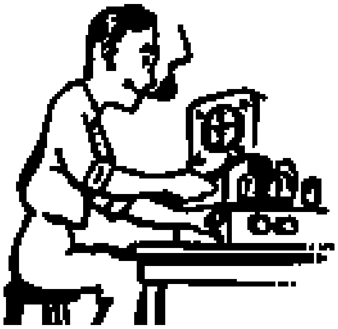


Homebrewer of the Month

Joseph Esmilla of Suburban Maryland

Simple circuits and quality parts yield top musical satisfaction

Enclosed are pictures of my present system which has evolved over the past six years inspired by reading *Sound Practices* as well as Japanese publications like *MJ* and *Stereo Sound*. My circuits are pretty straightforward and conventional, nothing radical or innovative. I am a violinist not an electronic engineer… I just paid close attention to using tubes that I am familiar with sonically, preferring Art Deco era preamp, input, and driver triodes for voltage amp applications in a given circuit topology based on years of listening and experimentation.

I used parts that sound good to my ears. Carbon resistors (Allen-Bradley, Riken, or carbon film types from MCM) for plate load and cathode bias. Paper in oil or copper foil caps by Jensen, Icar or Facon for coupling. Cerafine, LCR or Solen caps for PS filtration, Black Gates for cathode by-pass and Kimber TCSS or AGSS for wiring in the signal path. Lately I've gotten good results using 19 gauge solid core 99.99% silver wire with Teflon sleeving, much more affordable than AGSS.

I did all the metal work using Greenlee chassis punches with lots of WD40 to cut through 1/8" thick aluminum plates. Except for the custom maple wood bases on the 300B monoblocks, the rest of the woodwork was also done by me using pre-cut lumber and a $10 miter saw box from Sears.

I am not much of a writer but I will try to describe the pictures and throw in a few comments.

My phono front end is a Garrard 301 "grease bearing" mounted on a homemade plinth using 7 layers of 3/4" thick, 22 x 20" birch ply. I used the 301 template to cut out the first 3 layers to accommodate the turntable assembly, the remaining 4 layers are solid except for tonearm mounting provisions. After all the necessary holes were cut,I used animal glue (used by violin makers) which is very thin in consistency and does not settle quickly so that I could align every layer before clamping them to dry overnight.

For tonearms I use a Fidelity Research FR64fx and an Audio-Technica ATP12T. My cartridges are an Ortofon SPU Classic GME and a Denon 103R in an Orsonic headshell. Both cartridges are fed through Mogami microphone cables to Tamura TKS 83 MC step-up transformers.

The SPU GTE is a very musical cartridge, very lush and delicate sounding. I listen to it to enjoy music by candlelight while sipping a glass of cognac. On some recordings, it can sound rather veiled and this is when I switch over to the 103R which is perfect for playing recordings that sound rather "slow" since it is an "accurate" sounding cartridge.

The FR64 and SPU are *gifts* from buddies in Manila who formed a club called SETUP (Single-Ended Triode Users of the Philippines) whom I have influenced to dabble with DIY and subscribe to *Sound Practices* because of their frustration with "high-end."

Initially, I thought I cured the 'impulse' upgrade syndrome (from WATT/Puppies to GRAND SLAMMS, SME V to Air-Tangent, etc.) that plagued my buddies—however, now that they've seen the light, I am constantly bombarded and hounded by e-mails discussing the merits of Amorphous core F5002, Permalloy NY15s, 10429s and Kanno OPTs. They've even built a transformer-coupled line level preamp using Tango NP216N iron. I'm sure this keeps Yokota-san of Sound Shop Big busy and happy, but I'm afraid their wives and girlfriends might not talk to me the next time I visit Manila!

My phono stage is based on the RCA tube manual phono circuit, using 5691s and battery bias. The line-stage is similar to the Berman featured in *SP #15*, with a 76 DC coupled to a 6SN7 cathode follower. I bypassed the cathode resistor on the 76 with a 100uf/10V cap since this gave a warmer and airier sound. To minimize microphonics on the 76s, I mounted the 5-pin sockets on rubber isolation spacers I found in a local hardware store that look very similar to those used in the Marantz 7.

The outboard power supply (barely visible in the picture below beside the left 300B monoblock) is a choke input type using a 5AR4/GZ34 rectifier producing about

Joseph and his DIY audio system in his 12 x 15 x 7.5' listening room

Globe 245 amp: Circuit is an SRPP 5691 with 2.2k,1W AB resistors,Facon .22uf paper in oil, 245 and a Tamura F475,5k OPTs. Kimber TCSS wire throughout.

275V for the line-stage and around 250V for the phono stage and a rectified DC filament line.

I only like SRPP with hi mu, lo gm tubes, finding the 6SL7/5691 best for the job. I tried SRPP 5687 and 6SN7 and understand why other people don't like SRPP.

I use AC filament supplies on all my power amps. In spite of the lower noise floor afforded by DC heated filaments on DHTs, I cannot find myself liking the "leaner"tonal balance.

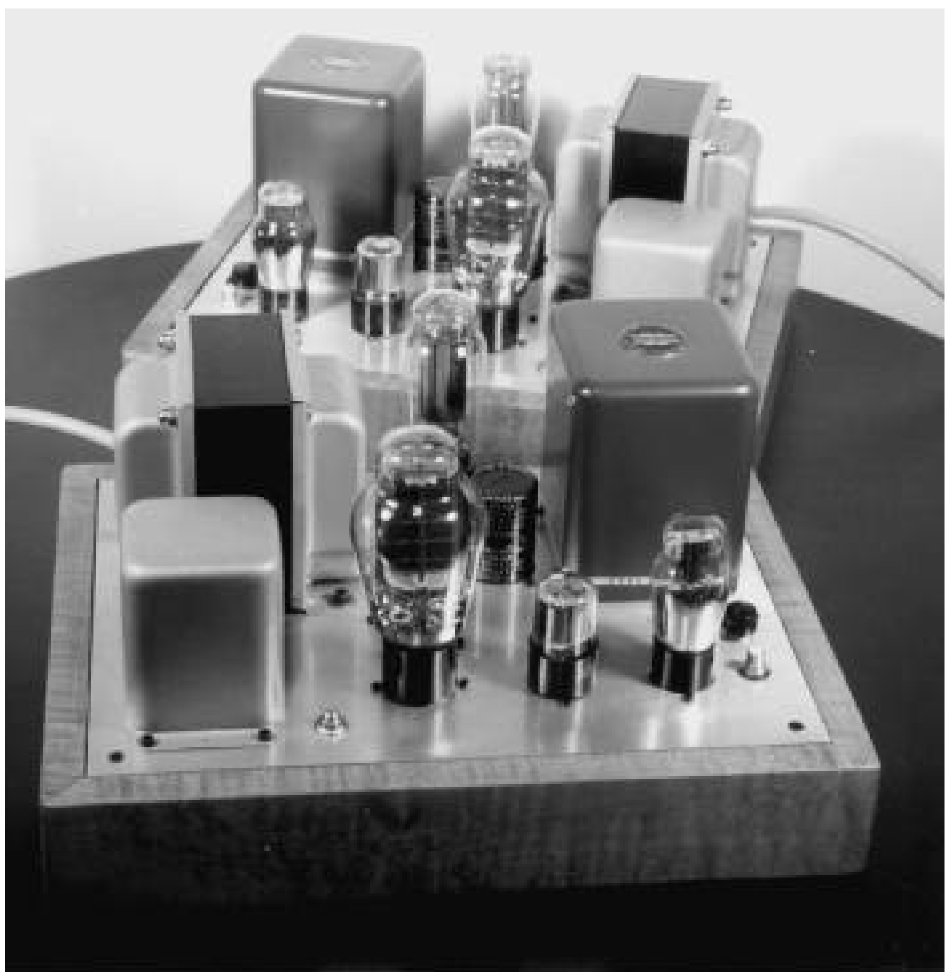
At the moment, I have five SE DHT amps at my disposal, this includes a Stereo 245 with Tamura F475s, Stereo 10/VT25A/801A with Tango FW20-7S, Stereo 300B with XE60-3.5s, a pair of monoblock 300Bs with Tamura F7002s and a Stereo 2A3 with U808s hooked to my TV/VCR hi-fi set-up in the bedroom driving "cheap 'n cheerful" (11 bucks a pop from MCM or Parts Express) paper coned 4 1/2" Pioneer full-range units in a homemade TQWT cabinet.

Except for the 245 amp, all my power amps share the same basic input/driver topology - DC coupled two stage circuit using low-to-medium mu triodes. My first attempt in building an SE amp used both sections of a 6SN7. I tried RC coupling between stages but prefer the added texture and dynamic nuances afforded by DC coupling.

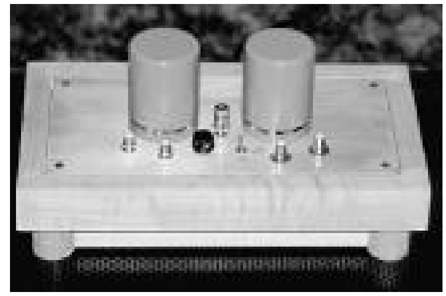
Later on, I investigated using 56, 76 and 27 since they are claimed to possess greater linearity than the 6SN7. After several prototypes and listening sessions l kept the 6SN7GTB at the driver stage preceded by a 76 or 56. Using a 76 as a driver tube just does not cut it for me; it sounds too lean. I also found that I like the airiness and warmth afforded by operating the driver tube around 6 or 7ma.At close to max. current (~10ma.), the sound becomes dry and analytical for my taste. For the input stage I shoot for about 3 or 4 ma. of current.

My latest 300B monoblocks use Cunningham 327 "mesh plates" (pulled out of an old Atwater-Kent radio I found at a flea market) at the input stage, DC coupled to 1/2 6SN7GTB. This combination is very transparent across the frequency band— less midbass crud and better definition, an almost 245 or WE205D-like vividness in the mids with delicacy and airiness in the highs!

The WE300B re-issues are indeed better than any version of the Chinese clones, but to me, the mesh-plate 327 probably contributed more improvement. I am talking about subtle differences here and the best way to describe it is that, once I take away the 327/WE300B combo, I know I'll miss



300B monoblocks: Circuit is a 76-DC-1/2 6SN7GTB-RC-300B-Tamura F7002, 3.5k permalloy OPTs. CLCLC power supply with a GZ37 rectifier and Cerafine caps. When he finds the time, he wants to try Cunningham "mesh plate" 327s pulled out of an old radio in place of the 76s.



ABOVE: Tamura TKS83 MC step-up transformers feature selectable impedance between 3 and 40 ohms and a provision for switching two inputs.

LEFT : Garrard 301 (early version) in a base made from laminated sheets of plywood

not having them!

Both the 10 and 245 amps possess a degree of refinement and finesse I could never quite capture with 2A3s (yes, even mono-plates!) or 300Bs. I use the 245 amp mostly for solo vocals accompanied by a small ensemble or piano and the 10 for jazz quartet or trio instrumental combinations. Both amps are excellent for string quartets and my choice is really dependent on my mood.

Found some Globe 280s over the summer and changed the rectifier from 5U4Gs—didn't hear a difference in sound, but looks *much* nicer.

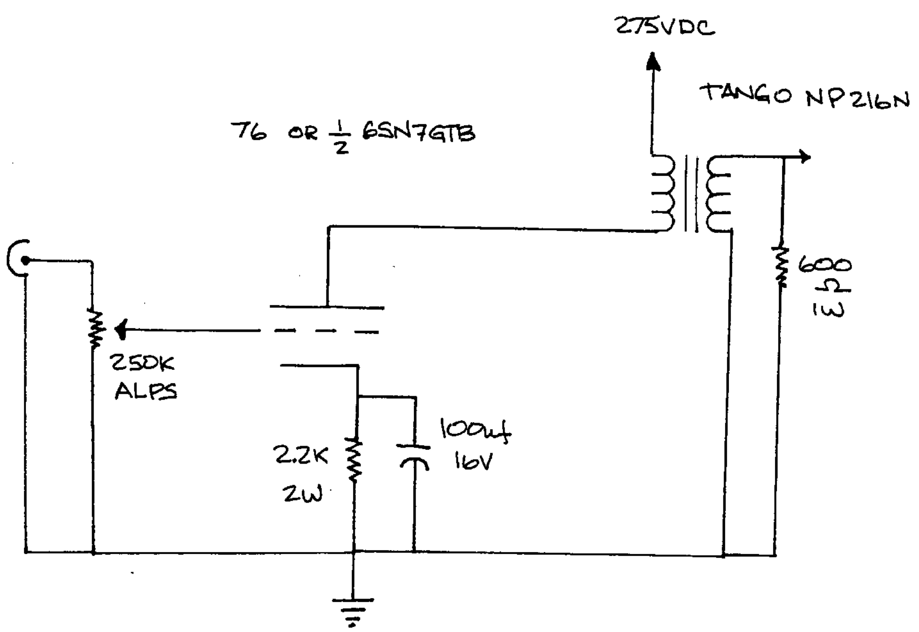
VT25/10 amp - 76-RC-76-RC-10/VT25-Tango FW20-7S. CLC PS using a 5R4GY rectifier.

Stereo SE 300B/2A3 amp using the same front-end and a similar CLC type power supply as the 300B monoblocks, but with Tango XE60-3.5s. Presently configured for SE300B operation, so that I can compare the sound of permalloy over regular "cut core"—my ears tell me that permalloy does have the edge in terms of midrange transparency but this is only obvious upon direct comparison.

Lately though, I'm realizing that there are Tango and Tamura "signature sounds", the Tango tending to be leaner and analytical whereas the Tamura is "juicier." Regardless of core material, both brands produce high quality sound and I would not want to open another debate as to which is *better*, but my taste tends to favor the Tamura.

For the past two weeks I've been listening and testing a pair of WE205Ds that are *en route* to Manila for my friends in SETUP. Since my power transformer (the Angela Universal) has dual HV secondaries, I soldered the 640VCT winding, changed the cathode bias resistor to a 1k, 20W and then "mismatched"the secondaries by using the 4 ohm tap to reflect a pri. Z of 7k when loaded with an 8 ohm nominally rated speaker. Actually, with 755As, it defeats the purpose since they are 4 ohms. Over the weekend I was over at my friend's house in NYC and we listened to it through his 8 ohm 604-8Gs. Using either speakers, the sound of the WE205Ds has the midrange quality of a 245 with the dynamics and slam of WE300Bs. They also go *much louder* than the 1.5W I measured—*very nice!!!*

My main speakers are Altec 755As on open baffles. I based this contraption on plans published in *Stereo Sound* "special issue" Vol. 3, 1996.The original plan called for a composite wooden material that is similar to



TRANFORMER COUPLED LINE STAGE USED/DEVELOPED BY MY "BUDDIES" IN "SETUP".

that used for chopping boards, but thinner, roughly 3/4”. Since 3/4” birch ply is relatively inexpensive, I converted the dimensions to inches and found these baffles to work really well. For almost a year I’ve been using a pair of 755Cs until recently, when I found a nice pair of Altec 755As.

A friend gave me 2 cu. ft. boxes, considered by many to be *de rigeur* for 755As, for comparison. After living with them for a few weeks, however, I still prefer the open-baffle for either 755A or 755Cs.

755Cs go about half an octave lower in the bass with less high-frequency extension compared to the 755A—could this be psycho-acoustic? In the midrange, the 755A wins, no contest. To me, however, the 755C is still a sonic bargain since it probably does 85-90% of what the 755A can in the midrange, that’s why I’m keeping mine as a spare.

The sound is very reminiscent of original Quads I had ten years ago. In terms of usable frequency range, they are equals. Just like Quads, there are no “boxy” colorations, an open and airy sound typical of dipoles, very life-like midrange, BUT much better rendition of dynamic contrasts and musical nuances when driven by single-ended DHT amps.

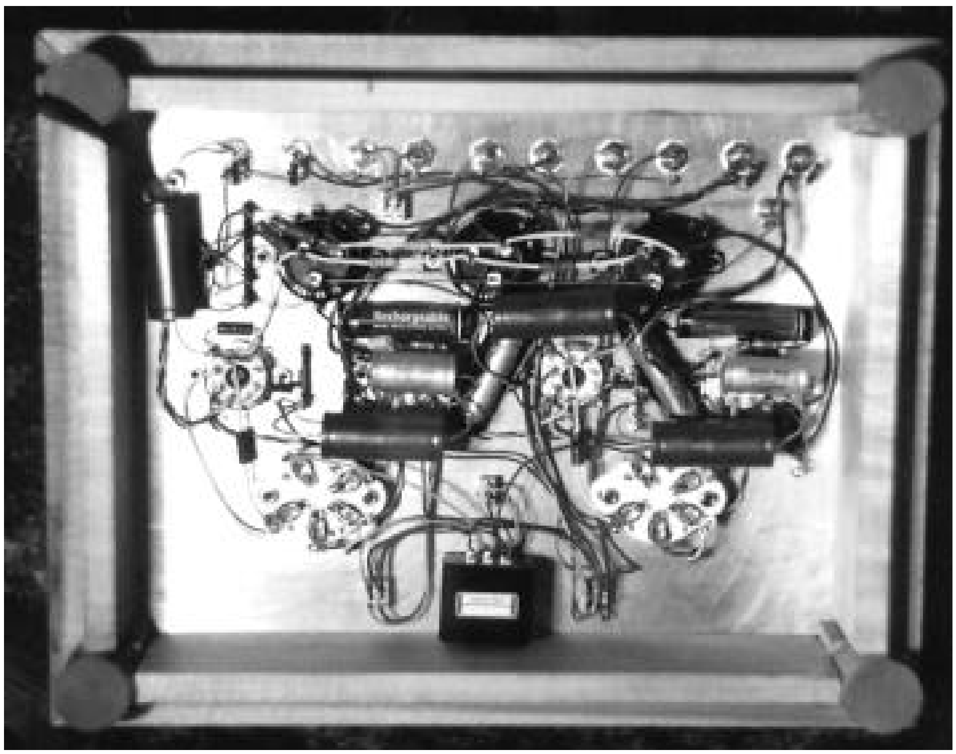
With a 300B or 2A3 amp, I can listen to Mahler symphonies on this system in my average sized room. The 10/VT25 and 45/245 being more suitable for the rather intimate setting of chamber music. Setting them up can be fiddly depending on your room. I used the same basic principles in finding the best placement for Quad ESLs.

I’ve shared this open-baffle plan with a couple of friends who were startled to find such a simple device to work so well. In fact, my friend Ding in NYC mounted a pair of 604-8Gs to enjoy his SE45 amp.

I hope others will give this setup a try. I spent about $75 for 3/4” thick birch plywood cut to size and shape by a local lumber yard and about a half day’s work putting it all together.

Other candidates for drivers I tried and heard include Altec 403A, 409B, Stephens FR80, Norelco 9710M and Diatone PM610Bs. Here’s a summary of my initial impressions:

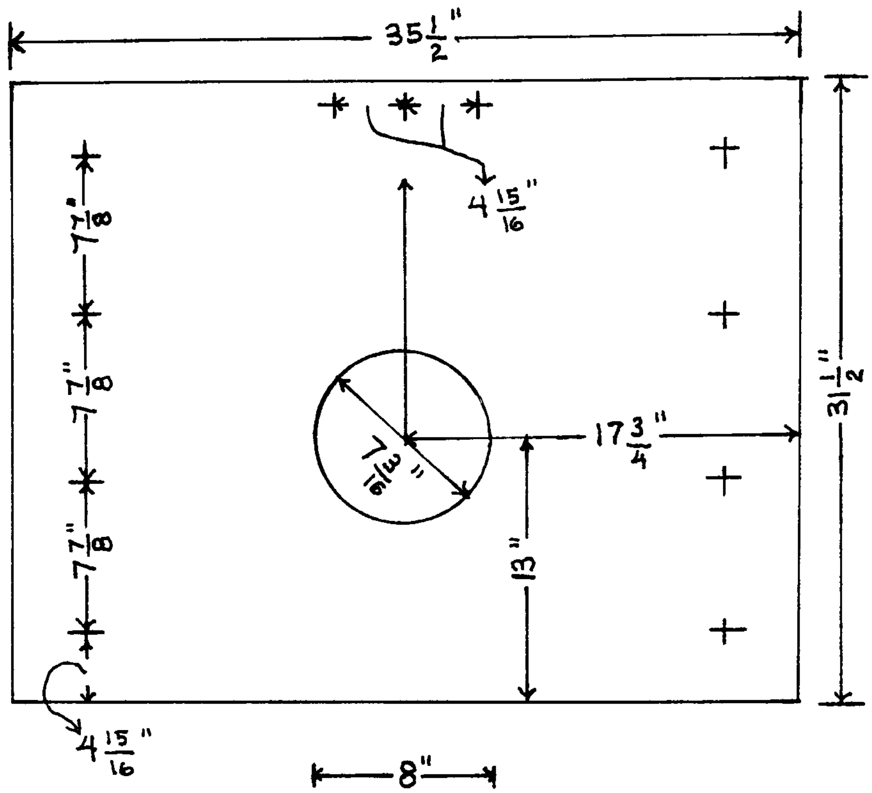
Diatone PM610Bs - I'm sure quite a few readers are familiar with these drivers. I acquired these in the original bass reflex box and didn't really like it too much, so I kept the drivers. The cabinet is overly resonant — colored mids, and boomy bass.

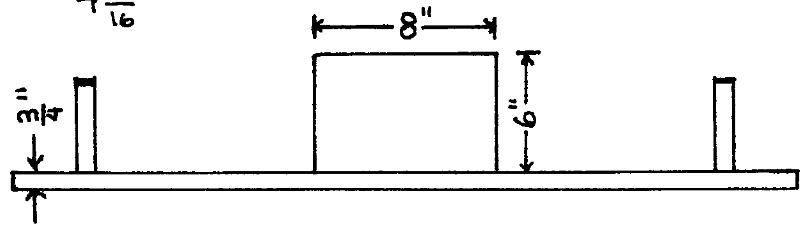


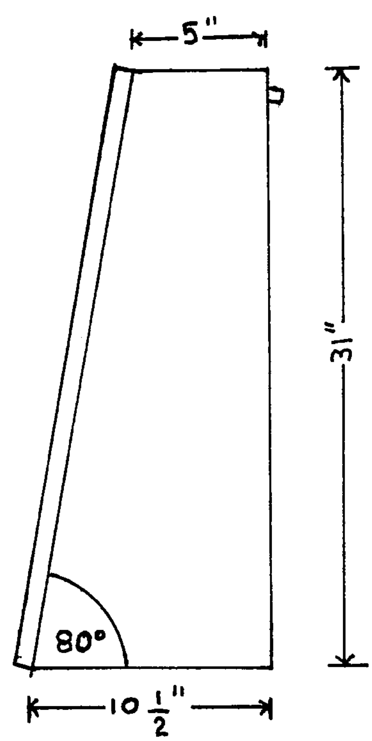
However on the open baffle, it started to sing. The midrange was warm and lucid but did not sound as "big" as the others in this group (smaller cone diameter???) and the tendency for the bass to boom was still slightly evident (too much compliance in the suspension??). Best performance with this driver is probably realized in a well braced bass-reflex cabinet or TQWT (quarter-wave pipe).

Stephens FR80 - The useable frequency range seem at par with a 755A, smooth and refined. However I found the sound rather dry and "closed-in", as if it cannot quite open up and boogie.

Altec 409B - Very efficient but also very dark sound, it surprised me that in spite of







the co-ax design, it had the least amount of treble output from this group. Maybe it will appeal to those who like BASS…or perhaps, I just had a pair of duds!

Altec 403A - this is a pretty decent sounding unit but unfortunately I only have one unit and had to listen in mono. The treble sounds more extended compared to a 755C. As nice as the tonal balance actually was, the midrange did not possess the "snap" of either 755s.

Norelco 9710M - Found this single NOS driver at a radio swapmeet over the summer. Again I had to listen to this in mono. There seem to be a lot of potential with this driver. It gives a totally different presentation compared to a 755A; with more bite and snap. Very dynamic and involving, however it can be argued that it is not as refined. Anyone willing to help me find a mate to this one?

Although I listen primarily to LPs, other sources include a Tascam DAP1 DAT player which I use for recording live performances (recitals and chamber music) with Shure SM81 mics, Sony TCD5M and Marantz PMD430 portable cassette decks, a Tandberg 3500X reel to reel, Scott LT110B FM tuner and a Philips CD921 with a DITB. Except for phono, cables are Kimber KCAG, PBJ and 4TC.

After several years of being involved in this hobby, I have determined that there is no such thing as *the best* component. A satisfying audio system entirely depends on synergy and voicing, best learned through DIY.

I like to view audio components in a similar manner as violins are evaluated by professionals. Guarneri del Gesus and Stradivariuses are established workhorses for world-class caliber violin virtuosos. Heifetz used a del Gesu throughout almost his entire career, whereas Milstein and

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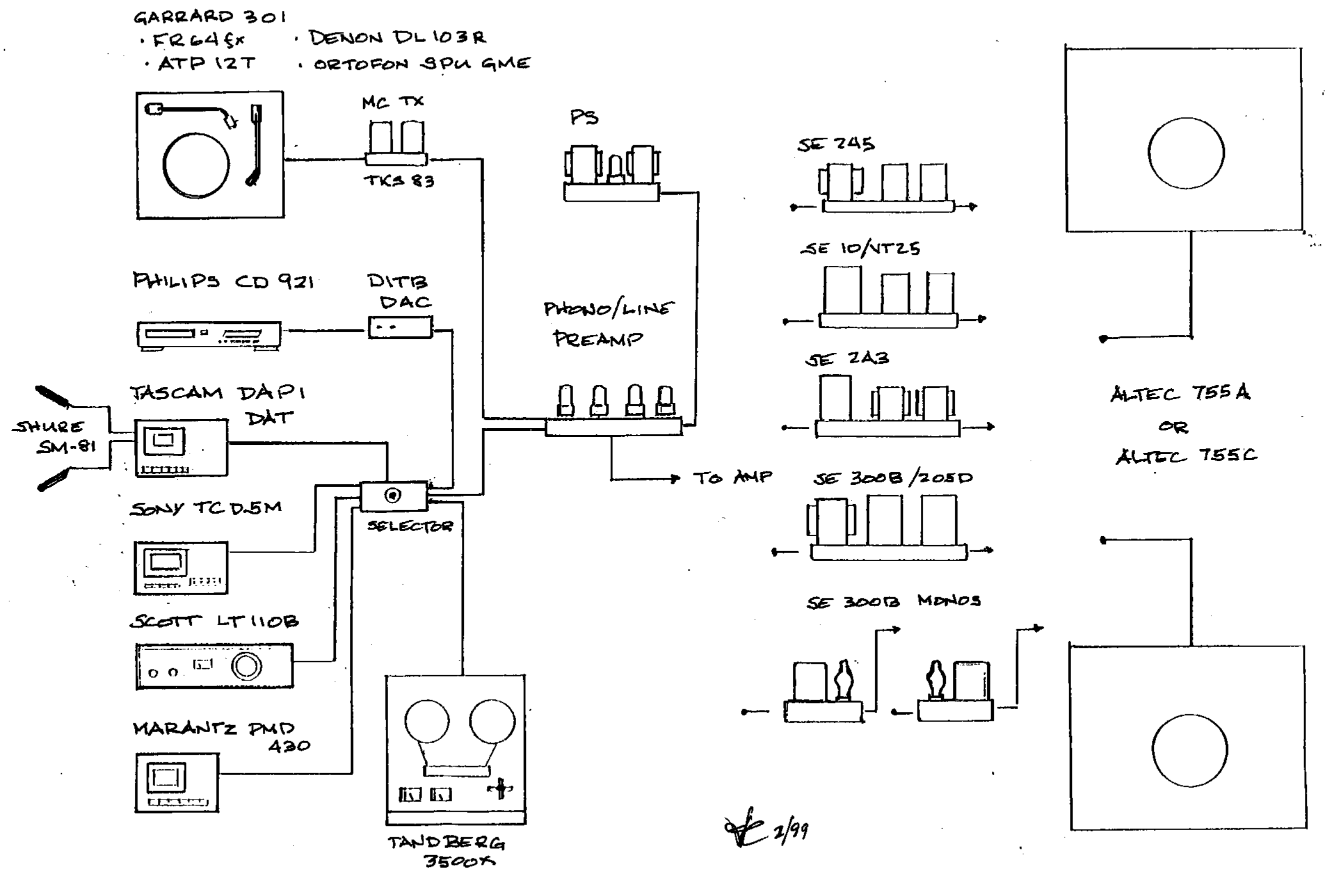
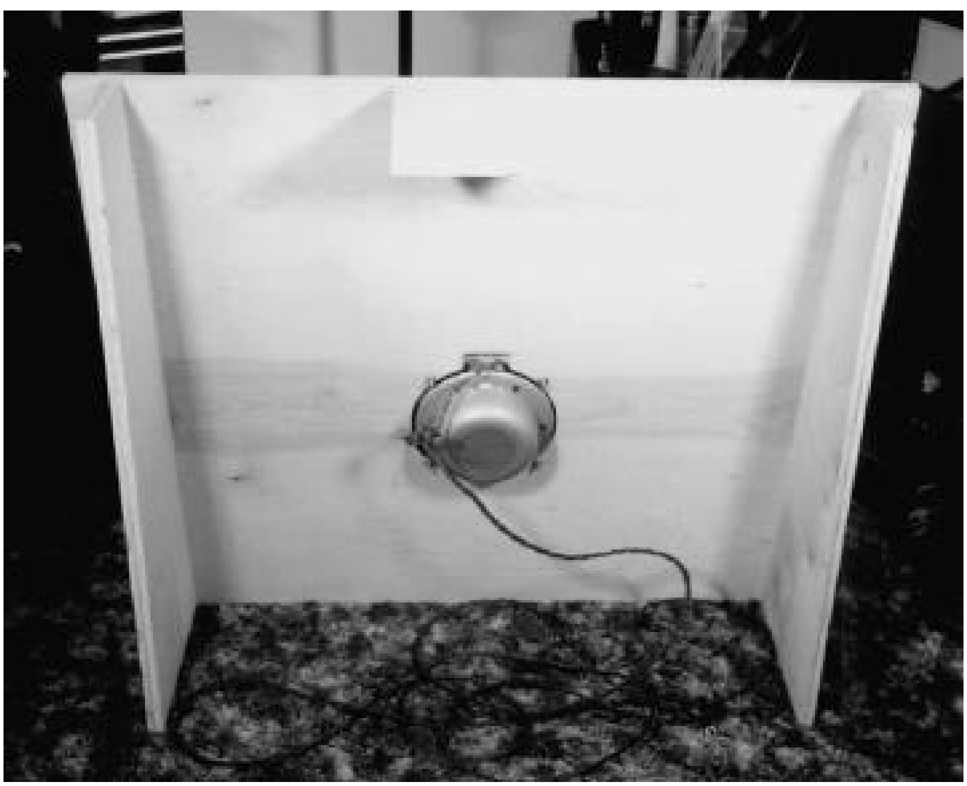
Building tips for the Open Baffle:

1. I used No. 8 - 2 1/2" "decking" screws to put the whole thing together.

2. Make sure you drill pilot holes for mounting the 'feet' and the top plate (clamps help make this task more convenient). Those 3/4" birch plys are tough!

Even with pilot holes, I had to give my hand-held electric drill a rest every now and then during assembly to prevent it from overheating.



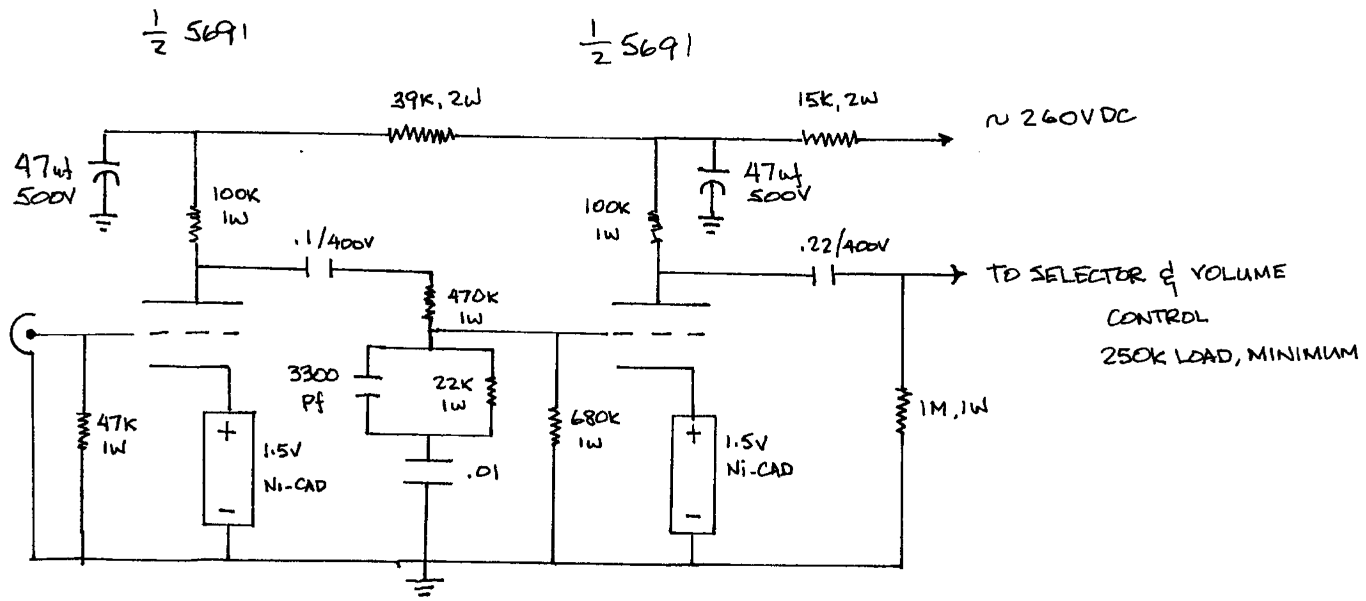


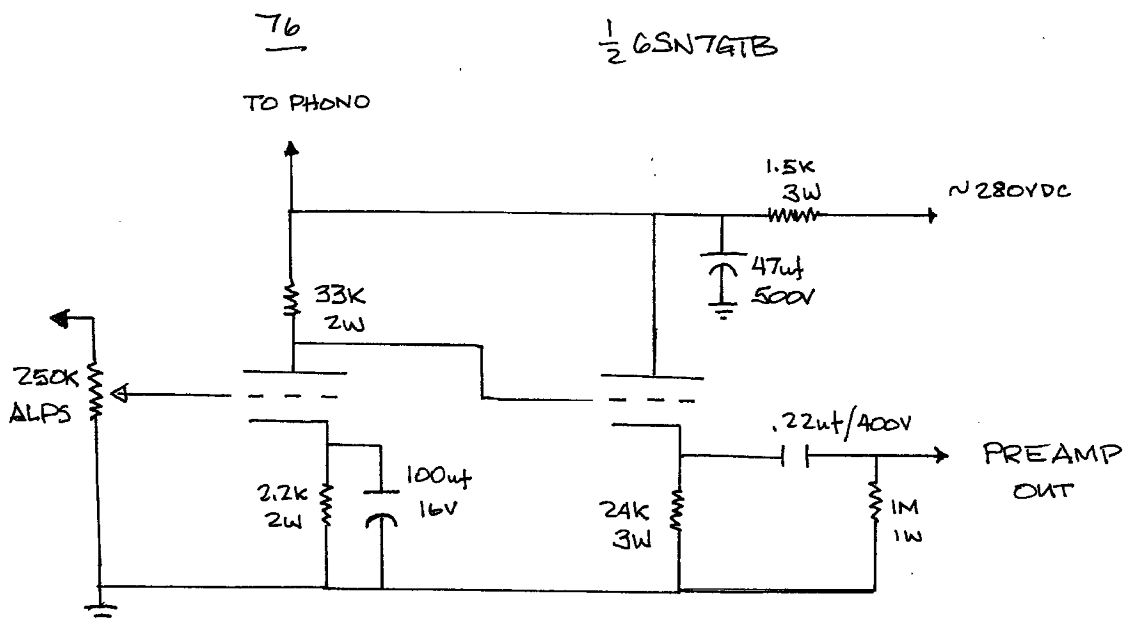
Oistrakh played on Strads. Kreisler played on both, as well as lesser known 18th and 19th century Italian, French and English violins.

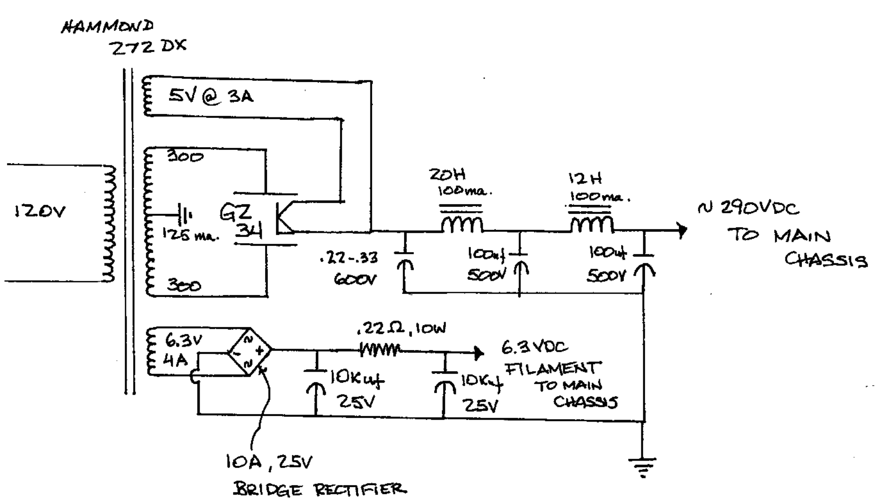
There is *no* objective process to evaluate a violin. No two Strads nor two del Gesu sound exactly the same, plus the fact that a particular violin will sound different in the hands of different players.

The bottom line is, these great violinists treated their instruments as tools and chose the best compromise to allow their artistry to unfold.

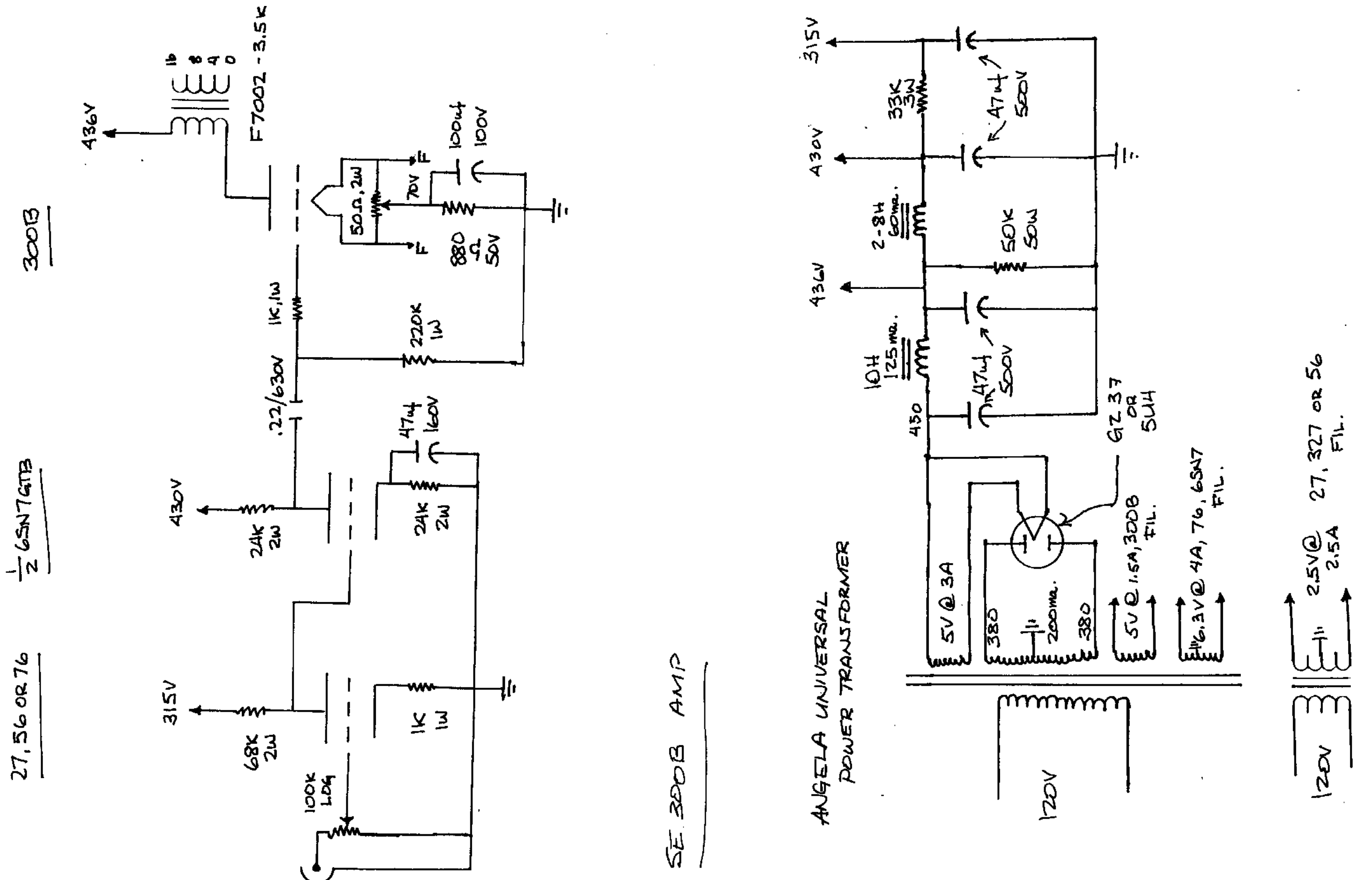
Perhaps it's about time audio hobbyists examine and extract ideas from this type of attitude in pursuit of their audio ideals.

