiting for? Get readin'!

Doc B.

advanced amplifier design class

We haven't done a very good job of promoting this class, and so I'd like to move the date to April 17 through 19, to give folks time to make travel plans.

This advanced class will be taught by John Tucker, John Camille, and myself, with a likely appearance by Paul Joppa as well.

This class will be different than the basic class we teach after VSAC. In that class, students are taught the basic skills necessary to build our standard kits, like proper soldering and wiring techniques. They are presented with the basic theory of operation, and they are exposed to various modifications to the kits, with the idea that they can take this knowledge and apply it to future projects, whether mods to the kits, or perhaps mods to other equipment they own.

The advanced class will place much more emphasis on theory, with the idea of giving you the tools to do your own designs from scratch. In this class, the textbook, the chalkboard and the notepad will dominate. The student will be shown the logical progression of equipment design much like the design development detailed in this issue, but with the added help of one-on-one discussion with the instructors, so that all this theory may be tailored to the students individual design ideas.

Price will be $350 for three days, which includes lunch and a textbook. The day lectures will most likely turn into freeform evening solder sessions, and students are encouraged to bring projects to work on during these after class "listening and lie swapping" sessions.

Basic electronic assembly and test equipment is available, as is an HP 35665A dynamic signal analyzer and a reference system for equipment audition.

There are two nearby motels, and we can most likely offer rides to and from the class.

If you are interested, please call soon, as class space will be limited.

C^4S loads available

The John Camille designed active load described in the Blues Master article is available from Electronic Tonalities for $25 the pair, which includes the stuffed boards and instructions for use - 360-697-1936 to order.

Back Issues

Back issues are printed to order - please allow two weeks for delivery - add $5 postage for orders outside the US

Volume 1 - 1994 issues - $20
a Williamson amp; Dyna Stereo 70 mod bakeoff; converting the Stereo 70 to 6GH8's; a QUAD system; triode input Dyna MkIII; MkIII vertical tasting; smoothing impedance curves; Altec A7; Ampexes Nagras and ribbon mikes; Triophoni, a 6CK4 amp; audio at the 1939 World's Fair; books for collectors and builders; V.T. vs. R.M.A. cross reference; FM tuner tube substitutions; Big Mac attack - the MI200; 6L6 shootout; a vintage "audessey"; more FM tuner mods; vintage radio mods; Heathkit rectifiers; PAS heater mod.

Volume 2 - 1995 issues - $20
Rectifier shootout, tube vs. solid; FM 1000 recap and meters; single ended 10 amp; triode output W-4; Optimus 990 - speaker for SE?; star grounds; tuner shootout; Living Stereo, vinyl or CD?; World Audio SE integrated; firin' up - smoke checking; Brook 12A schematic; 6C33 vs. 3C33; Heathkit power transformers; 6B4's + MagneQuest = SEcstasy; W5 mods; triode operating points; Dyna restorations; Marantz 7,8 and Scott LK150 impressions; hackable vintage gear; Quasimodo - PP 805 amp; restoring a Scott 340 in 75 minutes; a dream system for 78's; cartridges and styli for 78's; Restoring a Lowther, Part 1&2; easy tube CD output hack; 6ER5 phono preamp; 304TL & 450TH SE operating points; hypothetical DC ESL amps.

Volume 3 - 1996 - $25:
Single Watt, Single Tube, Single Ended, an amp for Lowthers; the Vintage Speaker Shootout of 1996, QUAD vs. Lowther, vs. A7; the Voigt Loudspeaker, the Single Ended eXperimenter's kit; cathode coupled SE 6AS7 amp; how to build the Superwhamodyne; refoaming AR woofers; mesh plate tubes; rebuilding QUADS; QUAD amp filter surgery; single gain stage amps; the Brooklet, and Brookson, choke loaded PP 6080 amps; transformer coupled PP 6DN7 amp; the Iron Maiden; Building the Lowther Club Medallion; the TQWT, a tapered pipe enclosure; IT 300B amp.

Volume 4 - 1997 - $25:
the Whampipe/Hyperwhamodyne; weird interconnects; winding your own SE output transformer; Tapered Quarter Wave Tubes; battery bias; onetuber 417A and 437A amps; DAC attack; 6BL7/211 SE amp; pro sound speakers at AES; 46 plate curves; what's all this about parallel feed?; parafeed line stage; C.W. horn divided by two; Svetlana meets Brooklyn; parallel feed SE 811A amp; parafeed 2A3 amp; Lowther fixes; Altec vs. the competition; VSAC 97 program guide; VSAC 97 photos; Andy Bartha's cool speaker cables; Paul Joppa's 6DN7 driver stage; S.E.X. kit schematic revealed; an Edgarhorn builder's story; direct coupled active loaded parafeed 45 amp; Brainiac's S.E.X. changes; VSAC 97 seminar notes; tweaking the one tube 6DN7 amp, Lowther drivers, and the Wright preamp; 300B S.E.X. amp conversion; mini monitor for 300B amps,

put on yo' pinstripes, git loaded , git fed , and git da' blues

Doc B. gets let out of the home just long enough to share some of his design methods in this two part thought piece on the development of an amp with the soul of a Blues Master