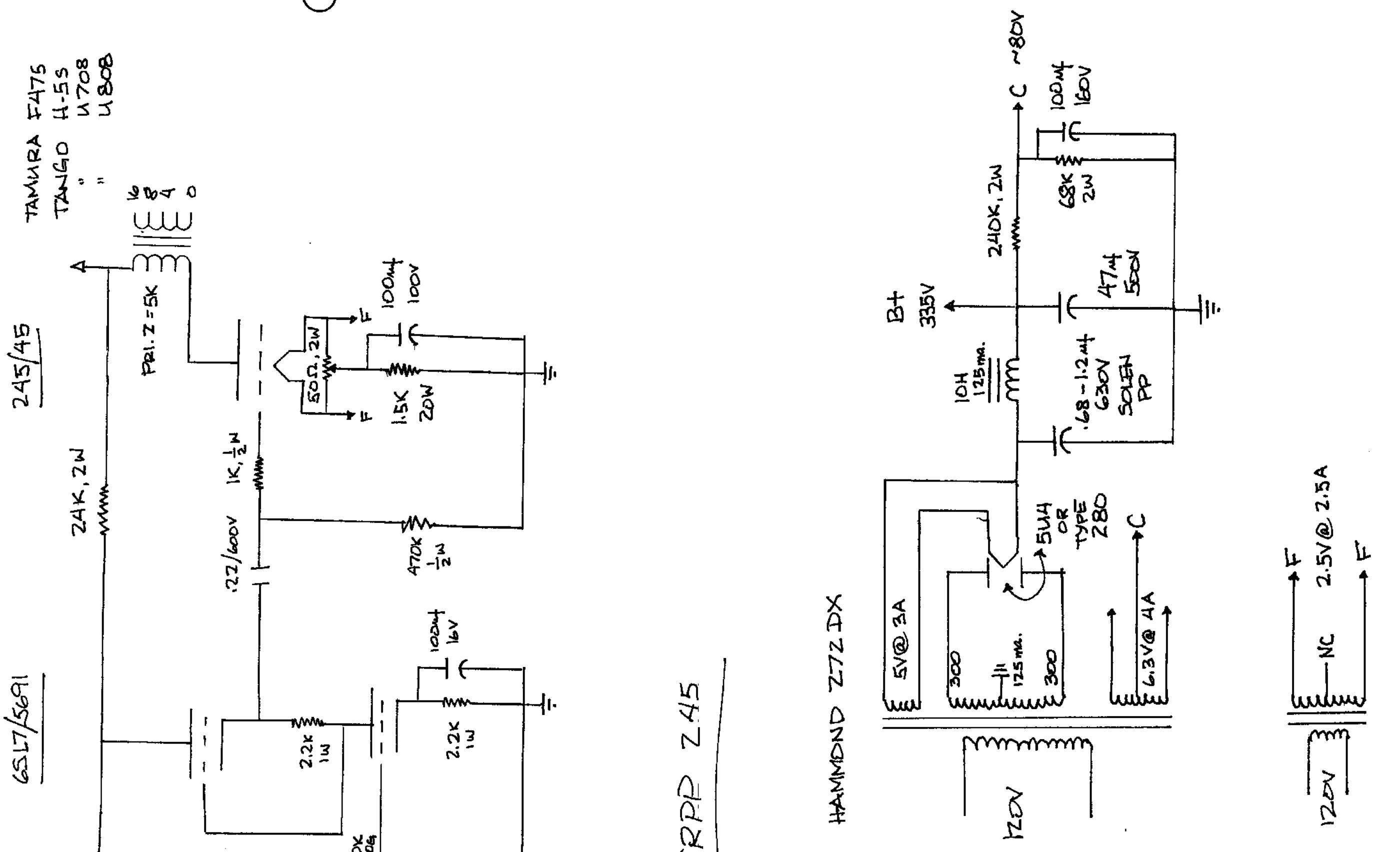






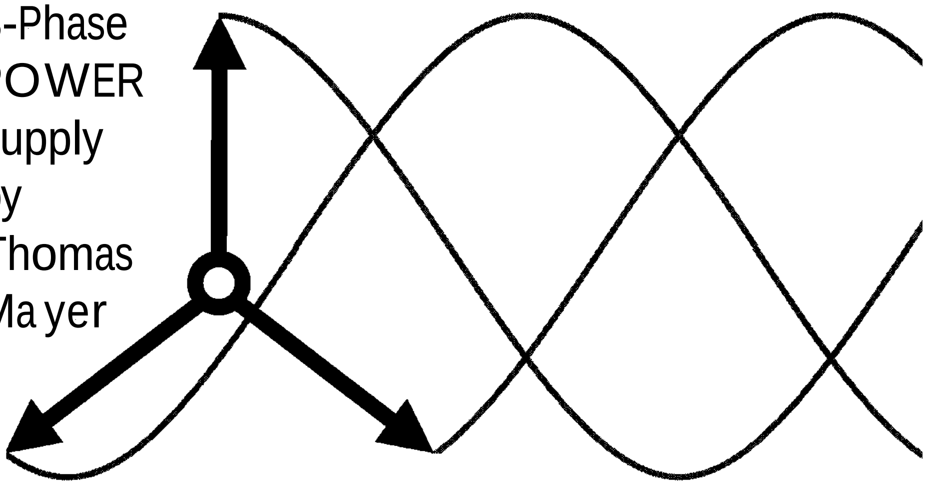
Preamp combining elements of the RCA phono stage and the Berman line stage, with battery bias for the phono stage





"Esmilla Labs" single 245 and single 300B amp schematics

3-Phase POWER Supply by Thomas Mayer



Most amplifier builders will agree that the power supply has as much influence on sonic performance as the actual circuit itself. In this article I will describe a power supply topology which has been widely used for industrial and transmitting applications but which seems to be ignored by audio designers.

Introduction

The generator in the power plant typically provides three "hot" phases and a neutral. The three phases being 120 degrees shifted towards each other. In the upper part of figure 1 these three phases (marked A,B and C) are illustrated.

Usually only one phase is used in a typical power supply. This is sufficient for most applications. However some more demanding devices can benefit from the usage of all three phases.

The most obvious advantage of a power supply which utilizes all three phases is high power capability. Typically large appliances use them. But there are other advantages which are also relevant for audio amplifiers.

A three phase supply however continuously draws current from one of the mains phases ensuring continuous power transfer from the mains without the need to resort to large storage capacitors to fill in the “gaps” between conduction intervals. Single phase supplies approach a nearly constant current flow when choke input is used;however the three phase supply achieves this in a much more direct and elegant way in my opinion

The key advantage of a three phase supply for audio applications is the increased frequency of the ripple after rectification.This is actually three times higher than with a conventional supply (300Hz for a 50Hz mains, 360Hz for a 60Hz mains). This means that much less effort in the smoothing filter is required than for single phase supplies to obtain the same hum level. At three times the frequency a choke has three times the impedance and a capacitor one third of the impedance. This translates into an increased filtering efficiency by a factor of 9 for a LC stage.

However, increased filter efficiency is not the only advantage. Besides having a higher frequency, the amplitude of the ripple right after rectification is much less than that of a single phase supply which uses an input choke. In fact, after rectification the voltage contains only about 4% of ripple. Some applications which don't require very low hum levels could probably work without any filtering. Ripple frequency and amplitude can easily be derived graphically.

This is illustrated in the lower part of figure 1.The dotted lines show the rectified phases A,B and C, while the overlaying solid line illustrates the resulting DC when these are added.

A three phase rectification scheme

Obviously, such advantages don't come without a cost.Figure 2 shows a three phase rectification scheme which is called "three phase star full wave " or "series three phase full wave". There are other rectification topologies, but in this article I will only cover this one since I believe that it offers the most benefits for it's use in audio amplifiers.

The biggest cost factor of this supply is the requirement for a special three legged transformer. Three phase transformers have three separate primaries and secondaries. Alternatively three separate single phase transformers can be used. Additionally six rectifiers are needed compared to 2 or 4 for single phase topologies.

In figure 2, primaries and secondaries are connected in a star configuration. This way transformers with regular primary voltage rating can be used. Alternatively it is possible to wire the primaries in a so called delta configuration.This means that the primaries are not connected between a phase and neutral but between two phases. In the delta configuration the neutral is not used at all.

However in a delta configuration the primaries see a voltage which is higher than that on a single phase by a factor of SQRT(3) which is approximately 1.73 (400V for 230V mains, 200V for 117V

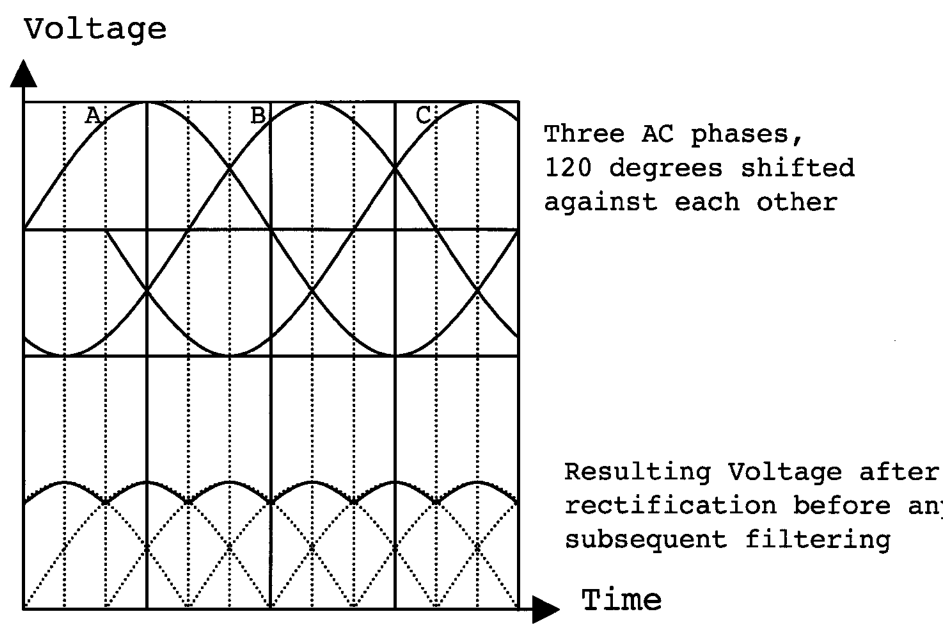


Figure 1—Shows the phase relation of the three mains phases and the resulting DC voltage after rectification. Note that the AC ripple is already very low before any subsequent filtering.

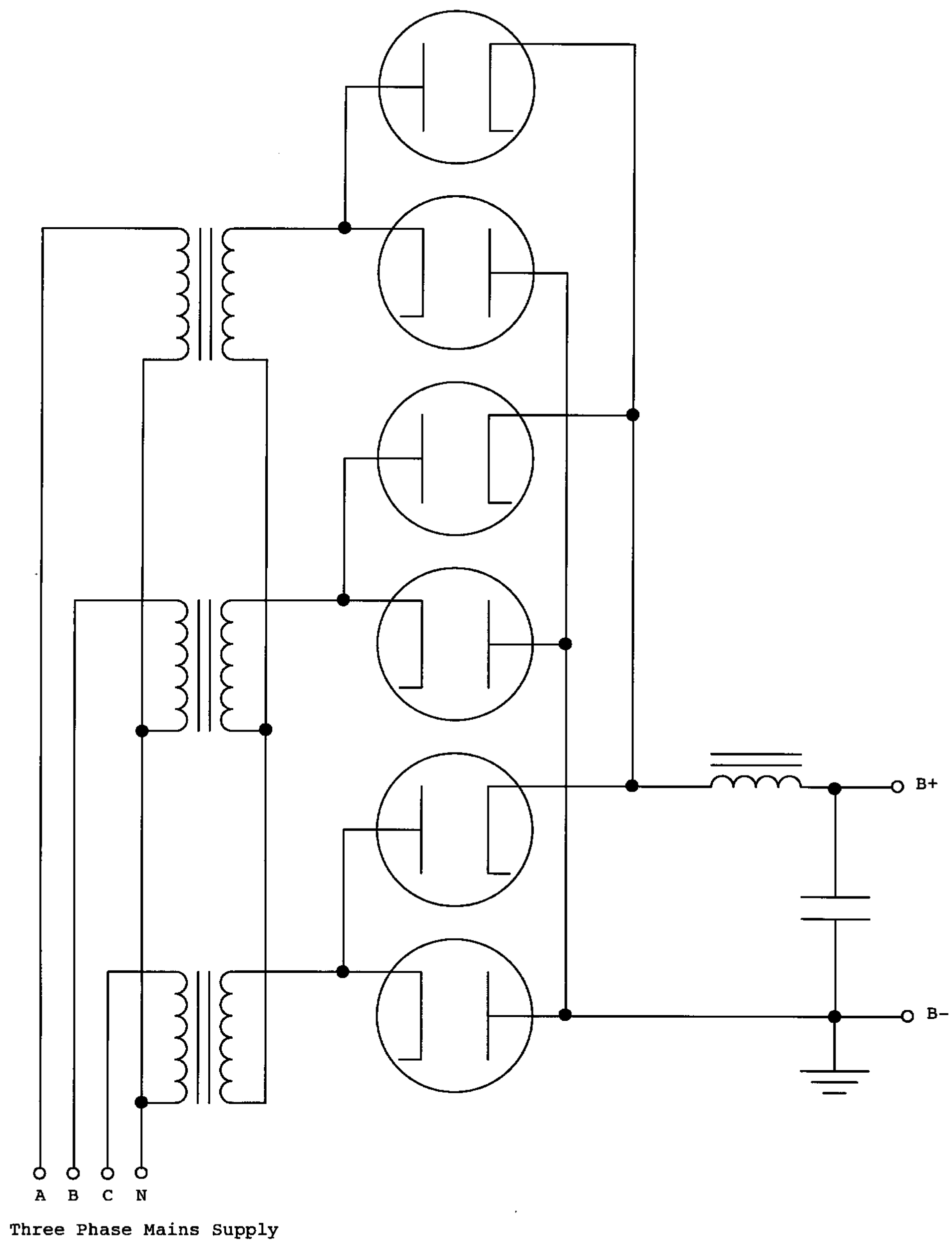


Figure 2—Simplified schematic of star-type three phase supply

mains). This would require different transformers.

In figure 2,the heaters of the rectifier tubes are not shown for simplicity. Please note however that three of the diodes have their cathodes on AC potential, while the other three are on the rectified DC potential. If the heater/cathode insulation is not sufficient or if directly heated types are used, four separate heater windings will be necessary, each biased to the appropriate potential.

Table 1 lists all voltage relationships for this scheme. As you can see the ratio between DC voltage and secondary RMS voltages is extremely good compared to conventional supplies. This means that less expensive transformers can be used which partially offsets the increased cost. Although more rectifiers are needed each one only supplies one third of the current draw. This enables the use of possibly cheaper types like TV damper diodes. And finally, less filtering is required which can easily save a LC stage. If you look at all these factors, a three phase supply could be less expensive than one would think at first sight.

A practical example

Now I will outline the design and construction of a three phase supply which I built for my SE 211/211 mono blocks. The amps consist of a 211 SE output stage which is driven by another 211 through an interstage transformer. Both stages use fixed bias. After having tried the three phase approach with an experimental set up which delivered the B+ to both stages in both amps I decided to build two separate "no holds barred" supplies. The results with the experimental supply were much better than the single phase unit I used before which used an oversized HV transformer, 872A and 1616 rectifiers and a choke input filter.

Each of the two supplies should provide completely independent B+ and filament voltages for driver and output tube. The required voltages were around 800V for the driver, 1250V for the output tube and 10V at 3.25A for the filaments. I wanted the high voltage to be tube rectified.

First, a decision needed to be made on the power transformers. Since three phase units are not very common I settled for regular ones. A local supplier had a stock unit which was a good fit. It has a 680VAC secondary with center tap and taps at 250V. Since the center tap is not needed this gave the possibility to obtain various different voltages (90/250/340/500/590/680). Additionally it has two separate 6.3V heater windings.

Since the driver and output stage supplies should be separate I needed 6 of these transformers for each channel.

One of the 6.3V heater windings on each transformer is used for the 10V filament supplies, while the other is needed for heating the high voltage rectifiers. The current rating of the 6.3V winding limited the choice of rectifier tubes. Since it only requires 1.2A I settled on the 6AX4GTB TV damper. For rectification of the filament voltage Schottky diodes were used.

The rectifier bank which supplies the 1250V for the output stage is connected to 3* 500VAC by using the appropriate taps. This would not be sufficient as such to reach the 1250V. The transformers provided +/- 5% adjustment taps on the primaries. I used these to beef up the voltage a bit. Additionally the secondary voltages are a bit higher than nominal since the HV windings are operated at about one fifth of their maximum current rating. The actual voltage is in the order of 550VAC. This would give about 1280VDC. With the voltage drop in the rectifiers the result is close to 1250V as required.

A driver stage voltage of 800VDC is obtained by using the 340V connection with the corresponding secondaries.

The two filament rectifier banks deliver approximately 15VDC at their outputs. Due to the DC resistance of the smoothing chokes (one in the supply, another one in the amp) just a bit over 10VDC are left at the filament pins of the 211s. This leaves a bit of headroom for adjustment.

All DC voltages (including filament) are smoothed by a choke input filter. For the high voltages 10Hy/200mA chokes from Lundahl are used. These units have an extremely low DC resistance (36 Ohm) and a high enough voltage rating between coil and core. The chokes used in the filament supplies are 0.1Hy/6Amps units from a surplus dealer. On the B+ sides the chokes are followed by a bank of three 8uF/660VAC oil caps in parallel.The filament voltages are filtered with 4700uF/25V electrolytics.

Figure 3 shows the schematic of the supply in full detail. Please note the biasing of the different heaters. The two corresponding diodes of the driver and output stage B+ supply share a single heater winding. The diodes which have their cathodes connected to a transformer secondary carry the same AC potential as the secondary of the driver stage supply of the same phase. The diodes with their cathodes on DC potential are hooked up to the driver stage B+.This keeps the heater/cathode voltage within the maximum for the 6AX4GTB. The slow warm up characteristic of the TV damper diodes automatically provides a delayed high voltage.

The photos show the assembly of one of the units step by step. Due to the weight (approx.140lbs) a sturdy frame construction was necessary. I used material which is intended for the construction of industrial style shelves. I mounted the units on wheels to keep these beasts movable.

Teflon insulated wires are used for all high voltage connections. Additional insulation sleeves are used to provide mechanical protection.The DC voltages are brought out on separate connectors for filament and B+.The grounds of all 4 supplies are kept separate and are intended to be connected in the amplifiers themselves.

Connection to the mains is via a 5-pin connector (3 phases, neutral and earth). An earth connection is also provided on the fila-

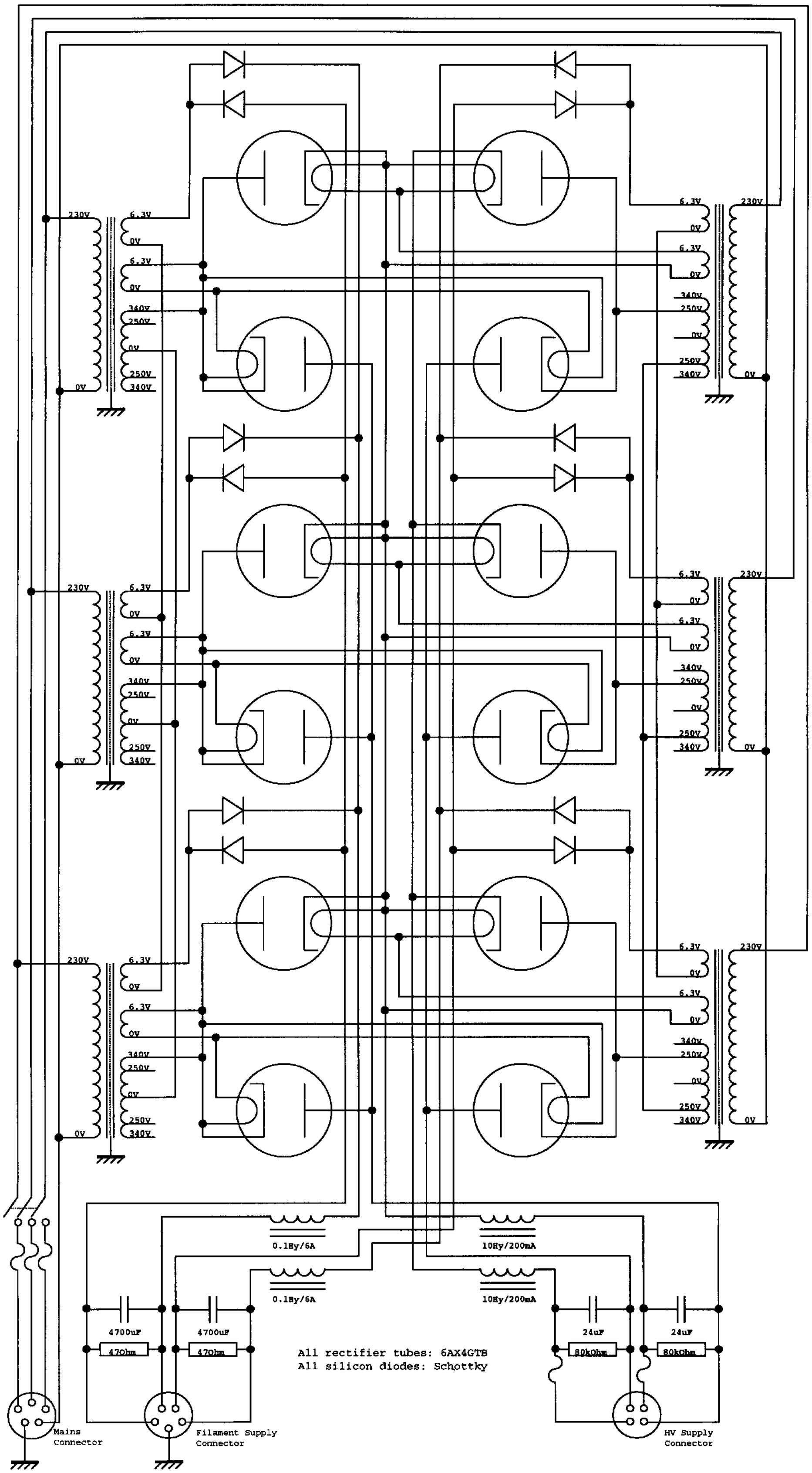
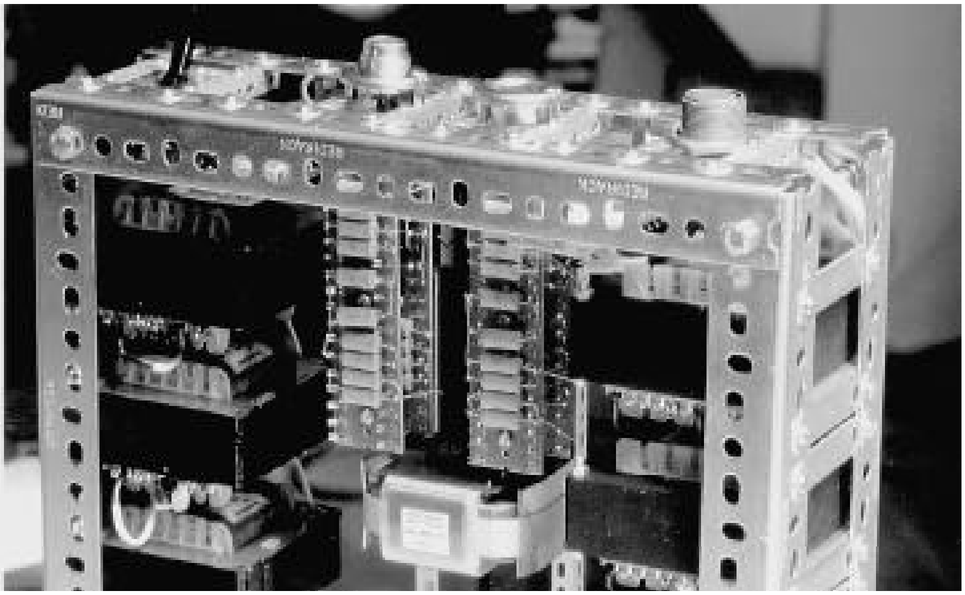
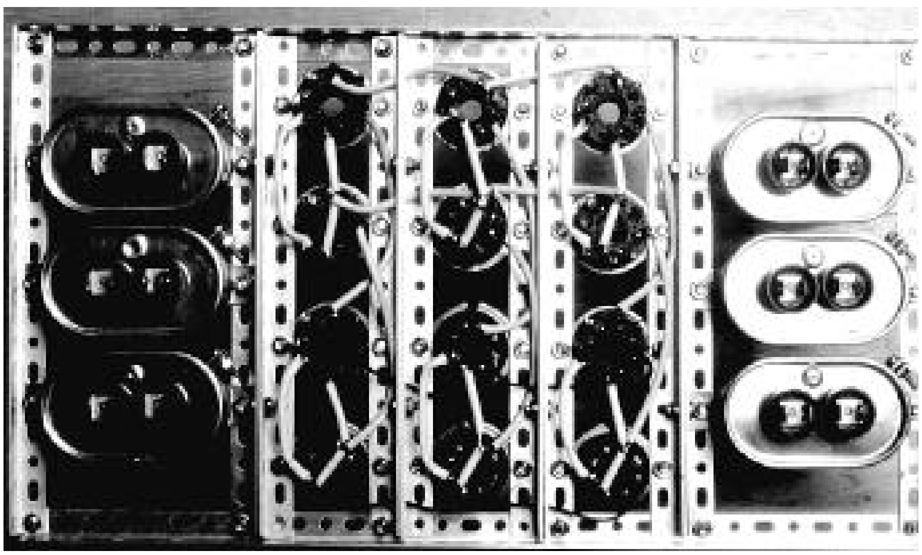
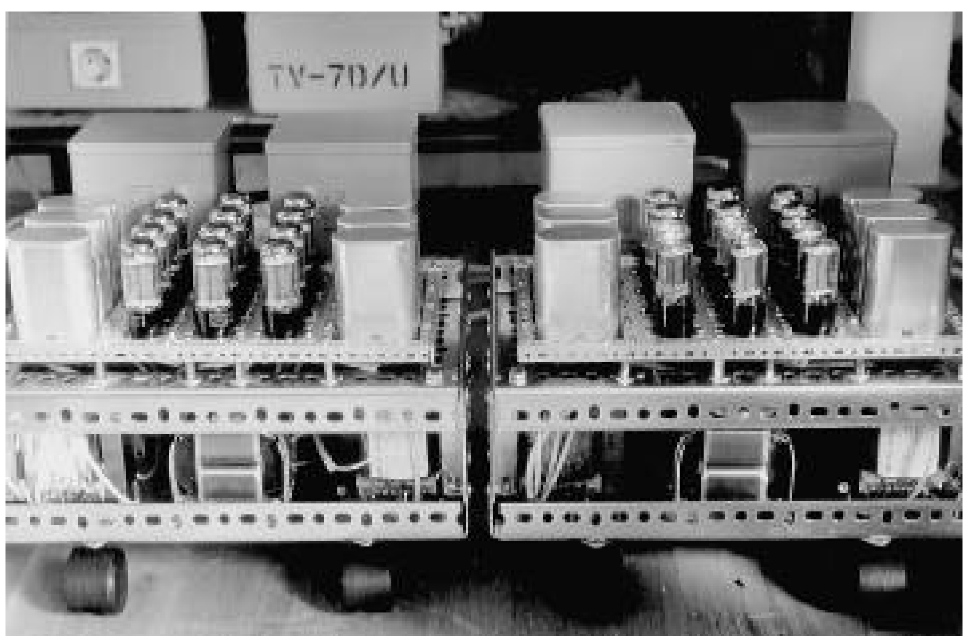


Figure 3—Complete schematic of supply, showing all details,including heater supplies and the bias arrangement which provides safe heater-cathode potentials for the rectifier tubes.







Top—Underside of chassis

Mid—Subassembly with rectifier sockets and HV caps. All HV carrying cables are teflon insulated with additional sleeves for extra protection

Below—Both supplies completed and working

ment connector to allow grounding of the amplifier chassis.

Performance

The hum levels on both the B+ and filament voltages are in the mV range at the outputs from the power supply units. Each voltage has a second LC filter stage which is in the amplifiers. This pushes the ripple amplitudes way down into the micro Volt range.

These supplies enable a freedom from hum which would otherwise only be possible with regulation or by using large filter capacitors. The possible sonic drawbacks of both have been discussed a few times in this magazine. However fluctuations in the mains voltage causes the DC voltages to bounce just as with unregulated single phase supplies. This never caused a problem in my setup however, since these tend to be quite small.

No load to full load regulation of these supplies is extremely good compared to the single phase unit I used before.

Soundwise the new supplies added some real slam to the lower frequencies with subjectively extended bottom end. The amps can also be driven to higher power levels before audible distortion kicks in. But the key improvement is the very low hum level.

I used to prefer AC filaments before, but after I have lived with these supplies for a while I don't want to go back.The very pure DC on the filaments enabled a transparency of the sonic presentation which has not been present with AC heating

All positive attributes of the amplifiers which have been present with a single phase supply have been preserved.

Closing remarks

Although SP readers are well aware of the dangers of high voltage, anyone who wants to try out the three phase approach should be extremely careful and not attempt to build such a supply if he isn't well aware of the hazards involved.Extra care needs to be taken when dealing with all three phases of the mains. The increased complexity of such a power supply bears much more possibilities to make a mistake which could be lethal.

When three separate transformers are used it is important that their secondary voltages are equal. Any imbalance would exhibit itself as 50/100/150Hz or 60/120/180Hz subharmonics in the ripple of the DC after rectification.This could offset the advantage of increased filter efficiency.

This article could merely touch the surface of this topic. Some more information can be found in the RCA transmitting tube manual (reprint of TT-5 available from Antique Electronic Supply) and in "Principles of Electron tubes" which is also available as a reprint from Audio Amateur Press.

If you are planning to build an amp with a no compromise unregulated supply you should give the three phase approach a thought.

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Transformer secondary voltages (RMS)

Erms = 0.427 * Edc

DC output voltage

Edc = 2.34 * Erms

Peak inverse voltage

Einv = 2.45 * Erms

Einv = 1.05 * Edc

Ripple voltage

Eripple = 0.04 * Edc

Ripple frequency

fr = 6 * mains frequency

Note: voltage losses in rectifiers secondaries and filter chokes are not taken into account

The Legacy of THORENS "TD" Series Turntable Classics

by Dr. Stefano Pasini

Put on your lederhosen
and spin a platter on that
Gepanzert Plattenspieler…

In the history of home audio, the name 'Thorens' and 'turntable' are more or less synonymous. Very few audiophiles haven't bought and used, at one time or another, one of these beautifully-engineered machines, either of the Swiss-era or of the later years, when their factory was moved to Germany. Wonderfully well-engineered, built so sturdily that they look like they're armour-plated, heavy, completely reliable and, if the need ever arises, hard-working like real professional decks, the best Thorens turntables are a joy to own and a pleasure to use.

The Thorens tradition is now carried on in Lahr with models like the '521/520', the sophisticated 'Ambience', the versatile '2001' and many other excellent decks. But the two real 'Golden Classics' of this marque were born many years ago; they are as different as they might be, but the Thorens 'TD-124' and 'TD-125' were, and still are, top-of-the-line machines. Like Ian Fleming's diamonds, Thorens are forever.

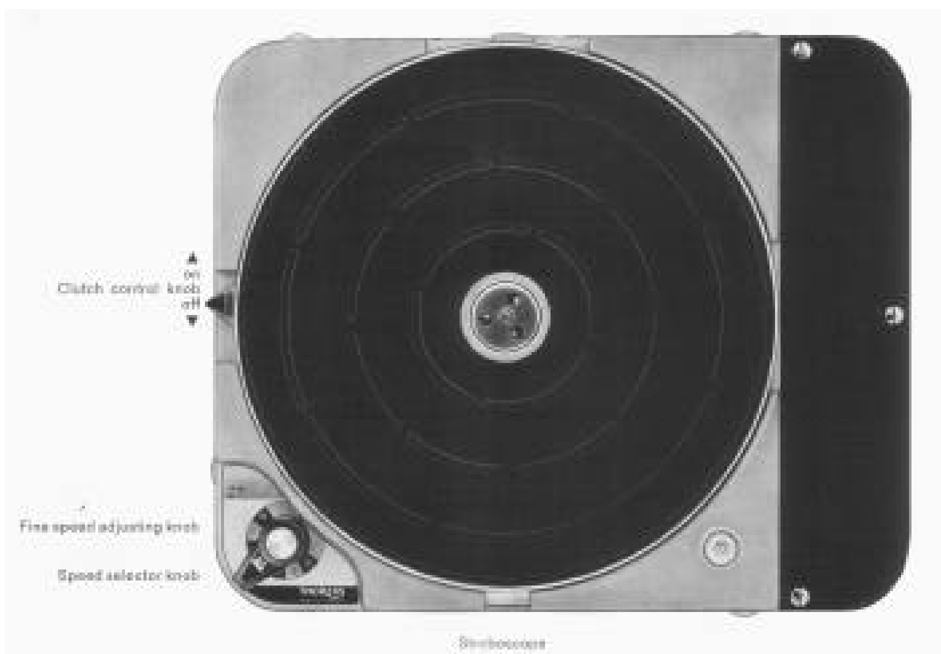
The history of Thorens began in 1883 in St.Croix, Switzerland, when Hermann Thorens founded a firm for the manufacture of clockwork for carillions, cigarette lighters, razors and harmonicas that eventually expanded to employ a workforce of 1,200 in 1929. Disc-playing Thorens machines were already well-known even before World War II, as the firm had already probed the world of music reproduction since the late Twenties with direct-drive motors (a Thorens patent of 1929!), 'Miratonal-Radio' receivers, 'Discophones' gramophones and even separate cartridges, like the 'Omnix' (1933) that required a tracking force of 'only' 110 grams, quite moderate for the times.

Switzerland just barely managed to stay out of the catastrophe of the war, and between 1939 and 1945 Thorens built, amongst other items, high-quality disc-cutting lathes for the Swiss PTT. In 1943 it introduced into its tiny home market a new record changer, the 'CD30', followed by the 'CD50', 'CD43', and various other models, simple motors and platters with no pretense of 'hi-end' performance, something for the average home customer of the times.

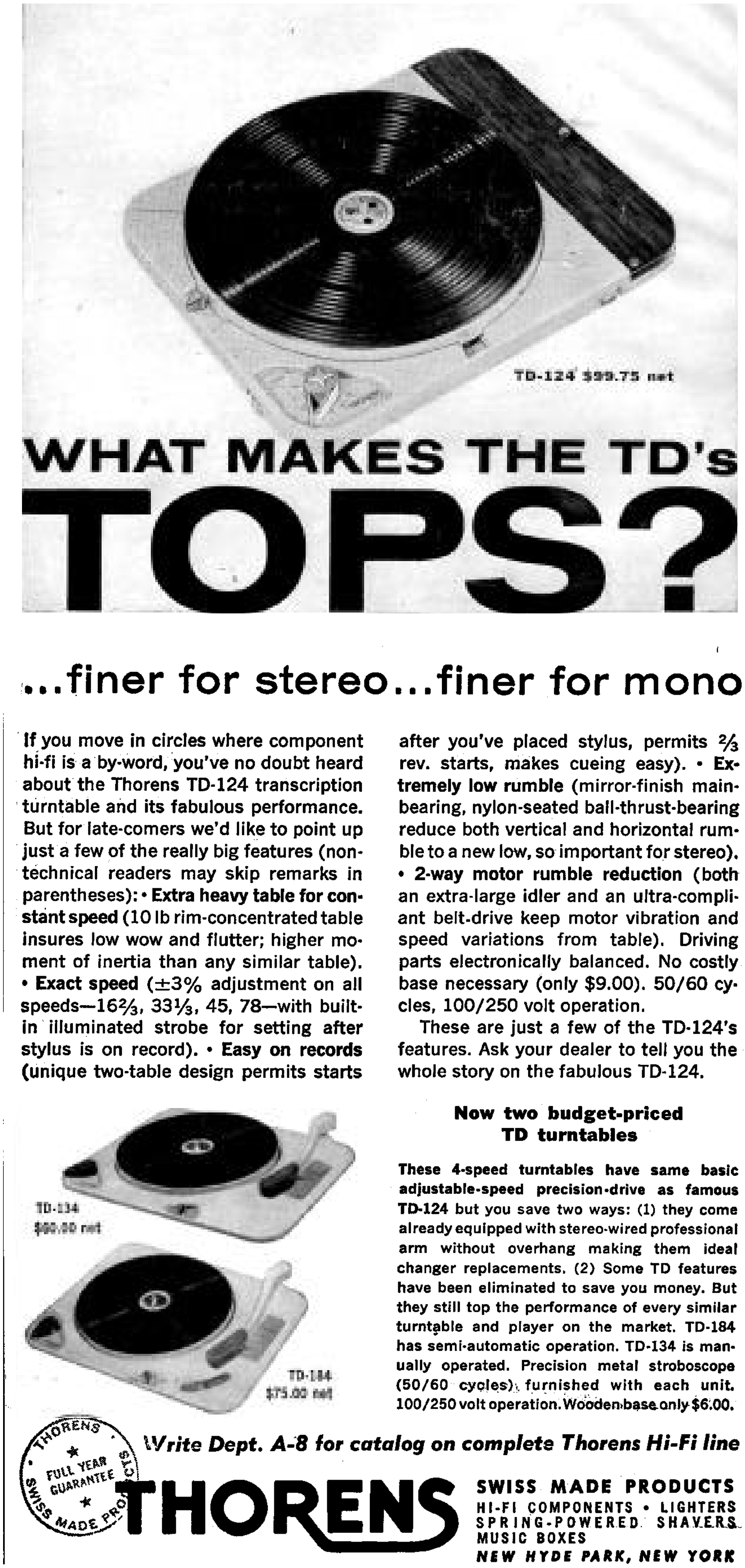
On the other hand, the market for sound-reproduction gear was expanding, and the pros were eager to buy new machines. After the end of the war, radio broadcasts resumed in earnest, and Swiss firms like Studer or Nagra, not having been bombed flat during the war like their German colleagues, were ready to build new advanced machines for the well-heeled professionals. Before the cautious managers of Thorens could build a deck to fulfill the needs of the radio stations, Wilhelm Franz beat them and the rest of Europe's industry with his formidable EMT '927' (1950), the Alpha and, for 27 years, also the Omega of the broadcast turntables.

The Thorens' forthcoming 'high-fidelity' turntable remained in the making for a long time. It is not unreasonable to think that in the process they exchanged data and information with EMT, as the relations with Herr Franz in Lahr had always been good. This might explain why, when the first high-quality Thorens 'TD' finally appeared, it sported a clear and utterly reassuring EMT flavour. But one may also be excused for suspecting that the Thorens managers, before finalizing the design of their turntable, had taken a close look also at the excellent Garrard '301' (first introduced in 1953). In fact the Thorens 'TD124', being aimed not at the all-out 'broadcast' market but at the wealthy amateur, is closer in design, size and philosophy to the British machine than to the German Leviathan.

The '124' was introduced in 1957, at first as a motor chassis only, leaving the choice and installation of the tonearm up to the cus-



Top view of the famous Thorens TD-124



tomer. That's why today you find so many '124's fitted with SME, Empire, FR-64, Shure, Ortofon or even Rek-O-Kut tonearms. Then, in 1958, the stereo record was officially introduced, and almost simultaneously Thorens unveiled its first really high-quality arm: the 'BTD-12'. Every EMT enthusiast will recognize this classic design as an ancestor of the fabled '929' professional arm.

Later on, just as Garrard re-designed the '301' to produce its '401' (1964), Thorens modified the '124', introducing its 'MkII' version in 1966. The most significant improvement was probably the installation of the 'TP14' arm with a redesigned, lighter-looking headshell, minor tweaks being at the same time applied to motor and transmission. The elegant cream paint of the '124' was thought to be old-fashioned, so, with a decision that I personally find regrettable, it was changed to a more sober (some might say *duller*) medium-grey finish. The speed-change lever and the speed adjustment knob were modified as well. The overall layout was unchanged since it had proven to be a winner.

The main feature of the '124'/'124 MkII' is its extremely sturdy aluminium chassis; another is the unusual transmission, designed to combine the advantages of the two main drive systems of the time, the vibration-filtering qualities of the belt and the rigid coupling of the idler-wheel. A powerful synchronous motor (which in the USA, in the style of the times, was christened 'Roto-Drive') turns a pulley and a short, thick belt, this one then driving the stepped pulley, the idler wheel and finally the heavy 4.5 kilograms cast-iron platter, whose 14 mm shaft rotates in a high-quality main bearing. It works very well, though at the price of a hefty weight (almost 15 kilograms for a '124 MkII' with 'factory' arm and plinth) and a remarkable degree of mechanical complication. You only need to compare the underside of a '301' and of a '124' to understand ....

All the moving parts of the '124' are generously oversized, to enhance the stability and reliability of the turntable. The main platter is designed to be always rotating, like a big, heavy flywheel, whilst the actual platter is the light aluminium disc placed over it.

The speed can be finely adjusted by means of a magnetic brake controlled by the owner with the rotation of a small knob on top of the speed-selection lever, and checked with the aid of an illuminated stroboscope, whose dots are painted under the outer edge of the main platter, constantly illuminated by an orange neon bulb, reflected by a mirror and visualized through a tiny window in front of the platter. Clearly this was an advantage over the Garrard '301', which at the time offered a 'strobe' platter only as an option and without on-board illumination.

Thorens allowed for the 16 rpm record, just in case, fitting a gear for this speed. The '124' was therefore one of the very few turntables that were born with a complete choice of speeds, 16, 33, 45 and 78 rpm.

Instead of opting for a pure 'Transcription Motor' approach like their British rival, Thorens decided to offer a chassis incorporating on its right side a wooden board, rigidly fixed with three screws to the underlying aluminium chassis, that could be drilled for the installation of any given 12" arm. The result is that the '124' and its arm form a reliable, vibration-free assembly with no possible reciprocal movement between arm and platter.

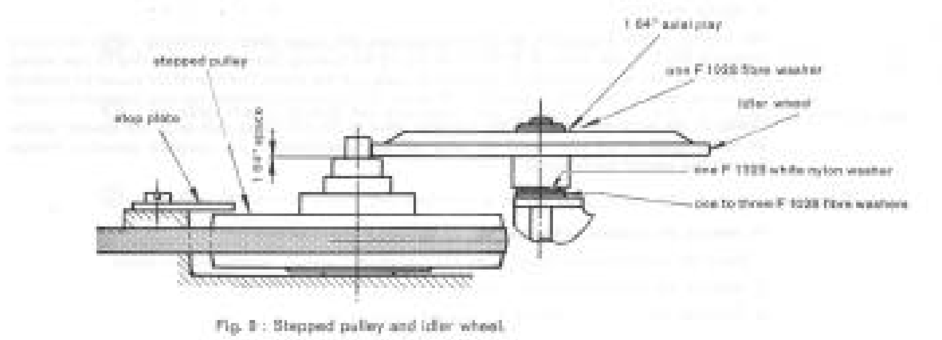
Though quite expensive ($99.75 for the deck alone without tonearm at the time of its introduction in the USA), the '124' enjoyed very good success from the beginning. Its very pleasant lines and the high quality of its construction were strong selling points, and the integral armboard of the '124' was probably a real advantage over the Garrard, because, as Haden Boardman rightly pointed out in SP Vol.2 #1, in those years nearly nobody understood the need for a stable, heavy plinth to mount these heavy decks on. Most '301' therefore ended up in overly-resonating cabinets, or, worse, sprung on a board while the arm was fixed to the same, with predictably horrifying results.

Though the '124' minimises the problem mounting the arm on the same chassis as the platter, one must admit that Thorens apparently had no clearer ideas than Garrard in this area. In the 'MkII' instruction manual, They advise customers that "....additional protection against acoustic feedback.... can be obtained by mounting the board freely on thick rubberhair or foam rubber mats. Special steel coil springs (parts CB 1172 and CB 962) are available as accessory upon request, to be used in place of the rubber dampers for installations where the turntable is submitted to strong extraneous vibrations...." You can sneer at these words, but this was the state of the art in 1966.