This is an attempt to combine a bunch of ideas that have been getting kicked around by the editorial staff the past year-

- ♦ We've felt the need to do another article where we describe some of the logic behind the values and types of components chosen for the given circuit
- ♦ We also need to give folks a 300B type circuit that uses the sexy Pinstripe parafeed output transformer.
- ♦ Many folks have asked me for circuits using the KR Enterprises tubes.
- ♦ This will also give me a chance to explain the new active load boards we are selling, and how to tailor them to your specific applications.

Leap of faith

OK, here's the gamble that comes with the program - this amp hasn't been built yet. To be sure, the basic building blocks, the active loaded driver, the parafeed output, have all been done. I use a VV52 amp that's a kissing cousin to this design. But there is no operating prototype exactly like this amp. Either we are very confident of our results, or we are quite insane. Maybe both. Are you willing to take the gamble?

Rationale

There are several things this circuit is not:

It isn't guaranteed to be the best amp in the world (but it should be *one of* the best)

It isn't cheap (but you get what you pay for)

It isn't an application that runs the tubes to the limit in the interest of saving you from going out and buying some decent efficient speakers to replace your current hogging, undynamic 87 dB tree trunks (but it should have a level of finesse below 1 watt that will stir your soul, and put out an easy 8 watts when you want some sledgehammer in that soul).

OK, consider that as some basic philosophical stuff out of the way.

Now here's some things I know work well, that I want to try to fit together in this project.

- Parallel feed output. Look, I don't care if you're sick of this. It's mo' betta. I for one am never going back to convetional airgapped SE. Bass articulation, bandwidth, natural voices, detailed recovery of harmonic structures, lack of edge, it all adds up to superior sound. So put on your pinstripes, and we'll git fed.
- Active loaded driver stage. I was skeptical about this concept when Tucker introduced this John "Buddha" Camille

design to me. I mean hey, we been fighting to get rid of sand in our amps for all these years, right? Well, that was a bias based on ignorance. The best sounding amps come from those with open minds. The load gives us essentially all the mu available from the driver tube, an important consideration, because I believe in two stage amp circuits. The load also helps the driver stage to match the bass articulation and super low distortion of the KR tube/parafeed output stage, and voila, that soft butt SE bass sound is gone, replaced with tight controlled bass and a dead quiet background that whups both traditional tube and solid state for natural, open presentation. The tube sound is still there, more of the good parts, less of the bad. So we'll git loaded.

- Direct coupling. Since we're going to the trouble of using parallel feed and active loading to increase the circuit's resolution and decrease it's noise floor, and since we already have a coupling capacitor at our output transformer, let's keep as much stuff as possible out of the signal path and direct couple this amp. Those of you who have built the 45 parafeed amp we published last year should be nodding your heads in agreement with what we've said so far. That 45 is one stunning little amp, if you have Exemplars. But you know me, I need more like 8 watts to get the sledgehammer in the soul with my 98 dB speaks. And so the quest becomes one for that extra 6.5 watts, without losing too much of the 45's goods in the process.
- KR tubes. There are a few tubes that stand out when it comes that certain magic in their presentation. Single plate 2A3s, 45s, 845s, 10Ys, WE 300Bs, name your favorite here. One of my faves is the KR series of tubes. I can walk into a room using amps with KR tubes at a show, and no matter what speaker is being used, immediately identify that KR sound and revel in its low distortion, liquidity and clarity. I roll all the different models together here, because they carry a strong family resemblance in their presentation. A personal favorite is the VV52, with its ballsy bass, but its rather insatiable demand for plate current makes it a rather difficult tube to work into a parafeed arrangement without going to monstrous custom made plate loading chokes. In order to keep this project doable on a broader scale, we'll design around the very sexy looking VV32BC, with it's flat topped cylindrical envelope and gorgeous blue glass. Yeah, that's how we git the blues...

OK, so there's some basic parameters to start our design process with.
Now let's see what we can do to integrate these bits to their best effect.

Finding an operating point

Let's start with the output tube. We could just as easily start with the output transformer, but they don't call 'em FS-030 amps, they call 'em 300B amps, right?
To figure out how we're going to run this VV32BC amp, we need to look at some operating curves.

HEY!

Don't start noddin' off on me here. You keep horses, you shovel some poop. You design amps, you do a little math. It's just the facts, homes.
The plate curves for a VV32 are on page 10
OK, what the heck are we looking at?

Plate dissipation

Well first off, we need to know what the plate dissipation of the tube is. Plate dissipation is measured in watts, and is quoted as a maximum wattage beyond which your tube goes bye-bye in an accelerated fashion. Maximum plate dissipation is 70Watts for the standard VV32 and the BC version can handle a bit more, due to it's ultra cool blue glass flat top envelope. But even at the special price Welborne Labs is offering to VALVE readers on VV32BCs for this project, I'm enough of a tightwad to run a bit down from maximum overdrive on the old plate dissipation to get maximum life expectancy instead.
OK, we know we have 70 watts dissipation possible from this tube, and now we need to see what the plate's voltage and current limitations are. The maximum voltage we can run is 550 volts. The maximum current we can run is 160 mA.
Next step - some math. Calm down, take a swig of that Jack Daniels. This is an easy formula.

power = voltage X current

The first thing you might notice is that, if you plug in the maximum voltage times the maximum current,

550V X 0.160A

(Continued on page 9)

(Continued from page 7)

you get 88 watts. No, that's not a mistake. It means that you can't run at maximum voltage *and* maximum current ratings at the same time.
Great, this is no effing help at all. How do we decide what voltage and current to use?
Well, this is where experience, recommended operating points, the plate curves, and a blind faith in the right to eXperiment comes in.

The Juggling Act

The KR book gives a suggested operating point, and I will say that these people know how to run their tubes. This point is 350V and 110 mA. Interestingly, they are not shooting for anything remotely resembling maximum dissipation, as

350V X 0.110A = a mere 38.5 watts.

And so we see that maximum dissipation may not be necessary to give the best sound with this particular tube.
OK, let's assume that this plate dissipation is a ballpark figure for what sounds best. This may be a naive assumption, but we have to start somewhere.
What are the other determining factors when it comes to choosing an operating point?
Well, the current capacity of the inductor loading the plate of the VV32BC comes to mind. In our parafeed case this will be the current rating of the plate loading choke we use. At this time the biggest production plate loading choke available is the MagneQuest B.A.C., rated for 80 mA.
Well that makes this choice easy, let's choose 80 mA as our plate current.
So, we get

38.5W/ 0.08A = 481.25V

So, we run at 481.25V, right?

Well, there's still more to the story. Have another sip of that J.D., flip that Elmore James over on the box, and bear with me.

Matching to the output load

Another consideration of our tube's operating point is how well the tube's plate resistance will match the impedance of our output transformer's primary. You will see standard plate resistance numbers thrown around for various tubes, like 800 ohms for a 2A3, but it's not that simple.
Plate resistance is a function of the tube's plate voltage and current. Paul Joppa has made a marvelous contribution to us homebrewers with simplified math for calculating plate resistance. It goes something like this:

(Plate Voltage/ Plate Current)/5=
plate resistance

So, for our suggested operating point we get

(480V/0.08A)/5 = 1200 ohms.

Now, the rule of thumb for SE amps is that the the impedance of the output transformer primary should be a minimum of 3 times the output tube's plate resistance
The primary impedance of the Pinstripe is 3000 ohms.

3000/1200 = 2.5, oops. This isn't really close enough to 3.

OK, we're kinda stuck with our current, we can't raise it any higher, which would lower the plate resistance of the tube, so let's lower the plate voltage instead, which will give us the same resistance lowering effect.
This is the part where Mr. Wizard sits on the perfect point to balance the see-saw on the fulcrum the first time, and Julia Child pulls a finished roast out of the oven that she popped a raw piece of meat into 20 seconds before.

Let's try 410V, just for the sake of argument (See? Like I don't already know this works)

(410/.08A) /5 = 1025 ohms

Hey, 3000 / 1025 = 2.93 - pretty damned close to 3.

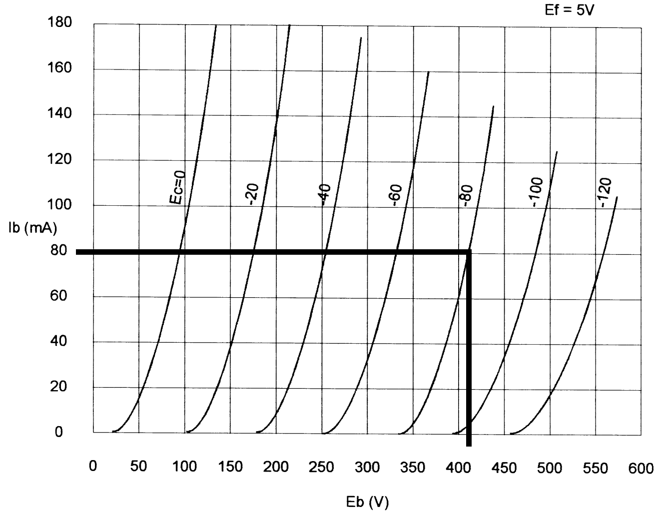
Power Output

OK, so what kind of output power are we talking here?
This is a point of some contention, because KR rates their tubes for a much higher output ability at a given plate dissipation than other manufacturers. The rule of thumb is 20 to 25 per cent efficiency for a single ended triode, but KR tends to rate their tubes at more like 35-38% efficiency. So, according to KR, the tube should be worth as much as 12 watts in this operating condition. I will conservatively estimate the amp's output at 8+ watts. This is in part due to the drive swing of the driver stage, which we will address in a bit.