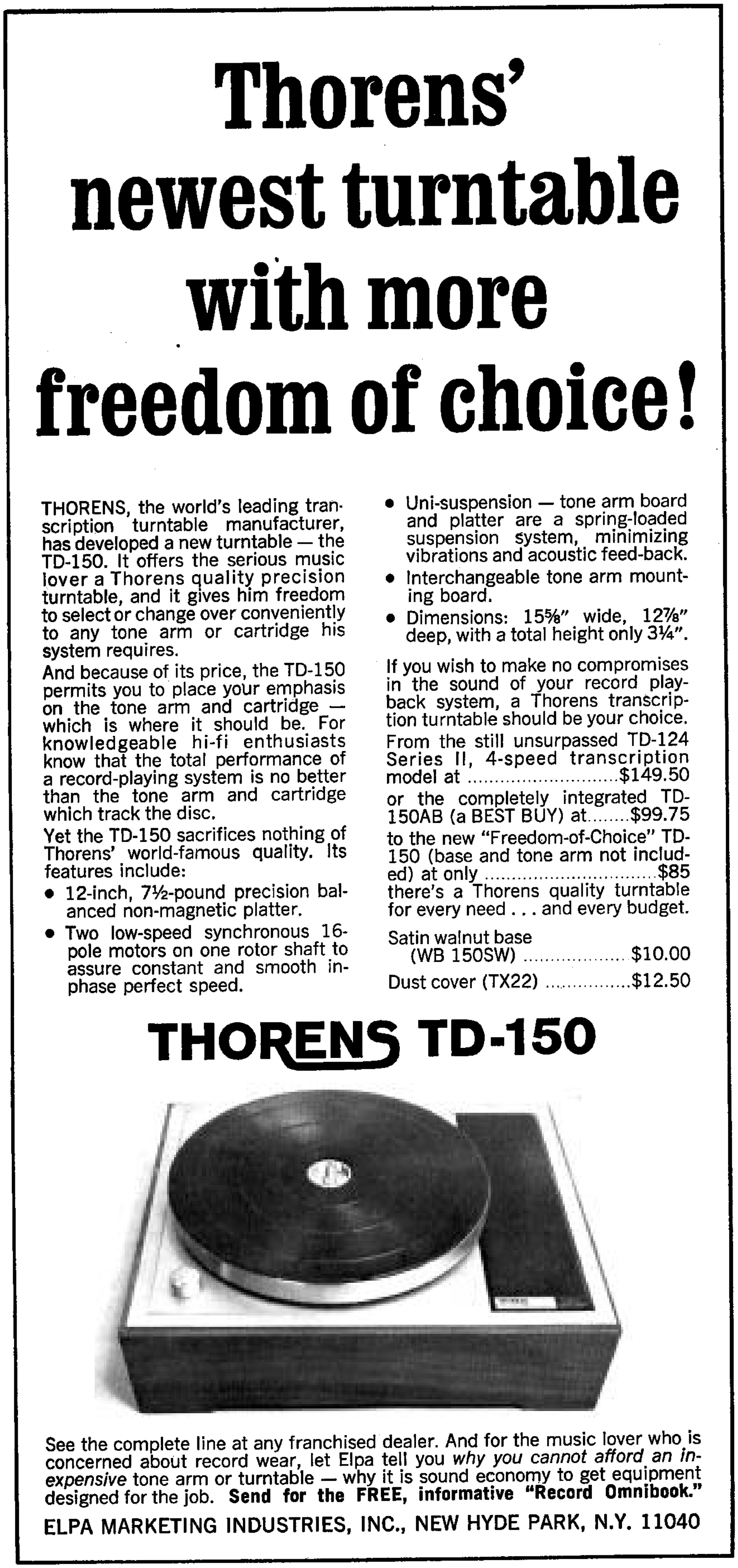
The winning image of the '124' had a positive effect on the other products of the Thorens range, like the much cheaper 'TD184' (1958), 'TD134' (1959) and the very effective 'TD135' (1961), the TD-135 had no strobe nor separate armboard, but offered the same excellent drive system as the ‘124’ with pitch control and the 'BTP12' tonearm of the more expensive model, later fitted with the 'TP14' when the 'MkII' version appeared. A '135 MkII' is a pleasant scaled-down '124/II', weighing 8.5 kg with a 2.9 kg platter on a 10-mm main shaft; the presence of a magnetic brake meant that you could vary its speed, but, lacking the built-in strobe of the '124', you had to plop a strobe disc on the platter.

An interesting but short-lived attempt to build an affordable high-quality deck was the 'TD121' (1962), a '124' without strobe and speed control but the same drive system, platter, bearing and tonearm. It was a bit like Porsche's strategy when they built the simplified 'Speedster' to make the '356' more affordable for the money-conscious American public. The reaction of the customers was not as enthusiastic as for Stuttgart's racy machines: though the performance of the '121' was very good, but a saving of $20 wasn't enough to lure the customer away from all the bells and whistles of the '124', so one either opted for the really cheaper '135' (and its speed control) or went to the top, buying the flagship of the range.

A very intriguing variation of the family was the 'TD-224', a fascinatingly complicated record-changer based on the '124' but with an unique feature: it could play a stacked pile of records not amassing them one after the other on the turntable, but actually



Underplatter view of the TD-124,showing drive system and detailed sketch of idler wheel mechanism.The stepped pulley is belt-driven.



changing them!. A 'robot' arm picked the record from a massive separate arm and returned it to this resting place when it had been played. An impressive machine, but its sheer size was probably excessive, like its weight and, of course, its price: the '224' was nearly twice as expensive as a '124'. As a consequence, the production figures of this weird, high-quality 'changer' were always quite low, though it was built for a record six years, from 1962 to 1968, always with the same '224' designation. There never was '224 MkII', like there never was a '124 MkI'.

A '124' or a '124 MkII' is one of the dreams of today's vinyl-oriented audiophiles, and for good reasons. Endowed with a well-engineered, heavy plinth, like Mr. Martin Bastin's amazing all-wood designs, and a suitable arm, its performance is staggering. And if you own a completely original, well-preserved deck of this series in fully original condition you will appreciate its build quality, its flavour, its unique style. It's one of those objects that you simply like to have around at home.

The second part of the Sixties saw a steady increase in the tenor of life of the Western Hemisphere. The citizens of Germany, Italy, France and the United States for the first time enjoyed the luxury of having some spare money and the time to spend it. Listening to good music became fashionable, and the second-rate sound of the old home systems, intolerable. The Japanese were the first to understand that there was a market that was just about to explode for good sound-reproducing equipment, and that this request would not be satisfied by the pricey high-quality components manufactured by the traditional firms.

Until then McIntosh, Garrard, Harman-Kardon, Marantz, Klipsch and, of course, Thorens had catered mainly for the needs of a restricted élite of wealthy individuals: the Far East manufacturers looked at the other end of the market instead, building cheap amplifiers and tape decks as copies of the Western originals, adding some convenience of use, a pleasant appearance, absolute reliability and, of course, a very low price. Their success was guaranteed by the inability of the 'classic' firms to react to this trend, to the general request for cheaper high-fidelity equipment for the home enthusiast that didn't personally own a bank.

To give credit where due, Thorens was one of the few manufacturers that had steadily explored the possibilities for less expensive offerings, and the proof is in models like the '121' and '135'. But the diffusion of high-fidelity listening in lower-income households often meant also a troublesome placement of the equipment. Whereas in the past the wealthy enthusiast could engage a cabinet-maker to build a suitably sturdy housing for his '124', the newcomer more probably placed the turntable wherever his house (and wife) would allow it. Any flat surface large enough was considered, sometimes even the top of the speakers, with predictably disastrous effects on the acoustic feedback of rigidly-suspended, massive idler-wheel machines with their rigid coupling between motor and platter.

Though its sonic performances in the right environment remained absolutely excellent, the '124' suffered from this new situation, and a new technical layout was therefore necessary. It was also indispensable to renovate the styling: the saying of the racing world that "there is nothing looking as old as last year's racing car" is very apt to describe the difficult marketing situation of the high-quality, expensive Swiss deck that, even in the improved 'MkII' form, was looking really antiquated to the ruthless eyes of the mid-Sixties customers, taught by the Japanese to look for slimmer designs. Low-chassis and lightweight construction meant 'new', 'fashionable' and therefore 'good', 'desirable' and massive Thorens or Garrard idler-wheel decks were junked, as were other old classics like the towering Empire '398-598', the Rek-O-Kut 'Rondine De Luxe' and the Russco or Gray broadcast machines.

Before the introduction of a new product, Thorens had to rationalize its production and lower its production costs, and this meant that it was impossible to continue to produce in a country with labour cost as high as Switzerland. After a brief and unproductive marriage with Paillard (maker of the Bolex cameras) lasting only from 1963 to 1966, Thorens moved to Germany and established its new HQ in Lahr, in the Schwarzwald, joining forces with EMT to create 'Thorens-Franz AG'.

Lahr is in an area renowned for classic clockwork, where Dual, Perpetuum-Ebner, Papst and other important firms in the audio field (many of whom are now sadly extinct) had their factories. For a while, Thorens-Franz AG's mailing label carried both the logos of Thorens and EMT, and the stamp of the Wettingen, Schweiz, Post Office. (Things here get a little confusing even for the historians).

The need for a new product philosophy was addressed in a typically thorough way: the complaints about the sensitivity to noise floor and acoustic feedback of the rigidly-suspended '124' and '135' led to the design of a completely different machine, the innovative mid-line .'TD150' (1965). Its style was completely different from its predecessors'; compact and slim-looking, but still weighing 8.5 kilograms, with a low profile and a modern appearance, the '150' was a bold step forward for the tradition-oriented manufacturer. Instead of an idler wheel transmission on a massive, rigidly-suspended chassis, it had a floating subchassis, a tiny motor and a comparatively simple belt drive. This was the first Thorens with the 3.4 kg two-part main platter that was subsequently carried on with only minor modifications up to today's models. The belt moved by the motor runs around the inner, smaller platter, a thick light-metal cylinder with a diameter of 160 millimetres that turns on a 10-mm shaft; the main platter simply lies over it. Clearly, the accuracy of the machining of the two parts along the interfacing ring is crucial for the good functioning of the system.

The new architecture proved to be quite successful. The '150' quickly earned a reputation for being very quiet. Its floating chassis was able to insulate the record/stylus interface from the external shocks providing an effective barrier against acoustic feedback. It was a simple machine (it had only two speeds, 33 and 45 rpm, no pitch control, no stroboscope) and its first arm, the 'TP13', probably wasn't very good, so many '150's were fitted with aftermarket tonearms, but it worked well and it was comparatively inexpensive, enough that it actually was a viable alternative to the cheap turntables coming, in tidal waves, from Japan.

The new Thorens was available from the factory in four versions, as for later models: 'TD150 AB' was the complete deck with arm and base, the 'A' had tonearm, no base, the opposite of the 'B', whilst the 'TD150 had neither arm nor base. It was an instant success, and this paved the way for the replacement of the aging '124', a completely new product designed in the facilities of the fabled 'Geratewerk Lahr'—in 1968, Thorens finally unveiled the 'TD125'.

It was a timely introduction. Just at the moment when mass-market hi-fi began to explode, Thorens offered a thoroughly top-of-the-line turntable that combined the best of both worlds, i.e. high quality, quietness, and attractive styling in a product that was evidently of a class of its own, and that did not have to fear any Far Eastern rival.

These qualities come, at least in part, from the thoughtful application of the solutions previously discovered on the '150' and '124'. Like its direct ancestor, the '125' has an integrated but detachable armboard, a strobe and a pitch adjustment, but the motor, substantially lighter than it had been in the '124', is controlled by an electronic system, thus allowing for the deletion of the magnetic brake.

Like the '150', the '125' is belt-driven and has a floating subchassis, but both the main frame and the suspended parts of the chassis are much beefier and heavier, putting the '125' in the same weight class as the '124'.

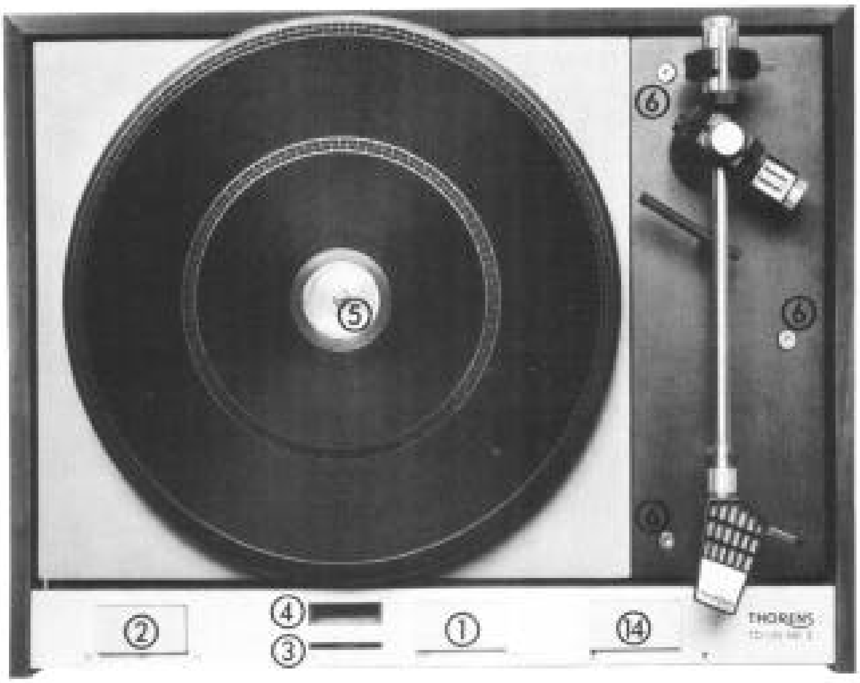
These interesting characteristics were assembled in a very heavy, stable deck with a unique styling. While the '124' had the overall appearance and finish of a vintage Swiss medical machine, the '125' was a sort of Sixties-German-hotel-furniture design, brushed aluminium mixing with straight-grain wood in an extraordinarily attractive design. The three laterally-sliding switches on the front panel (two for the machines sold without a stock Thorens arm and therefore without 'factory' arm lift) are still instantly recognizable as a trade-mark for that model, which also sported the added convenience of a hinged, spring-supported, high-quality Perspex cover.

The stock arm was the 'TP25' with the 'TP50' headshell (now very scarce!), a classic design that was a nice piece of kit for the money. A really unusual feature of the '125' was the choice of its three speeds: 33, 45 and 16 rpm. No 78 rpm! A very unusual, some might say weird, decision.

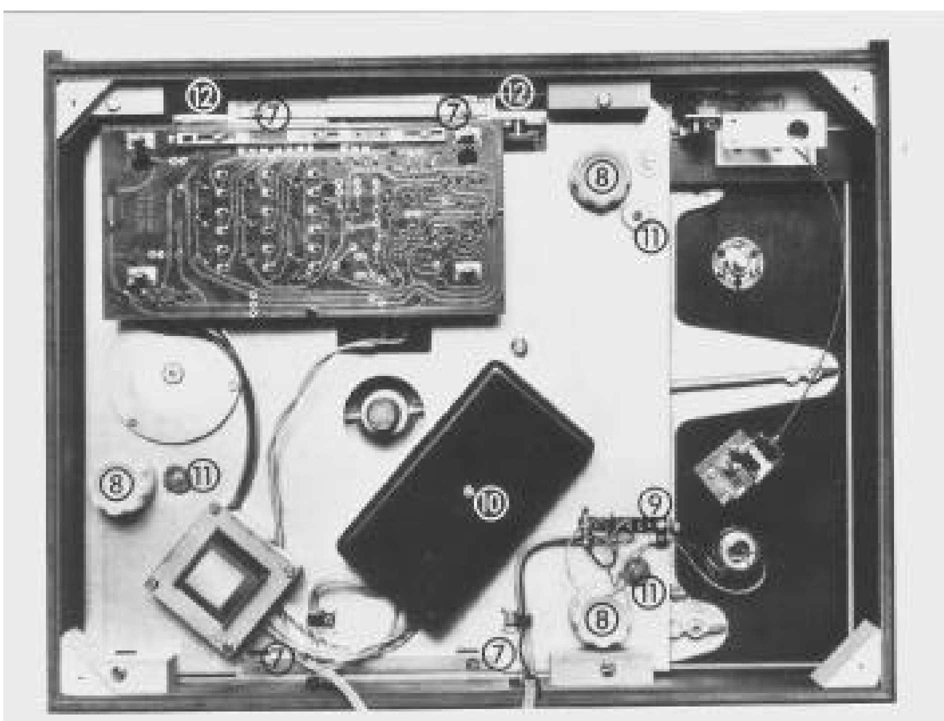
This layout was carried on in the 'TD125 MkII' introduced in 1972, improved with the provision of a friction device to smooth the start of the rotation of the platter, a different mat, and a better tonearm—the all-new 'TP16', a high-quality, still undervalued straight arm that was to be Thorens' battle axe for many years to come.

Cleverly, the '125' was designed to be adapted easily to all the main markets, from Europe's 220 Volts/50 Hertz to America's 110 Volts/60 Hertz. Overlap between the production of the '124' and its heir was very short, almost non-existent.

The armboard design of the '125' is quite different from that of the '124',which is screwed on a metal frame on the right side of the main chassis. Being a part of the chassis' casting, this frame is unmoveable and makes the installation of some 12" and most 16" arms quite tricky on the '124'.



1- AC mains On/Off switch
2- Speed Selector (16/33/45 rpm)
3- Pitch control wheel
4- Stroboscope window
5- 45 rpm record adaptor
6- Arm mounting board fixing screws
14- Tonearm lift control
7- Base fixing screws
8- Levelling knobs
9- Tonearm wires connector
10- AC fuse holder w/ protective cap
11- Chassis 'Safety' retaining nuts
12- Slide buttons fastening screws



Thorens TD-125 Top and bottom views

In the '125', the armboard does not have such limits, since it lies on three supports sticking out of the right side of the main chassis without any metal frame surrounding the edges. Therefore, even if the stock board and base supplied with the armless '125/125 MkII' were still not wide enough for 16" arms like the SME 3012, it was easy to fix the problem. The customer wanting to install his 'FR-66' or Grace '565' could order item #JP512, a factory-made conversion kit featuring a longer control panel for the base and a wider board, or simply make a custom base and wider board by himself. This voided the use of the mounting frame #CE 509, designed to install the turntable into 'furniture'. To stiffen the suspension of the '125' it was also possible to order purpose-built rubber grommets (#CB 909) to replace the chassis' springs.

The '125' design was so appealing, and its performances in terms of rumble so good, that EMT, involved from the beginning in the design of this model, developed a professional version. The 'EMT 928' was basically a '125' with a reworked electronic system, a much more sober look (all grey and black) and a '929' tonearm. It's obviously the 'definitive' evolution of the '125' design: it's heavy (15.5 kilograms), complicated, expensive, and extremely fascinating. Its performance is even better than the Thorens products, owing to the excellent characteristics of the EMT '929' tonearm, and also because of its completely different chassis.

Belatedly admitting that the wooden separate armboard of the standard deck isn't completely satisfying, at least for professional standards, the '928' upper deck is a single-piece metal casting. The hardware is all precision grade, as befits a beknighted EMT product. Wilhelm Franz decided for a different range of speeds as well, so the '928', very sensibly, offers to its users the joys of 33, 45 and 78 rpm, which was exactly what Thorens should have done with the ‘125’ in the first place.

The '928' also has a stylus illuminating device and can be fitted with transformers for the use of the excellent EMT 'TSD-15' cartridges (this was model '928 003'), a hugely stiffened suspension— a bit like the much later 948/950, and a splendid acrylic-felt platter. All in all, a superb, if somewhat cumbersome-looking, deck.

Unfortunately, the belt drive proved to be unfit for a professional usage, and as the '928' cost almost three times as much as a '125', it couldn't be a real contender in the money-conscious amateur market of the times. The '928' was therefore quickly dropped and the German firm went on to develop its own formidable direct-drive turntables ('950', '948' and '938'). The '928' was the last EMT model produced while Wilhelm Franz was still alive (he died in 1972) and it's a clear proof of the high regard of the 'Thorens-Franz AG' people for the basic design of the '125'. Though scoffed at by EMT traditionalists, it is a really wonderful machine. If you fancy this kind of turntable, you can't find anything better than a '928'. It's very expensive, but extraordinarily fascinating, really the ultimate '125'.Grab one if you can... Trouble is, they made very few '928', so they're probably the rarest of all the EMTs now and priced accordingly.....

The ‘928’ story confirms that the design of the '125' is really extraordinary, so much that even dead-serious professional-oriented people like EMT thought that it deserved their sacred logo. Never mind know-it-all experts claiming that, apart from the monumental 'Reference', the '124' is the only Thorens to have. The '125' is an all-time classic, and the 'MkII' was, and I want to say that it *still is*, a formidable turntable. Its solidity, balance, and overall quality actually beat every other 'mainstream' deck on the market in those years. Considering its high price, it has been a real best-seller.

In USA, the '125' was quite expensive: in 1969 you would pay $280 for a 'TD125', $385 if you ordered the classic Ortofon arm, and it was a lot of money when an Empire '398' cost $199 dollars, an 'AR' was $78 dollars, and a Dual '1219' semiautomatic turntable was offered at $159.50.

Not that it was much cheaper in Italy—a 'TD125 MkII' in 1972 cost 175.000 liras as a deck or 235.000 with the 'TP16' arm, and that was some money. To put things in perspective, the last great British machine of its kind, the Garrard '401', was at the same time sold at 140.000 liras (obviously without arm or plinth). The market success of the '125' helped the sales of the cheaper 'TD165' (95.000 liras) and 'TD160' (110.000 liras), both introduced in 1972, as heirs to the '150'. These smaller decks sold like hot cakes in the sellers' market of the time. Thorens, in the first half of the 70s, was quite a fashionable brand.

It's a pity that, having reached such a formidable peak of functionalism, styling and performance Thorens didn't stick to its guns longer. In 1974 the '125 MkII' was suddenly replaced by the 'TD126', a new deck with the same engineering concepts, more electronics, a larger chassis to accommodate longer arms (but still not the 16"), 33/45/78 rpm, and illuminated pushbuttons instead of sliding switches on the control panel. If you look at it as an improvement over the '125 MkII', you'd probably be deluded, as the performance isn't significantly better while the price, with the stock 'TP16' arm, was much higher. The '126' was good, but not good enough to replace its almost perfect predecessor, over which it didn't offer real advantages.

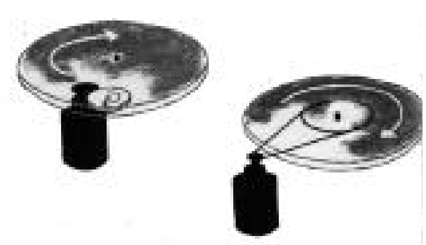
The EMT ‘928’—Professional version of the Thorens TD-125

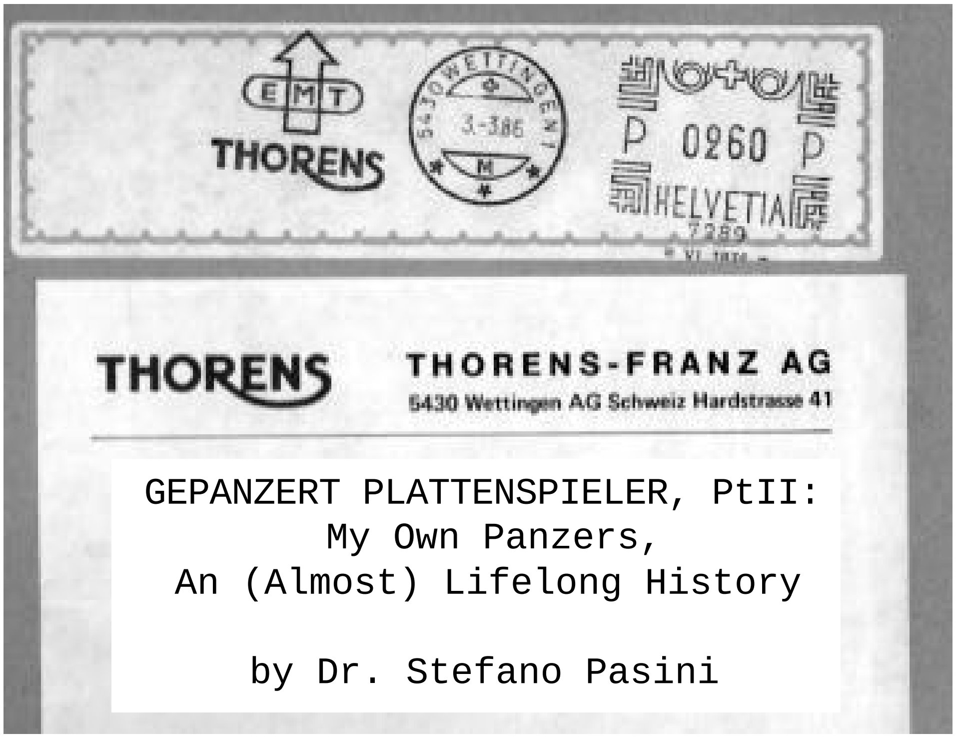
In hindsight, the '126', though a decent turntable, was the beginning of a long downslide for the Thorens name, 'Reference' notwithstanding. The arrival of the CD (1982) and the subsequent boom of digital audio destroyed the turntable market almost overnight The firm went through a lot of troubles before being rescued a few years ago by wealthy investors who are carefully rebuilding its name and product range.

Now 'Thorens Audio HiFi-Vetriebs-GmbH', owned and managed by Herr Helmut Leitner, is a small, healthy firm that builds a complete range of really excellent turntables and tube electronics. Mrs. Evelyn Schmidlin, at the Export-Department, is as helpful as one can ever hope and she cares for the requests of foreign enthusiasts with real attention. Thorens today has factories both in Lahr and Berlin, and, although the famed 'Geratewerk' sadly doesn't exist anymore, Thorens' quality level is still very high. The '2001 Isotrack' turntable is one of the best decks for the money I've heard recently.

A little-known but really amazing fact is that for the 'classic turntable' enthusiast and owner, Thorens offers a real service lab where it is possible to service, repair and restore your old deck. And I don't mean antique '316's or 'Prestiges', I mean any Thorens built since the '124'. They're quite busy these days, as requests for service and restoration of classic Thorens have boomed. The spare parts catalogue is two inches thick, and the kind lady managing the service department, Frau Renate Schmidt, remembers all of them by heart....

It's quite inspiring to see a new firm, firmly oriented towards the future of high-fidelity music reproduction, being still very much faithful to tubes, vinyl and their own old, fabulous turntables. Looking at their record, you understand that you can buy a new one with confidence, and if you can find a shop that has one connected in their listening rooms, I'm sure that you will. As soon as I can test one in a proper listening room (my own, for example....) of those new, wonderfully-designed and built Thorens, I'd probably buy myself a '2001' or an 'Ambience'...





GEPANZERT PLATTENSPIELER, PtII: My Own Panzers, An (Almost) Lifelong History

by Dr. Stefano Pasini

I bought my first '125', second-hand, in 1975. It was a perfect 'MkII' with a SME 3009 arm and it was like a Lamborghini and a Jaguar rolled into one piece for my young eyes and near-empty pockets. After a while, desperately wanting a second turntable (remember when the amps had TWO phono inputs?), I bought a fourth- or fifth-hand '124' for what amounted to, I think,$10. It was a first series, in perfect condition, with its original arm but no base, so I built one and connected it—and was shocked by its quality.

Of course, I couldn't admit to my fellow enthusiasts that I thought that a turntable that was considered just an old idler-wheel piece of junk could be as good as a neat modern '125' or one of the new fashionable direct-drive decks coming from Nipponia, but, even being no audiophile (I wouldn't dare to tell you to which piece of transistorized garbage I had hooked the Thorens at the beginning....) I was stunned by the clear sound and utter silence of that allegedly 'obsolete' turntable.

Years passed, amps and speakers and tape decks and tuners and Michells and EMTs and Voices of the Theatre came and went, but I always had two or more Thorens around. I own twelve of them now, and they never let me down. Even the cheaper 'TDs' have their dignity, and even the more desperate wreck can be easily resuscitated, something you can say only of a few top-grade products.

These days, I listen to a EMT '950' with '929' arm and an EMT XSD-15 in my main system, to a Garrard '301' on a Shindo plinth with an SME 3012 and a Denon 103 in the second (the EMT is infinitely better....) and a special 'customized' Thorens '125' in my third system.Somehow, this the one I love most. I mean, the EMT is absolutely admirable in its ruthless efficiency, but it's a machine that's untouchable in its perfection, if you modify something you would very likely spoil it. Granted, the Garrard has its 'Olde Worlde' charm and all that, but it's someone else's recipe, not mine.

With the Thorens decks, I enjoy a much more personal approach. I keep most of them absolutely spotless, in mint condition for my personal delight, but the ones I bought for $10 or $20 during the Eighties, often half-wrecks that I rescued from the scrap heap. Those are the underdogs, the forgotten heroes that I really love. I like to restore them, rebuild all that I can, and then modify them according to what I read and/or what I think. Yes, I like to modify some of my decks.... boy, do I ever tweak them! And I've never found one that answers so positively to tweaking as the '125'.

I've worked a lot with the '124', the '301' and the '401', plus many other decks, but the '125' remains my favourite, because it is wonderfully compliant. I mean, build the '124' a wrong plinth and you risk a dire degradation of its sonic qualities. This simply is not a concern with the '125'. So let's see together what we can do to improve the sound and/or operation and appearance of our Thorens.

My own trustworthy TD-125…

Before we talk about 'tweaks', however, let me utter a cry of pain. Now that vinyl is fashionable again all around the world, and that real or presumed audiophiles have discovered the qualities of turntables like the '124', the '301' or the EMT '930', there is a rush to buy those elderly decks, then, unfortunately, some of them are then heavily modified with the dubious idea of improving their performance. I cannot see how a comparatively uncultured Far East amateur can judge himself to be better than Hermann Thorens, Wilhelm Franz and their all-German-speaking engineering teams.

If the modification only involves secondary, easily replaceable parts (cables, connectors, etc) I'll let the offender go with a warning. However, I strongly object to the barbaric acts committed on decks that arrived to 1999 in a perfectly original, unspoilt condition and now have been drilled to fit a second arm, cut to make space for a quartz-controlled supply, and generally butchered to give to its owner the aura of a 'dedicated audiophile'. I think that this kind of barbarism awards its perpetrator only the label of 'culturally impaired'. Unless one is prepared to recognize the real historic value of an old classic deck, he'd better stick with cheapo CDs. What can you do with those guys? I don't know, either, though *electrocution* is one of my ideas.

Of course, this does not apply, as I said before, to an abused wreck that you rescue from the garbage can. In this case, since originality has been lost forever before you found it, you can try something new and maybe useful on it. So I'm telling you what I have done in the past and things I'm still doing, but I am asking you to refrain from modifying any original deck you might find.

WARNING: what follows might be a rude shock to some 'purists'.....

Servicing a used '124' and '125' (and any other vintage Thorens, in fact!) is easy, provided that the deck is complete and the motor or electronics have not been hopelessly burnt. Thorens always used good materials, so usually you need only to strip, clean, polish, and lubricate the machine, checking all of its parts carefully.

In the process, you will have the chance to use a whole lot of weird and potentially harmful instruments of your choice, something I always relish. Being an eye doctor, I enjoy the benefit of taking a long hard look at the idler wheels' rubber and at the stylus tips with my biomicroscope, while to pick up turntable noise there's nothing better then the old, dear stethoscope. I've used it on turntables since I was a junior medical student (that's 20 years ago). Lucio Cadeddu, the Editor of the famous on-line Hifi magazine 'TNT', one the more interesting and outspoken online audiophile magazines, has been one of the first connoisseurs to spread the word about this device and its 'audio' use.

The stethoscope is a revealing tool. Place it on the plinth of a running deck and you will hear, more often than not, all kind of noises, thumps, whirrs and hums. Not even a Tektronix can give you as much information on the condition of your deck, I am sure. Using the stethoscope 'before' and 'after' any procedure will not tell you if the modification has improved the musical quality of the turntable, but surely will help you to understand if you have solved a problem. I use a German-built stethoscope, of course, hoping that my Thorens will feel better for that. I also use an oscilloscope, but it's a simple machine that I use mainly for the tracking of the hums along the signal cables.

What you will learn, using the stethoscope, is that a high-level belt-driven deck is usually far more silent than a comparable idler-wheel job, on par with excellent DDs. (I hear purists and idler-wheel junkies frown.) The '124' is not a noisy table, but you will hear distinctly any 'flat spot' of the idler, if, unluckily, yours has one.

You will also hear bearing trouble easily, as its resulting rumbling noise is easily detected, but it's not easy to fix unless you decide to change the bearing, so, while you have the turntable stripped on your bench, it's worth checking carefully the main shaft and sleeve. This bearing wear can also occur in belt-drives, but less frequently, probably because the belt pulls less strongly on the platter and exerts less sideways force on the main shaft than a spring-loaded idler-wheel system.

Either way, a trick worthy of a used-car salesman will help you: putting a more viscous oil in the bearing will help reduce this noise. 99% of the times a thorough cleaning and lubing will make your Thorens once again as good as new.

That's probably why I love using Castrol GTX3, a 'thick' oil, instead of other very sophisticated products. I once tried the 'factory' EMT oil, and it's good if the bearing is OK, otherwise I stick to the Castrol, which is also much, much cheaper. I'd like to try the 'Mobil D.T.E.' medium-heavy oil that EMT recommended for its '928' as well, but I can't find it in Italy. Belts and idler-wheels will have to carefully cleaned with warm water and soap, then rinsed. NEVER use turpentine, alcohol, etc, on old rubber.

Power cords and connecting (signal) cables of the decks built before 1990 are quite mediocre. They weren't very good to begin with, so now that they're old, they are usually *very* bad. If you have a stock '124' in pristine condition, let it alone with the stock cables and use it for display purposes. If the deck was found in bad condition and you have to rebuild it anyway, junk the old cables and go for new ones throughout, fitting a shielded power cord in the process.

The plinth of an original deck has to be cleaned and then polished with plenty of beeswax and elbow grease. This effort pays off handsomely in the overall appearance of the restored/refurbished machine. And this is, more or less, all I think that ought to be allowed to be done to old turntables in original condition. Let's talk tweaks now.

For the tonearms, I'm afraid that I have some strange personal opinions. To begin with, I do not like SMEs very much. The new ones must be good, but are they're awfully expensive and I do not like their style. The classic 3009/3012 series is good-looking, well-engineered, and perennially fashionable, but I do not believe that they are exceptional. Also, the fixed-headshell models will give you nightmares when it's time for cartridge changes.

Over the years, I've fitted almost everything else besides SMEs on my several '125s', from a Mayware MkIV to a Dynavector '505' and Stax or a Rabco 'SL-8'. Having developed a soft spot for Grace tonearms, I've tried also the '545', '840F' (such an elegant design!), '704', 747', finally settling as of today on a '707 MkII' mounted on a special, custom-made armboard. The Dynavector '505' works wonders, but only with a 124 on a heavy plinth. Also, it's quite tricky to use (no lift, etc). I understand that the '507' is easier.

The design of the armboard itself is more important than most people would think, at least in the '125'. For a while, people designed and cut their own armboards from wood, Perspex, even glass and cheap plastics. This will give the arm a place to be bolted onto, but often nothing more than that. A good armboard is a *must*, otherwise the purpose of providing the deck with a solid 18 kilogram plinth will be negated.

This is especially true for the '125', where the armboard is supported by those three metal 'fingers', but it's not fixed around its perimeter. This can spoil its overall rigidity and cause some subtle resonance around the 'free' edges (i.e., the three sides not adjacent to the metal chassis).

I've experimented quite a bit with boards, inventing for myself a 'code' to identify at a glance the armboard I'm using: matte black is the original 'factory' board, light-grey is a reproduction in some different wood or even plastic, light green is for 'fancy' boards. My '707' is now installed on a wafer of two slices of oak sandwiching a 3 mm foil of soft Neoprene (rubber). The three layers are glued together, Ideally, this construction should help to kill the board's unwanted resonance and it appears to work quite well.

I've never tried an all-metal armboard, simply because it's complicated to arrange for someone to cut them from sheet aluminium or copper. I wouldn't use steel or iron for fear of magnetic trouble! I'm not sure that, in the end, a metal armboard wouldn't ring like a bell. I plan to experiment with a glass-plastic sandwich sometime soon.

One thing that I always do with a '125 if I'll use it for playing records in earnest, is to remove the bottom panel. This flimsy wooden sheet is a sort of 'dust cover', but it creates a closed 'box' that I don't like, since it can introduce an undesired 'boominess'. I feel it's better to get rid of it pronto. An added benefit of removal is easy access to the knurled knobs of the suspension, making the levelling of the unit much simpler and easier.

Since the chassis/subchassis assembly of the '125' is clearly decoupled, I feel no great urge to put conical points underneath. I use rubber supports, and they work great with the stock plinth. I will report that I once tried to screw a 'bare' '125' to a very heavy wooden plinth and the sound didn't change a bit. I'd guess that the springs of the counterchassis insulate it so well that you don't really need to provide a better plinth, and the belt absorbs most of the very few vibrations produced by the tiny motor of the '125'. I've tried to put some damping material (Neoprene, sponge, even hard rubber) in the springs to dampen their floating, but the results weren't very good. At the end, this only introduced some sensitivity to acoustic feedback.

Of course, this way of thinking doesn't apply to the '124', which absolutely needs a heavy, sturdy plinth because of its powerful motor and idler-wheel drive. I like to mount a '124' on a very heavy, high-density ply base, taking care to screw the chassis firmly to the plinth from underneath, using the four support screws, the ones carrying the height-adjusting nuts as retaining bolts, for four nuts and washers. Between the chassis and the plinth I like to put only four grommets of hard rubber. Some would probably prefer a harder material, hardwood or maybe even metal (I never tried it). With a final mass of over 20 kilograms for a typical plinth, I feel that you do not need cones, but if you were to fit a good quartet of brass points, surely they wouldn't harm the sound a bit.

Some like to fit 16" arms to the '124' and special power supplies. You can, of course, but the small amount of vibration that an idler-wheel deck can produce would be amplified by such a long arm, whilst a high-grade shielded AC cord will solve 90% of the problems related to the '124' and '125' power supply. You have to try to believe.

I stop with the power cord upgrade and use a fairly high-mass arm for the '124', like the excellent stock 'TP-14' or the reliable Audio Technica 'ATP-12', an old favourite. On the '125' I use lower-mass tonearms, like the '707 MkII' I mentioned before, but I do not despise the 'TP-16' arm, a good, medium-mass design that is easy to set up and use with almost any type of cartridge.

I also found the Mayware 'MkIV' to be well suited to the '125', at least with the Denon '103' I routinely use as a benchmark cartridge for the various decks I'm working on. As a footnote, I would like to say that whilst I always try to extract something more from my 'hot-rod' '125' and '124', I've never messed with my EMT '928'. like its bigger brothers, it is way too well-made and engineered to risk to spoiling it with some goofy ideas and clumsy workmanship. EMTs are somewhat intimidating, probably having something to do with the astronomic prices of their spare parts!

My constantly-tweaked, first-series '125' (no clutch) is somehow the 'moral flagship' of my collection, as it's the only Thorens normally listened to. The older decks are used in turns to keep them moving, but few of them sound as good as I'd like. As for the '124', I have a 'MkII' that I'm perennially working on…waiting for a new plinth now,in fact.

I have another beautiful, completely original '124 MkII' on display. This one is towering above the other decks in the middle of my turntable collection, and I think that it deserves this commanding position, standing proud in its original battleship-grey livery amongst the other machines of my small but dedicated collection, surrounded by lesser but always worthy Thorens and surveying from a vantage position the day-to-day work of the EMTs. I'm sure that Herr Thorens and Herr Franz would be proud of this layout.

THORENS

Produktionsdaten der Thorens-Plattenspieler

Type	Year
TD 104	1978-1981
TD 104 II	1980-1984
TD 105	1978-1981
TD 105 II	1981-1984
TD 110	1977-1982
TD 115	1977-1982
TD 115 II	1982-1984
TD 124	1957-1965
TD 124 II	1966-1968
TD 125	1968-1971
TD 125 II	1972-1975
TD 126	1976-1976
TD 126 II	1976-1977
TD 126 III	1977-1986
TD 127	1983-1984
TD 134	1959-1964
TD 135	1961-1964
TD 135 II	1965-1968
TD 145	1975-1976
TD 145 II	1976-1978
TD 146	1983-1986
TD 146 II	1986-1987
TD 146 V	1988-1991
TD 146 VI	1992-
TD 147	1982-1985
TD 147 Jubilee	1983-1985
TD 150	1965-1968
TD 150 II	1969-1973
TD 160	1972-1976
TD 160 II	1976-1984
TD 160 IV	1987-1988
TD 160 V	1988-
TD 165	1972-1976
TD 166	1975-1976
TD 166 II	1976-1987
TD 166 V	1988-1991
TD 166 VI	1992-
TD 180	1990-
TD 184	1958-1962
TD 224	1962-1968
TD 226	1981-1986
TD 230	1986-1988
TD 230 Excl.	1988-1992
TD 230 II	1988-1990
TD 230 III	1991-1991
TD 250 IV	1992-
TD 290	1991-
TD 316	1985-1988
TD 316 II	1988-1991
TD 316 III	1992-
TD 318	1985-1988
TD 318 II	1988-1991
TD 318 III	1992-
TD 320 TP 16 III	1984-1986
TD 320 TP 16 IV	1986-1988
TD 320 II	1988-1991
TD 320 III	1992-
TD 321	1985-1988
TD 321 II	1988-1991
TD 520	1986-1989
TD 520 II	1989-1992
TD 521	1986-1992
TD 524	1983-
TD 535	1988-1991
TD 2001	1989-
TD 3001	1990-
Ambiance	1988-1990
Concrete	1988-1992
Phantasie	1986-1988
Prestige	1983-
Reference	1980-1981

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Friends:

I am currently looking for any data, schemes, history, production figures, i.e. almost anything about the Telefunken professional turntables, like the PS 81 idler-wheel decks I've just bought and its successor, the direct-drive PS 81 DD.

StefanoPasini
stefpas@tin.it

Siemens/Klangfilm Postwar Cinema Amplifiers (W-Germany and Austria)

by Dipl. Ing. H. Jakobi, Sulzbach, Germany

The name “Klangfilm”stands for Siemens ‘ famous cinema/theater range. Klangfilm directly translated means “the sound of cinema” or the “sound of the film”. Siemens produced some of the most sought after power amplifiers and speakers, as well as some remarkable preamplifiers and mixers.

Made in W-Germany were the models: KL-401, KL-402a, KL-403a, KL-502a, KL-408a, KL-203/4 and the KL-V-410. There are other models, but they are ELA amps, using only 100 ohms output transformers and so not useful for the average audio enthusiast.

Made in Austria is the model KL-5418, there might be more Austrian models but in more than fifteen years research,this is the only one I came across, and I could not find any literature on this model.

Klangfilm used only three power tubes, the EF-12 (just after the war, which is a small version of the EL-156, and sounds very smooth and beautiful, if made by Telefunken); the German professional F2a11, and later the EL-34. The driver tubes were the EF-12, an early version of the famous EF-804 (very similar to the EF-86, but far superior); later the ECC-40, an early version of the ECC-82 (12AU7) and then the ECC-83. Rectifiers were the EZ-12 and ,later, the GZ-34.

All amplifiers were designed for cinema use, which means that the ultra-sensitive inputs should not be used for home audio It is a shame that one cannot make use of the outstanding input transformers, but... they can be used for other designs! Most users just connect the input to the grid of the 2nd, or if less gain is needed, even to the grid of the 3rd of the drivers. An input resistor in the region of 1 Kohms in series to the grid and a 100-220 picofarad C will be all that is needed to suppress high frequency disturbances or oscillation.