(Continued on page 11)

KR ENTERPRISE VV VALVES

VV32B



The VV32B is an ultra-linear, low frequency, high power triode tube capable of producing 25 watts of pure class-A power. The tube features a new ribbon filament construction and the KR Enterprise exclusive patent design with 32 cathodes. The VV32B possesses a vacuum of 10^{-9} Torr, a maximum grid current of 20 microamperes and absolutely constant emission over the life of the tube. All KR Enterprise tubes are warranted for a period of 1 year or 2000 hours.

Average Characteristics

Plate Voltage .... 350 volts
Plate Current .... 110 mA
Grid Voltage .... -60 volts
Amplification Factor 3.9
Transconductance 6000
Plate Resistance .... 600 ohms
Load Resistance ....2500 ohms
Power Output .... 15 watts
THD .... <0.1 %

Maximum Conditions

Not simultaneous ratings

Plate Voltage .... 550 volts
Plate Dissipation .... 70 watts
Plate Current ..... 160 milliamperes

Filament Rating

Voltage .... 5.0 volts, a.c. or d.c.
Current .... 2.0 amperes

But that is running ahead of ourselves. Now that we have an operating point, and an output load, what else do we need to calculate?

Grid Bias

Let's get our relative voltages straight for starters.
The plate of the tube needs to be 410V above the filament. Now that we have moved our operating point to 410V and 80 mA, look back at the plate curves. For a given voltage (use our newly found 410V) and given plate current, there is a given grid voltage that the grid of the tube needs to be set at. These voltages are shown next to the sweeping curves running across the graph, and are negative values. Why? Because the grid is made negative relative to the filament of the tube. This sets the current draw for a given plate voltage.
Note here that by plate voltage, we mean the voltage of the plate relative to the voltage of the filament, not necessarily the voltage of the plate relative to ground. This is particularly important to remember in light of the fact that we will be direct coupling this circuit.

OK, looking at the curves and plotting some lines, at 410V and 80 mA I get around -80V grid bias. Easy number to remember.
So let's use this as our operating point, and see how it fits the rest of the program.
80V grid bias means that the grid of the tube needs to be about -80V relative to, or 80V below, the filament.
Sooo, we need to get 410V+80V from our power supply, plus what we need to operate our driver tube, if we use cathode bias.
Which is what we shall do. Cathode bias sounds better to me in this kind of circuit, and that's all the reason I need to try something.
Cool. That means we get to calculate the next part of the puzzle.

What's next?

At this point in the design of a capacitor coupled (between driver and output) amplifier we could calculate the value of the cathode resistor and the cathode bypass cap for the VV32BC.
But, since we are direct coupling our driver stage, we must raise the grid of our output tube to a potential above ground that is equal to our driver's plate voltage relative to ground, while maintaining the grid to plate to filament relationship we have already established for the output tube.
Whew! I had to read *that* a few times after I wrote it!
And so we need to know the driver's operating conditions before we can figure these values out.
We'll come back to the problems of calculating the cathode resistor and bypass capacitor after we work out the driver stage details.

The driver

I mentioned before that I like a single tube driver stage. My philosophy is "keep the number of stages down, and you have fewer opportunities to screw up the music".
But this means we have to get all of our gain to drive that big ol' VV32BC in one shot. OK, so how do we figure out what kind of tube we need?

How much drive?

Let's start by assuming that we don't want to drive the grid of our VV32BC positive. So we will take the maximum signal we need to drive the grid of our VV32 as 80V, the grid bias.

How much gain?

Now let's consider how much drive our preamp may offer us. I use a parafeed line stage, and the practical output limit is around 3V from this unit.
Let's be a bit more conservative, no sense having our preamp limiting out just as our amp does, and figure we want to get to maximum signal swing with an input more like 2V.
OK, now we calculate the gain of the tube we need:

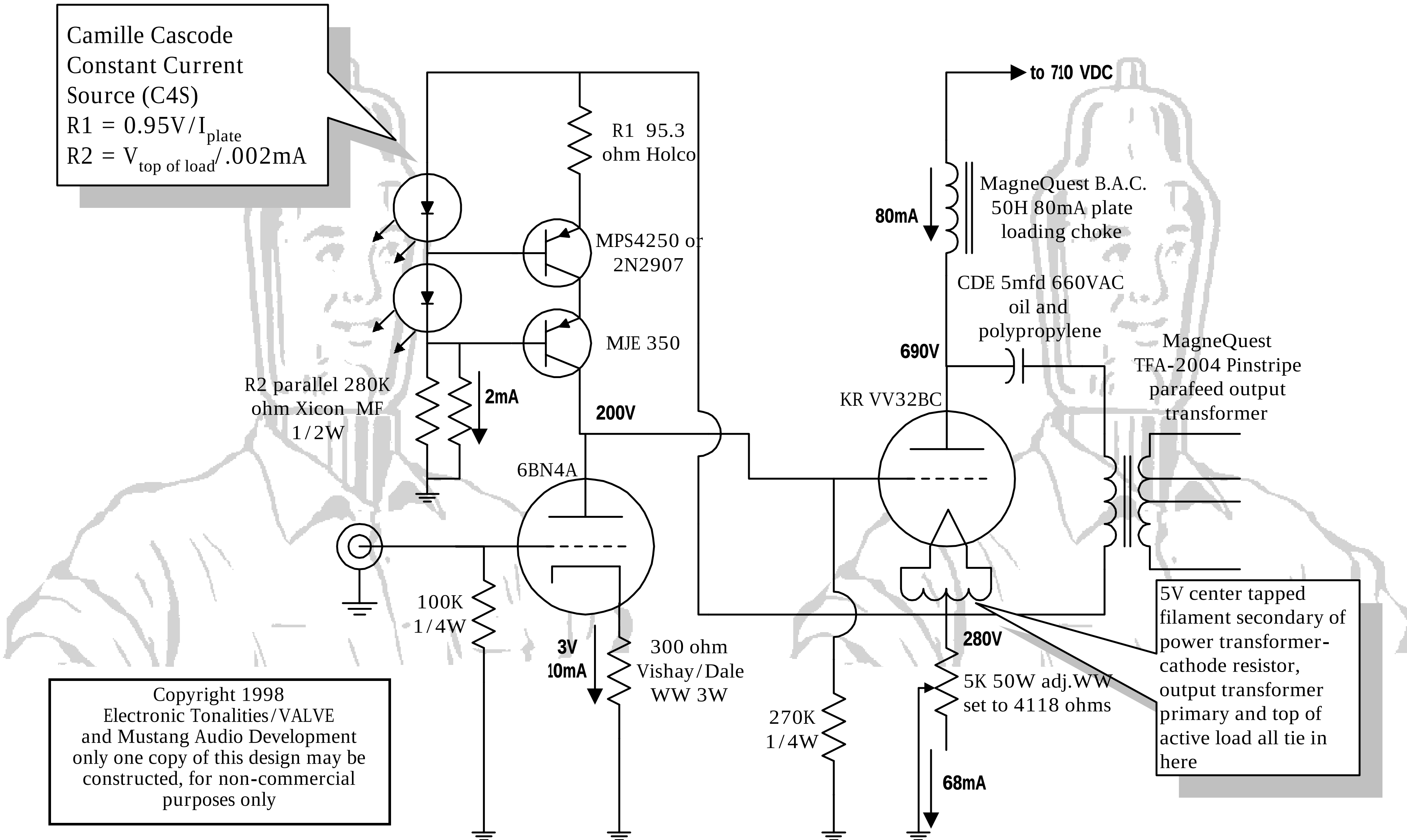
80V/2V = 40.

Enter Mr. Wizard again.
Let's look at the specs of a 6BN4A, one of those neat little 7-pin RF tubes from the late 50's/ early 60's.

The 6BN4A has a mu of around 43, so that works out.
The next question is, can it swing 80V?
We need to check that our tube's plate can operate at at least twice this voltage - check, the 6BN4A can run as high as 250V on the plate.
Cool.
OK, like we did with the VV32, how do we determine the operating point?

First let's look at the maximum dissipation.
Hell man, this is a cheap little tube, don't care if we turn it and burn it, and they sound great running hot.
Max dissipation is 2.2watts.
(Continued on page 14)

The Blues Master

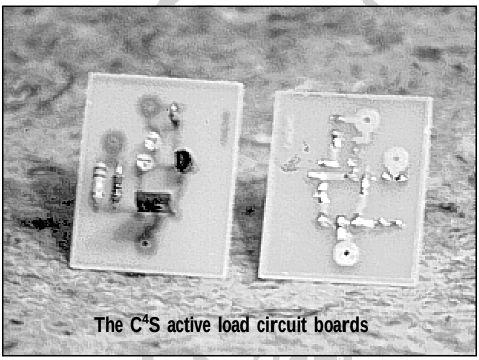


(Continued from page 11)

Let's be just slightly conservative and run at 2 watts. An easy point to pick on the plate curves is 200V on the plate, 10 mA, and -3V grid bias. At this point we should be able to easily handle the 80V grid swing we need, as long as we are getting enough gain from the tube.

Normally at this point you have to calculate how much gain you really get from the tube, given the particular plate load resistor you use. But we decided to use our active load, which presents such high impedance (Buddha has measured at least 22 megohms) to the tube's plate, that for all intents and purposes, our mu is 43.