With some luck one might find an old pair of matching input transformers and to use for balanced input. But beware, it is better stick with the simple “grid” entry, instead of using a bad transformer.

The heart of these amplifiers are their outstanding output transformers, which nobody can wind anymore with this quality. All parts are first class, it is not recommended to modify too much, and most of the electrolytic condensers will work for many years. In the early KL-401a only paper-in-oil condensers are used. These sadly can dry out, and it is recommended to replace them with similar types.

The build quality is typical W-German, Mercedes like, long lasting and precision mechanics, best parts quality: Siemens ceramic insulated silver foil coupling-C’s (!!!), MP or paper-in-oil C’s, etc., will be found as a standard! Tube rectification with highest quality chokes is standard, the power transformers are oversized, use the best materials and are usually 110/120/220/240 volts, 50/60 Hz.

All tubes can still be found easily, only the F2a11 is expensive, but then it is a professional long life tube and shall last at least 8000 hours, if matched pairs are used. Very important: do not use cheap EL-34’s! Only original Telefunkens, Valvo’s (which are also sold under Philips, Miniwatt, Siemens, Amperex, and yes... also the famous Mullard was made by Philips Valvo in Holland!) must be used for full potential. Do not use the E-German EL-12 (also EL-12N) made by Hoges, it is inferior! The best is the Telefunken, the stronger EL-12/325 and EL-12/375 can take higher plate voltages and are suited as well.

As the F2a11 (and the F2a, which just has a different base) are such extraordinary pentodes, which cannot be found elsewhere, I decided to have the data here as well:

Type Longlife prof. Tetrode
Filament 6.3V/2A
(indirectly heated)
Platevolt. 250V
Platecurrent 97 mA
Max platevolt 425 V
(some books suggest 600V max.!)
Gridvolt 250V (max. 425 V)
Neg. gridvolt -19V
Platedissip. 30W

The way this tetrode is built makes it perfect for triode configurations. It sounds extremely natural if applied correctly, even in a non-triode circuit!

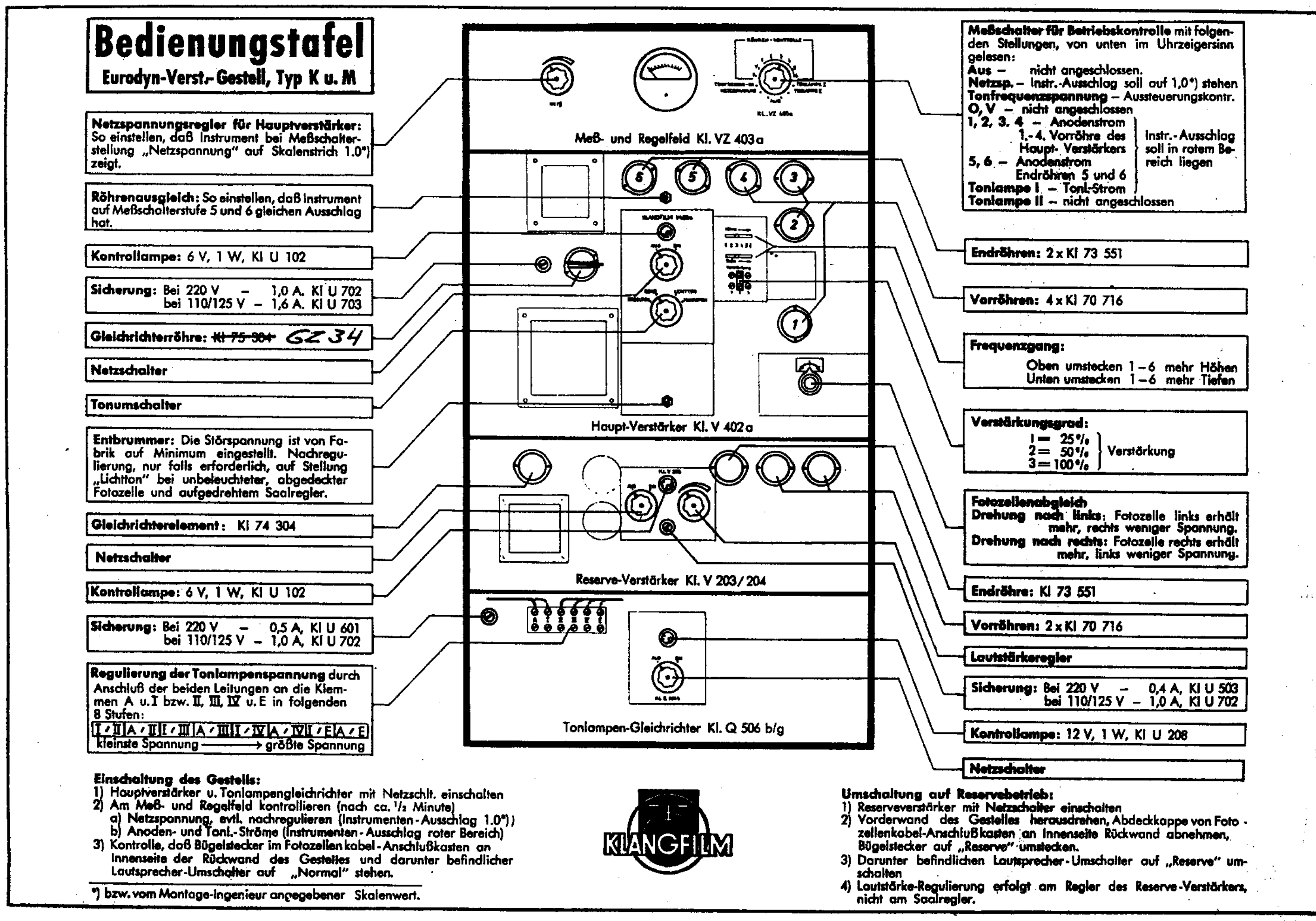
IMPORTANT: Klangfilm used a Klangfilm code for most of their tubes, starting with a KL like for the other units. For the post-war amps we have the most important codes: (prewar codes will be shown in part II!)

KL-70715 = EF-12
KL-70716 = EF-12k
(k stands for “klirrarm”= low noise)
KL-73550 = EF-12
KL-73551 = F2a11
KL-76303 = RGN 2504

Tubes used in the later models like the EF-40, ECC-83, EL-34, GZ-34 have no KL code!

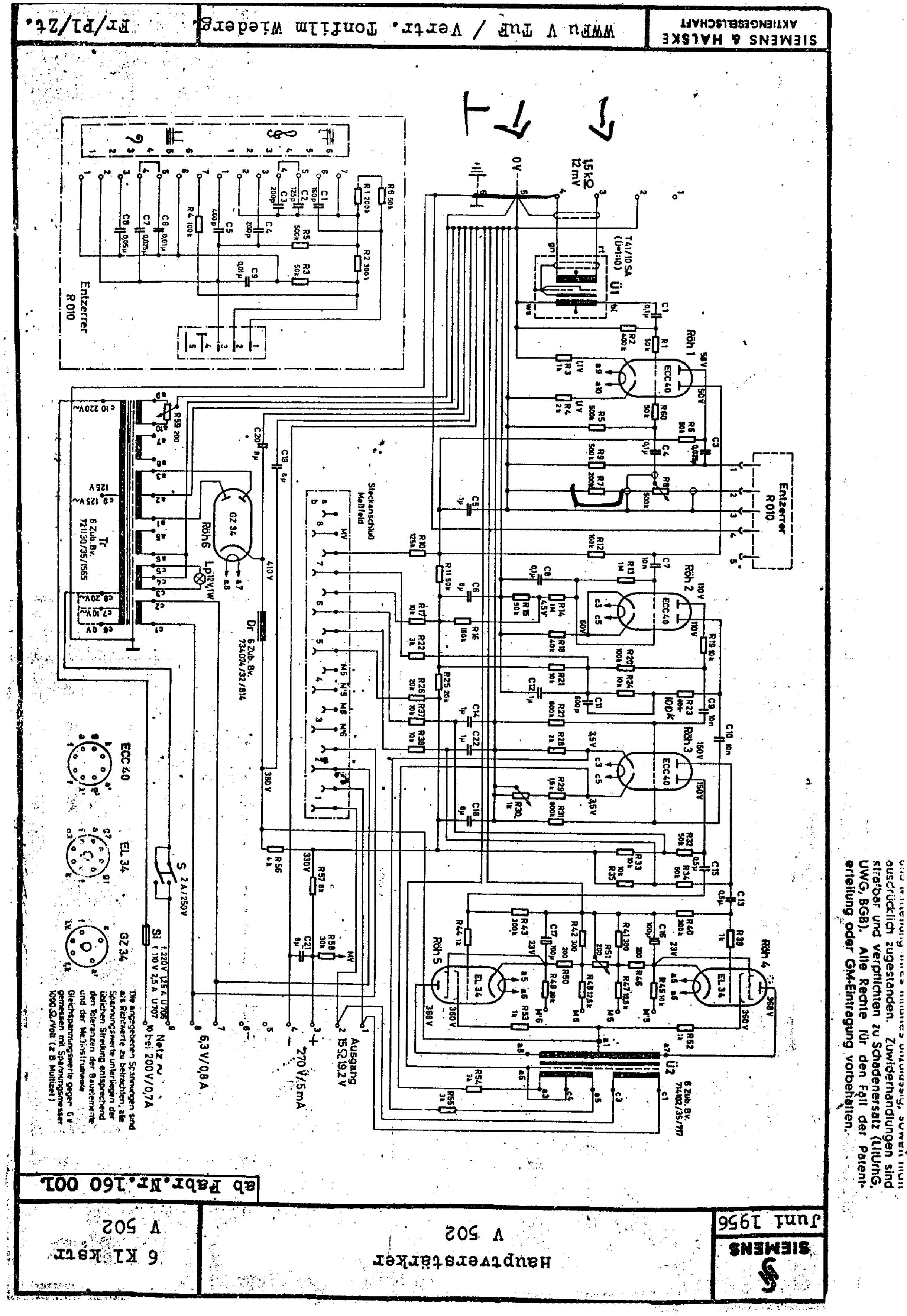
The KL-401a: This unit is made with a cast frame and is very heavy (about 60 lbs.). Four EF-12’s are used, and a special tone control unit (volume, bass and treble) can be plugged into the circuit between the input tube and the 3rd stage (not advised for best performance). Without the tone control unit it is easiest to use the grid of the 3rd EF-12 as the input (V-3). The rectification is done with the EZ-12, a very common rectifier used in German studio and cinema technique, and in early models with the RGN-2504, which is in its mesh plate versions together with the RGN-2004 the very best rectifier I ever heard.

We find paper-in-oil condensers throughout the whole circuit and a wonderful output transformer with 15 ohms and 200 ohms. 200 ohms were not needed for ELA speakers, but for some special Siemens speakers which will be introduced in a later part. The EF-12/375’s in the PP output stage are triode connected (without the usual 100 ohms resistor, the screen grid is directly connected to the plate!)



The KL-402a and 403a (identical): These amps are nearly the same in circuitry as the 401a, but use precision welded galvanized steel sheets in the case and are 19" rack-mount (like all amps built after the 401's). Instead of the EZ-12 the GZ-34 is used as a rectifier and a better tone control unit is used (if needed). MP-condensers replace the paper-in-oils (and are still better than all MKP's or electrolytic C's!) and we find Siemens silver foil coupling C's. I compared this amp with the famous Marantz 9's. The KL-403's outperformed the Marantz with ease! I am not kidding! Even the KL-502a,after modified to triode connection of its EL-34's did.The KL-403 is on the same level as the famous WE-86, and this means something as it does not use 300B's. It is as dynamic and immediate, a little less euphonic and with more clarity and speed. A fantastic amp. And built to last forever. And... the price is about 40% of the Marantz Model 9).

The KL-502a: This amp uses the well-known EL-34 and is in my ears the very best EL-34 amp ever built, if triode connected (connect each screen grid of each EL-34 via 100 ohms on the plate and only use "real" EL-34's as mentioned before). It outperformed the Marantz 9 with ease, and is very close in its sonic signature to the KL-403a. The driver/input tubes are


SIEMENS & HALSKE
AKTIENGESELLSCHAFT
WWFu V TuF / Vertr. Tonfilm Wiederg.
Fr/Pl/Zt.
Hauptverstärker
V 502
6 Kl kstr
V 502
Juni 1956
ab Fabr.Nr.160 001

Stückzahl	Benennung	Teil	Zeichng. Norm	Bemerkung
		C20		
1	Metallpapierkondensator	C21	8 uF	
1	"	C22	8 uF	
1	"	C23	0,25 uF	
1	"	C24	0,25 uF	
1	"	C25	16 uF	
1	"	C26	16 uF	
		C27		
1	Metallpapierkondensator	C28	0,25 uF	
1	"	C29	8 uF	
1	"	C30	8 uF	
1	"	C31	8 uF	
1	Entzerrer komplett		Kl. V 403 a Tz. 3	
1	Netztransformator	Tr1	Kf.Bv. 2509/003	
1	Eingangsübertrager	Ue1	Kl. U 060	
1	Ausgangsübertrager	Ue2	Kf.Bv. 2306/005	
1	Drossel	Dr	Funk.Bv. 2404/1	
1	Signallampe	Sl	6 V, 1 W, Kl. U 102	
1	Schalter	S 1		
1	Schalter	S 2		
1	Sicherung	Si	1,0 A, Kl. U 702	
1	Sicherung (Beipack)	Si	1,6 A, Kl. U 702	

Stückzahl	Benennung	Teil	Zeichng. Norm	Bemerkung
1	Schichtwiderstand	R44	100 KOhm	
1	"	R45	100 KOhm	
1	Drahtwiderstand	R46	300 Ohm	
1	"	R47	300 Ohm	
1	Drahtdrehwiderstand	R48	200 Ohm	
1	Schichtwiderstand	R49	5 KOhm	
1	"	R50	5 KOhm	
1	Drahtwiderstand	R51	180 Ohm	
1	"	R52	180 Ohm	
1	Schichtwiderstand	R53	10 KOhm	
1	"	R54	10 KOhm	
1	"	R55	10 KOhm	
1	"	R56	10 KOhm	
1	"	R57	50 KOhm	
1	"	R58	5 KOhm	
1	Drahtdrehwiderstand	R59	200 Ohm	
1	Schichtwiderstand	R60	100 Ohm	
1	"	R61	100 Ohm	
1	Papierkondensator	C1	0,025 uF	
1	"	C 2	0,025 uF	
1	Metallpapierkondensator	C 3	1 uF	
1	"	C 4	1 uF	
1	"	C 5	1 uF	
1	"	C 6	0,25 uF	
1	"	C 7	8 uF	
1	Keramik-Kondensator	C 8	100 pF	
1	Metallpapierkondensator	C 9	1 uF	
1	"	C10	2 uF	
		C11		
1	Papierkondensator	C12	0,025 uF	
1	Metallpapierkondensator	C13	8 uF	
1	"	C14	1 uF	
1	"	C15	8 uF	
1	"	C16	1 uF	
1	"	C17	8 uF	
1	"	C18	1 uF	
1	"	C19	0,25 uF	

Stückzahl	Benennung	Teil	Zeichng. Norm	Bemerkung
1	Schichtwiderstand	R 1	1 KOhm	
1	"	R 2	2 KOhm	
1	"	R 3	1 KOhm	
1	"	R 4	1 KOhm	
1	"	R 5	2 KOhm	
1	"	R 6	1 KOhm	
1	"	R 7	3 KOhm	
1	"	R 8	3 KOhm	
1	"	R 9	250 KOhm	
1	"	R10	1 KOhm	
1	"	R11	100 KOhm	
1	"	R12	500 KOhm	
1	Schichtdrehwiderstand	R13	500 KOhm	
1	Schichtwiderstand	R14	30 KOhm	
1	"	R15	100 KOhm	
1	"	R16	2 KOhm	
1	"	R17	30 KOhm	
1	"	R18	50 KOhm	
1	"	R19	60 KOhm	
1	"	R20	50 KOhm	
1	"	R21	50 KOhm	
1	"	R22	100 KOhm	
1	"	R23	1 KOhm	
1	"	R24	500 KOhm	
1	"	R25	150 KOhm	
1	"	R26	50 KOhm	
1	"	R27	20 KOhm	
1	"	R28	10 KOhm	
1	"	R29	2 KOhm	
1	"	R30	400 Ohm	
1	"	R31	50 KOhm	
1	"	R32	300 KOhm	
1	"	R33	100 KOhm	
1	"	R34	50 KOhm	
1	"	R35	60 KOhm	
1	"	R36	40 KOhm	
1	"	R37	20 KOhm	
1	"	R38	2 KOhm	
1	"	R39	20 KOhm	
1	"	R40	20 KOhm	
1	"	R41	20 KOhm	
1	"	R42	100 KOhm	
1	"	R43	100 KOhm	

Nr.	Art der Änderung	Tag	Name	Nr.	Art der Änderung	Tag	Name

	Datum	Name
Konstr.	13.	4.51
Geprüft		
Normgepr.		

Klangfilm G. m. b. H.

Klangfilm G. m. b. H.

Stückliste für Verstärker

Nicht für die Fabrikation ! (3 Blätter)

Kl. V 402 a Blatt 1

Ersatz für:

Ersetzt durch:

Stückzahl	Benennung	Teil	Zeichng. Norm	Bemerkung
1	Schichtwiderstand	R 1	100 K Ohm	
1	"	R 2	50 K Ohm	
1	"	R 3	50 K Ohm	
1	"	R 4	200 K Ohm	
1	"	R 5	500 K Ohm	
1	"	R 6	100 K Ohm	
1	"	R 7	200 K Ohm	
1	"	R 8	300 K Ohm	
1	"	R 9	1 M Ohm	
1	Papierkondensator	C 1	0,02 uF 250	
1	"	C 2	0,02 uF 250	
1	"	C 3	2500 pF 250	
1	Kunstfolien-Kondensator	C 4	150 pF 250	
1	" "	C 5	300 pF 250	
1	" "	C 6	100 pF 250	
1	Kunstfolien-Kondensator	C 7	250 pF 250	

Nr.	Art der Änderung	Tag	Name	Nr.	Art der Änderung	Tag	Name

	Datum	Name
Konstr.	28.5.	1951
Geprüft		
Normgepr.		

Klangfilm G. m. b. H.

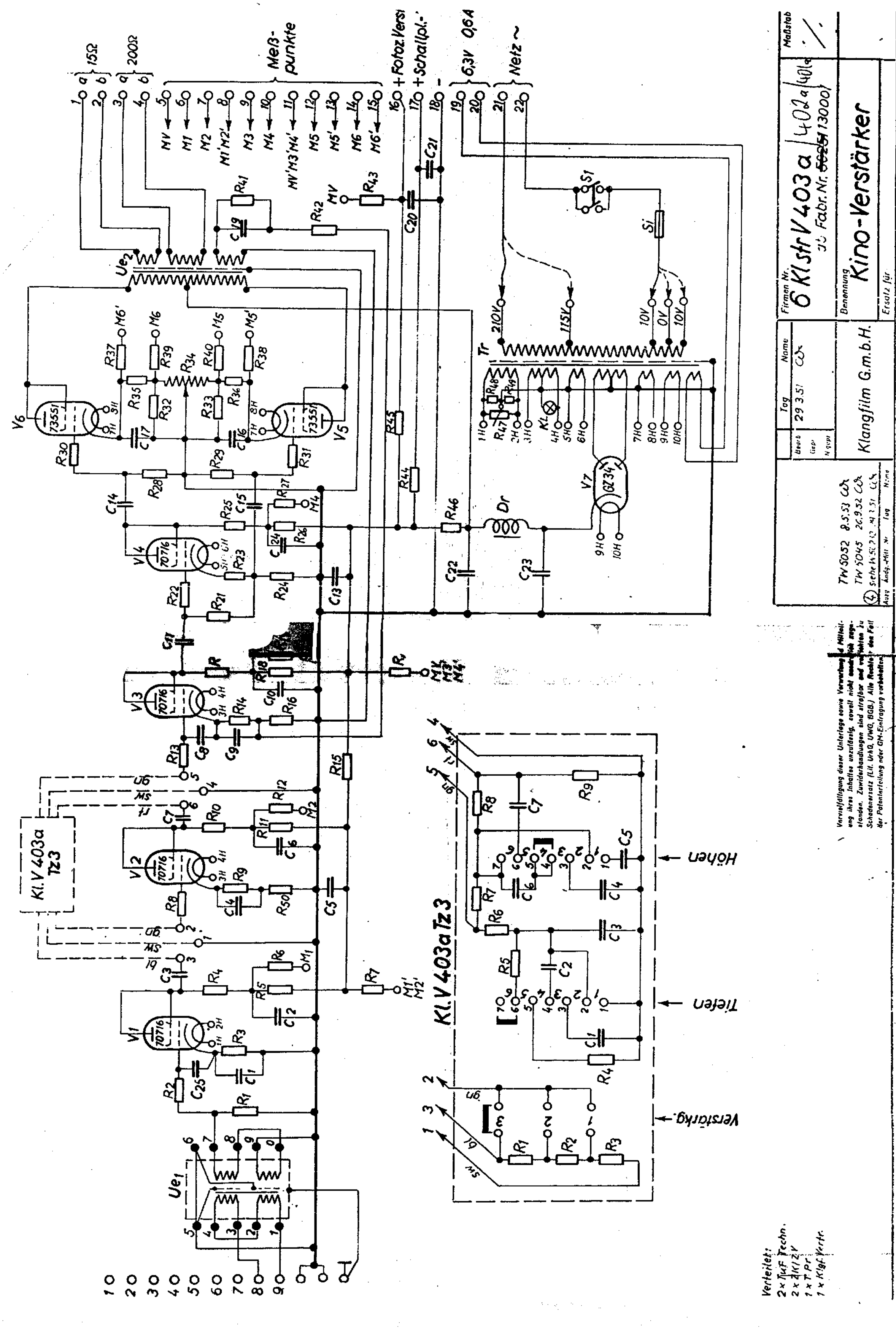
Klangfilm G. m. b. H.

Stückliste zum Entzerrerkasten (s.Kl.V 402a/403a/pri) Nicht für die Fabrikation!

Kl. V 403 a Tz.3

Ersatz für:

Ersetzt durch:


Kino-Verstärker
Klangfilm G.m.b.H.
Kl.V 403a Tz3
Höhen
Tiefen
Verstärkg.
Netz ~
Meß-punkte

the ECC-40's (3) the rectifier is the GZ-34. Best parts are used as in the KL-403.

The KL-408a: This was an amplifier built for smaller cinemas, and it is not on par with the models mentioned before, which does not mean that it does not sound good. It sounds pretty close to the Marantz Model 8b, and it is a matter of taste (as always) which one sounds better. There are two inputs which can be used, a 500 Kohms unbalanced and a balanced 3 Kohms using a very good permalloy input transformer. Again, this amp sounds best when the EL-34's are triode connected as described before. Sadly the C's in the PS are electrolytic types, but at least of good Siemens or Bosch quality. Check them and if you can, replace with MP's. The rectifier is again the GZ-34. Build quality is otherwise on the same level as the others.

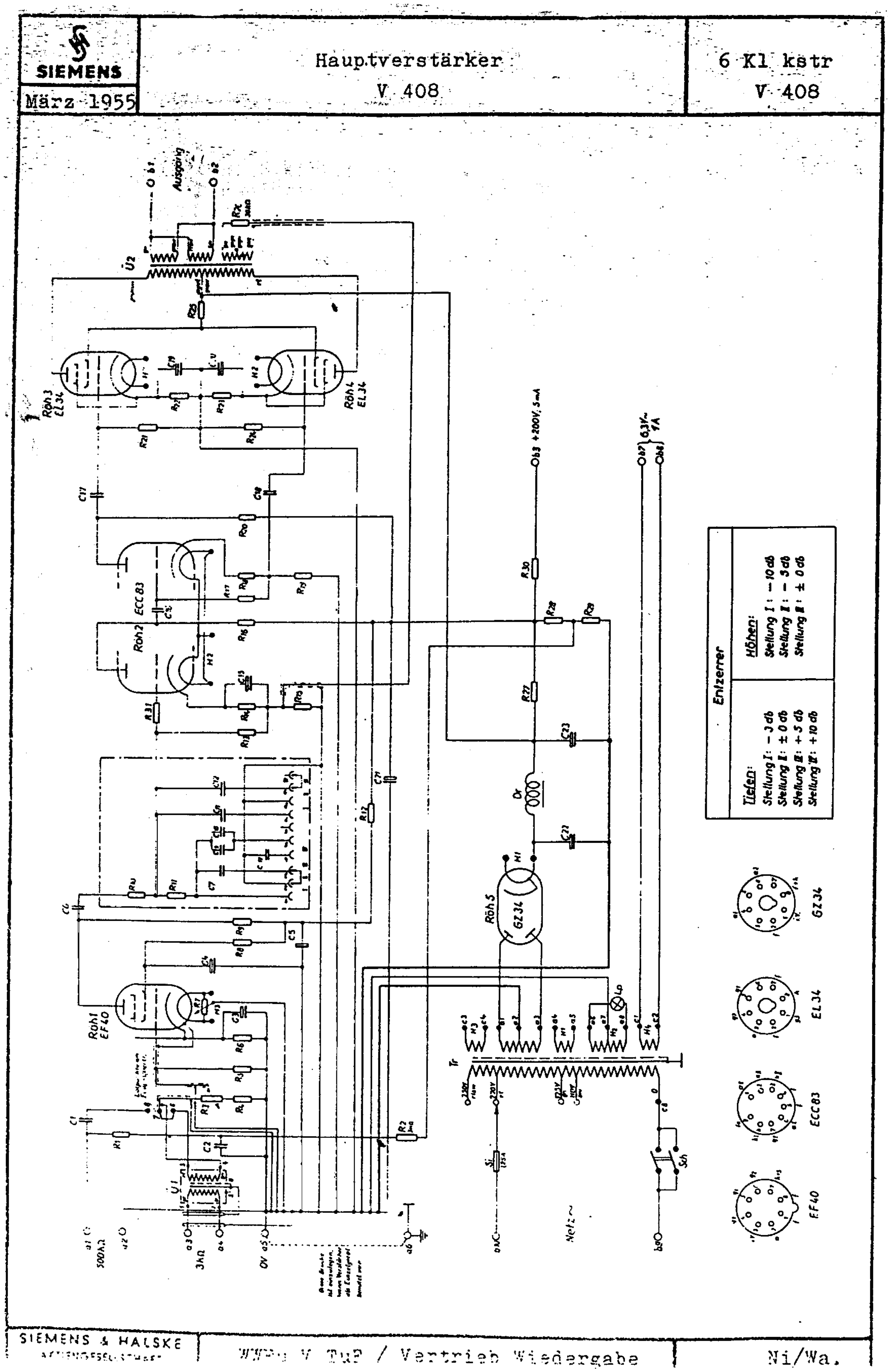
Now we come to the most sought after KL-amps, the KL-203/204 and the later KL-V-410 amps, which are so called "Reserve Verstarker" which means amps for emergency. Well, they are by no means cheaply built amps, only the power output is low, as they are single ended pentode amps (F2a11 SE) and produce therefore only about 7 watts, but they are very, very clean watts. But these amps are overrated! They are not on the same level as the others with the exception of the KL-408a, which are outperformed with more attack, clarity and "being there", which is typical for single ended designs.

We finish Part I with the KL-5418, which was made by the Austrian branch of Siemens (called *Klangfilm* there as well). This branch produced some very remarkable units, for example the late "Ed" tube was made there (a famous European triode, the industrial version of the AD-1!) as well as an ultra rare speaker called the Klangfilm "Euronette", a full range wooden/textile tractrix horn (not to be mixed up with the prewar "Euronette" power amp).

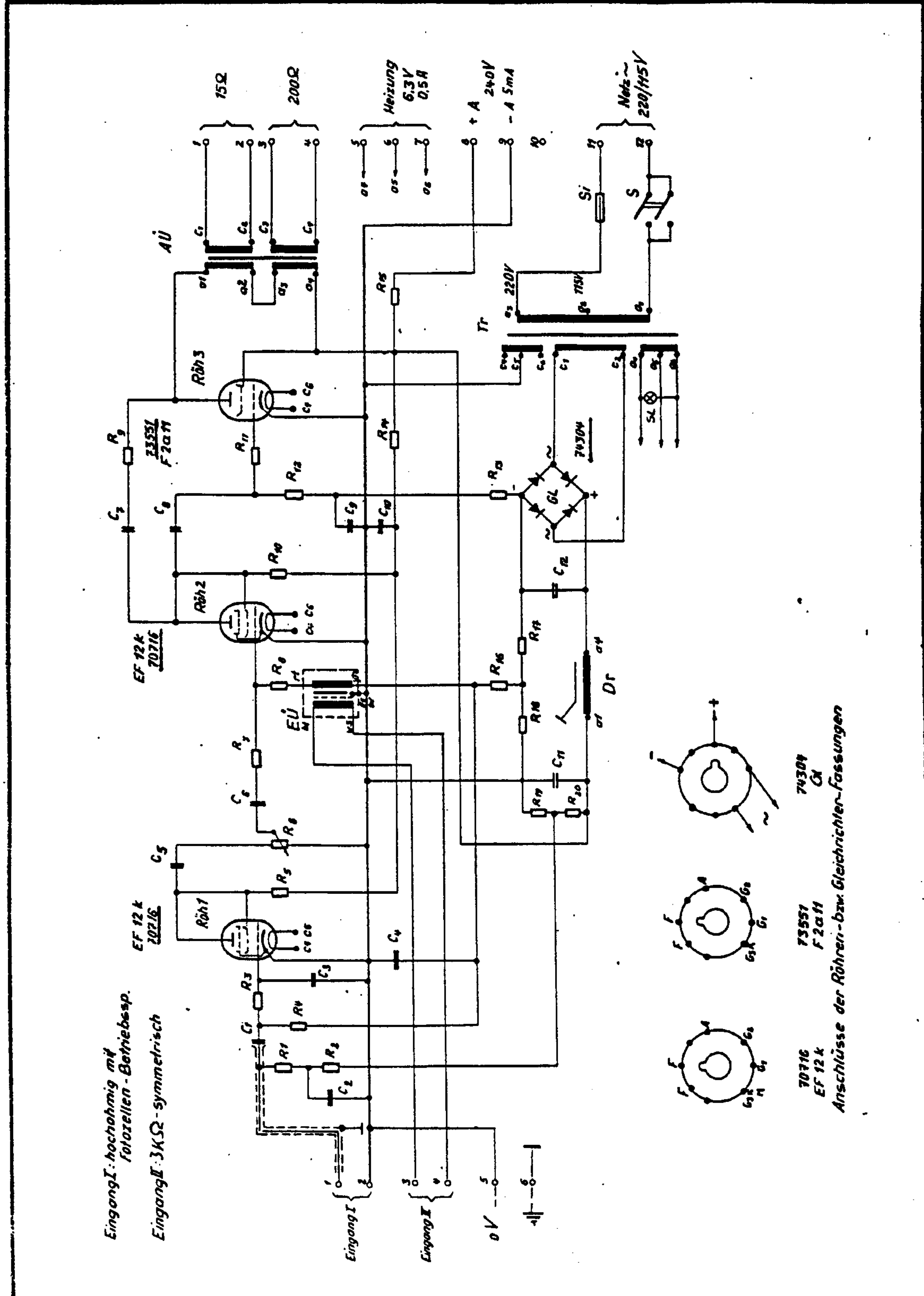
This amp uses again EL-34's (ultralinear) and triode connected it sounds as good as the KL-502a. It uses a rare rectifier called the Z2c, which is again an industrial tube like the Ed, is totally different in its design approach to the German power amps. Most parts are Austrian made, and it is necessary to change all the orange coloured 100 uF electrolytic C's as they are prone to be dried out.

Austrian-made Kl-5418— Shown without rectifier above

KL-401a —shown without tubes


SIEMENS
März 1955
Hauptverstärker
V 408
6 Kl kstr
V 408
Röh1 EF40
Röh2 ECC83
Röh3 EL34
Röh4 EL34
Röh5 GZ34
Ü1
Ü2
Ausgang
Tr
Dr
Netz ~
+200V, 5mA
6,3V~ 1A
500Ω
3kΩ
0V
Entzerrer
Tiefen:
Stellung I: −3 db
Stellung II: ± 0 db
Stellung III: + 5 db
Stellung IV: +10 db
Höhen:
Stellung I: −10 db
Stellung II: − 5 db
Stellung III: ± 0 db
EF40
ECC83
EL34
GZ34
SIEMENS & HALSKE
WWPu V TuP / Vertrieb Wiedergabe
Ni/Wa.

SIEMENS August 1954	**Reserve-Verstärker** **V 204 a**	**6 Kl ketr** **V 204 a**



SIEMENS & HALSKE AKTIENGESELLSCHAFT	**WWR WA G Vertrieb Klangfilm**	**Pr/Bn.**

SIEMENS Aug.1954	Reserve-Verstärker V 204 a	6 Kl ksk V 204 a

R 1	Schichtwiderstand	100 kOhm
R 2	Schichtwiderstand	3 MOhm
R 3	Schichtwiderstand	100 kOhm
R 4	Schichtwiderstand	1 MOhm
R 5	Schichtwiderstand	150 kOhm
R 6	Schichtdrehwiderstand	500 kOhm pos.log.
R 7	Schichtwiderstand	500 kOhm
R 8	Schichtwideratand	150 kOhm
R 9	Schichtwiderstand	500 kOhm
R 10	Schichtwiderstand	100 kOhm
R 11	Schichtwiderstand	1 kOhm
R 12	Schichtwiderstand	200 kOhm
R 13	Schichtwiderstand	100 kOhm
R 14	Schichtwiderstand	50 kOhm
R 15	Schichtwiderstand	2 kOhm
R 16	Schichtwiderstand	1 MOhm
R 17	Schichtwiderstand	60 Ohm
R 18	Schichtwiderstand	30 Ohm
R 19	Schichtwiderstand	150 kOhm
R 20	Schichtwiderstand	125 kOhm
C 1	Kondensator	5000 pF
C 2	MP-Kondensator	2 µF
C 3	Keramik-Kondensator	50 pF
C 4	MP-Kondensator	2 µF
C 5	Kondensator	0,01 µF
C 6	Kondensator	0,01 µF
C 7	Kondensator	1000 pF
C 8	Kondensator	20000 pF
C 9	MP-Kondensator	1 µF
C 10	MP-Kondensator	1 µF
C 11	MP-Kondensator	16 µF
C 12	MP-Kondensator	16 µF
Tr	Netztransformator	
Dr	Siebdrossel	
AÜ	Ausgangsübertrager	
EÜ	Eingangsübertrager	
S	Netzschalter	
Si	Sicherung (für 220 V)	0,5 A Kl U 601
	Sicherung (für 115 V, im Beipack)	1 A Kl U 702
Sl	Signallampe	12 V/ 1 W Kl U 105
Röh 1	Röhre EF 12 k	Kl 70716
Röh 2	Röhre EF 12 k	Kl 70716
Röh 3	Röhre F 2a 11	Kl 73551
GL	Steckgleichrichter	Kl 74304

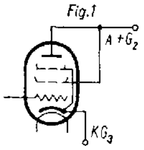
SIEMENS & HALSKE AKTIENGESELLSCHAFT	WWR WA G Vertrieb Klangfilm	Pl/Schl.

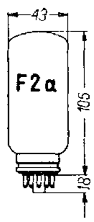
T.			U_f	I_f	Cl.	U_a	U_{g2}	$U_{b(g2)}$	R_{g2}	U_{g1}	I_a	I_{g2}	S	R_i	R_k	R_o	P_o	$U_{g1\approx}$	h	P_{g2}	P_a
			V	A		V	V	V	kΩ	V	mA	mA	mA/V	kΩ	Ω	kΩ	W	V	%	W	W
					A	250	250			—7	95÷97	14÷20			60	2,2	10	4,6	10		
					stat	425	425			—19	60	10	14	25	290						
					AB	250	250				114÷128	16÷32			140	5	20	7,3	4		
						330		330	1		136÷160	20÷33			160	5	32	10,5	4		
						425		425	3		120÷154	18÷30			250	6	40	16	5		
					B	250	250			—11	60÷140	9÷32				4	20	7,4	2,5		
F 2 a	Siem	1	6,3	2		330		330	1	—15	76÷160	11÷33				5	32	10,2	3		
F 2 a 11	Siem	2	6,3	2		425		425	3	—22	50÷160	8÷31				6	40	15	2,5		
						425		425	1,5	—22	56÷190	9÷40				5	50	15	4		
					A	330	Fig. 1			—13	90÷94	(μ = 17)	22	0,8	140	1,5	5,5	9	10		
					AB Fig. 1	250	—				100÷108	—			200	3	6	7,5	1		
						330	—				140÷152	—			200	3	12	10,3	1,5		
						425	—				130÷146	—			300	5	20	15,2	2,5		
						425	425	maximum (I_k = 140 mA; R_{g1} = 0,5 MΩ; $U_{f/k}$ = 80 V)												5	30

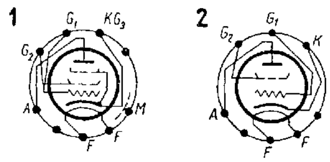
[1]) vide * 4

C_{g1}	C_a	$C_{g1/a}$	
pF	pF	pF	
20,5	13	0,45	pentod.
14	15,5	7	triod.