So we can take 2V of input signal and easily see 80+ volts out, if we set the supply to our active load high enough.


The C⁴S active load circuit boards

OK, we have a good driver tube and an operating point. Let's get to work on this active load biz.

The active load we are using is rather different than the load we presented in the 45 parafeed amp circuit last year. This one uses a couple of LEDs to increase the impedance, and this circuit is more durable than the last one as well.

The two transistors and the two LEDs stay the same no matter what operating point we use. In fact the neat little boards we had made will come stuffed with these components, you will only need to add to resistors which set the current and the bias.

The active load creates a Constant Current Source (CCS) for the plate of the 6BN4A. To set what that constant current is, we use the formula :

0.95Volts/ I =R

to calculate the value of the current set resistor. In other words, we use Ohm's law again, always wanting a .95 volt drop across this resistor, regardless of the current we set to go through it.

For our 6BN4A running at 10 mA we get

0.95 V /0.01 A = 95 ohms

So we have our first resistor value. But don't forget to figure out what power rating you need, P=VI.
We get 0.0095W. Use a 1% 95.3 ohm Holco here, PN 279-95.3 from Mouser.

The next resistor sets the bias of the load, in other words, how much voltage drop occurs across the load from the input to the output.
We said we wanted the plate of our 6BN4A to be at 200V, so that's the voltage we want at the output of our active load.
The voltage we want at the input, above that current set resistor, is at least the swing we want to see from the plate of our driver tube, plus the plate voltage.
Sooo, we have 200V plus, what did we say we need to swing the grid of the VV32BC? 80V? OK, we need a 280V (or if you wish to be picayune 283V, including the -3V grid voltage of the 6BN4A here) supply. Keep this in mind, and we'll discuss where to find that 280V in a little while.

By the way, the MJE 350 transistor we are using has a collector-emitter breakdown rating of 300V. That means we don't want to set the voltage at the top of the load any higher than 300V above the output, or plate voltage, or poof, no more load. Not critical at all with the 80V differential we are dealing with here, but something to keep in mind for your future active load projects.

OK now we need to calculate the bias resistor value. The bias side of the active load, which runs through the LEDs and down through the bias resistor to ground, draws 2mA.
Ohm's law again.

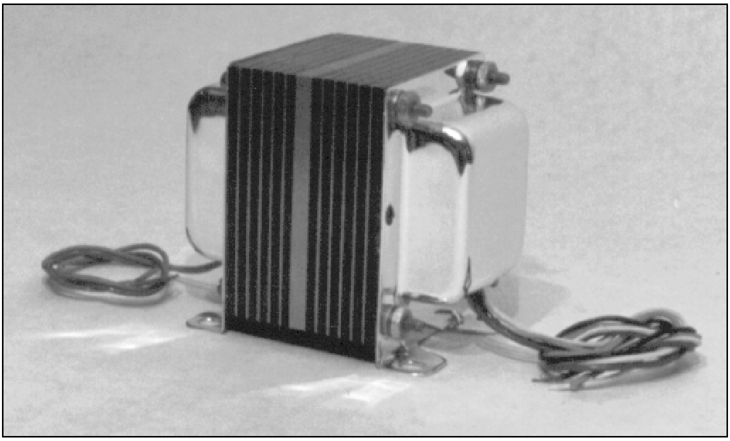
The resistor needs to be

V/I =R

280V/0.002A = 140Kohms.

(Continued on page 17)

THE PINSTRIPE



The heart of the Blues Master

- 3,000 ohm primary impedance, 4,8 and 16 ohm secondaries.
- the legendary midrange quality of the TFA-204, now with phenomenal bass and treble speed and texture
- measured frequency response of -1dB at 2 Hz and 26 kHz
- perfect for SE 2A3, SE 300B, PSE 50s, SE VV300B, SE VV32B, even works with the VV52B!
- alternating laminations of M4 steel and nickel - pinstripes!
- stunning polished solid brass bell ends
- use with 2A3/300B and the new, larger EXO 04 60 mA 50H plate loading choke and B.A.C. 50H 80 mA choke -VV32Bs!

Perhaps the most beautiful transformer ever made

special price - $225 each.

Hyperpinstripe version, shown above, with nickel “sandwich”, $250. All nickel TFA-2004 also available , $275 each with solid brass bell ends

(Continued from page 14)

This time we really need to check that power rating requirement.

P=VI = 280Vx .002A = 0.56 watts.

We'd better use two 1/2W 280K Xicon 1% metal film caps in parallel for this, Mouser PN 29MF500-280K. The board is setup for just such a combination, as well as series connections, so you can tweak a couple values together to get just what you need for various applications.

OK the plate of the tube is taken care of. How about the cathode?
Because of the active load setting the current, this is a cakewalk. Just figure out what value resistor you need for the 3 volts bias and 10 mA plate current we already determined for our 200V operating point:

V/I=R=3V/0.01A=300 ohms.