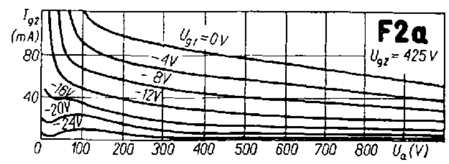
Fig.1

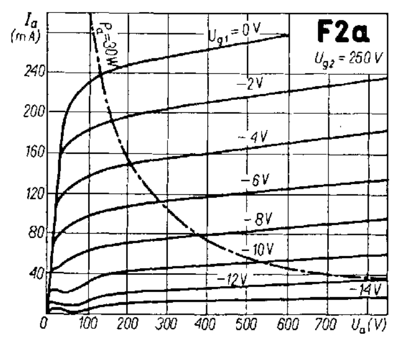


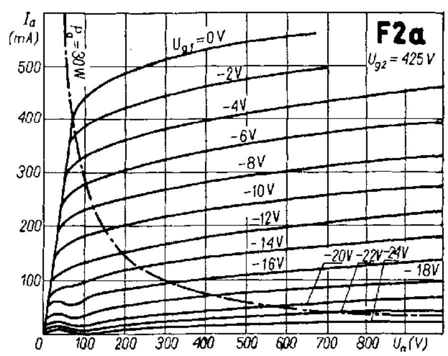


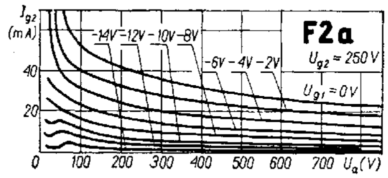


F2a F2a 11









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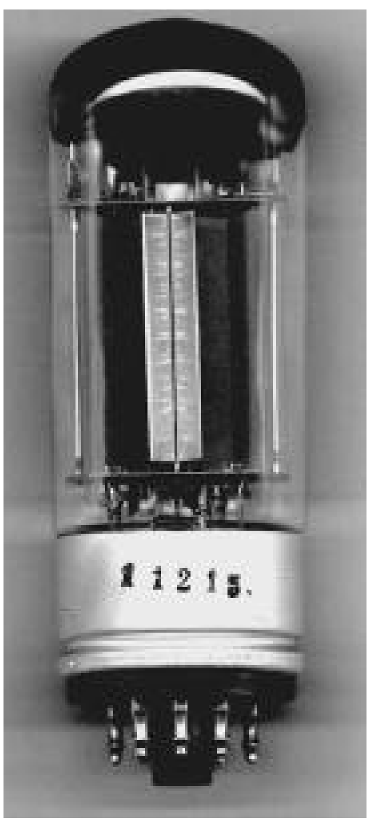
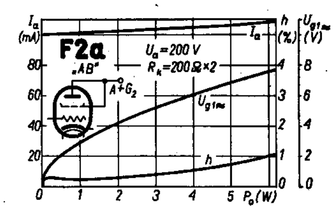
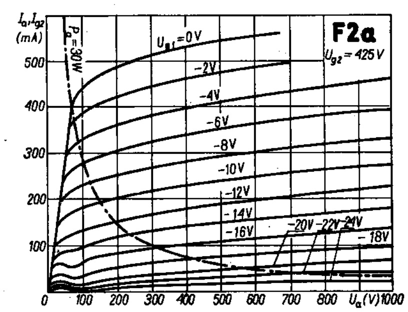
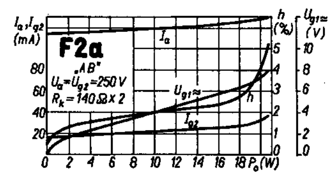
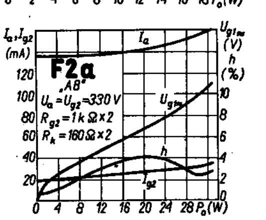
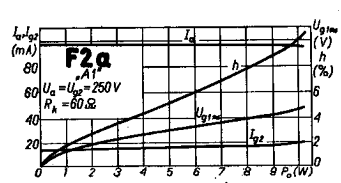


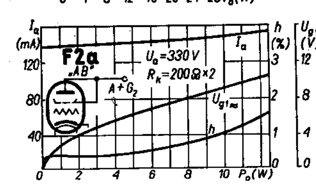




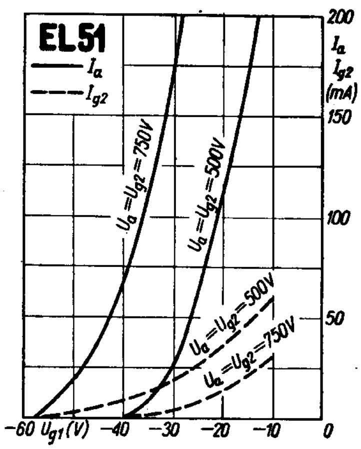


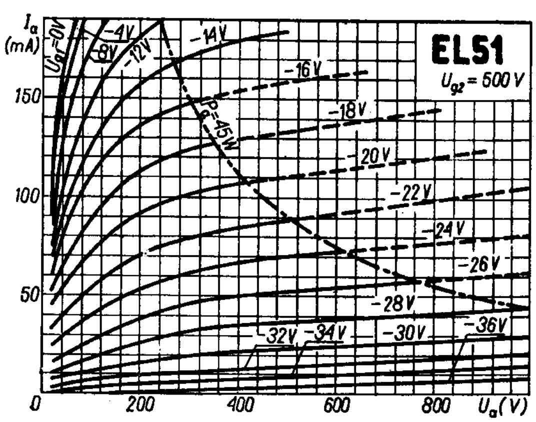


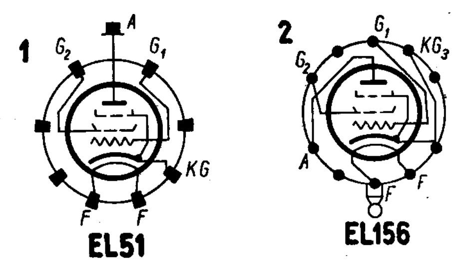


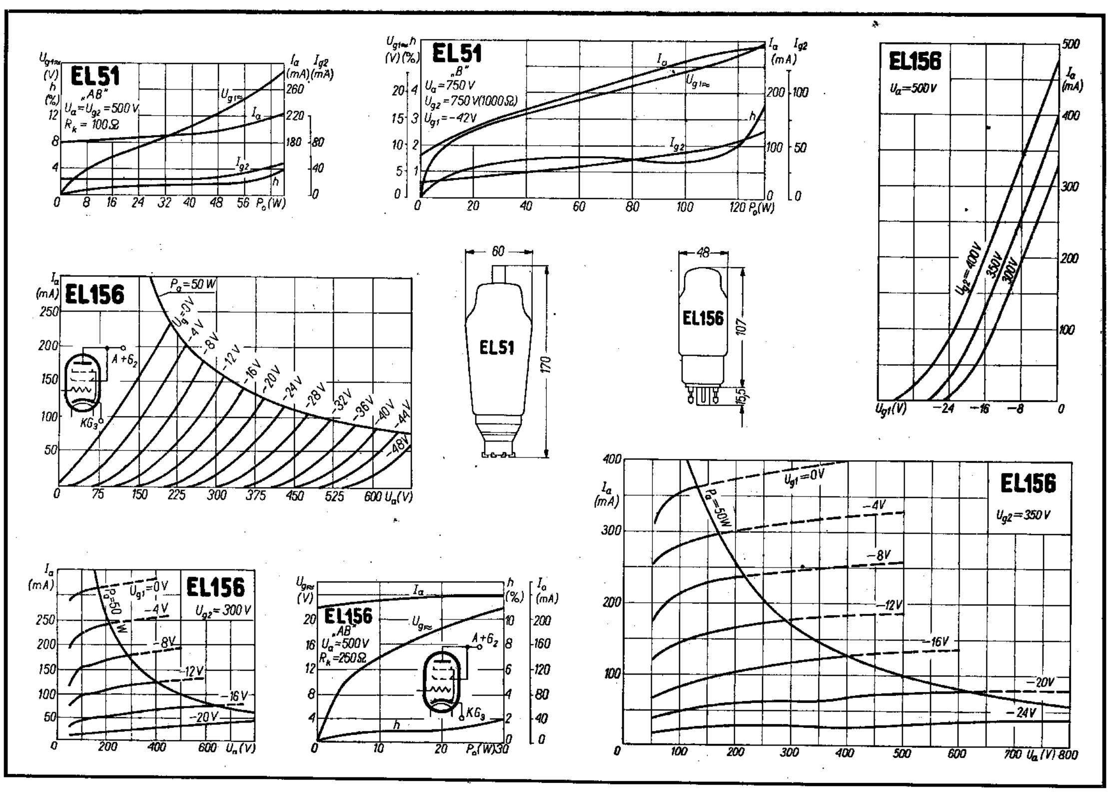


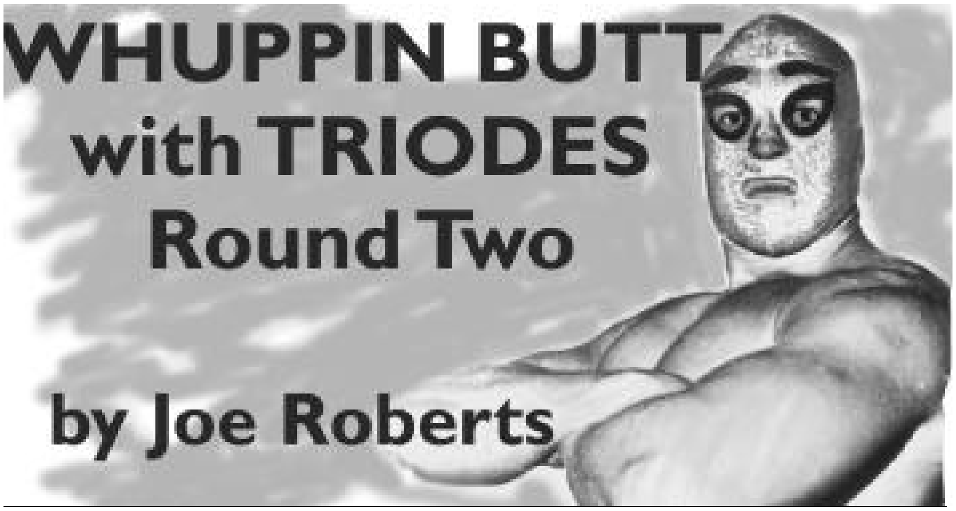
T.	(manufacturer)	(base)	U_f	I_f	Cl.	U_a	U_{g2}	U_{g1}	I_a	I_{g2}	S	R_i	μ	R_k	R_o	P_o	$U_{g1\approx}$	h
			V	A		V	V	V	mA	mA	mA/V	kΩ	g_2/g_1 (a/g)	Ω	kΩ	W	V	%
					stat.	500	500	— 22	95	12	11	33	16					
					stat.	750	750	— 42	40	6	7	55	16					
EL 51	eur	1	6,3	1,9	AB	500	500		(95÷115)×2	(12,5÷30)×2				100	4,8	70	20	6
					B	750	<750	— 42	(40÷150)×2	(6÷35)×2	(R_{g2} = 1000 Ω)				6	125	29	7
						750	750		maximum (I_k = 200 mA; P_a = 45 W; P_{g2} = 7 W; R_{g1}=0,7 MΩ; $U_{f/k}$= 50 V)									
					stat.	400	400	— 36	75	7								
EL 151	Tlf	2	6,3	1,9	AB	450	450	— 24	117×2	20×2				200	2,8	90	19	
						800	450		maximum (P_a = 60 W; P_{g2} = 5 W; R_{g1} = 0,1 MΩ)									
					stat.	800	300		55÷65		10	25	13					
					A 1	350	250		120÷116	15÷24				60	4	15	6	8
					A 1	450	280		112÷108	17÷27				90	3,8	25	9,2	9
					AB	600	300		(80÷ 95)×2	(10÷18)×2				160	8,5	65	13,5	4
					AB	600	350		(80÷100)×2	(10,5÷24)×2				200	7,6	80	18,5	4
EL 156	Tlf	2	6,3	1,9	B	800	300	— 20	(45÷100)×2	(4,5÷20)×2					11	105	15	5
					B	800	350	— 24	(45÷120)×2	(5÷25)×2					9,5	130	18	6
					stat.	350	—	— 16	140	—	12,5	0,8	(12)	(Fig.1)				
					AB	500	—		(110÷120)×2	—	(Fig.1)			250	2,8	30	22	2
						800			maximum (I_k = 180 mA; P_a = 50 W; P_{g2} = 8 W; R_{g1} = 0,1 MΩ; $U_{f/k}$ = 50 V)									











Still wrestling with the hardware…

Looking back over recent tube audio history, one would have to say that single-ended triodes sure moved in fast and heavy for such an unlikely idea.

Unlikely, that is, from a technical electronics standpoint.Clearly, the notion had a lot of instant popular appeal as a sort of philosophical gesture. These days the finger automatically points at media hype, but I think the growth of SE had more to do with a willingness to believe in a new promise. It was a social movement of sorts.

Simple, low-power amps were a novel and radical idea, generating a context of mystification and surprise, and inspiring all sorts of revolutionary thoughts in the minds of audiophiles. Based on the cosmic implications projected onto the idea of SE, the amps were expected to live up to a higher set of aesthetic and spiritual ideals than the average unwashed tube amp off the street.

For a time, many believed that single-ended power amps *had* to sound good, before they even heard one. They had faith in what was basically a total unknown. *Why* is a very interesting question that has to do with a lot more than engineering principles, although certain pro-SE engineering arguments can be very instructively made.

Out there in the fertile minds of the audio mania public, the simple-as-dirt SE triode amp somehow got twisted up in a web of bizarre holistic single-ended intrigue, becoming a symbol for something bigger than bigness itself, occupying the sphere of creative lifestyle mapping and even taking on a deep spiritual new-agey dimension that most home appliances and tools do not inspire among their users.

Simplicity has always been holy to tweaks and single-ended no-feedback triode amps redefined the possibilities of minimalism.If *simple* is the goal, here was the golden path to the promised land. Get behind the wheel of a single 300B and you're there.

The sages say "Less is more" and perhaps it is—but it is still *less*, and if there is a SE-DHT Zen paradox at play, this is it.

One kind of power trades off against another kind of power. Low power amps have certain abilities that higher power units might not, but the argument goes both ways, back and forth, quite a few times.

Projecting from past lessons, I believe that it's a mistake to block *any* path just because it isn't the purest, coolest way to design according to this year's modes of techno-elitism. SE fanaticism sure is fun, but the ears know that there are plenty of valid ways to play music with electronic equipment. Open minds and clean ears are what paved the way for SE triodes. The further exploratory power of this open-to-whatever-works attitude is still tremendous. There's *always* more to discover.

Well, what next? Mini-watt amps may be great at special jobs like biamping,but thier low power ratings present obvious practical constraints, things being as they are with loudspeakers. The power shortage undeniably limits the systems we can build with this good-sounding technology. So, what about triode amps with more output power? Can we get some extra juice without paying too high a price? Although I am perhaps the world's biggest fan of low-powered SE triode amplifiers, one must admit that, in terms of output power, the only way from there is UP.

So, if either kicking some wide-range booty or expanding the practical applications of triode-fueled musical reproduction are among our goals, as they should be, let's see what else is up besides single-endeds.

A survey of old books shows that given known technology, available materials, and a few forgotten tricks, there are many ways to break the eight-watt barrier with some degree of class. And maybe some of them would not require selling our souls to the devil, although attitude shifts and mental readjustments may be required.

Back to the source

I wanted to build the 1948 Peerless A100 kit amp featured in SP #16 for about fifteen years, ever since I found that ancient issue of *Radio and Television News* at a flea market. Reading Melvin Sprinkle's article took me back to those innocent years before the coolness of SE, *wu*, the first watt, amorphous cores, and other fun wackyness of the last ten years of hyper-fi elaboration, back to the source.

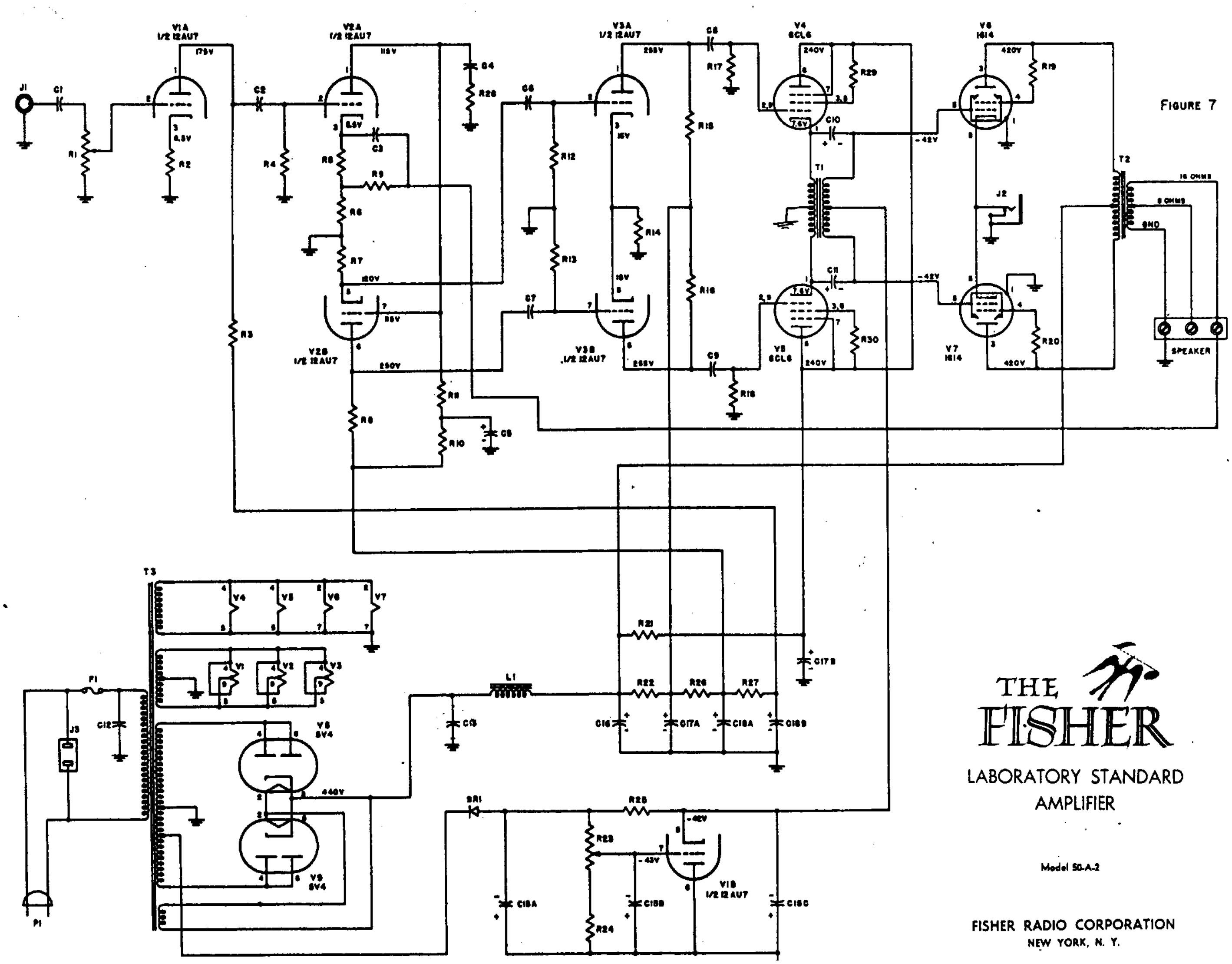
What the ancestral Altec pro designers were after was a high-power TRIODE amp for home use, a very "purist" sort of thing back then, as it is today, now that we have relearned what triode amps can do about musical enjoyment in the home.

Okay, the power triodes in the A100 were an indirectly-heated variant, not our holy DHTs, the mode of operation Class AB2 not *pure* Class A, and the amp incorporates some now-dreaded global feedback, but this artifact of bygone industrial pro-audio design was obviously a high-aspiration package for the crack sound engineers who put it together.

Its link with our generation's practice is through the buzzword *triode*. When you wanted very high quality reproduction and were willing to pay a few extra dollars per watt, there was a lot to be said for triode amplifiers…and there still is.

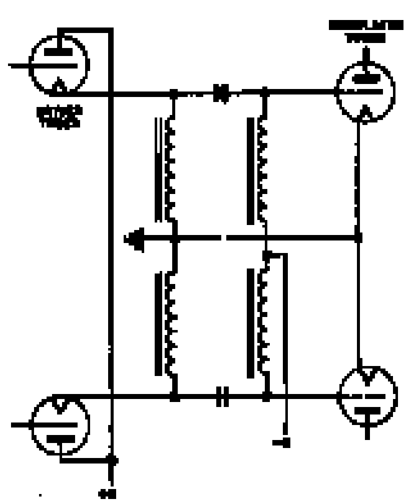
In this design, Altec tried to address the power economy of the triode amp, beefing up the efficiency with Class AB operation. Contemporary triode hifi buffs insist on nothing less than luxurious Class A, the power limitations and the rapidly rising cost curve for output power above a few watts not withstanding.

Class A is expensive. An equal investment in tubes and parts delivers progressively much higher power in Class AB, AB2, or B operation—and so it was that triodes were typically used in olden days, even in exacting high fidelity applications such as cost-nearly no-object cutting head amps and such.



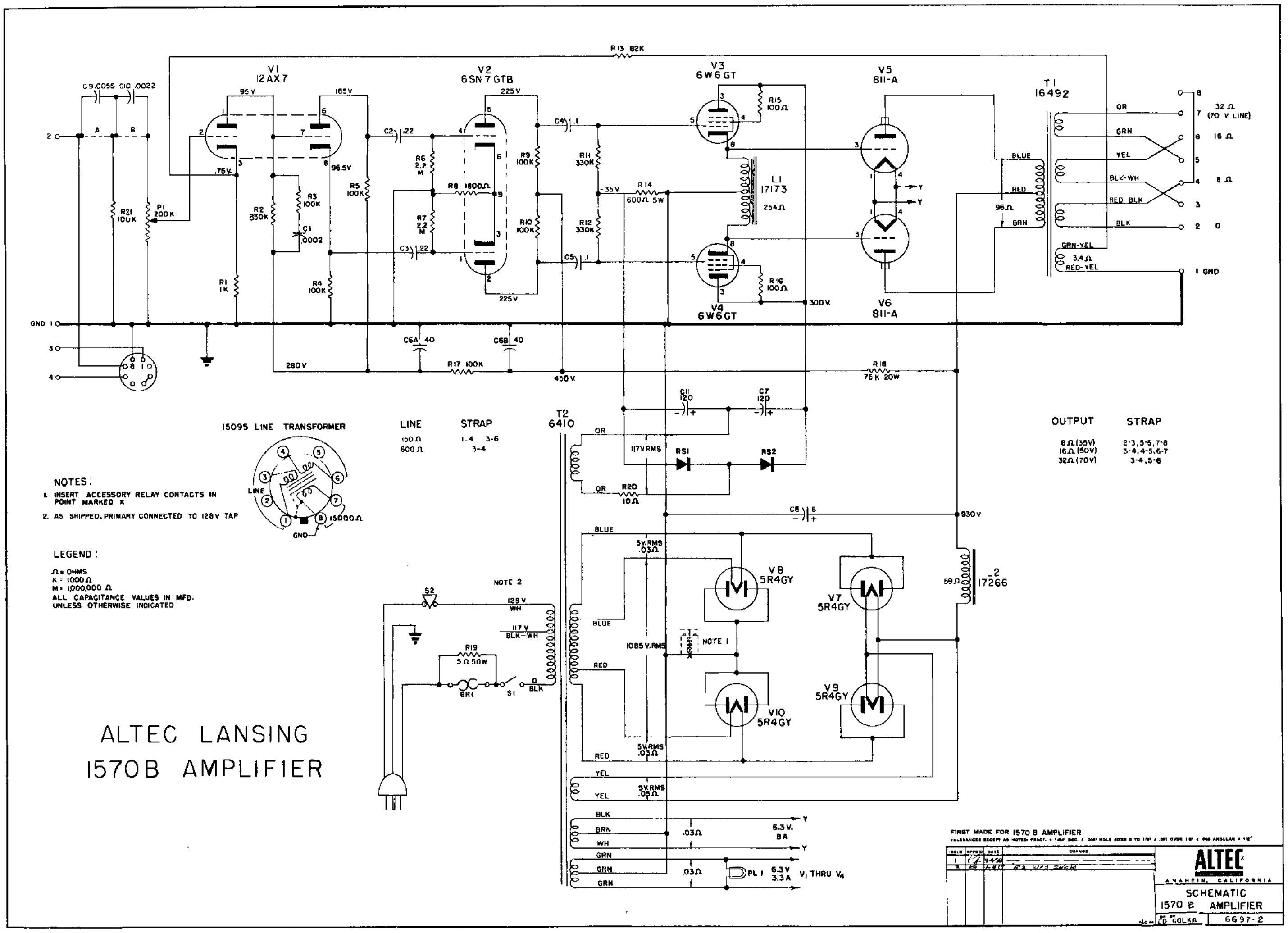
Symbol	Description
C1, C2	Capacitor, Molded Tubular: .1 mfd; 400 V
C3	Capacitor, Ceramic: 24 mmfd, 10%; 500 V
C4	Capacitor, Ceramic: 220 mmfd; 500 V
C5	Capacitor, Electrolytic: 1 mfd; 450 V
C6, C7	Capacitor, Molded Tubular: .01 mfd; 400 V
C8, C9	Capacitor, Molded Tubular: .1 mfd; 400 V
C10, C11	Capacitor, Electrolytic: 20 mfd; 150 V
C12	Capacitor, Molded Tubular: .01 mfd; 600 V
C13	Capacitor, Molded Tubular: .01 mfd; 1000 V
C15-A,B,C	Capacitor, Electrolytic: 20 mfd; 100 V; Com. P
C16	Capacitor, Electrolytic: 80 mfd; 500 V
C17-A,B	Capacitor, Electrolytic: 40 mfd; 450 V
C18-A,B	Capacitor, Electrolytic: 40 mfd; 450 V
R1	Potentiometer, Composition: 500,000 ohms
R2	Resistor, Composition: 4700 ohms, 10%; ½ W
R3	Resistor, Composition: 100,000 ohms, 10%; ½
R4	Resistor, Composition: 470,000 ohms, 10%; ½ W
R5	Resistor, Composition: 2200 ohms, 10%; ½ W
R6	Resistor, Composition: 1000 ohms, 10%; ½ W
R7, R8	Resistor, Composition: 47,000 ohms, 10%; ½ W
R9	Resistor, Composition: 2200 ohms, 10%; ½ W
R10	Resistor, Composition: 100,000 ohms, 10%; ½
R11	Resistor, Composition: 47,000 ohms, 10%; ½ W
R12, R13	Resistor, Composition: 470,000 ohms, 10%; ½
R14	Resistor, Composition: 4700 ohms, 10%; ½ W
R15, R16	Resistor, Composition: 100,000 ohms, 10%; ½ W
R17, R18	Resistor, Composition: 470,000 ohms, 10%; ½
R19, R20	Resistor, Composition: 68 ohms, 10%; ½ W
R21	Resistor, Wirewound: 4000 ohms; 15 W
R22	Resistor, Composition: 2700 ohms, 10%; ½ W
R23	Potentiometer, Wirewound: 10,000 ohms; 2 W
R24	Resistor, Composition: 2200 ohms, 10%; ½ W
R25, R26	Resistor, Composition: 4700 ohms, 10%; ½ W
R27, R28	Resistor, Composition: 10,000 ohms, 10%; ½ W
R29, R30	Resistor, Composition: 100 ohms, 10%; ½ W
F1	Fuse: 3AG; 3.2 Amp. Slo-Blo
J1	Jack: 1 Female Contact,
J2	Jack: Closed Circuit
J3	Jack: 2 Female Contacts

ABOVE: Though not the fashionable thing to lust after today, triode-wired PP pentodes with a low-impedance cathode follower driver stage were hot stuff in some upmarket early 1950s hi-fi amps, such as the Fisher 50A (6S4s or triode-wired 6CL6s driving triode-strapped 1614s) and later 55A which used this drive scheme for claimed efficiencies in excess of 55% with 50 watts out.



LEFT: Suggested driver topology for 1940s state-of-the-art high power modulator from Reuben Lee's 1947 text, "Electronic Transformers and Circuits."

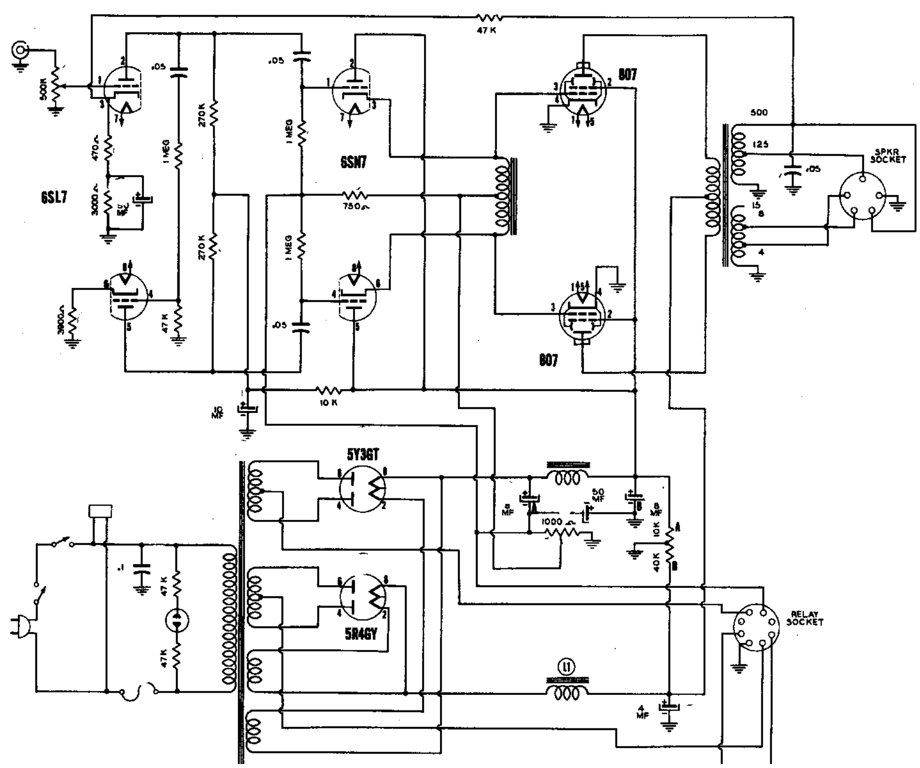
Iron core components are employed to provide required AC impedances with low DC resistance for minimum power loss, an important consideration in high power Class B amps which often presented substantial cathode current and grid current demands.

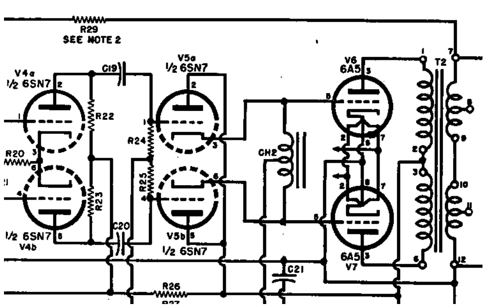


ABOVE: Famous Altec 1570B PP 811A amplifier put out 165W from 70 Hz to 20 kHz. People crazy enough to run these green monsters at home seem to like them a lot.

RIGHT : Bogen 807 P A Amplifier from early 1950s with similar driver scheme.

BELOW: Driver stage of Peerless A-100A 6A5G amp from SP#16 uses down-scaled version of 1570 driver arrangement





There weren't many home hi-fi "triode" amps in the Golden Age of postwar hi-fi but those that appeared were Class AB2 high-power jobs—30 W for the Brook 10C and 50 W for the Fisher 50A. Thirty-plus watts was big power back then,some of the most potent amps available.

Things haven't changed all that much. Then as now, some high rollers wanted both high-power *and* triode quality. Unlike today, well-engineered Class AB or B PP triodes were then considered luxury-grade designs. Today's man wants A all the way.

All of the above-mentioned amps used interstage iron to cope with the DC requirements of AB2 service and you don't usually see this in vintage hi-fi amps. The transformers and chokes were there out of electronic necessity, not because of coolness factor. I doubt there was any "coolness factor" to interstage iron in 1948.

A comparison of circuits shows the Peerless A100 amp to be a "baby 1570" circuit, derived from the Altec 165 watt big mother 811A amps that powered drive-in movies and large-scale PA systems nationwide. In essence, the A-100s as triode hi-fi amps were a by-product of the reigning concepts of high-power triode commercial amp design, downscaled to domestic requirements.

My point about the historical respect for Class AB amps is not to argue that pure Class A1 (no grid current) operation isn't the best way to run tubes because *obviously* it is. A1 might be an energy inefficient, low power out way to do things but the constant current conditions of A1 greatly simplify challenges for the whole amp design.

Efficiency is gained by shutting one of the tubes off, fully or partially, for part of the duty cycle. When that starts happening, life gets tricky fast. Class AB and B amps are a dance of tubes switching on and off, grids driven into conduction, and related demands on the driver stage and output transformer, not to mention the need for a power supply that will keep up with all this energetic activity.

Short and simple, the more efficient the amp, the further away from the safe waters of simplicity we stray. Efficiency isn't free.

I understand that from a certain fashionable techno-purist perspective, the Peerless amp is a nightmare come true but I was thinking it might sound good anyway. That's why I finally built a pair after all that thinking about it.

Building my 1999 Peerless Amps

Since I was so enthusiastic about this experiment, I decided to go all out, using only the best components I could possibly scam, mooch, and gouge from my favorite suppliers and friends.

After a year or two of shameless begging, I had a pair of B-stock walnut chassis liberated from my pal Gordon at Wavelength, a nice set of repro Peerless iron from Magnequest in exchange for the race car pic in #16…

Then I had a box of exceptionally nice 2x10 mF 600V rectangular Micamold oil transmitting caps with inch-long ribbed glass terminals, pried from Ron Welborne's private stash, before I hammered him for a "friendly price" on the lot. I'm sure Uncle Sam paid some serious dough for these first time around. I didn't want to repeat that mistake.

Whew…collecting quality parts for a major project like this is hard work, but well worth the effort,I must say.

Speaking of parts, there are a lot of them in this amp and I had to work to fit everything onto a 14 x 12" plate. I had to use some steel sheet to isolate the input pot to kill hum, and some wires are longer than I would have liked.A 17 x 14"chassis would have been a real plus, especially with the big oil caps, but too late for that now!

For small parts, I chose classic American stuff that would have been the coolest in 1948. Allen Bradley carbon resistors and Type J volume pots, surplus ceramic power resistors, E.F. Johnson ceramic sockets, and Vitamin Q caps.

I couldn't resist using a Western Electric 4 mF oil cap for the 6J7 screen bypass because I found a couple of these industrial beauties in original Signal Corps packaging years ago and I've been waiting for a circuit where I needed 4 mF to come across my bench! The gold and black water-slide decal makes these the baddest vintage parts in the junkbox.

On the other hand, I did install some extra decoupling with fresh datecode Cerafine caps and I used a couple late-model Black Gates where funky 1940s electrolytics were specified in the original plans.

Then, I switched out the Vitamin Qs upon arrival of the "care package" I weaseled out of Charlie Kittleson at VTV Pro Shop, importer of Ultratone silver and paper oil caps. I wouldn't have kept them in the amp if they didn't work better than the Qs, but I couldn't argue with the combination of softness and sparkle the silver caps added. I'm not much of a silver freak,but I did like the smooth but well-defined flavor of the Ultratones enough to try to mooch a couple more when I need livelier and more airy coupling caps than classic surplus paper-in-oils. Be sure to mention "Joe Roberts Labs" when you place your order to pave the road for future "review sample" raids on VTV Pro Shop.

In the end, although I intended to stay as original to the classic design mentality as possible, the parts selection process led to many modern audiophile substitutions and even the old parts I used were generally higher-grade than what Altec used. Why limit myself?

The end result is that my 1999 Peerless amps look like what they are—fancy homemade hyper-fi triode amps of 1999, an eclectic melange of selected fancy parts, from new to 60 years old, arrayed on a hardwood presentation-style chassis that those rack-mount minded ALTEC sound engineers would never specify for an hard-working audio frequency amplifier.

How Do They Compare?

I suppose the big question is not how cool my homebrew project is as an *objet d'art*, but rather how do these feedback push-pulls compare to a SE no-feedback triode amp I could build with the same level of attention and the same basic parts quality, for about the same investment?

I would have to say that the comparison is very instructive and says a lot about the relative ups and downs of SE amps. One thing that is gone with the PP Peerless amps is that over-the-top emotional expressiveness that is the recognized specialty of no feedback SEs. The Peerless amps are more controlled and restrained, which is both a plus and a minus, depending on when you ask and how I'm feeling.

Unlike the pleasantly puffy low end of my SEs, the bass of the Peerless amps comes across well-damped and tight. Some of the apparent weight behind the low end delivery of SEs is lacking, replaced by improved transient edge definition, but I've been wondering whether a lot of SE bass, while quite pleasant, isn't overblown and melodramatic anyway.

I'd have to mirror similar assessments across the audible frequency range:This PP triode feedback amp seems to be freer of sonic special effects than a lot of the single-endeds I have known and loved.

I suppose one could say that these PP amps sound more realistic and natural in many ways because they don't engage in audience manipulation like SEs. However, the juicy excesses of SE are part of what I liked about the breed.What's wrong with a little excess when you're in the mood for it?

The pronounced character of some SE amps seems to work in favor of music listening *sometimes*, but this depends on the system, program material, and listeners, on a case-by-case basis. The Peerless was more tonally austere than the average 300B SE, but the color and vividness was still there. The leaner sound of the A100 added some emotional contrast which can get drowned with a really lush. beautiful sounding SE.

Probably, SE triodes are still the undefeated champs of midrange, but in most situations low-power NFB SE bass is definitely *beatable*, even though often not bad. One answer to this age-old dilemma, of course, is multi-amping, perhaps still the ultimate way to go if you've got the space, the amps, and the inclination to mess with it.

Is this push-pull amp a world beater? No, I wouldn't go that far. In fact I think I could build a single 300B amp for the same money that could well turn out better, if "better" means more dramatic, more impressive and attention getting. The Peerless amps aren't much of an audio circus act compared with a lot of the stuff out there.

I do miss the psychedelic SET midrange a bit, be lying if I said otherwise, but I like the tasteful natural presentation of the upper mids and highs from this amp as well as the snap factor and rhythmic aptitude. Not dry, not over the top, not soft, not hard-edged, the Peerless amp project gave me a well-balanced upbeat result that is quite a satisfying listen. It has balance.

Maybe I'm just burned-out on reviewing, but I can't think of very much to say about the sound of this amp even though I like it a lot—and that is a compliment, I think.

THE ATMA-SPHERE M-60,Mk.II

As discussed above, the noble goal of whuppin' butt with triodes is best approached with an open mind regarding topologies, techniques, and tubes. Lo-watt SE-DHT has a lot going for it, no doubt, but the would-be butt-whupper might want to cast out a wider net.

One amp topology that hasn't lately enjoyed the cachet it used to have is the Output Transformer-Less (OTL) scheme. Maybe with good cause, because the OTLs that were major excitement back in the old days just never really delivered the goods, if the goods you were looking for are the absolute very best in sound.

Perhaps one reason that OTLs got stuck at *very good* and never hit the *jaw-dropping great* level is that the traditional OTL scheme *a la* Futterman required a huge capacitor at the output to block the B+ from running through your speaker cables and voice coils.

Though traditional OTLs with massively parallel sweep tubes and 3000 mF output caps had nice body in the lows and mids, the highs usually sounded kind of snuffed out and/or grainy. I blame the cap, although the very high levels of negative feedback used in Futtermans probably didn't help with the mechanical sound tendency.

Many old-time tube devotees thought getting rid of the "nasty" output transformer was worth putting a several thousand mike electrolytic cap directly in the speaker line, but I personally never had a problem with output transformers, except that good ones are not free.

Over time, audio hipster ideology shifted to the belief that transformers sound good and folks want more and more iron, anywhere, everywhere. Today, a poll of maniac audiophiles would probably show that iron is well-loved and it is *capacitors* which are believed to be the scariest devices in audio. In these pro-transformer days, OTLs have lost much of their former cognitive appeal.

Still,if one could get rid of the cap *and* the output iron, *that* might be something to hear. And *that* is what Atma-sphere has been doing for almost 20 years with their adaptation of the 1950s Wiggins Circlotron bridge circuit to OTL amplifier design.

Atma-sphere keeps the DC out of the speaker coils by using equal-but-independent floating power supplies on the two sides of the bridge in such a way as to have the output terminals between them at zero VDC potential.

Ralph Karsten, chief designer at Atma-sphere, is a tube nut of the first water, been around for a long time and he's seen it all. He's very thoughtful and well-studied on the general subject of tube audio, and although he's been in the biz for decades, he's still really excited about tubes and very refreshing to chat with because he obviously still loves what he does. Beyond that,he's an outre ethno-musician, former sitar and sarod picker, now specializing in Native American flute! As just another white boy blues harp player, I'm impressed!

Well, more than twenty years ago, Ralph latched on to the kernel of the old Circlotron scheme and took it places it had never been before. The original EV Circlotron amps were Class B pentode jobs with output transformers, bearing little concrete resemblance to the refined and patented Atma-sphere OTL topology.

On a structural level, "circlotron" is just a geometry, a configuration, like SE and PP, and it can be adapted to many uses. The M-60 design is an output capacitor-less OTL that is a pure Class A, low or no negative feedback (factory option), genuine triode design, using inexpensive 6AS7 output tubes, delivering a whopping 60 Watts output into 8Ω. Looking at it that way, sounds pretty interesting, and a whole lot more interesting than the vintage Circlotrons, which were mainly techno-curiosities.

The only buzzword purism sins these amps commit is that a) The M-60 is *not* a single-ended design and b) It uses *indirectly heated* tubes instead of the canonical DHTs. So what, this well-conceived scheme is, in all fairness, exotic enough to hold its own in any parade of lunatic fringe designs. If a triode OTL isn't arcane enough,get a life, you know?

Actually, the manufacturer worked hard to make the M-60s a practical *non-exotic* product, as simple and trouble free as possible, based on common tubes that would be widely available in the future. The lifespan of a tube amp is fairly long and Ralph likes to think in terms of a "twenty year rule" which implies that he wants and expects to be able to support 1999's Atma-sphere amps in 2020.

The M-60s classic silver hammertone, deco-mil-spec retro styling make for killer industrial art up on the shelf. Form-function electronics surplus *objets trouvees* like jeweled red and amber pilot lights with real incandescent bulbs, bat-handle toggle switches, and a photo-etched mil-style nomenclature tag evoke the saga of tube electronics through the ages.

This classic form-fits-function visual design is a virtual celebration of the romance of bygone technology. With the pilot lights glowing and the 6AS7s all lit up, they put the Christmas tree to shame.

Yet, like anything that is cool about being self-reflexively retro, the M-60s don't overdo the act.Indeed,when they're on there is so much luminescence from the tubes that it is hard to focus on the metalwork! With tubes galore like this, you don't need ornamentation to augment the visual appeal.

One brute fact that struck me was the moderate weight of the M-60s. Although each chassis has a substantial 17 x 13"footprint, my last stupid-heavy, oil capped, choke input power supply, output transformered DIY linestage weighed more than one of these under-30 pound OTL monos!

As mentioned above, it is also easy to notice that there are a LOT of tubes in these monoblocks, definitely a tube-lovers' tube amp! The output stage consists of eight 6AS7s per side, an industrial dual triode that has the sexy coke bottle curves that gentlemen prefer. The manufacturer uses and recommends Russian 6AS7s and warns against NOS RCAs because they tend to flash over at turn-on. NOS Sylvanias, apparently the prototype for the Russian versions, will work just fine.

Fortunately, 6AS7s are a durable industrial type, plus a common and reasonably priced current production tube, so retube considerations shouldn't be too painful. Atma-Sphere gets about $20 each for cherry picked Russians and you can probably pick some yourself for even less.

The voltage amp and driver stages use four 6SN7s per side. The voltage stage uses a differential cascade arrangement employing two bottles, with paralleled halves of a 6SN7 working as a current source for the differential pair. The output of this unconventional voltage amp hookup is coupled to the grids of the 6AS7 array via a pair of 6SN7 cathode-follower drivers.

The input of the M60 is capable of being driven by a differential input via the front panel XLR jack, or via unbalanced RCA inputs with a little shorting jumper stuck into the XLR, as seen in the photo. Atma-sphere's preamps employ balanced differential outputs to maximize this capability and present the opportunity to have a balanced differential system all the way through.

I suppose the ultimate irony of the Nineties would be to take one of those high-fashion line stages with a balanced transformer output and drive the OTL with some output iron. Why not? It's still legal to get crazy like this, for now.

Like all OTLs and tube amplifiers generally, but OTLs especially, the M-60s like a highish impedance load, 8 ohms or better. The M-60 is rated at 60 watts into 8 ohms but 45 at 4 ohms. With 4 ohm speakers, the damping is somewhat compromised and the bass can sound a bit undercontrolled, according to Ralph. Atma-sphere's bigger OTLs, using more output tubes for lower output impedance, are happier with 4 ohm loads.

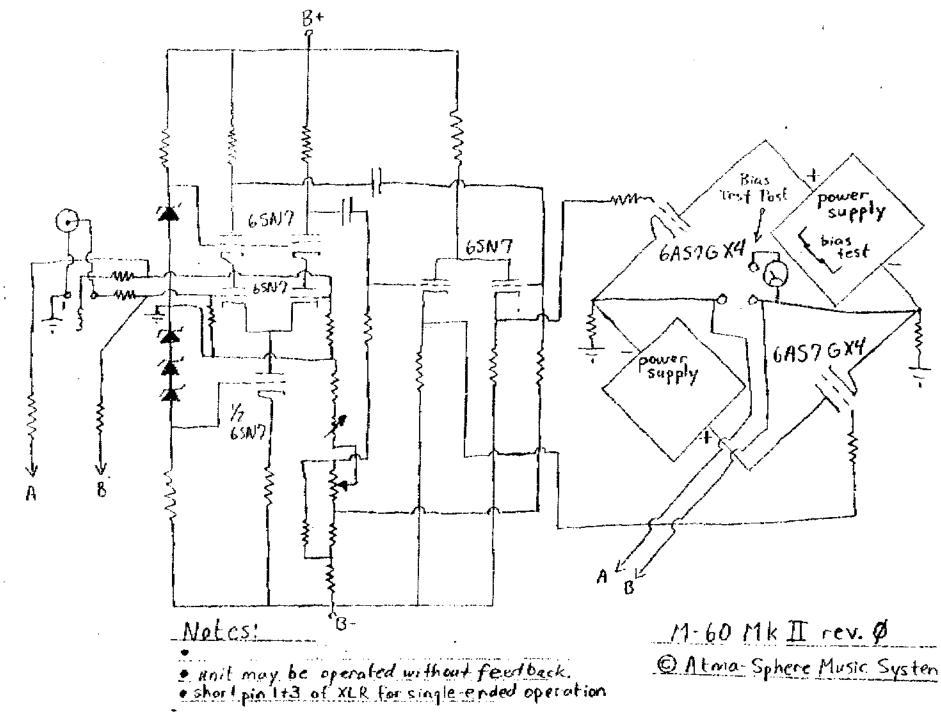
The M-60 is usually shipped with a moderate 2 dB of negative feedback to assist in driving low Z loads, but they will send you amps with no feedback upon request. The dividing line where feedback starts to help is the 8 ohm point.Above 8 ohms, it doesn't matter much if the amp has the feedback or not.

Ralph claims that they tried a feedback switch but the difference between no feedback and 2 dB feedback was quite subtle. On the other hand, the effect of switching between 8 dB and no feedback,which they also tried, was quite dramatic and suggested that the lesser amount of feedback was far the better option.

One of the reasons the M-60 aroused my interest is that it is available in kit form.My ears always perk up at the mention of a kit. Aside from the abstract pleasures that kit building provides, its hard to ignore the positive economics of going the kit route. The storebought version goes for $4195 and basic kit goes for only $2495! That's getting close to the point where you can get a biamp quad set of M-60 mono kits for the price of one pair of ready-mades, a discount not to be sneezed at.

Although the M-60 chassis is quite spacious and the components are not crammed into the box,this amp has a lot of connections in it, a lot of wiring snaking about. By the looks of it, I would have to rate this a kit project of at least moderate

Atma-Sphere M-60 Mk.II OTL Amplifier
Schematic Diagram



difficulty and scope. Like the Peerless A100 discussed above, the M-60s have a lot more parts in them than most simple SEs, so this would be a somewhat bigger undertaking than a 91 amp or similar DIY SE special.

Since it's a kit, though, you're saved from the exacting dog work of the metal shop and you can rest assured that the end product will look better than what 99% of garage homebrewers could accomplish. And what you'll end up with is a name-brand item, in case you ever want to move it along. There's not much buyer demand for ugly scratch-built homebrew OTLs these days, so you can build it for less yourself from scraps and throw all your investment away.

Compared with what you can buy ready made in 60 watt monoblock triode OTL amps for $2495, I'd have to say that the Atma-sphere kits easily hold their own, if you know what I mean. Seems like a good value package for the money, even without hearing it. And I am pleased to give these amps an enthusiastic thumbs-up for the way they sounded too.

Although I have only heard four or five OTLs, these are easily the best OTLs I have heard, but beyond that I'd have to say that they are wonderful TRIODE amps, enjoyment+ for music listening. I found myself digging out old R&B vocal harmony sides and roots reggae records to play on the M-60s. Great, great T-Bone Walker amps and outstanding for bluesy female vocals like Etta James and Dinah Washington, the M-60s have a lot of character and create a lot of atmosphere in the listening room…or is that *Atma*-Sphere?

There's no mistaking the special tube flavor of the sound of the Atma-Spheres, a nostalgic, grandiose tone that evoked a classic vintage tube amp sort of charm, but I would be hard pressed to name any specific vintage amps that sounded like these do. Most vintage amps don't compete with the M60s in terms of immediacy and fresh air. These amps are colorful without sounding deadened or muffled like most antique units.

Even though the M-60s were a new experience for me, they sounded very familiar, very friendly. Smooth beyond smooth, the M-60 is easily the most fluid, grain-free amp I ever heard in my life. Very easy listening. Maybe THIS is why people want OTL/OCL amplifiers?

The mental image I'm trying to find words to describe is the big triode jukebox sound—vivid, dramatic, super bouncy bass, big liquid midrange, 3-D effects out the yin yang. The M-60s are a very fun-filled, hedonistic listening experience that has a lot of the tonal romance of a 300B single with much more grunt and power.

I say *romance* because like a triode SE, the M-60s present a blatantly "tube enhanced" portrayal, but like the good SEs, the M-60s do it in a refined and sophisticated manner that adds to the comfort and enjoyment level of music listening without coming across as a cheap overdone special effect.

Right before packing them up, after a couple hundred hours use, one Sovtek 6AS7 heater went out. Didn't even notice at first because the amp kept playing fine. Could have been like that for a week or two before I noticed it. No explosions, no fires, no meltdown. To be honest,I couldn't even hear a difference. OK, I'll turn in my reviewer's license at the door.

Otherwise, the amps ran problem free for the nine months I had them. Some tweaking and adjustment is required at setup and during the initial burn in period.After that, they didn't require any attention. I was worried that they would be flaky about adjustment but they were very stable. When I swapped them in and out of my system, I periodically checked the bias and balance, they were more or less still right on.

Worthy of note is that sixteen Class A 6AS7s definitely throw off some British Thermal Units as a by-product of that fifty watt Class A output. Ha, Ha—Did you think Class A was free? I noticed the extra warmth in the listening room after the amps cooked for a while but I live in sun-baked Texas and I'm used to running low watt two tubers.

I will mention that my fellow Texan, John Day (who lives in a part of Austin just as hot as here) heard these M-60s and blurted out the analysis that "they sound like a powerful, well-broken-in engine!" He begged me to borrow them to run his Altec A7s and he was on the verge of buying, until his wife threatened to move in with her mother if he bought another tube amp. John says they're the best amps he ever heard on his horn system. I say about time you heard a real amp, bubba!

Another Austin audio buddy, jazzbo triode DIYer, Dexter Guilford, came over to hear the Peerless amps a few weeks ago and he promptly called LaFevre and bought a set of Peerless kit iron. Different strokes for different blokes.

The moral of the story—aside from the obvious implication that I should be out shaking down manufacturers for even more payola—is that there is still a gold mine of good ideas off the beaten-track and a lot of potential payback in prospecting out in the unmapped fields of audio experimentalism. The chances are that you and I would find much to enjoy among the possibilities.

The real subject of this article is something that is impossible to put into words: how these amps sounded similar, while sounding quite different. I'm trying to probe how they are both examples of triode amps, without invoking the almost-useless, non-descriptive buzzword "The Triode Sound," even though that's what I'm wanting to say.

Both amps have the quiet background and the natural yet colorful tonal palette I expect from triode amps. Both designs were relaxed and smooth without being muddy and obscure, and that's a quality I can definitely relate to triodes.

Both amps were forgiving of the quality of the source material, being friendly to less-than perfect records and recordings. As Herb Reichert once put it, "A good amp is one that plays *all* of your record collection." Triodes, to me, mean *easy listening.*

The M-60s were a bit softer than the Peerless amps, the bass was a bit more full and punchy, and they were perhaps somewhat smoother than the PP homebrew monos, all the while sounding three times as powerful, which they are.

The A100s had a bit more of a high-definition information retrieval illusion and the whole presentation was slightly shifted toward brightness a notch from the bouncy, rich midrange of the M-60s. The A100s had more gritty bite in the upper mids than the Atma-spheres, which was nice on cymbals, but,from another perspective, the utter lack of any nasty edges was a positive feature of the OTLs.

Despite certain pronounced differences in flavor between these amps, there's a remarkable alikeness in fundamental presentation characteristics—the way they projected music into room space, how they rendered texture into the body of the sounds, how they engaged the ear— which is not to say that either amp sounded generic.

The two sets of amps represented two wildly divergent concepts of amp design, yet they sounded like they were swinging from the same family tree, the top branch on the Triode Bush, perhaps.

I mentioned the triode similarity aspect to Ralph Karsten and he suggested that maybe this is an example of a wider phenomenon where the sound of amps tends to converge as said amps get "better." He said, "Music only sounds one way—like itself—and this is why as amps and speakers get better they should exhibit less difference. So it should come as no surprise that two high quality triode amps of different design should sound similar if all the ducks are in a row."

There could be something to that line of thinking, although I'd want to leave the question of "better" as open as possible to allow for future surprises.

I will say this, that as I listen to more triode amps—single-endeds, push-pulls, low power or high power, directly heated or indirectly heated—I'm hearing a lot of the same things. Good things.

Atma-Sphere
160 S Wheeler
St. Paul,MN 55105
612-690-2246 voice
612-645-3675 fax
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For more on Atma-Sphere products, mods,and user comments,check out the Independent Atma-Sphere Users Group—

http://www.condor-connection.org/asog

Our goal with our amplifiers was to create a new type of amplifier that had never been made;not just for the fun of it (although we had a lot of fun anyway) but because it might serve the music. The result was the world's first reliable OTL (a term that sometimes makes us cringe because of the unhealthy legacy left behind by Futterman and his heirs).

We made the amp reliable by also creating the world's first symmetrical OTL, negating the need for the dreaded negative feedback that kills music. We believe in the principle of Occam's Razor: the simple solution is probably the right solution—so the amp has only one stage of gain, making it, so far as the music is concerned,the simplest tube amp in the world.

It is the only amp in the world that is Class A, all triode, fully balanced (differential) throughout, zero(or 2db) feedback with a single stage of gain and a direct-coupled output.A bit of a mouthful,but the better your speaker the easier it is to hear how much better it is.By comparison, it is a little less colorful than most SE designs, due to its lower distortion. You'll get used to that real fast. Once you get used to hearing this, SE amps tend to sound harsh by comparison.

We don't like feedback at all but were forced to deal with the issue in the M-60.The problem is that altogether too many people want to use tube amps with the wrong type of speakers.So if you haven't heard it before, you are hearing it here now: IF YOU LIKE TUBE AMPS, STAY AWAY FROM FOUR OHM SPEAKERS!!

The fact of the matter is,ALL tube amplifiers perform better on 8Ω or 16Ω than they ever could on 4Ω.Of course, having said that,there are a lot of 4 ohm speakers that work fine with our amps,but all other things being equal they would all work better if they were 8 ohms instead.

OTLs have gotten a bad rap not only on account of reliability but also load sensitivity. The thing about that that surprises a lot of people is the revelation that transistor amplifiers are actually MORE load sensitive (although in the opposite direction,less power into high impedance, the opposite of tubes).

We have built the only DHT OTLs in the world. We used the 300B (4 per channel) and produced 14 watts into 8 ohms. The amp sounds very similar to our 6AS7 based designs, in fact, the choice of output tube has only a small bearing on the sound we achieve.

I've often thought about using the 2A3,since it would be a cinch, but once you've gotten used to really clean power its hard to get by with less—I like to rock! 2A3s would require quite a few on hand to do anything significant.

We have finally introduced the S-30, a 30 watt stereo amplifier, in our quest to offer OTLs at an affordable price. Actually, our vision has always been to build the 'OTL for the masses', something that was only a dream before we made reliable OTLs a reality.

Despite the fact that we make only balanced amps and preamps, we have always felt that we had more in common with the single-ended crowd then the powerhouse (read: club-handed) push-pull camp. That is because we have shared the vision of simplistic circuitry with Class A triodes and zero feedback. For what its worth, we have been making triode amplifiers for a longer period (over 21 years) than any other manufacturer in the world.

The SE revolution served to legitimize our way of life;in the 70s we were simply thought of as nuts ("triodes? really? I gotta go.."),in the 80s, quaint,if not a little exotic, and in the latter half of the 90s (after 20 years) we are finally experiencing market acceptance. The presence of high efficiency speakers has been a boon. We have many Lowther and horn customers (and have had a long relationship with horns on the home front as well).

One nice thing about this OTL technology is that the sound is not limited by high power. Our larger amps actually sound better than our smaller amps,flying in the face of conventional wisdom.

This means that lower efficiency speakers can be used, but even with a set of the 220 watt MA-2 MkIIs,its nice to have a speaker that has efficiency in the low nineties rather then the mid eighties! If you ever want to hear how good the recording really is in Black Sabbath's "Paranoid," you simply have to have a speaker that's easy to drive!

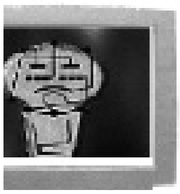
By the way, our amps are so reliable that they hold up easily as guitar amplifiers. The only problem is that they don't 'bite' like conventional guitar amps do because they won't distort as much.

A last word. The thing that has always made Sound Practices a cool mag has been the simple fact we must emphasize having fun in the process. FUN is the most important aspect of audio. Avoid der tube Gestapo! I hope you get where we're coming from.

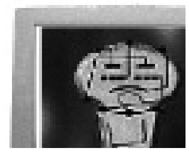
Thanks and happy listening!

Ralph Karsten

DARLING FEST '99



Our DIY cybergang meets in the flesh



by Jeremy Epstein

The "Be–There–or–Be–Square" audio event of the week, for sure!

One of the facts of modern life is that you can make friends now before you ever meet them. One such friend I've made is rocket boy Bob Danielak,who, when he is not engineering power systems for com satellites, designs and builds (oh, how he builds!) a wide variety of audio equipment. I had made his acquaintance via e-mail when I took a design of his, an RIAA preamp, and hacked it all to hell. We hit it off and kept up a running discussion of long standing.

One of the topics we touched on was Bob's "Darling" amp, during the early stages of its evolution (see SP #15.) He was touting his little SET amp design,using the 8532 seven-pin-mini single triode as its driver, and the 1626 pre-WWII power triode as its final tube, as a great bang-for-the-buck project. I was dubious at the prospect of building a <1 watt circuit as my first triode amp, but the words "cheap" and "fun" kept resounding loudly from his description. I decided to try and build a push-pull version of his design, an intimidating 1.5-watt behemoth, and Bob helped me cut and paste a circuit together using an IT phase splitter.

I built one. It sucked.

I quickly rebuilt it into an IT coupled, single-ended amp using the two 1626 power triodes per channel in parallel, since they were all wired in there anyway. It used a 6SN7 dual triode as driver for both channels, because I like the sound of this tube. In my dusty pile I found a 6BY5 dual damper diode pulled from the back of a discarded TV, so I had tube rectification and everything.

It kinda sucked too, but it was a step forward. I'll spare you some of the gorier experiments along the way, but finally I decided to try ditching the IT altogether and cap-coupled the driver straight into the parallel 1626's.

This one didn't suck. In fact, I played it for about 200 people at Blackie Pagano and jc morrison's thermionic love-in, nyNoise, and the crowd was very happy with it.Suddenly I was a "made" member of the NY Triode Mafia. The highlight of the day, however, was meeting my faithful consigliere, Bob, face to face. (Face to face to face, actually: he brought his identical twin brother, Rich.) Since then, with Bob's wise counsel, I've developed an even better, DC-coupled version of this amp. All these amps have, true to Bob's word, delivered shockingly good value. I promise you, if you build one, you will be ruined for expensive tweaks forever, so the project will pay for itself, eventually.

One eye-opener I discovered in my DC-amp explorations was that the conventional power supply arrangement for a two-stage amp, with a pi filter between the B+ tap for the final tube and the B+ tap for the driver, does not sound as good as a single B+ tap arrangement.

Moving the driver tube's supply to the final tube's B+ tap was one of the biggest improvements I heard during the development process. The soundstage increased from the size of an East Village apartment bathroom to the size of a hotel ballroom with just this one switch. Doing this also allows you to increase the value of the driver plate load resistor (you drop voltage there instead of in the pi filter) which gives better driver linearity, all else remaining equal.

Bob has confirmed this improvement in his amps. We have speculated about it and our belief is that the reorganization of the lead/lag of the power supply time constants sounds better. The single tap approach creates a 180-degree difference in phase between the two stages' PS demands at all frequencies, instead of a frequency-dependent lead/lag. This was the biggest design contribution I was able to make—my approach is more that of a mechanic than a designer, Bob did most of the heavy mental lifting. The only caveat is that the B+ tap you use must be filtered well enough to begin with for use in the driver stage: the conventional arrangement is usually for the purpose of improving the filtering of the B+ for the higher-gain driver stage. Doing this

may be good engineering but we found it exacts a sonic price. Ps decoupling between stages is unnecessary in a two-stage circuit.

Another thing I discovered, at nyNoise, was how much fun it was getting out of my basement and meeting some of the people who I had known only as e-mail addresses. I met Larry Moore and "AnnaLogg" there, and the "Darling Fest" project got its start that day.

All the while, back in his garage strewn with tubes and Fiat guts, Bob was performing all manner of vivisections on hapless donor chassis. He was working more with single-1626 final stages, because he hears a more precise and delicate image from these than he does from a 2 x 1626 final stage. (He may be right,too, but I gotta be able to play "Live At Leeds" from time to time, y'know?)

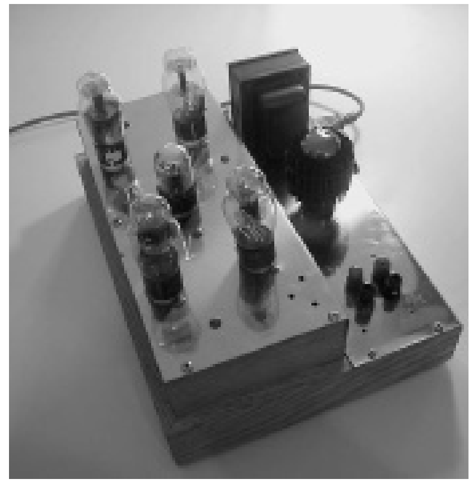
After he published his article, and while we continued posting progress reports to the JoeNet e-mail list about our further experiments, we attracted some fellow travelers. There are at least a couple more people who have built Darling-style amps (there may even be dozens, I get frequent e-mail queries and Bob gets many more.) I have also seen another different circuit on the WWWeb, developed by a Japanese enthusiast, which uses a 1626 final stage. Apparently, the word "cheap" can be translated into Japanese.

Bob doesn't have an electronics problem,he says, "I can quit any time I want." Nevertheless we were able to take seven different amps of his, and add to them my three, plus one made by that fellow Larry Moore who is quite the amp craftsman. Larry built his with a volume knob, and he goes forth like Johnny Ampseed, patching this nifty little SET amp into the signal chains of everyone he meets.

In numbers, at least, we thought we were getting somewhere. En masse we wormed our way onto the schedule of the New Jersey Audio Society, at the invitation of Valerie Kurlychek, a.k.a. "AnnaLogg."

Bob, his twin brother Rich, and I negotiated the spaghetti-like roads of Brick, NJ and arrived at "Anna's" door early one Sunday afternoon. She gave us a quick demo of the house system, which delivered more output power in one channel than all ten of our amps combined. Nice power, too.

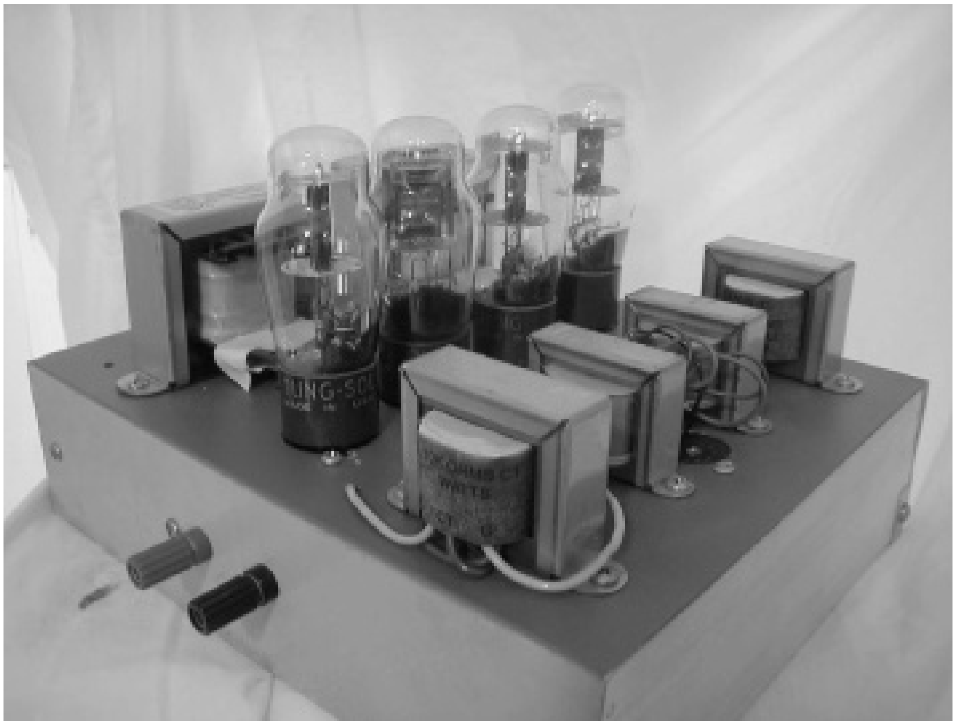
Some folks started straggling in soon thereafter, and we put in a pretty full day: the "Darling Fest" started about 2 p.m. and we were still playing "let's try . . . " and "what if we . . . " after 8:30. We promised her an entertaining day, and I believe we delivered. The listening panel was uniformly well pleased,and we got comments like "This has been a real eye-opener," and an incredulous, "We're still under 1 watt output here?"



For me, a dozen amp setups are too many to listen to in one day. We played anywhere between two and eight tracks on any one amp, and we played a single benchmark cut on each (a version of "Take Five" by a group led by original Brubeck drummer Joe Morello.) We sure heard far more drums! My preference in auditioning equipment is for month-long trials, (Ongaku donors, take note) covering all sorts of music, and I did try to provide some variety in the cuts I selected for our quick comparisons : Eddie Cochran, Kurt Rodarmer, D.L. Menard,Ray Charles.

The "house" software contrasted nicely with my selections:"Anna" came up with the Joe Morello and a sweet-sounding disc of recordings made using a Stradivarius violin which were particular hits. The Strad disc made very good use of the Darling family's strong points, and a lot of eyes rolled back in a lot of heads while it was playing.

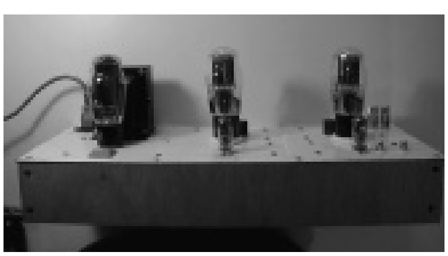
Ancillary equipment included an excellent pair of Von Schweikert VR4 Generation II speakers, and some very spiffy front end equipment :Musical Design Signature 2 CD player, Balanced Audio Technology VK-5i line amp and Margules Audio phono pre. Phono cables were WireWorld Gold Eclipse II, and the preamp was connected to the phono stage with Harmonic Technologies



Truth-Link. Speaker cables were Vampire as were the CD-player-to-line-amp interconnects. I imagine the pile of interconnects cost more than any two or three of the amps!

All the Darling amps (some to a greater degree than others) were able to create a very convincing sense of instruments in space, and the music almost NEVER seemed to get stuck inside the speakers. Also, as a family trait, the Darlings were unfailingly musical with no listener fatigue or egregiously phony tonal balance that I could detect.

The single Darlings (one 1626 output tube per channel) definitely had volume "issues" in this setup (the 91-dB speakers were being asked to fill maybe a 12'x22' space.) The most noticeable challenges were sustained crescendos: playing them loud pooped the "singles" out dramatically. One listener thought this was a sign that the PS reservoir was too small.Larry might say that the pipe refilling it was too narrow. These are good directions for future refinements. The Darling amps, as a rule, do not always fare well on audio obstacle courses. They just play music.



Some listeners were very enthusiastic about the original, octagonal Darling. A few people thought this amp had the best sound of the day (when run within its limits.) This amp was also put forth as a terrific candidate for the top of a biamp setup, which it is. Betcha can't build just one!

"For me, the best of the single-single-ended class was the"Sakuma Darling" (1626 driving 1626, with transformer coupling at the input, between stages, and at the output.) This amp had a good combination of quality and quantity of sound, and it overloaded more gracefully than its classmates. I liked this amp both in the "fest" setup and in a pre-trial at home.

It painted a fine image, and it reproduced music with a pleasing sense of coherence and weight, but I did sense there was some "overhang" on transients. This may have been an artifact of ringing transformers. Bob thinks this can be remedied by applying some rocket-science to the trannies' secondary loads, and if so, this amp could be a big winner.

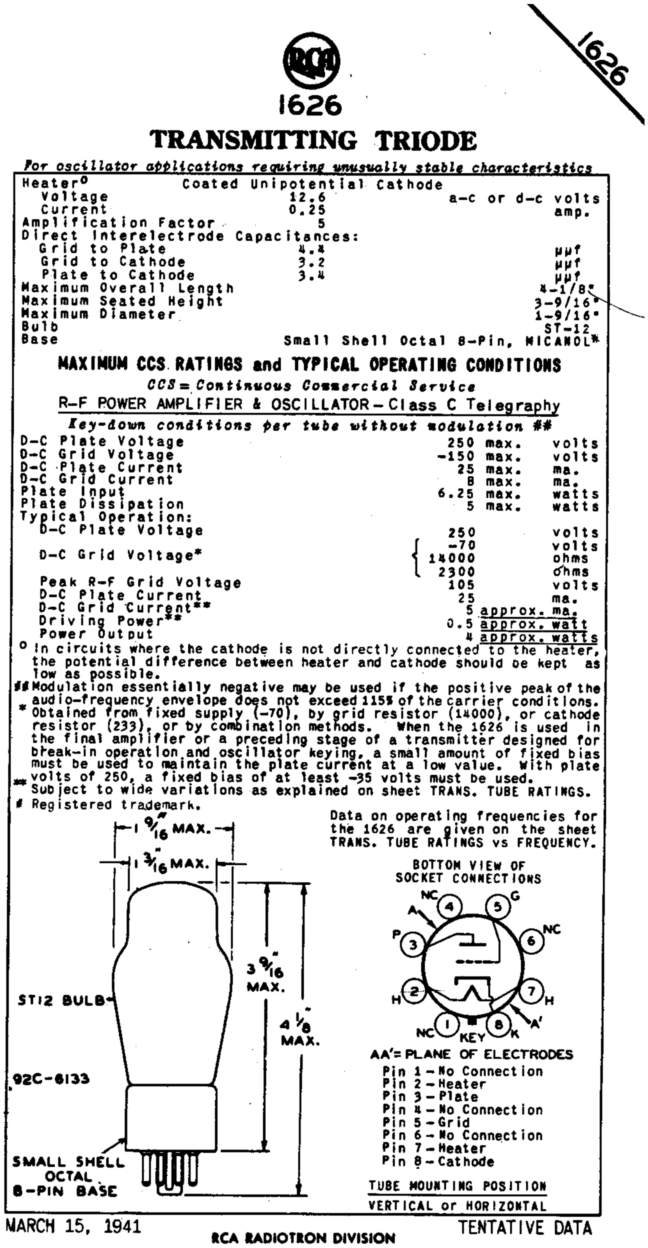
Certainly my IT-coupled amps were not in this class, despite the fact that they used many of the same parts. Cheapskates, rest assured these are the under-$15 sort of interstages, not the over-$150 sort."

My two double Darlings (2 x 1626 per channel) fared very well in regard to volume and a sense of weight, but some listeners noticed a decrease in the precision of the imaging with these amps, a little smearing in the treble as it was described to me. (We had several very good listeners and they weren't shy!)

The DC versions of both the single and double Darlings were, to my ears, much better than the cap-coupled versions in all respects. I am lucky to be a neighbor of Don Garber's (he's the manufacturer of the awesome Fi line of SET amps) and his enthusiastic endorsement of DC coupling was what led me to try this in a Darling-style amp. Bob's little "problem" is what led to his experiments, I think. (The DC Double Darling has the Fender "Champ" guitar amp output transformers, but almost all the rest of the amps used Hammond 125E's. Another variable.)

Larry Moore's wrinkle was a convertible Darling amp, which was suited for either a single 1626 or 12V6 (12V version of the 6V6 beam power tube, here triode connected) as the output tube. The 12V6's were slightly more powerful, slightly more "accurate" sounding, but maybe not as lush. Our quick comparison was not enough for me to make up my mind, the difference seemed subtle to me. I want to do some more listening with this amp Larry is pretty clear that he likes the 12V6 setup better.

The bug up Larry's ass is lowering power supply impedance; to that end, his amp,



RCA

1626

TRANSMITTING TRIODE

For oscillator applications requiring unusually stable characteristics

Heater°	Coated Unipotential Cathode	
Voltage	12.6	a-c or d-c volts
Current	0.25	amp.
Amplification Factor	5	
Direct Interelectrode Capacitances:		
Grid to Plate	4.4	μμf
Grid to Cathode	3.2	μμf
Plate to Cathode	3.4	μμf
Maximum Overall Length		4-1/8"
Maximum Seated Height		3-9/16"
Maximum Diameter		1-9/16"
Bulb		ST-12
Base		Small Shell Octal 8-Pin, MICANOL#

MAXIMUM CCS RATINGS and TYPICAL OPERATING CONDITIONS

CCS = Continuous Commercial Service

R-F POWER AMPLIFIER & OSCILLATOR – Class C Telegraphy

Key-down conditions per tube without modulation ##

D-C Plate Voltage	250 max.	volts
D-C Grid Voltage	-150 max.	volts
D-C Plate Current	25 max.	ma.
D-C Grid Current	8 max.	ma.
Plate Input	6.25 max.	watts
Plate Dissipation	5 max.	watts
Typical Operation:		
D-C Plate Voltage	250	volts
D-C Grid Voltage*	-70	volts
	14000	ohms
	2300	ohms
Peak R-F Grid Voltage	105	volts
D-C Plate Current	25	ma.
D-C Grid Current**	5 approx.	ma.
Driving Power**	0.5 approx.	watt
Power Output	4 approx.	watts

° In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

* Obtained from fixed supply (-70), by grid resistor (14000), or cathode resistor (233), or by combination methods. When the 1626 is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, a small amount of fixed bias must be used to maintain the plate current at a low value. With plate volts of 250, a fixed bias of at least -35 volts must be used.

** Subject to wide variations as explained on sheet TRANS. TUBE RATINGS.

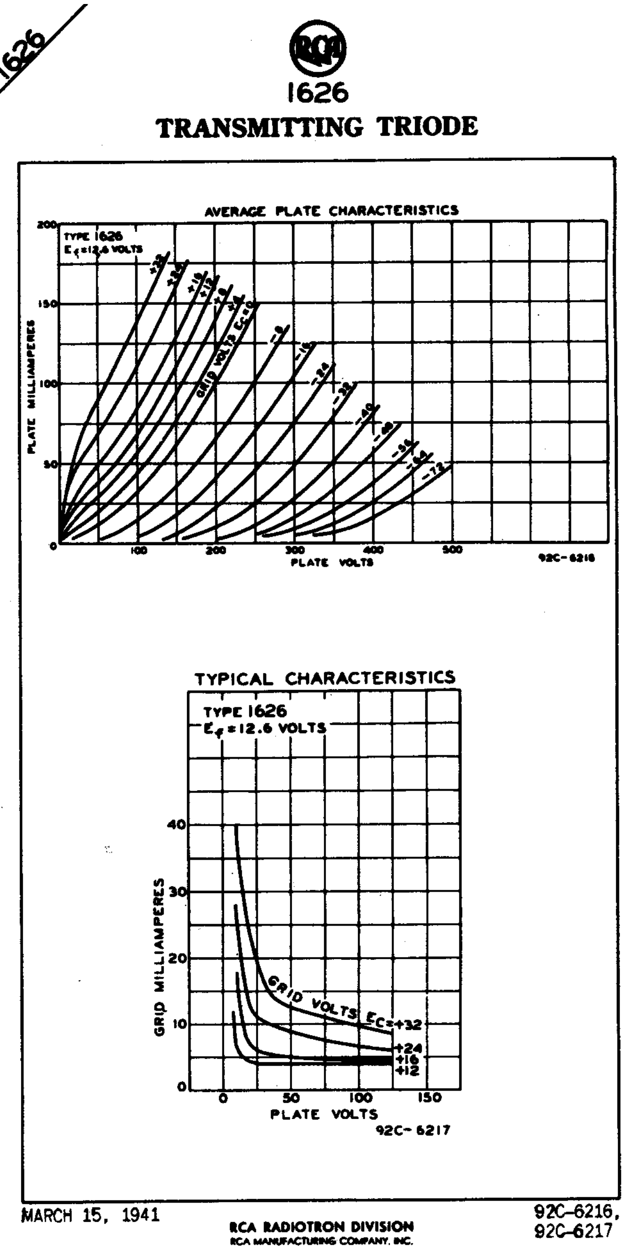
\# Registered trademark.

Data on operating frequencies for the 1626 are given on the sheet TRANS. TUBE RATINGS vs FREQUENCY.

Pin 1 – No Connection
Pin 2 – Heater
Pin 3 – Plate
Pin 4 – No Connection
Pin 5 – Grid
Pin 6 – No Connection
Pin 7 – Heater
Pin 8 – Cathode

TUBE MOUNTING POSITION
VERTICAL or HORIZONTAL

MARCH 15, 1941 — RCA RADIOTRON DIVISION, RCA MANUFACTURING COMPANY, INC. — TENTATIVE DATA

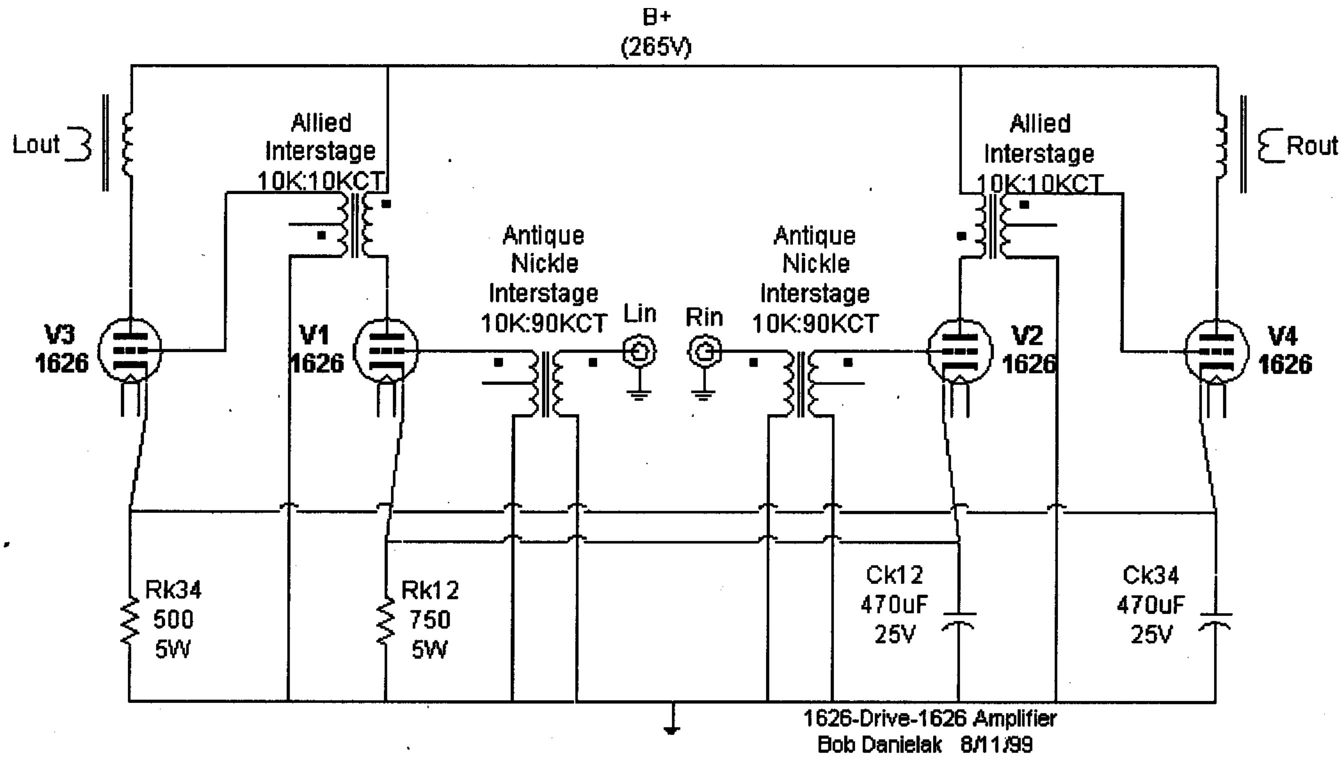


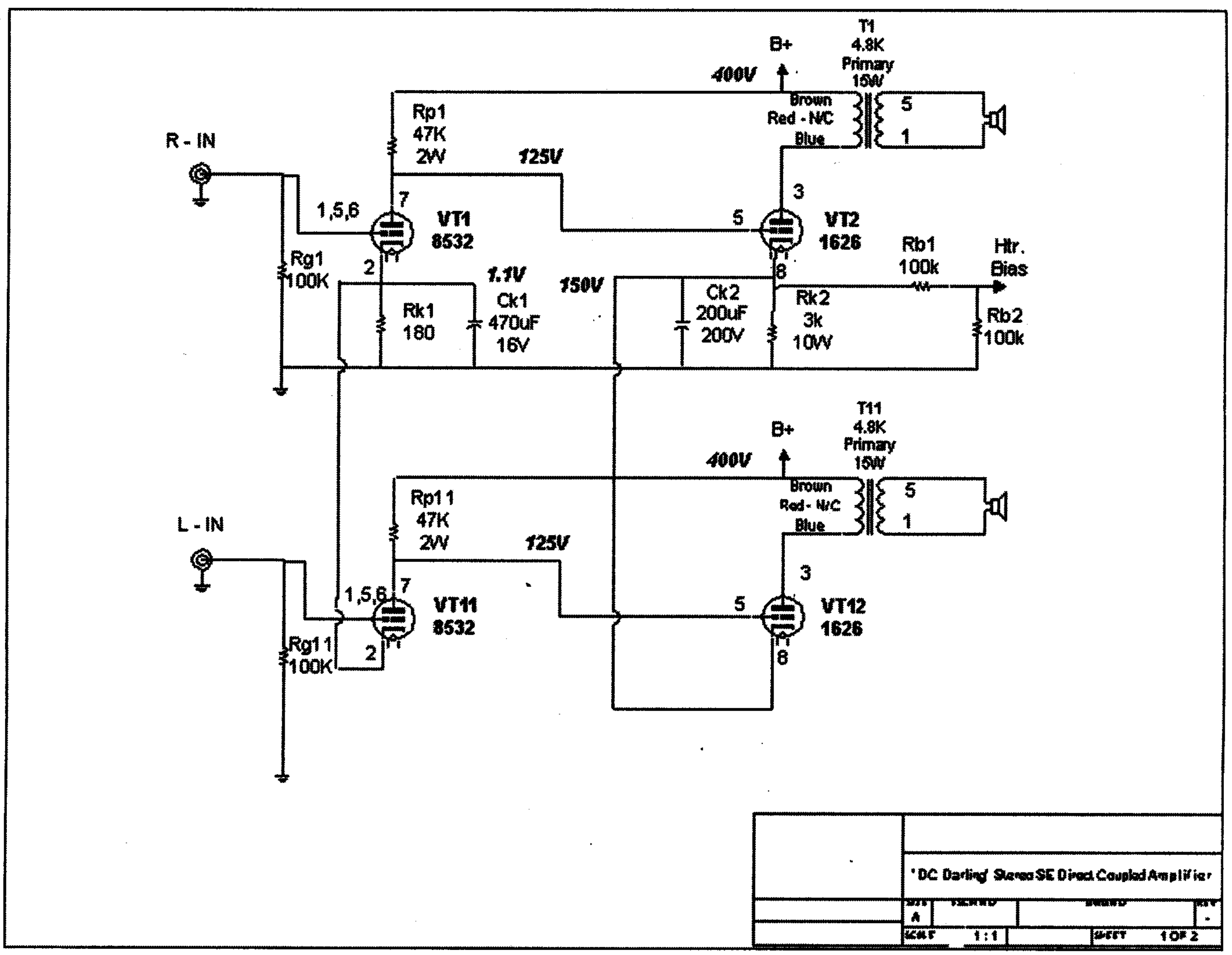
though small,nevertheless has dual,parallel, power transformers. It is a clear winner in terms of good looks: the amp features a gleaming copper top plate and surgically neat wiring below decks.

We auditioned a bold, noble experiment of Bob's, the Darling 3.5 :3 x 8532 driving 5 x 1626 per channel, using three parallel power trannies, developing 3.5 watts output. This amp was clearly the most powerful Darling, but there was definitely a diminishing-returns limit being reached : the amp had little of the delicacy and precision of the smaller amps, in fact it sounded a bit rough. This was despite the apparent top-end extension provided by a pair of classy One Electron UBT-1 output transformers.

I'd have liked to hear these trannies in another amp, but we had so many amps to audition, that we couldn't do all the clip-lead testing we wanted to do. There is material here for at least another day's listening, what with power supply variations and iron tasting and whatnot.. I wondered if this 3.5 model was perhaps fighting ultrasonic parasitic oscillations with its massively-parallel processing, and Bob wondered the same thing. Anyway, this design needs some more work before I would give it the go-ahead as a recommended project. At 3.5 Watts I would give the nod to a 2A3-based amp, which would be much simpler to build.The 3.5 was easily the most "psycho' DIY unit : 16 tubes is a lot to pile on top of a chassis, even one painted in a demented purple-with-white-polka-dots-and-black-blood-dripping-down color scheme. (MADD: Mothers Against Drunk DIY.)

The last Darling was actually housed in the chassis of Bob's first experimental model. It's now parafeeding some cool, octagonal UTC line matching transformers and uses a 12SL7 SRPP driver. The para-darling was popular but I myself had some reservations to me, this amp brought the music back into the speaker box much more than the others had done and its image had less depth to my ears. However, “Anna” thought the soundstage it threw up was particularly wide. It seemed to be about the equal of the


B+
(265V)
Lout
Allied
Interstage
10K:10KCT
Allied
Interstage
10K:10KCT
Rout
Antique
Nickle
Interstage
10K:90KCT
Lin
Rin
Antique
Nickle
Interstage
10K:90KCT
V3
1626
V1
1626
V2
1626
V4
1626
Rk34
500
5W
Rk12
750
5W
Ck12
470uF
25V
Ck34
470uF
25V
1626-Drive-1626 Amplifier
Bob Danielak 8/11/99


B+
400V
T1
4.8K
Primary
15W
Brown
Red - N/C
Blue
5
1
R - IN
Rp1
47K
2W
125V
1,5,6
7
VT1
8532
3
5
VT2
1626
Rg1
100K
2
1.1V
Ck1
470uF
16V
150V
Rk1
180
Ck2
200uF
200V
8
Rk2
3k
10W
Rb1
100k
Htr.
Bias
Rb2
100k
B+
400V
T11
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Primary
15W
Brown
Red - N/C
Blue
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L - IN
Rp11
47K
2W
125V
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7
VT11
8532
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"DC Darling" Stereo SE Direct Coupled Amplifier
A
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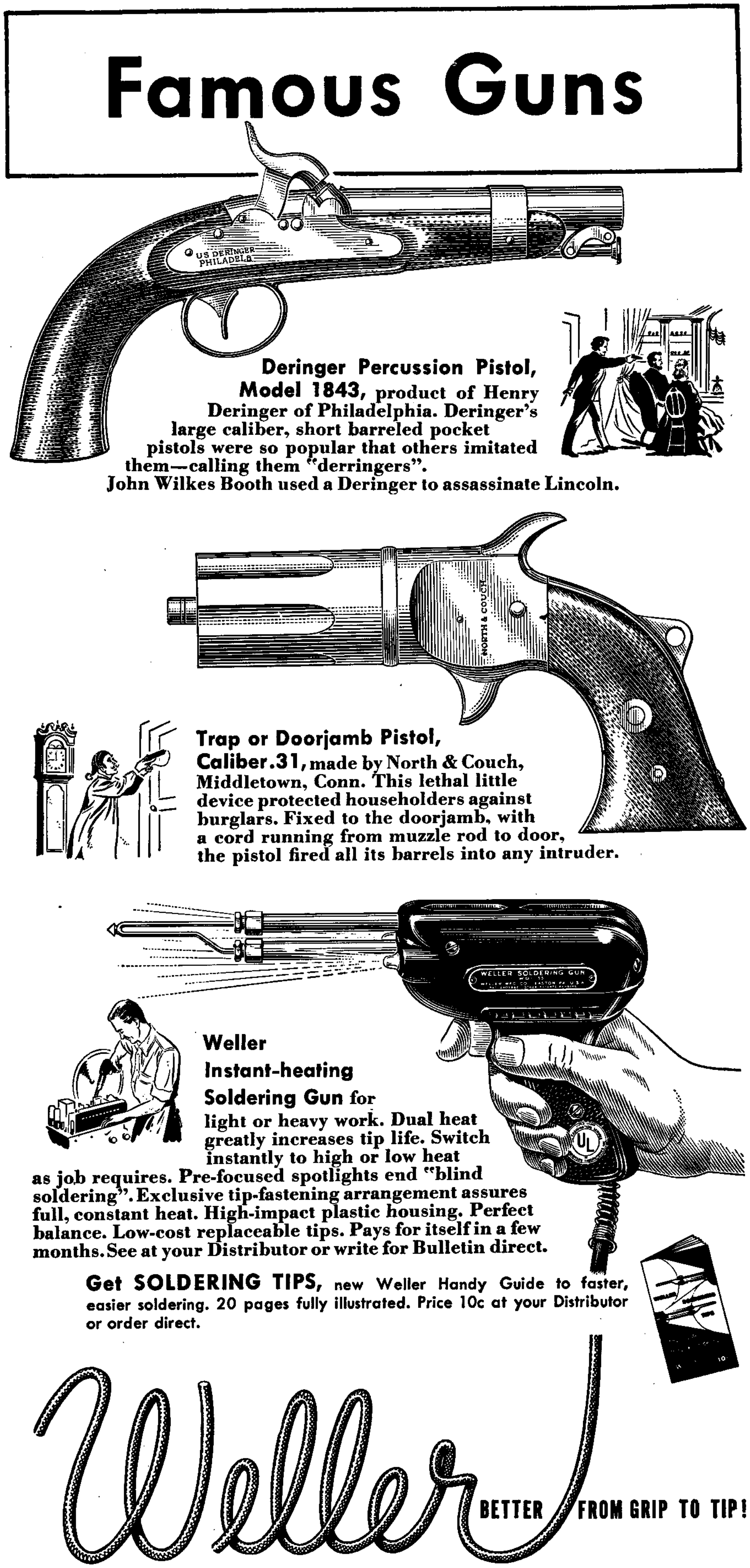
1 OF 2



Sakuma-darling in its ability to play loud.