Power rating?

VI=P=3V x 0.01A = 0.03watts.

How about something cool here, a Vishay/Dale wirewound 3 watt (total overkill) 300 ohm resistor, Mouser PN 71-RS2B-300.
Bypass cap?
The load does such nice things for us in terms of creating so much higher impedance than the plate impedance, and in giving us so much gain, that we can skip the bypass cap here, and reap the benefits of no cap sound.

Cathode Resistor

Better pour one more shot from that bottle of Jack D., and put on some Little Sonny - here comes more math.

OHM's Law- remember this, and you can do 75% of the electronic calculations you'll run across in amp design:

V=IR,

or as we rewrote this before

V/I=R

So, to calculate the cathode resistor we need to consider our plate current, .08A, and the voltage drop across the cathode resistor. OK, now brace yourself. We will think this direct coupled situation through, step by step, to figure the voltage drop we really see from the filament of the VV32 to ground

Let's start at the filament and work down:
First we know we need 80V drop between the filament and the grid of the VV32.
Next, we know the grid of the VV32 and the plate of the 6BN4A need to be at the same potential.
The 6BN4A plate needs to be at 200V (203V for you nitpickers) above ground.
And so we see that the filament of the VV32 needs to be 80V+200V=280V above ground.

OK, remember how we figured we needed 280V at the top of our active load? Yes, as bizzare as it sounds, the perfect place to put the top of the active load is at the top of the VV32s cathode resistor. We'll connect it there. Some of you will complain that the driver should be able to swing well past the 0V grid point. Please trust me, this is worth sacrificing the extra drive for.

This means that the load will draw off 12 mA of our 80 mA current draw through the VV32. And so our cathode resistor must drop the remaining current, 80-12=68 mA, across 280V.

We plug this voltage and current into Ohm's law and get

V/I=R or 280V/0.68A = 4118 ohms.

Easy. But we're not done yet. That resistor is dissipating some serious power, and we need to calc what kind of wattage it needs to handle. Power is easy, we already did this one when we calc'd the plate dissipation of the VV32:

Power = VI or 280V x 0.068A = 19 watts.

OK, it's pretty obvious that a 4118 ohm cap is not going to be an off the shelf item. One fairly easy solution would be to use an adjustable wirewound. How about an Ohmite 5K 50W unit, PN 588-AR50-5K. Just use your ohmmeter to set the adjustable slide to the proper value before firing up.
Or if you prefer, you could put a 4K 25Watt Ohmite wirewound (DigiKey L25J4K-ND), and 100 ohm 3 Watt Ohmite wirewound (DigiKey 43F100-ND) in series, remembering to calculate the power ratings and being a bit conservative.

Cathode Bypass Capacitor

In a "normal" amp we need to figure the value of the cathode bypass capacitor that will keep us from losing power to degenerative feedback, and more importantly, to keep our tube's plate impedance low, preserving the output stage's bandwidth.

For this we can use a conservative rule of thumb formula that will get us through another few percent of the calculations we need to do when designing an amp:

$C_{k\ (microfarads)} = 1{,}600{,}000/FR_k$

C_k is the value of the capacitor we are looking to find, in microfarads, and R_k is the value of our cathode resistor. F is the frequency we wish this cap to function as a bypass down to, e.g., the low frequency roll off. Let's use 10Hz here to get well below the lowest frequency that supposedly matters, 20Hz.

1,600,000/(10)(4118)=38.9mfd
Ah, quite a convenient value, awfully close to 40 mfd.

You could try a Black Gate, Nichicon, Panasonic, or maybe even a Cerafine, rated for 350V or higher. I'd probably be unconventional and pick a CDE 40 mfd 370VAC oil and polypropylene motor start cap from Mouser, PN 5987-370V40.
But, we shouldn't need this cap at all if we hook our parafeed output up right, we can just forget it. More on this in a minute.

Parafeed Coupling Capacitor

Problem the next:
Calculating the coupling capacitor for our parallel feed output transformer.
This one we solve by looking at the reactance frequency chart published in the Audio Cyclopedia.
The chart tells us that for a 50H choke like the B.A.C., we will need at least a 4 mfd coupling capacitor to get down to 10Hz. The voltage rating should be based on the voltage the plate is sitting at (in the worst case, 280V+410V=690V, but we will show a work around for this that makes the differential only 410V in a sec) plus the peak positive swing that the AC signal coming off the plate will go through. In our case, let's figure about 80V grid bias times the tube's mu of about 3.9, or 312V. At 1012V peak, we'd be talking oily cap here, folks, or two 630VDC film caps, at least 8 mfd each, in series.
My choice would be the CDE 5 mfd, 660 VAC (that's good for at least 1000VDC, so we can probably get away with one) oil and polypropylene motor start capacitors from Mouser, part number 5987-660V5.0.