For dessert, I set up the DC-coupled 2A3 amp I recently finished, and it worked well to show what the Darlings did and didn't do well. My DC 2A3 is truly a child of the Internet: I got a nifty hum-reduction circuit from another e-mail pen-pal, Steve Bench, and used info about a "tuned choke" LC trap for the power supply which I gleaned from the rec.audio.tubes USENET newsgroup. I ordered parts from Angela Instruments' and Fair Radio's web sites, and e-pal Bob schmeered me with the Chinese 2A3's and the ceramic sockets for my Johnson—don't try *that* at high voltages!!

The 2A3 was clearly "big brother." I used AudioNote T-144 output transformers, which allowed for a bit more top and bottom extension as compared to the cheaper Hammonds and Champs. The 2A3 put out somewhat more power, but some of the Darlings imaged every bit as well as this sweet DHT, sounding just as liquid and as smooth. "Anna" had a sublime bit of software which sounded spectacular through this setup (it would have sounded transcendent through an AM radio, too): a 45-RPM test pressing of the Dallas Symphony playing Rachmaninoff's "Symphonic Dances For Orchestra," recorded in 1967, clearly using no compression and a simple signal chain. Wow!

I had been 5th row center at Avery Fisher Hall the night before and I think her system sounded better than a real event in some ways. Much better imaging—the recording is fairly dry which made for beautifully precise placement of instruments. The tonal balance was as close to perfect as I can recall hearing over a playback system.

Dynamically, well, at one point I just muttered, "Dang!" as the full orchestra hit a powerful accent, which sounded very crisp indeed.

(An aside : a personal highlight of that visit to Avery Fisher Hall was when I pointed to the photo of Mr. Fisher that graces the lobby, and asked my wife if she knew what he had done to amass the fortune that had made his philanthropy possible. The look on her face when I told her that he built tube amps was priceless.)

At the very end of the night, the diehards who were still left tried biamping the speakers. Our first attempt, with a Darling on top and a couple-hundred-watt BEL SS power amp on the bottom, didn't quite work.We had no means of balancing the two and of course the Darling played way too loud for the BEL to keep up. (Yeah, right.)

We tried the Darling on top and the 2A3 on the bottom: this did balance better. But by the time we got to it, I was no longer capable of listening critically enough to say whether it was a step forward or not.

At that point we reluctantly decided to pack up and say our goodbyes. Our hostess with the mostest was misty-eyed to see us go without at least leaving her some gear to remember us by. As an event, it was a big success: one guy who had driven four hours to get there never lost the big grin on his face all day. There were some great hammer-and-tongs tech discussions, with plenty of new ideas to keep all of us busy for many months to come.

I find it very gratifying to get out of my workshop and off of my computer, and to meet some of my colleagues in the flesh :we have a lot of fun together, and it makes me feel like a little less of a geek. Or at least like a geek among geeks!

Here is a summary of the listening lineup, with some circuit details :

1) The original Darling (octagonal chassis, as seen in Sound Practices #15) : 8532 driver, 1626 final, Hammond 125E output transformers.

2) The red (evil twin of the green) Darling : same circuit but slightly different power supply.

3) The Double Darling : 6SN7 driver, 2 x 1626 final, 125E OPT's. 6BY5rectifier.

4) The convertible, copper-top Darling, set up as 8532 driving 1626, 125E OPT's. Dual power transformers in parallel.

5) The convertible, set up as 8532 driving 12V6.

6) The DC Darling (or "Monica" - it also goes around naked) 8532 DC coupled to 1626, 125E OPT's. The direct-coupled driver affords slightly more gain than the cap-coupled original Darling design.

7) The DC Double Darling (or "Leo" : Fender "Champ" OPT's, Fender

Stratocaster jack hardware) 8532 DC coupled to 2x 1626, "Champ" OPT's. 5AR4/GZ34 rectifier.

8) The "Darling 3.5." 3 x 8532 driver, 5 x 1626 final. Three parallel power transformers, One Electron UBT-1 OPT's.

9) Sakuma-Darling, AES "Nickel Wonder" IT in 3:1 step-up configuration -1626 - Allied 10K:10K interstage - 1626. 125E OPT's.

10) Para-Darling, 12SN7 SRPP driver, 1626 final, parallel fed to UTC line-matching trannies. Voltage doubler power supply.

That was it for the Darlings. Then :

11) DC 2A3 : 8532 DC-coupled to 2A3, AudioNote T-144 OPT's. 5AR4 rectifier, Steve Bench's hum-reduction diode circuit, "tuned choke" power supply filter.

12) Biamp, green evil twin top, BEL SS power amp bottom.

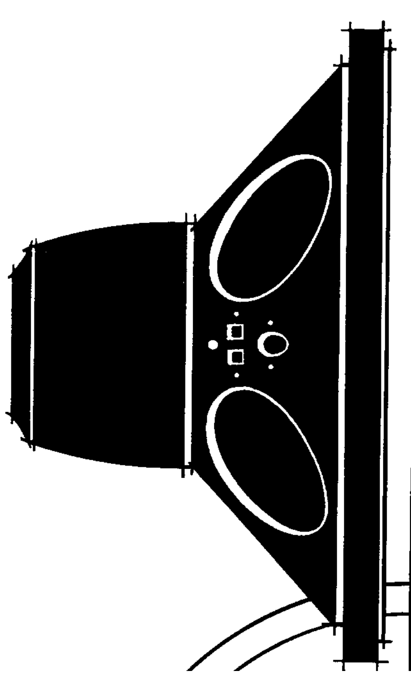
13) Biamp, octagonal Darling top, DC 2A3 bottom.

14) Green evil twin (identical to red evil twin.)

Quite a day!!

Thanks to Zelda at Clippy's 92-hour Photo Finishing for her assistance, to all the participants in the JoeNet for the ongoing education, and to Bob Danielak for being both way out in orbit and right down to earth.

We would all like to thank AnnaLogg and the NJAS for theirhospitality and for making this get-together such a success. See you at nyNoise 2000!"



A Homebrew HORN for TANNOY Dual Concentric Loudspeakers

by ROY HILSLEY

Reviving a 1960s classic…

I consider myself to be very lucky. My father introduced me to hi-fi when I was a teenager. That was over forty years ago! In those days audio electronics and hi-fi was very much an experimenter's hobby and my father loved to put electronic components together to make all manner of things. He built our amps, tuner and speakers—first for mono and then stereo. He even built our first TV set!

The early hi-fi shows in England were held at the Hotel Russell in London and we would visit to look, see and hear the latest audio innovations. My father was a music lover and could play the piano. He knew what sounded natural. At one of the shows he was so impressed with the sound made by one particular manufacturer that he ordered a pair of the speakers at the show. They were Lowther Acoustas (with PM6A magnets). These little gems were fast and very dynamic and we lived with them for several years but Dad always complained that they lacked really deep bass.

We fired them up with a Beam Echo pre-amp and a home brew Mullard 5-10 amp. This was a push pull EL84 ultra linear design. Great sounding design (based on the Leak Stereo 20) which he used with these speakers for several years until the Lowther surrounds deteriorated and he got fed up with adjusting the magnet to prevent periodic voice coil interference.

He was by then firmly committed to the sound of horns and he decided to try another approach using Tannoy dual concentric drive units. These very novel speakers have a horn loaded HF unit concentrically mounted within a large bass driver. They were made in three frame sizes: ten inch (called III LZ), twelve inch and a mighty fifteen inch unit and were supplied with a separate crossover. Tannoy units could be mounted in horn loaded or reflex cabinets and plans were available from Tannoy. My father bought two III LZ drivers for a horn loaded speaker project. Unfortunately, he never got 'round to building those speakers.

Many years passed and when I cleared out the old house, I came across these drivers and they captured my imagination. Those old units looked like new and yet were over 35 years old, but somehow the design looked right with the pepper pot drillings at the throat of the HF horn and the substantial cast frame.

I was at the start of the trail of audio simplicity and rebirth. I had owned typical hi-end British made transistor based hi-fi for many years and was listening to inefficient milti-driver speakers. They were, however, lifeless and had no

dynamics. Yes, I am sorry to say that I had become a victim of the press hype.

Dad had managed to collect all sorts of audio "junk" over the years and during the course of trading this at a vintage audio store in the UK I discovered that the industry was being revolutionized by the experimental amateurs again. Valves were back. Minimalist SE designs were advocated. Horns were being rediscovered. I discovered *Sound Practices*.

I started using a modern push pull valve amp for a while and then decided to build a pair of SE amps to my own design, 417A, 6J5GT transformer coupled to a VAIC 300B. Next came a home brew phono pre-amp (similar to the Siren Song) and what joy. The transition from high feedback transistor designs to no feedback valve designs revitalized my record collection and gave me so much more music and much more pleasure. The fun I had making changes then listening and making changes again.

After a while I became satisfied with the amps and I decided to try horn speakers. I started by trying a vintage pair of Lowther Acoustas. I loved the speed and life but soon became dissatisfied with the bass.

I decided to take up the project which my father had not managed to complete. I studied plans for the Acousta published in *SP* and I looked at the cross sectional plans of the well-respected Tannoy GRF enclosure published in old copies of *Hi-Fi News*. These designs gave me some ideas.

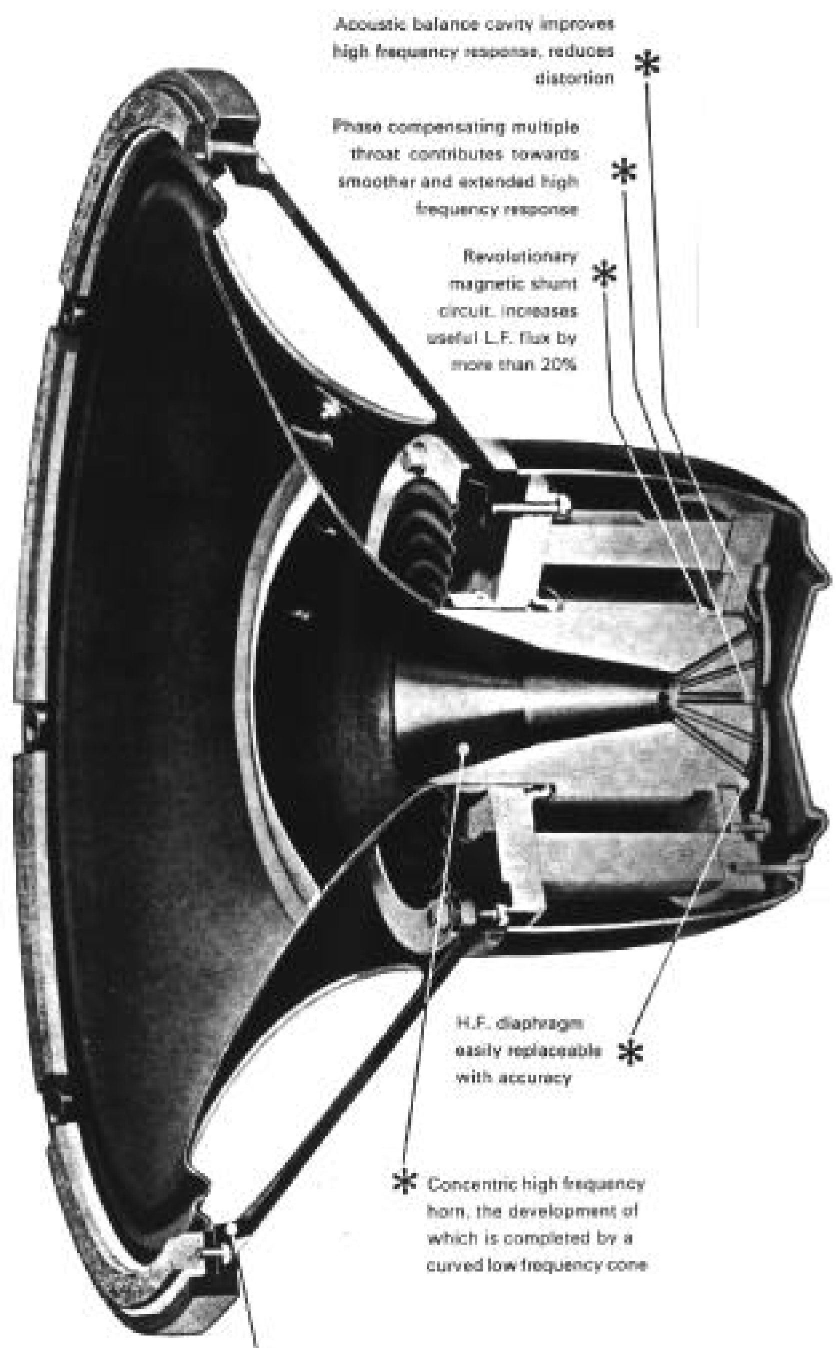
I wanted the efficiency and projection of horn loading, but with deeper bass, but I also wanted the cabinets to be dimensionally acceptable and wife friendly! The ideas crystallized into the cabinet shown in the photograph and illustrated in the sketch plans. The design is not theoretically founded on a particular horn flare. I adopted an empirical approach. I listened to, studied and measured other horns and based my design on what might look right and work. The plans are given as a basis for you to try a simple-to-build horn enclosure for Tannoy dual concentric units. You are free to experiment and improve or modify.

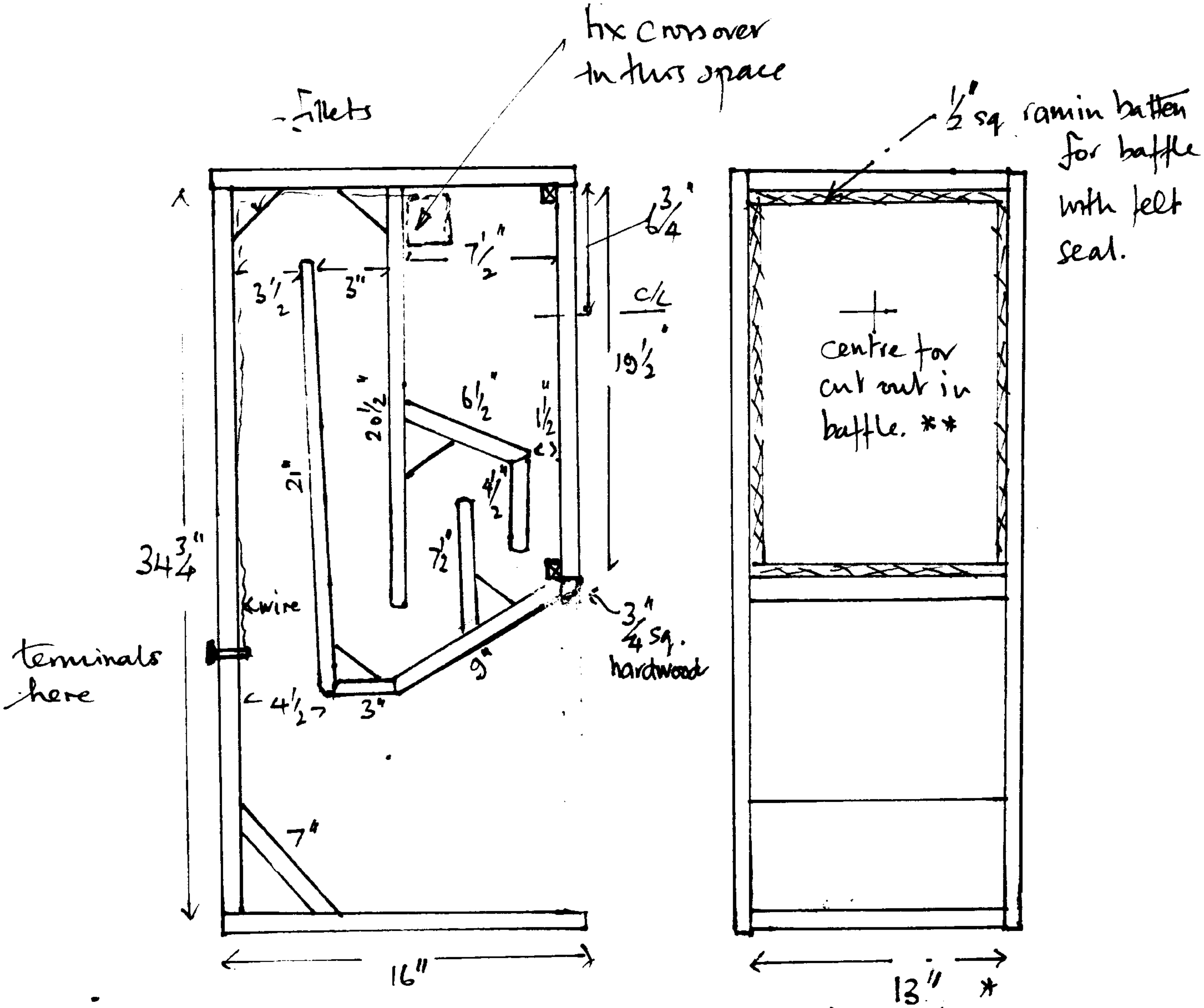
Cut the wood to the sizes shown. I used veneered plywood. There are two cabinet widths possible. One for the ten inch units and another for the twelve inch units. Assemble the top, bottom, rear and inner panels to a side panel. I used a "filler" type of fast-setting mastic glue. Do not glue the front baffle and remember to run internal speaker wires.

Make sure that the horn is airtight. Make the bass horn throat about half of the area of the bass cone. Glue liberally and smooth internal folds with glass paper (sand paper)as well as you can before you fix the second side panel. Make the front panel baffle airtight by using a gasket made of thin felt glued to the internal batten. Screw the baffle to the internal batten with about eight brass countersunk wood screws. Fit the crossover in the space shown on the plan. When construction is complete, sand down all external surfaces, oil and polish to suit.

When the glue is set and the polishing done fire them up—you will not be disappointed! You should be listening to deep tuneful bass with a solid image and good projection. The Tannoy HF horn will give you a clean midrange and top end projection. These speakers are efficient so you can drive them with your 10 watt or so valve amps.

In comparison to the Acoustas, you will hear deeper bass without the characteristic mild "honk" which I think the Lowther cabinets have. These Tannoy horn speakers have less of a "hot seat" stage as an added benefit. They are not particularly sensitive in respect of placement and I turn them in just a little and use them about a foot from the wall for best effect in my room.





* wide for 111LZ unit

13 3/8"

* wide for 12" unit.

Materials

side panels = 18 mm

top, bottom, baffle = 14mm

internal = 12 mm.

all fillets = 4 mm.

** cut out hole in baffle 9" ϕ for 111LZ
11" ϕ for 12"

Plan for Homebrew Horn for Tannoy Dual Concentric Speakers

RWH Sept '98

Tannoy "Monitor Gold" Specifications

	"FIFTEEN"	"TWELVE"	"III LZ"
Frequency response	23—20,000 Hz.	25—20,000 Hz.	27—20,000 Hz
Polar Distribution for 60° inc. Angle	–4dB at 10,000 Hz.	–3dB at 10,000 Hz.	–2dB at 10,000 H.
Power Handling Capacity	50 watts*	30 watts*	15 watts*
Impedance Via Crossover Network	8 ohms (5 ohms min.)	8 ohms (5 ohms min.)	8 ohms (5 ohms min)
Flux Density L.F. Gap	13,500 gauss	11,500 gauss	10,000 gauss
Flux Density H.F. Gap	18,000 gauss	15,000 gauss	15,000 gauss
H.F. Voice Coil Diameter	2"	2"	2"
L.F. Voice Coil Diameter	2"	2"	$2\frac{1}{2}$"
Intermodulation Products	less than 2%	less than 2%	less than 2%
Bass Resonance	26 Hz.	28 Hz.	30 Hz.
Magnet Assembly Weight	13 lb.	$7\frac{1}{2}$ lb.	$6\frac{1}{4}$ lb.
Magnet Material	Ticonal G	Ticonal G	Ticonal G
Crossover Frequency	1,000 Hz.	1,000 Hz.	1,200 Hz.
Overall Diameter of Frame	$15\frac{1}{4}$"	$12\frac{3}{8}$"	$12\frac{1}{32}$"
Overall Depth	9"	$7\frac{1}{2}$"	$6\frac{1}{2}$"
Fixing Holes P.C.D.	$14\frac{1}{2}$"	$11\frac{3}{4}$"	11"
Weight: (Crossover network & Switch panel as separate units)	21 lb. 13 ozs. (crossover 4 lb.)	12 lb. (crossover 4 lb.)	10 lb. 4 oz. (crossover $3\frac{1}{2}$ lb.)
Finish: Cover	High impact plastic	High impact plastic	High impact plastic
Frame	Stove enamel	Stove enamel	Stove enamel
Magnet Assembly Parts	Cadmium plate	Cadmium plate	Cadmium plate

Second-order Harmonic Distortion Cancellation in the SE Amplifier: Is it a sound practice?

by Ivan L. Johnston

...or is it distortion of distortion?

I've been struggling with this question since having first read about it in *Glass Audio* 4/96 (*Harmonic Cancellation Improves the SE Amplifier*).When I designed my PSE 845 Power Amplifier, I considered using second harmonic (H2) cancellation between the driver and output stages. Intuitively, increasing the distortion of any stage within an amplifier just did not sound like a good idea, and preliminary measurements during the prototyping of the first two stages confirmed my suspicions.

For those who are not aware of what I mean by H2 cancellation, I am referring to the practice of intentionally pre-distorting the signal at the driver stage, such that the second harmonic distortion that is produced by the output stage is canceled. You will find several articles in recent and not so recent issues of *Glass Audio*, touting the benefits of H2 cancellation (4/96: *Harmonic Cancellation Improves the SE Amplifier*, 5/96: *A 15W SE Amplifier With 6C33C-B* , 2/98: *A Pspiced Preamp With THD Cancellation*, 5/98: *Canceling Harmonics in SE Amplifiers*). The driver stage is typically either loaded down to increase the distortion, or the bias is intentionally mis-adjusted such that the H2 at the output of the amplifier is minimized. The distortion that is generated by the driver stage should most correctly be referred to as "complementary distortion",since it is simply the same form of distortion as that produced by the output stage, but out of phase. This should not be confused with inverse distortion, which is an entirely different subject.

Attempts to quantify the affects of H2 cancellation based on measurements made using real-world hardware have proven frustrating. It was easy to see what happens with a single test tone, but IMD tests indicated that there was what could best be described as a dirty noise floor over a large band of frequencies, which is difficult to quantify using traditional measurement techniques. Measurements are also limited by the dynamic range of the instrumentation, which for an HP3561A Signal Analyzer is about 80 dB. It has been suggested that distortion artifacts that are as much as 30 dB below the noise floor of an amplifier may have a significant influence on the perceived quality of sound produced by the amplifier.

In order to get a clear picture of what is going on beneath the noise floor, I decided to arithmetically model a simple two stage amplifier and analyze the results using various configurations for the driver stage. Rest assured, however, I will not be presenting a lot of complex equations involving high-order polynomials and Fourier analysis, the simulation model and the results are presented in a relatively easy to understand graphical form.

The model for each amplification stage is based on a polynomial. There are two coefficients in the polynomial that are adjusted as necessary to establish the desired amplitude of the H2 and H3 distortion products. Real triodes also generate higher order harmonics, but I do not think that this will invalidate the model or the results, since the higher order distortion products generated by triodes are typically very low. I considered using a higher order polynomial, but I could not find any published data showing the relative amplitudes of the higher order distortion products for the 300B. The noise floor is artificially created using a random number generator to produce Gaussian white noise. The same seed value is used for the noise generator in each of the simulations, so the background noise floor is identical in each case. Each amplification stage provides unity gain, so this eliminates errors that could be attributed to different amounts of gain in successive stages. All in all, I consider this to be an optimum environment for exploring the potential of each system topology.

Figure 1 illustrates block diagrams of the two models that were analyzed, the Two-stage Amp With a Linear Driver and the Two-stage Amp Utilizing H2 Cancellation. The output stage is exactly the same in each model. The output stage models the characteristics of a 300B operated with 350V from plate to cathode, 60mA of standing current, and a 3K Ohm load impedance. This is your typical 8W 300B output stage. The distortion values

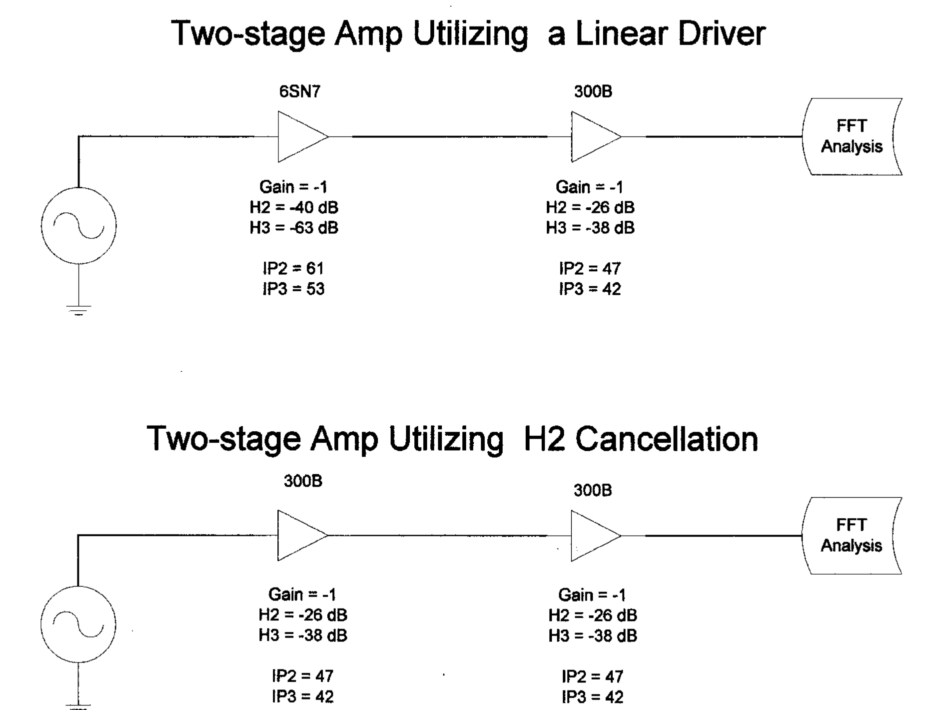


Figure 1—Block diagrams of models under analysis

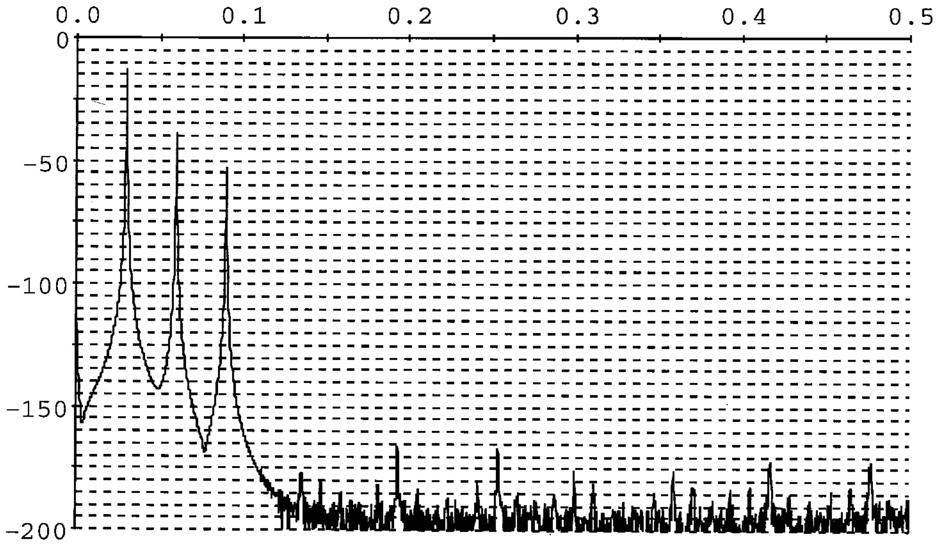


Figure 2—300B, one tone sinusoidal input

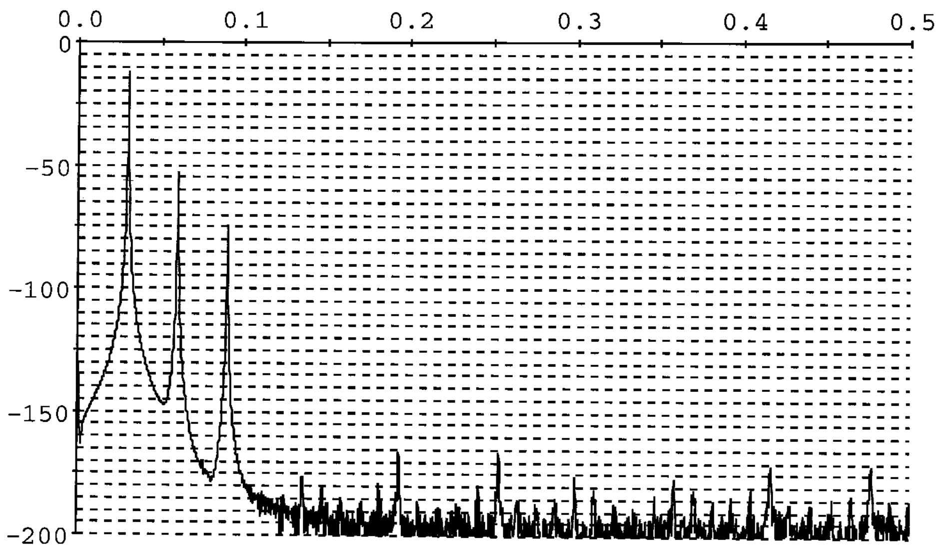


Figure 3—6SN7driver, one tone sinusoidal input

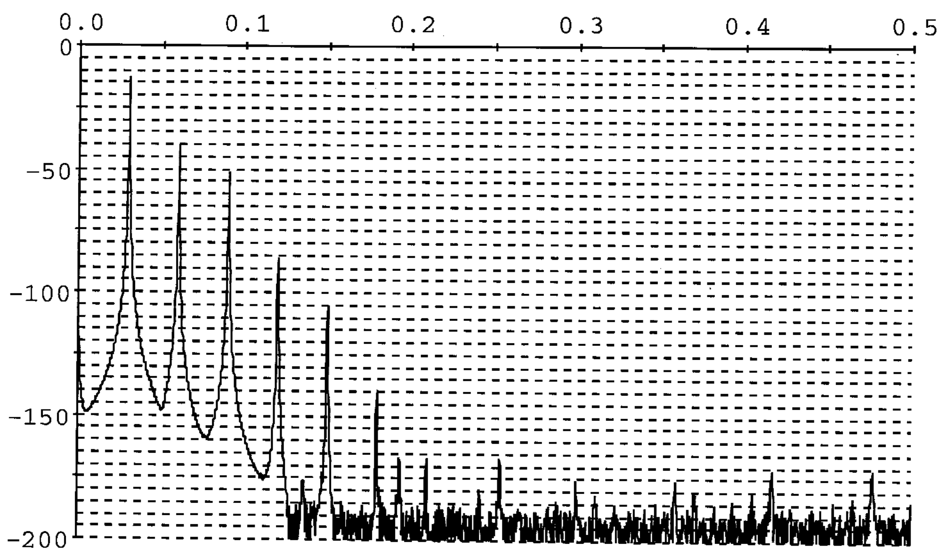


Figure 4—Two-stage amp , linear driver

(H2=–26dB and H3=–38dB) and operating points were taken directly from the Western Electric data sheets. Figure 2 illustrates the response of this stage, with a sinusoidal test signal applied to the input.

The driver stage for the first model simulates the characteristics of the 6SN7 used with transformer coupling and a cathode resistor bypass capacitor. The distortion figures for this stage (H2=–40dB, H3=–63dB) were taken from Lynn Olson's excellent article that appeared in *Glass Audio 4/97* (*Sound of the Machine: The Hidden Harmonics Behind THD*),and represents the distortion of the driver stage at 50Vrms, which is just sufficient to drive the 300B output stage to full power. Figure 3 illustrates the distortion characteristics of this driver stage, again with a sinusoidal test signal applied to the input.

The driver stage for the second model, the model utilizing H2 Cancellation, utilizes the 300B model for both the driver and the output stage. This is representative of using a 300B to drive a 300B, with direct coupling and the exact same load impedance for both stages, the theoretical optimum application of complementary distortion.

The plots of the results were made by performing an 4096-point Fast-Fourier Transform (FFT) on the output of each model. I used a Hanning function to compensate for the bin spreading that results from the finite number of samples that are processed by the FFT, so the results are quite accurate. These plots are analogous to what you would see on a spectrum analyzer. The x-axis represents frequency relative to the sample rate, which in this case is 100kHz, so the x-axis value of 0.1 corresponds to 10 kHz.The y-axis represents the amplitude on a logarithmic scale, so the measurements are in decibels (dB) relative to an arbitrary reference.

Let us first examine what happens when a single tone is processed through these two different amplifier models. Figure 4 illustrates the spectrum of the output of the first amplifier model, with the linear driver stage, reproducing a single test tone. Notice that there are distortion products extending to the seventh harmonic. How can this be, the model of each amplifier stage only produces H2 and H3? The answer is simple, the H2 and H3 produced by the driver stage are turned into H4 and H6 in the output stage, and the H5 and H7 are intermodulation distortion (IMD) products. These higher order distortion products are literally "distortion of distortion." Figure 5 illustrates the output of the model using the non-linear driver stage. As expected, you can see that the H2 level has been reduced approximately 25 dB. There is a price for this reduction in H2, however, note the large increase in the higher order harmonics. The H3 has been increased by 6 dB (6 dB is a doubling of the distortion!), the H4 has increased by 6 dB, the H5 has increased by 22 dB, the H6 has been increased by 34 dB, and the H7 has been increased by 42 dB.

Figure 6 and Figure 7 illustrate the results for the two models when simulating a two-tone intermodulation distortion test.Notice how the IMD products rapidly fall-off for the model using the linear driver stage. Close examination of the IMD products from the model using the non-linear driver stage, Figure 7, shows that there is suppression of some of the IMD products that are close-in,but again there are now IMD products that extend much higher in frequency.

Conclusion

I believe that Chapter 14 of the *Radiotron Designers Handbook* should be required reading for everyone involved in audio amplifier design. Langford-Smith discusses some studies performed by Olson and Shorter, in which it was found that the higher order harmonic distortion products should be weighted, in order to make these measurements correlate with subjective listening tests. Olson's study suggested a weighting factor in which the measurements for each harmonic should be multiplied by the harmonic number, while Shorter's results suggested that the measurements should be multiplied by the square of the weighting factor!

Clearly there is a price for the reduction in H2 that the cancellation technique provides. The third and higher order harmonic distortion products that are generated by the driver are additive to the third and higher order distortion products that are generated by the output stage. By directly additive, I mean that the percentage of each harmonic at the output of the amplifier (excluding the H2 component) is approximately the peak sum of the distortion produced by the driver and output stages, not the RMS sum.The THD (the sum of all the harmonics taken as a whole) is always the RMS value of all the harmonics, which is why you end up with a lower THD measurement when you cancel out the large H2 component.The IMD test results are more difficult to interpret,but it is fair to say that there are more IMD products generated when using the non-linear driver stage,

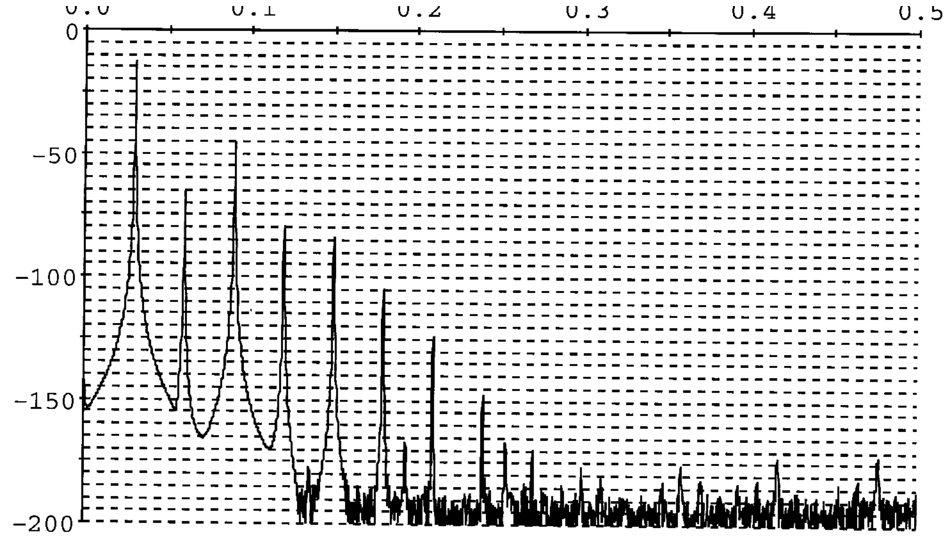


Figure 5—Two-stage amp, non-linear driver

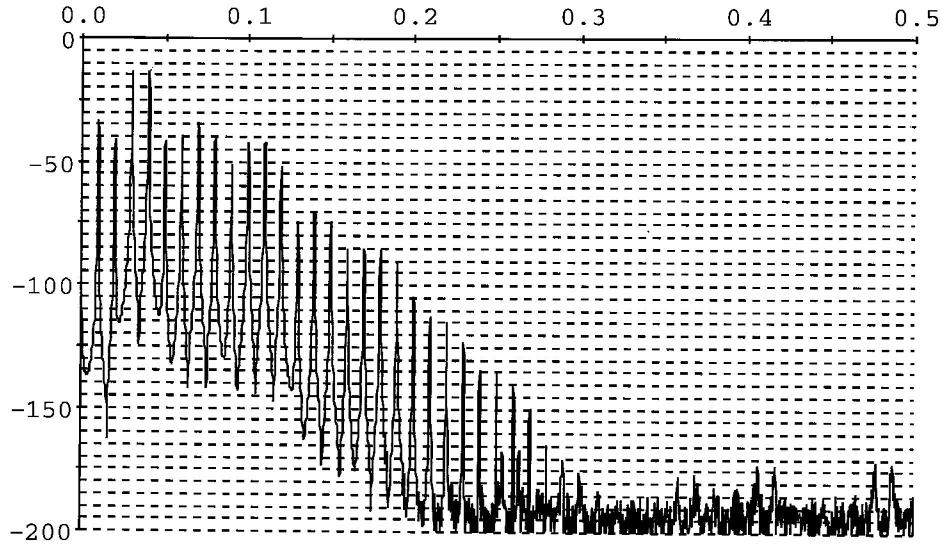


Figure 6—Two-stage amp, linear driver, two tone test

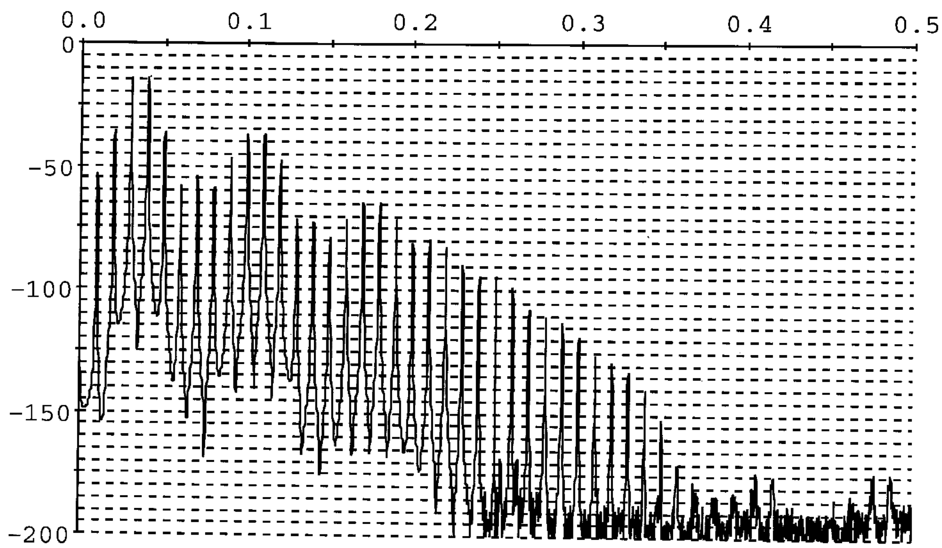


Figure 7—Two stage amp, non linear driver, two tone test

although there is a reduction in the amplitude for many of the close-in IMD products. To some extent, the IMD products are spread out over a larger frequency band when the non-linear driver stage is used.

Ultimately, each of us must choose what sounds best,as that is the bottom line. I have experimented with H2 cancellation using my own hardware, using test equipment to setup the driver stage with enough distortion to cancel the H2 at the output of the amp. It is very satisfying to achieve extremely low THD measurements with a single-ended design without using negative feedback, but are we measuring the right thing? After critical listening, I have concluded that for my ears, in the context of my system, a linear driver stage sounds better, despite the higher measured THD. I find that the difference is most notable when reproducing piano music and female vocalists. With a linear driver stage, the notes of the piano smoothly decay into a black background. When the highly non-linear driver stage is used, there is an edge of graininess that is clearly audible as the piano notes decay. There seems to be less space between the individual notes. The sound of some female vocalists can change significantly, to me there seems to be an edge added to some voices when the non-linear driver stage is used. Do not take my word for this, listen for yourself. I have always subscribed to the theory that SE amplifiers sound good in spite of the high levels of low order distortion, not because of them.This leads me to conclude that the reason they sound so good is the relative absence of high order distortion products. If this premise is wrong, if SE amplifiers sound good because of high levels of euphonic H2 distortion, it could be that the change for the worse is the result of the reduction in H2,and not the increase in the higher order distortion products. Since the reduction in H2 is accompanied by an increase in the higher order distortion products when the H2 cancellation technique is utilized, it is impossible to isolate the effects.

The popularity of the single-ended triode amplifier, without negative feedback, is in my opinion largely due to the fact that there is no substitute for linearity at the device level. The concept is simple, build the amplifier using the most linear devices available, and use those devices in circuits that extract the full potential of those devices, eliminating the need for negative feedback. The current trend of using distortion cancellation,intentionally increasing the distortion at the driver stage, is very disturbing. In my opinion, those who are touting the benefits of distortion cancellation in SE amplifiers have gone full-circle. They have resorted to techniques that result in low THD measurements, for specsmanship, at the expense of musicality.

About the Author :

Ivan has over 20 years of experience working with electronics. He is presently a Senior Engineer at Interstate Electronics Corporation, Anaheim CA, where he designs signal processing hardware and software that is used in military Global Positioning System (GPS) satellite receivers, and missile tracking systems. In his spare time, Ivan designs and hand-crafts custom preamplifiers and power amplifiers, and he regularly gets out to listen to live jazz at various venues in Southern California. You may contact Ivan at the following address:

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Caligula Incarnate!

Burning down the house with PP Parallel 6080s

by Jim Carlyle of Auckland, NZ

...Or was that Nero?