If you have some cool old oil caps (use PCBs at your own risk), or want to stack Solens or Black Gates, go for it. My best luck has been with the oils. Parafeed changes a lot of the old rules about what sounds fast and what sounds clean when it comes to caps. Oils loose that slow, dull sound when used with parafeed, and even premium film caps can get an upper midrange "shine" to them through the parafeed setup. Sure glad I hung on to my old Vitamin Qs and them big ol' transmitter caps.

But wait, we have to work around a couple of potential problems. First let me spout that the circuit will sound best when that cap goes below the bottom end of the OT primary and the top end of the OT primary connects directly to the plate of the output tube. Hell, I don't know why, but it always sounds better with the cap in the lower leg.
BUT, Mike LaFevre and I will not guarantee the Pinstripe for operation at such high voltages, as the core, the secondary and the case will be at ground potential, and the coil will be at 690V, so if you try this, you are completely on your own! If you are willing to void your warantee and take the risk, put the cap below the OT and enjoy the music. If you want to play it safe, put the cap between the plate of the VV32BC and the top leg of the OT primary. This way the coil is at roughly the same ground potential as the case and the secondary.
OK, we still have a potential problem. Either way, if we take the cap all the way to ground either below or through the Pinstripe, we need a cap with a 1012 V rating.
Well here's a good way to reduce the voltage rating demand on the cap.
There's no real reason we need to tie the bottom leg of this OT/coupling cap combination to ground. We could instead tie it to the top of the cathode resistor.
Ahh, now we have just reduced the DC component of the voltage requirement on our coupling capacitor to the 410 V between the plate and the filament, so our voltage requirement has reduced to 410V+312V=722V, a bit safer level for a 1000V rated cap, and our OT primary is only 280V above ground. Remember that the cap is floating in this condition, and insulate the case accordingly!

Now, remember the discussion about not needing a bypass on the VV32's cathode resistor?
Since we just tied the primary of our output transformer across only the coupling cap and plate and the cathode of the VV32BC, the

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WRIGHT Sound Company

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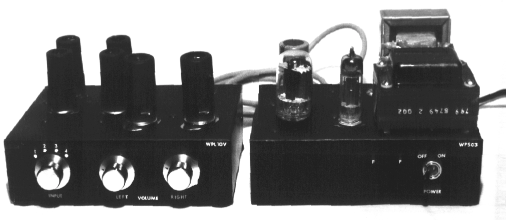

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cathode resistor no longer contributes to the plate resistance feeding into the output transformer's impedance. Only the plate resistance of the VV32BC figures into the picture, and so we no longer require a bypass cap on the cathode resistor to maintain our 1:3 impedance match. Cool, huh.

VV32 Grid Resistor

Well, that just about covers our output stage setup. Oh, how about a grid resistor on the grid of the VV32? I have heard some rumors that lower value grid resistors, like 50K, work well with the KR tubes. A value this low doesn't make a lot of sense to me. In general, the only good reason for a low grid resistance in front of triodes is to to leak off the space charge which collects on the grid. This collection of charge can change the bias of the grid, roughly .25 to 2 V.
On a 417A biased at 1.56V, this can be a real problem, and 417As like low value grid resistors in front of them.
But we are talking about a tube biased to -80V, and on top of that, we are using cathode bias, which tends to adjust the bias voltage as the plate current changes anyway, pulling it back to where it belongs. One factor which can cause plate current to creep is the presence of gas in the tube, but the KR tubes claim to be the hardest in the world, so this should not be an issue.
And so, except for the consideration of space charge build up, seems to me the best grid resistor is the highest value you can get away with, as this will loose the least gain, and put the least strain on our direct coupled driver stage.
The rule of thumb grid resistor value at which space charge begins to build up seems to be around 250K, so something in the 100K to 250K region should work well. I have tried values ranging from 540K down to 135K in my VV52 amps, 270K seems to give the best top end extension without an noticable decrease in gain. So let's use that value.

6BN4A Grid resistor

Now that we are dealing with a tube that only has -3V of grid bias, let's be a little more conservative and use 100K ohms to help avoid that space charge. This should still be plenty load for most preamp's output impedances, except maybe a PAS, but what the hell would you be doing using a PAS with an amp this nice, right?

Don't despair, we'll have a parafeed preamp design in a future issue that can keep up with this amp quite nicely, as would Bill Petrowski's 6J5/76/56 parafeed preamp from last year's issues.

On to the Power Supply

OK, that covers all the little bits and pieces of the amp circuit, save for the stuff like tube sockets, binding posts, RCA jacks, etc. I leave these decisions to you. And of course I'll tell you to wire the amp with Jena Labs wire and use our cool new Big Stud binding posts...

Now we move on to another philosophical discussion. There are nearly as many ways to design a power supply as there are to design an amp. That's what we'll do next month. -B.