The mad emperor! Or was I just mad to build it? You be the judge. For $NZ1100 (US$550) I have a 4W/25W 80lb all-triode, genuine class-A, zero-feedback highly-resolving amplifier. And the 4 watt mode drives 86db/Watt Magneplanar MGIIIa's (tri-wired) in my 24' x 16' x 8-1/2' room just great. Use the 25 watt mode for a real blast. Impossible? The secret? Well, the sixteen output triodes slide into class AB, then AB2, then B as you crank it. Disgusting? Actually overload is extremely gradual on music, although 4W/25W is all you get on a sine wave test.

Forget about 845's, 300B's, 2A3's, 10's. Buy a dozen same-brand 6080's for $60 (total, not each!) and select eight so that two pairs give similar totals (left side push and pull) and the other two pairs give their totals similar (right side push and pull). This tube is the lowest mu triode in the universe (mu = 2) which results in the hugest available peak plate current swing *without needing grid current*. Say good-bye to driver transformers, low grid circuit impedance, class A2, and Miller Effect. Welcome in low plate impedance and high intrinsic speaker damping.

Problems? Yes, there are. Two in fact. First, these triodes have such low impedance that some specimens act like diodes, and start thermal runaway under fixed bias in 25W mode, when new. Put them aside out of your dozen. Secondly, these triodes need HIGH voltage grid drive. Feed your driver 6SN7's around 600 to 800 volts from a slow-turn-on 5AR4 FWBR with silicon diodes on the earth legs. Easy. Safe. Cheap. Effective.

Do I see heads shaking: "what about linearity?," meaning even spacing of plate current curves. Few people know that the 1950 RCA Tube Manual included a class-A zero-feedback 6AS7 circuit, with distortion versus power curve showing 2% at full power!

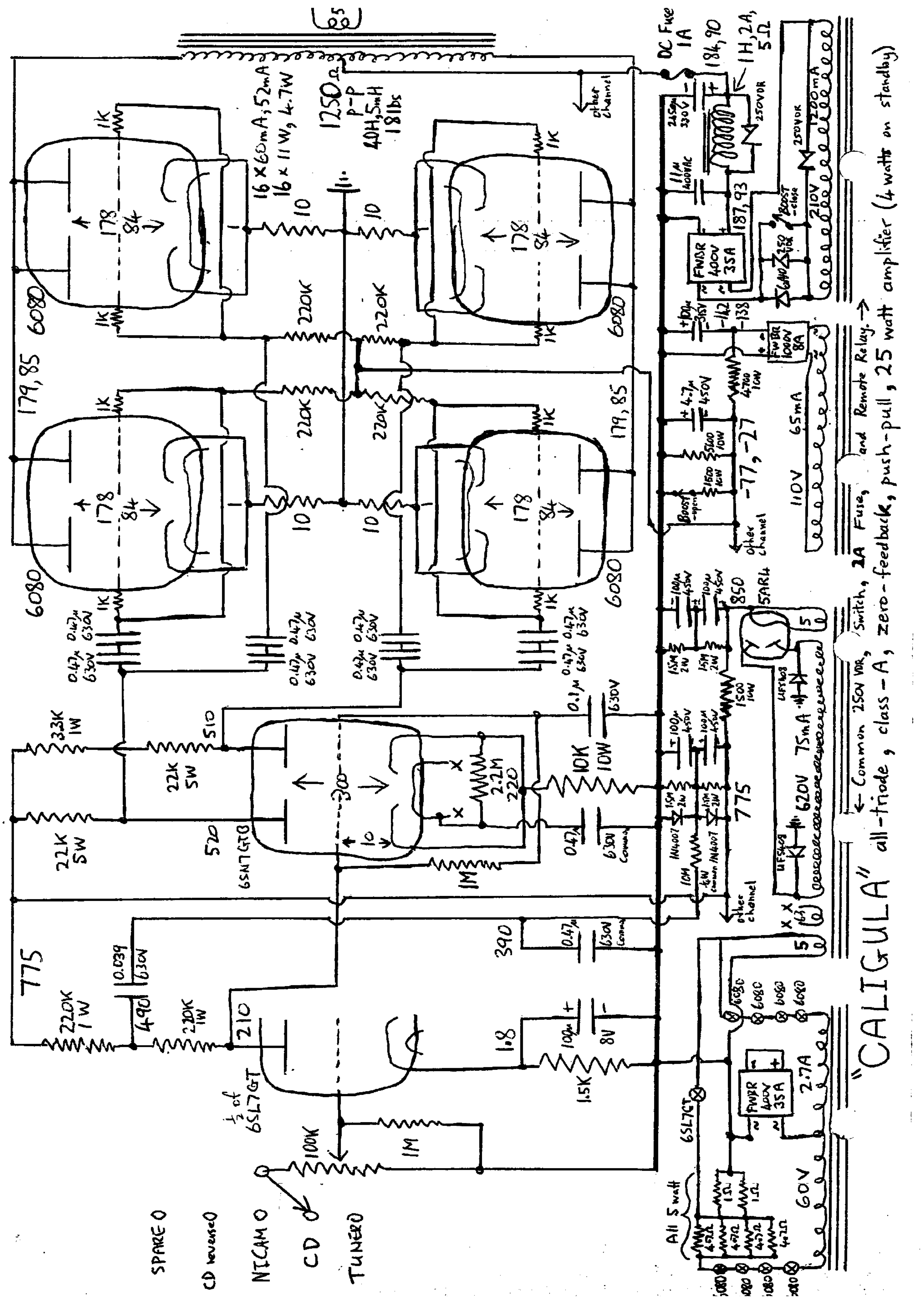
Do I hear, "what about single-ended mellow?" Having built amps and speakers since 1958, and passed a B.Sc. Radiophysics, and bought a 300B SE II with oil caps on Broadway New York in 1997, I can *assure* the fanatics that S.E.'s magic is simply gobs of 2nd harmonic distortion totally *masking* digital nasty distortion. Yes, MASKING is a deeply-researched phenomenon. The SE 300Bs lasted two days with me. Sure they made all sources sound inoffensive, but I prefer to hear all the detail. Oops. Honey, the editor just canned the article.

Here in Auckland (pop. 1 million), New Zealand's largest city, I have been selling amps and amp kitsets on a modest scale. So far every visitor to audition has purchased one of my range, mostly using 6AS7/6080. My amps are named Minuet (6BX7), Sentinel, Chimera (EL84 ultralinear), Pizzo (807), Skyline, Bravura and Caligula (top model). But this article is free for non-commercial use. It's not so special anyway, but, as Don Garber of "Fi" says about his 2A3 amps (and I visited him in Brooklyn),"none have come back yet."

The basic circuit is simple, having only one capacitor position in the signal path. The 10Ω cathode resistors allow current checking by voltmeter probe if you ease the tubes half out for testing. Record the readings, do some arithmetic, then shuffle the tubes as described above. The power system looks a little dramatic, but is still minimalist. The bottom left 60VCT tranny plus resistors heats eight 6080 at 2.5 amps, with a shorted FWBR to restabilize it if one bank of 6080 is removed in scorching weather. Only remove circuit right bank.

A custom tranny of 50.4VCT would be simpler. The 6080 heaters are wired alternately around the chassis, so that deactivating four still leaves a push-pull stereo amp of half power in, say, severe summer heat. The unusual 6SL7 heater connection was simply expedient.

My main power tranny is a 230V/230V at 250W isolating unit, used backwards giving 210V output. The boost switch converts from half-wave choke input to FWBR choke input. Note that the 11uF paper capacitor (2x5.6) falls to zero voltage between pulses, effectively choke input...*He must be mad*...high signal slides the p.s.u. toward capacitor input causing the voltage to rise. Music sounds like about 10W/60W subjectively. During resting a 10uF electrolytic exploded, as expected. Must be paper/oil rated for 400V.A.C. to stand the high ripple.


"CALIGULA" all-triode, class-A, zero-feedback, push-pull, 25 watt amplifier (4 watts on standby)

Note also that the 6A10 diode has no reverse-recovery-ringing problem because the bridge diodes feed the choke positive current from ground after each pulse ends! Freaky eh? Current for nothing. The twin readings on the power amp circuit refer to boost, low settings respectively. Other power supply topologies could be used (e.g. 12.6V @ 10A for the heaters), but I found that anything over 200 volts caused too many tubes to go into thermal runaway on initial tests. Don't be scared off. If they are stable for three minutes when new and cold, they will never runaway later, because heat causes the supply voltage to drop slowly, even with a choke of only 5Ω cold. Simply measure all eight on "low", then put your probe on the highest one while switching to "boost". If the reading keeps rising beyond 1.6 volts (160mA through tube) then you have a runaway. The average should be about 20mA.

Note that the preamp/driver tranny rated at 310-0-310V full-wave at 125mA,like mine, but used as 620V *full-wave bridge*, derates to about 75mA as shown in the parts list.Also, a 5AR4 can take up to 1100 volts AC in bridge mode because the anodes do not swing negative.

Puzzled about the 0.039 capacitor? Don't ask. Just do it. It is my subtle 0.6db magic ingredient that helps give the selling sound. But there are no special quality capacitors or resistors here. Get your own.

The 18 lb. output transformers were a real saga.I visited Manhattan's Steve Berger representing Tango (Japan) and was shown some wonderful products. I visited Staten Island's Herb Reichert, who had just finished "The Feral Eye", and simply adores Tango. I also discussed an 1800 ohm to 8 ohm custom design with Jack Elliano of Electraprint Audio, Las Vegas, which would give me 1250 ohm to 5.5 ohm for the Maggies. Costs looked high when taking into account shipping to New Zealand.

I eventually realized that a local wiring guru here could do it provided I calculated the layers/gauge/turns/interleaving. Using the Radiotron Designer's Handbook 4th Edition, the design took a few hours trying wire gauges until everything fitted into the turns ratio, with no part-layers. Final amp performance is -1db at 6Hz and 16KHz.

You have to get down to 20Hz divided by your damping factor (3 in this amp),or your triodes start to suck big current before you reach 20Hz.A famous commercial product starts sucking at 60Hz.By 20Hz at full drive its 300B plate currents exceeded 140mA each, and climbing! Wimpy output transformers were the reason. It measured flat to 20Hz but sounded tuneless like a reflex speaker. Perhaps a later article could go more deeply into designing your own output trannies from the Radiotron charts and formulae. Size does matter.

Parts List for Caligula 6080 PPP

Hardware
22"x 13"x 24" chassis
Power lead and grommet
2 switches
Rotary switch
100k log ganged
2 knobs
4 RCA input panels
8 speaker posts
2 fuseholders
12 octal sockets
8 feet and screws
Wire, solid core
Coaxial cable

Transformers
210v@2.7A isolation trans
R-129 60V@2.7A
R-10 620V@75 mA,5V@3A, 6.3V@2A,5V@2A
R55 110V@65mA
Choke 1H@2A, 5Ω (mount with "I"s oriented toward the back of the chassis)

Outputs—1250Ω P-P to 5.5Ω,Pri L = 40H, Leakage=5 mH, PriR=47Ω, Weight=18lbs. 5 1/4 x 4.3/8 x 2 3/4" stack

Tubes/Diodes
6080 X 8
6SN7GTB X 2
6SL7
5AR4
FWBR 400V@35A X 2
FWBR 100V@8A
UFS408 X2
1N4007 X2
6A10
VDR 250V X 4

Resistors
1.5M@2W X 5
1M X 4
220k X 12
22k@5W X 4
10K@10W X 2
2.2k X 2
1500Ω@10W X 2
10Ω@1W X 8
10M@1/4W
1Ω@5W X 2
1.5k X 2
2.2M X 2
5600Ω@10W
4700Ω@10W
4.7Ω@5W X 4
1k@1/2W X 16

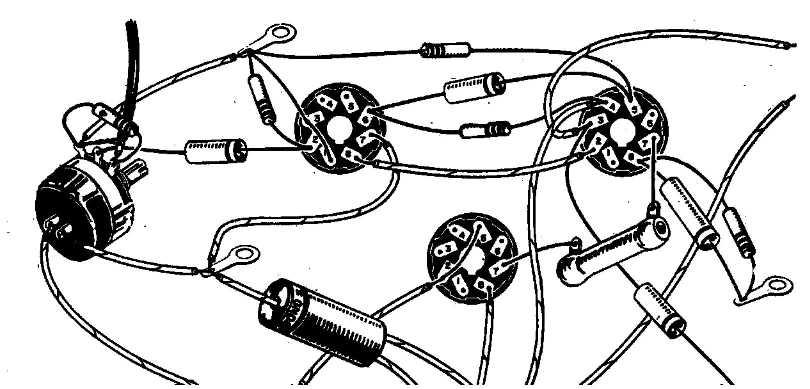
Capacitors
0.47µF/630V X 18
0.1µF/630V X 2
0.039µF/630V X 4
100µF/450V X 4
100µF/315V
100µF/8V X 2
2450µF/330V
4.7 µF/450V
5.6µF/400VAC Paper X 2

And now, saving the best 'til last: THE SOUND. Valve amps vary enormously, especially with zero feedback. This one is giving me stunning articulation of bass, highly resolved mids, and rather sparkly tops, certainly not recessed, but not too forward either. Customers like it,and so far the sales records 100%.What more can I say?

Notes on Circuit

Note that the 250VDR's prevent avalanche of the main rectifier during switching to "low". During bench testing, one punched-through to a dead short,caused by trying to switch off current through an inductor.

Note that the "boost"switch is "make"H.T., but "break" bias to be fail-safe in the event of a bad switch contact.This made the H.T. and bias time-constants impossible to match on both going-high and going-low. Do not increase the 4.7uF bias capacitor or your 6080's will briefly saturate when you switch to boost. Not healthy for emission.



SURROUNDED by TUBE SOUND

Part 1: The "Foz Reference" Phono Stage

by Jim Fosgate, Fosgate Research

The F*oz built 100+ phono amps*
…here are the two favorites

Many of you will be surprised to learn that I am a total "tube freak" as well as an audio professional. Tubes are where my heart is…I grew up on tubes working in my fathers Radio and TV repair shop in Indianapolis in the fifties. I remember building my own audio circuits back then with used parts, and circuits I found in Howard Sams *Photofacts*. My speakers were home made Jensen Imperials with Electrovoice drivers.

Like most people, I went "Solid State"when it came along. I remember wondering why my collection of records didn't sound as good as I thought they once did.I thought it was because my listening abilities had improved or my taste in music had somehow changed.

In the later Seventies, I invited a friend over to audition my system, a setup that I was quite proud of. This guy was a classical musician and tube listener. After listening for a while, his only comment was: "If you have a chance, you should listen to some tube equipment again." This stuck in my mind and one day at a garage sale, I found a Dyna Stereo 70, PAS Preamp, and FM-3 Tuner, for nine bucks, similar to ones I had once owned.The amp needed a 5AR4, and a fuse, but the tuner and preamp were working, so I decided to give them a listen.

I was really surprised! This old stuff was blowing my solid-state stuff away! My mind was boggled! My old records even sounded the way I remembered them. There was only one thing to do: sell all my solid state equipment,go back to tubes, and never look back again.

I started collecting old tube equipment, tubes, and parts when it was cheap to buy what most people thought was junk. I was afraid it was all going away, never to return again, and I wanted enough equipment to last a lifetime. I listened to many of these units and started building from circuits found in *Audio Amateur*, and other places. Back then it was necessary to use mostly used parts since today's tube renaissance had yet to occur.

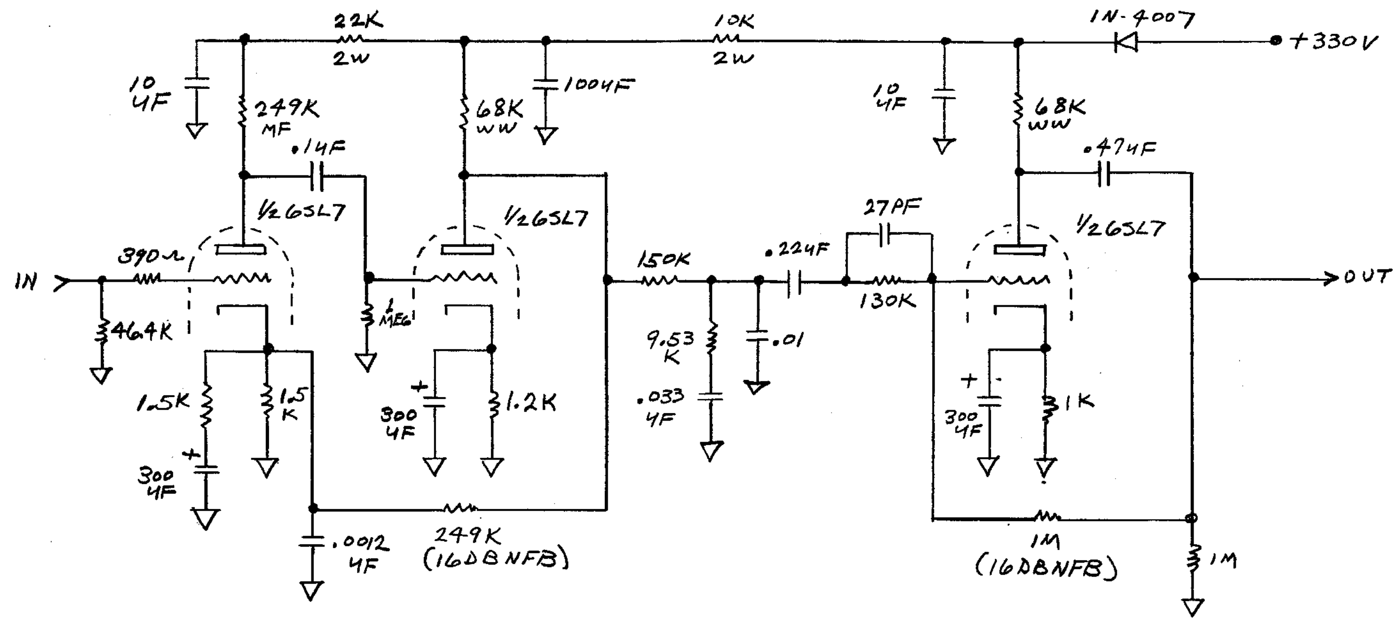
I built about all of the classic circuits and then started rolling my own. I was glad when *Glass Audio* came along because there were more circuits to play with. I built many of them, as well as circuits I found in *Sound Practices* when it came out. It's sure nice to see the revival of tube equipment and the availability of high quality parts again. It's a blast to see the ratio of Solid State to Tube stuff at the Consumer Electronics Show, about 80% tubes the last few years.

As part of my explorations, I built a pair of model WE 91 Single Ended 300B power amplifiers, which caused me to revise my ideas on the use of negative feedback.I tried several circuits with and without negative feedback to see what the relative benefits are. I found that the results can go either way, depending on the circuit and how the feedback is applied.One thing for sure, negative feedback is not a cure-all—sometimes the cure is worse than the disease, and it has been over-done more times than not. I believe that negative feedback *can* provide positive effects when properly applied to the correct circuit.

I realize that many SP readers feel that negative feedback is something to be avoided at all costs. To provide another point of view, I present the following three circuits, which I believe represent proper uses of the negative feedback concept,for your construction pleasure.

Keep in mind that negative feedback was always used to cut records. The stereo cutting head amplifiers have very effective motional negative feedback systems to cor-

The Foz chilling out in his well-appointed audio lab



PHONO PREAMP SIMILAR TO CITATION IV
10-10-99 JIM FOSGATE PASSIVE EQ, WITH FEEDBACK

rect nonlinearities in frequency response produced by the mechanical transducer. Cutting head armatures typically have a mass of several grams that must be accelerated up to hundreds of centimeters per second in a fraction of a millisecond, and this process may be repeated up to several thousand times a second.So, if negative feedback is a "totally bad thing," the record could not possibly sound as good as it does—no matter what we do in the phono preamp!

Two of these circuits are phono preamps, which represent one of the greater design challenges because of the low signal levels, the required 38db of RIAA equalization, cartridge loading problems, and so on. The other circuit is a simple line stage providing a low output impedance, without resorting to the conventional cathode follower topology.

What I want my system to do is "take me back to the original performance." Some of the circuits I've auditioned have a "sameness" in the sound that comes out on every recording—*that* is a coloration. I want to hear the recording, not a coloration.

Citation IV

Of all the phono sections I auditioned from the golden age period I liked the sound of the *Citation Model Four* best overall, even though it used fairly low cost parts in the stock unit. Stuart Hegeman designed this circuit in the late fifties, following his earlier *Citation Model One*. These preamps were the first designs I found that employing passive Phono EQ. Stu believed in ultra-wide-band-width and low distortion, he knew his circuits well and did some very fine design work.

I am presenting my modified version of this preamp. The original circuit used 12AX7 tubes. Through the years I have tried all brands of 12AX7s, but much prefer the sound of 6SL7s to 12AX7s. The 6SL7s are more microphonic but are very quiet, and sound oh….so….very…fine… in the midrange, maybe due in part to the round plates.

The JAN 6188 Phillips ECGs (military equivalent to the 6SL7s) are the quietest I've found. This preamp is unbelievably quiet for a tube circuit, (the quietest I've ever heard) and has enough gain to work with some of the low output moving coil cartridges. The use of 16db negative feedback around each amplifier stage provides greater definition from the 6SL7s than one might expect, probably due to the increased high frequency bandwidth.

The Foz Reference

The second phono preamp is my current reference unit. This circuit uses feedback equalization, but the equalization is split between two amplifier sections. Half of the RIAA equalization is accomplished in the first two stages with negative feedback.The other half of the equalization is accomplished in the last stage with negative feedback.

I have tried using single feedback EQ around two stages but I have not been able to "tame" the huge amount of feedback required for the RIAA equalization. Square waves always looked a little weird and the top end sounded strained. By dividing the EQ into two sections, we create a completely different animal.

A non-conventional three-position bass boost circuit is included as well, providing 3db or 5db of bass boost,and a flat position. The reason I put this in was because I have adjusted the tonal balance of my system for digital sources, and some of the older records sound a little bass thin in comparison to the digital material, but some are right on the mark. With the boost switch I can make them all sound the way I like 'em, but you may, of course, omit this function.

I used fixed bias in each stage, with the second and third stage bias obtained from batteries. I hear deeper, tighter bass with fixed bias, and the sound is more dynamic overall than with self-bias circuits.

I measured the output impedance one day and found that the impedance is about one fourth that of a stage with an un-bypassed cathode bias resistor. We could of course bypass the resistor with a capacitor but it would need to be a several thousand micro-farad cap to have the same effect, and capacitors that big usually don't sound all that good. The best cathode bypass capacitor is obviously going to be none at all.

The tube sounds better with the cathode grounded and the bias applied to the grid. The lower output impedance helps drive long cables or solid-state recorders without sonic degradation too. My turntable is mounted some distance from the line stage, requiring about 15 feet of cable. I found that the cable they sell at Wall Mart for the digital satellites under the RCA brand name, (RG 6) is low cost, low capacitance, and good sounding. You need a connector that crimps to the shield because the shields are not solderable. I use Tiffany RCA connectors which are a tight press fit.

For the bias batteries, I use three AA alkaline cells soldered directly into the circuit. AAA cells are OK if you do not have the room for the AAs. No need to use separate cells in each stage, but it won't hurt anything either. The battery life should be several years, probably equal to shelf life, because there is virtually no drain whether the circuit is on or off.

Line Stage

The third circuit pictured is the line stage that I'm presently using. It also uses fixed battery bias and negative feedback. I have seen this circuit called an anode-follower, which may or may not be technically correct. It provides low output impedance, and can drive long cables or a solid-state power amplifier (with an increase in the value of the output coupling capacitor value to about 1uf). With a 392k feedback resistor it measures 9.5db gain, and 2k output impedance. With a 1M feedback resistor it measures 15db gain, and 3.5k output impedance.

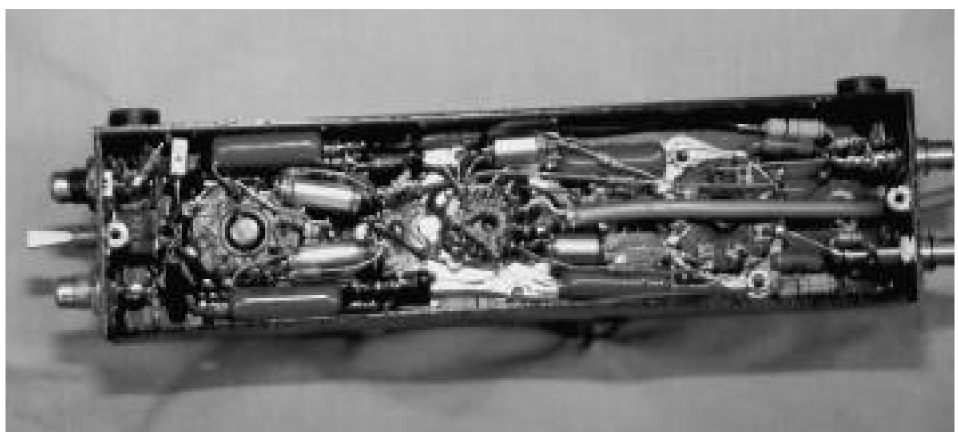
My longest cable run is to my left front channel amplifiers, about 50 feet. I measured about 835 PF on this RG6 cable, not bad for a cable of this length.The line stage drives it just fine. I like the sound much better than circuits that use cathode followers, not that cathode followers sound bad, they really don't—until you take them out of the circuit and hear the difference. They just sound better to me when they're gone. I can't figure out why, it doesn't make sense, but that's been my experience with them.

I have included a loudness control on the line stage that is bound to stir-up some controversy. The volume pot I used is made by Alps, and sold by Radio Shack as part number 271-1732C for $1.99.A stepped attenuator is the way to go if you want the best possible sound, less grain,and better fidelity for sure on super sounding systems, but the "Alps" sounds pretty darn good, best control you'll ever find for two bucks.

As you undoubtedly guessed by now, I believe in loudness controls, especially for listening at fairly low sound levels. Long ago a couple of guys by the name of Fletcher and Munson did a lot of work analyzing how our ears work and published a family of curves that show how the frequency response of our ears falls off at lower sound pressure levels.

What the curves show is that if you play back a recorded performance at a considerably lower level than that at which it was recorded, it will sound like it does not have as much bass as it did at the live performance. Try this test yourself, turn the volume down and listen to the bass…falls off some doesn't it?

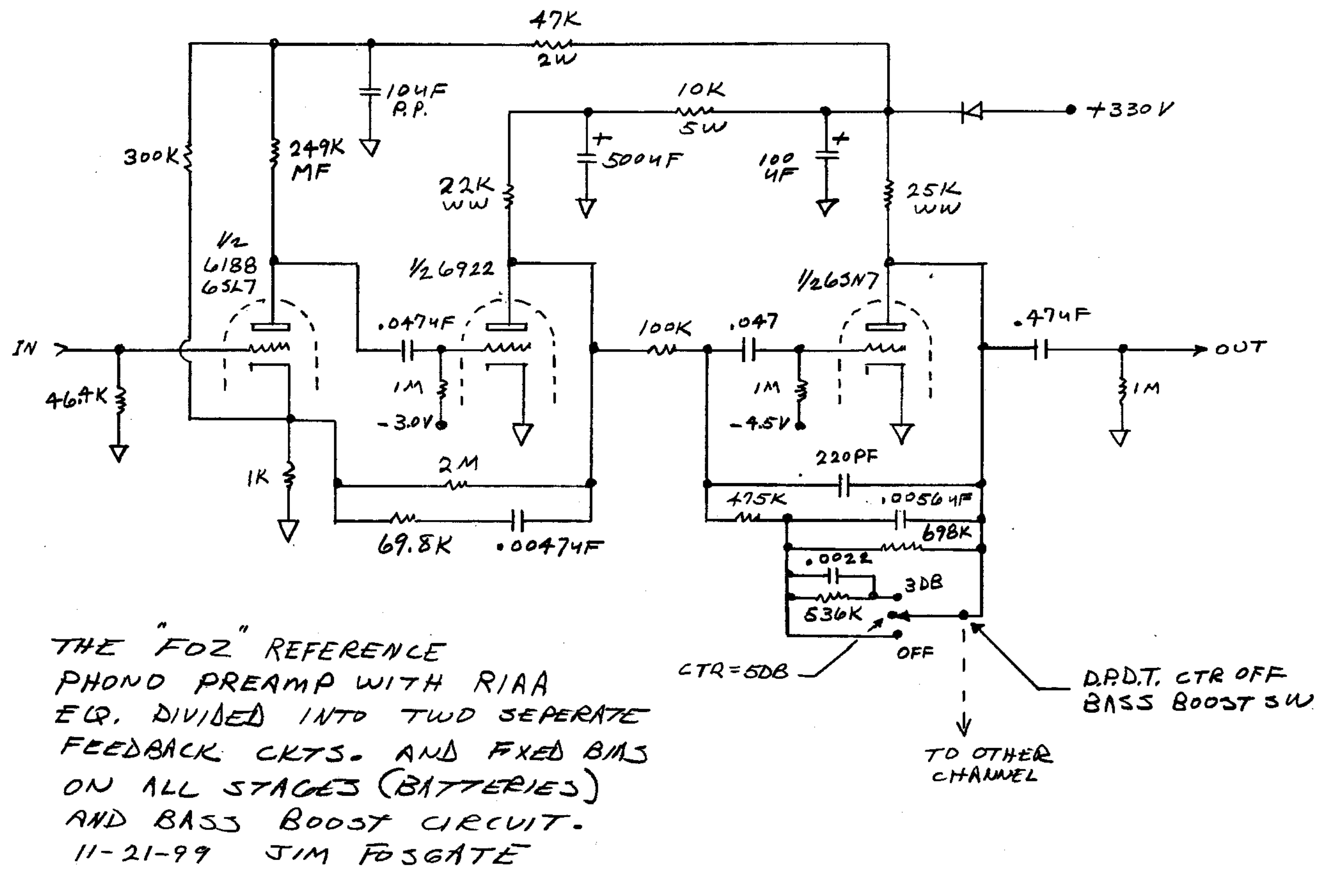
A good loudness control can cancel this effect out completely, so that the bass sounds about the same level as you turn the control down. It's very important to get the over all system gain right when using a loudness control,too much gain = too much bass boost too soon and it will sound bass heavy



when you turn the level down. Too little gain = not enough bass boost soon enough and the bass will still sound like it is falling off at lower levels.

Change the 392K feedback resistor if you need to, until the bass balance stays about the same as you turn down the volume. (A larger value increases the gain;a lower value decreases the gain) Almost all of the early audio designers used loudness controls. Try one, you just might like it! The switch gives you the option of turning it off if you don't like the effect on a particular selection.

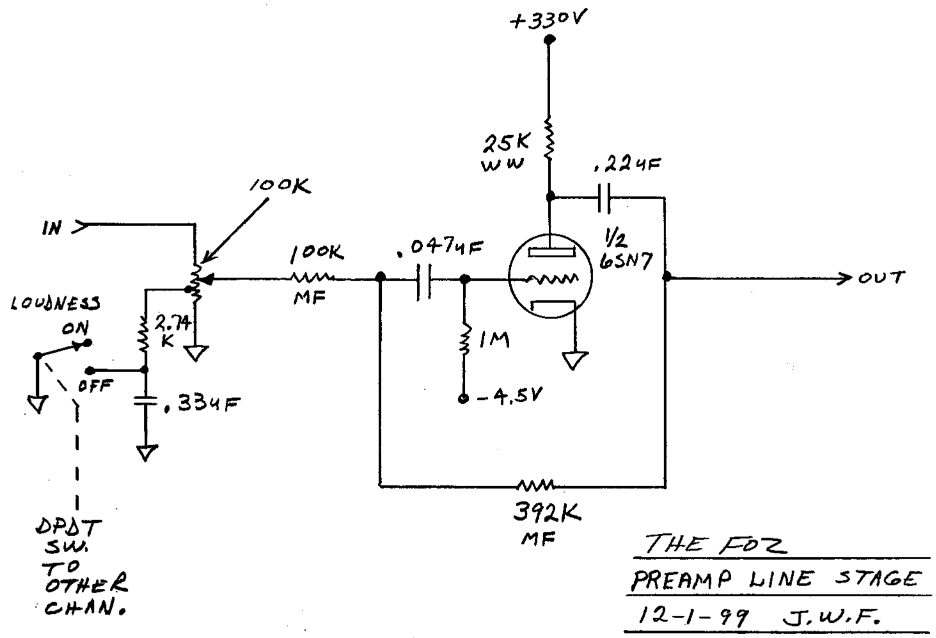
The quality of the parts affects the sound in



negative feedback circuits but probably to a lesser degree than non-feedback circuits. I use metal film resistors most places including the plate loads in the first stage of the phono preamps. I measured the input stage preamp noise floor at 7db lower with metal films than with an Allen-Bradley 240K 2 watt carbon resistor. The noise floor is low enough to use the AB if you are using a high output phono cartridge, but you will need a metal film or metal oxide for low output cartridges.

As far as tubes go, I use the Sovtek 6922 because they sound very smooth to me. Most 6SN7s sound good in these circuits. I was lucky to find some surplus 1942 vintage US Navy CTL 6SN7GTs with round plates. The guy I bought them from said they had been spares aboard US Navy ships during WW2. Talk about nostalgia, can you imagine listening through a tube that floated over the high seas during WW2! What a story they could tell us.

Layout and grounding have a very strong impact on the sound of any phono preamp. I build my cases using glass epoxy printed circuit board material, and do point-to-



point wiring using the copper case foil for the ground plain. The PC board material cost for a preamp would be about the same as a small chassis. I shear the material with a standard paper cutter, as found in office supply stores.

To make the box, I tape the pieces together and "tack solder" the edges with a soldering iron, next I run a bead of solder around all the seams and solder threaded standoffs for nuts to the bottom to hold the cover on. I drill holes for the bypass capacitors and stand them up. I use an Exacto knife to remove some foil to create a PC land to solder the leads to. After the case is sanded and painted it is the neatest little package of tube electronics I've come up with, and it sounds great too.

I believe in large filter capacitors in the 330v power supply. The output cap I use is usually about 500uf with a 10uf PP capacitor across it.The big cap gives super stable output voltage at low frequencies with rock solid bass, the 10uf PP bypass gives low impedance at the mid and higher frequencies, for a very smooth detailed top end.I do not like using small bypass capacitors across the electrolytic can sound funny sometimes.

Foz Reference System

You would probably get a kick out of my main reference system.My listening room is fairly large, 24 feet by 34 feet; with ten foot high ceiling, and about 45 people can be squeezed in for a demo.

The electronics consist of an all-tube five-channel tri-amplified surround system,with passive crossovers built into the amplifiers. The tweeter amplifiers are single ended at 6 watts each.The mid and bass amplifiers are push-pull at 55 watts each.There is no global feedback in the tweeter or midrange amplifiers, and about 12db negative feedback on the bass amplifiers. All the output tubes are EL 34s. Don't knock 'em, these amps will blow you away!

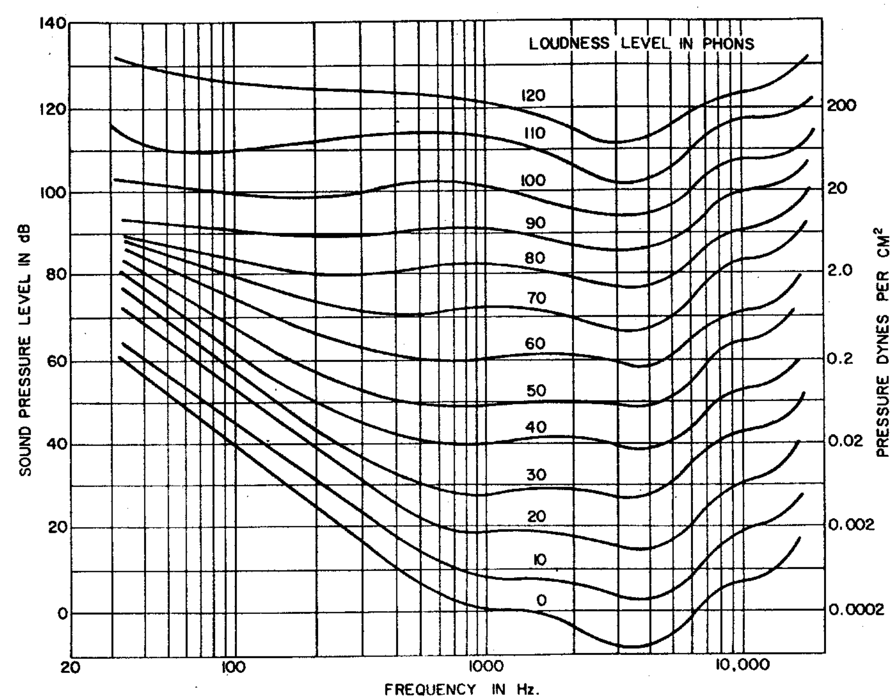
If you think it's a lot of work modifying two channels of amplifiers when you get a new idea, you should try modifying fifteen amplifier channels! I sure wouldn't need to go to the gym that day for a workout.

The surround processor incorporates a new "breakthrough" technology I have been working on. It converts the stereo signals into high separation surround,using six dual triodes for the complete audio path and solid-state circuits for the steering logic.

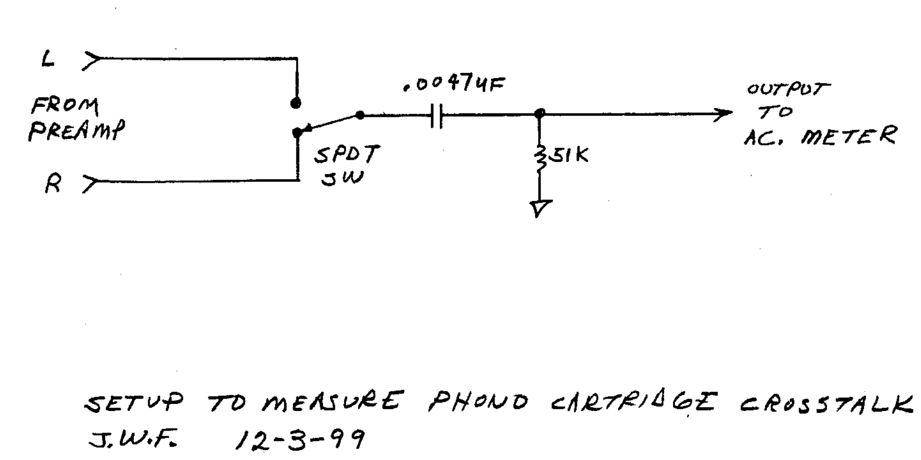
The turntable is a VPI-TNT 2 with an ET-2 air bearing tone arm.My current cartridge is the Audio Technica AT-440/OCC, available for around $100 retail from J&R Music World. This sleeper blows away all of my other cartridges, including some very expensive MCs!

One thing guaranteed to improve the performance of your phono system. is proper setup It is best to mount the preamp as close to the turntable as possible and connect directly to the wires coming from the arm if you can,or at least shorten the wires. I mount my preamp directly under the TNT-2 turntable and connect directly to the arm wires. My arm cable measures only 50 pf cable capacity.

The Audio Technica cartridge is happy with this load or up to about 100 pf, and with these preamps, it measures less than plus or minus 1/3 db deviation across the audio band on a CBS test record. It is best to load a low output moving coil cartridge right at the cartridge. I solder the load resistor directly to the clips that attach to the car-



The Fletcher-Munson curves,hearing data that the high-end industry forgot. Loudness compensation was a standard feature of quality vintage-era preamps.



tridge (do not solder to the cartridge terminals, the heat can ruin the cartridge).

If your arm has adjustable axial-tilt,it can be adjusted electronically to obtain equal separation across the channels (equal cross-talk). Due to production tolerances, most cartridges will not end up at exactly 90 degrees to the record and will "open up" when correctly adjusted. Connect the output of the preamp to an AC meter with the HPF filter and switch circuit shown. (The filter reduces the low frequency rumble so it does not affect the reading) Play a pink noise or 1khz signal on the left channel from a test record and read the cross talk in the right channel. Repeat the process for the other channel,play a right channel signal and read the cross talk in the left channel.The idea is to adjust the axial tilt for equal cross talk, usually 20db or better. Repeat the process as many times as it takes to get equal readings. If your cartridge must be tilted way off of the 90-degree position, it could be a defective unit.

My video projector is a ceiling mounted ten-foot diagonal. The speakers are flush mounted in the walls with oversize infinite baffling for the woofers. The corners of the room are all 45 degrees to control diffraction and resonances. There are four 10-inch woofers on each front channel and two on each back channel for a total of sixteen woofers.

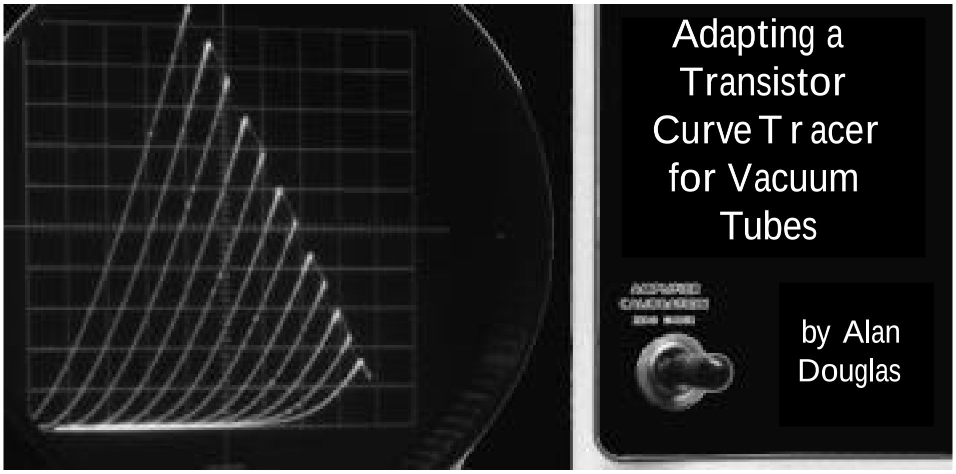
The mids are 5 1/8"aluminum cone drivers, two per channel. The tweeters are Vifa 1" horn loaded silk domes. The room is located in the basement far away from the bedroom and has concrete walls and ceiling. All I need is a generator and some food and I've got the perfect bomb shelter!

The ceiling is a suspended type with acoustical material above to create a bass trap. The walls are heavily carpeted for sound absorb-shun. I can listen in the middle of the night at "full throttle" without waking my wife or bothering the neighbors.

In the dark (which is of course the only way to listen), the glow of the tubes gives me a warm,nostalgic feeling. I am surrounded by thousands of records all around the room. The tubes provide enough heat to warm the room here at 6,000 feet in the Utah Mountains on the coldest winter nights. The system takes me just about anywhere I wish to go, truly a music lovers dream come true.

I hope you find something useful here. I've enjoyed writing this article, have fun.

Yours truly… The Foz



Adapting a Transistor Curve Tracer for Vacuum Tubes

by Alan Douglas

Playing with vacuum-tube curve tracers is fun and is at least as productive as building amplifiers. The bad news: there was only one commercial curve tracer, the Tektronix 570, and practically all of them are spoken for by now.

The good news: there are low-cost alternatives. Transistor curve tracers have always been more popular than tube models,

since transistor specs are so variable; in fact they are still very useful, especially for repair work where original replacement semiconductors are not available.

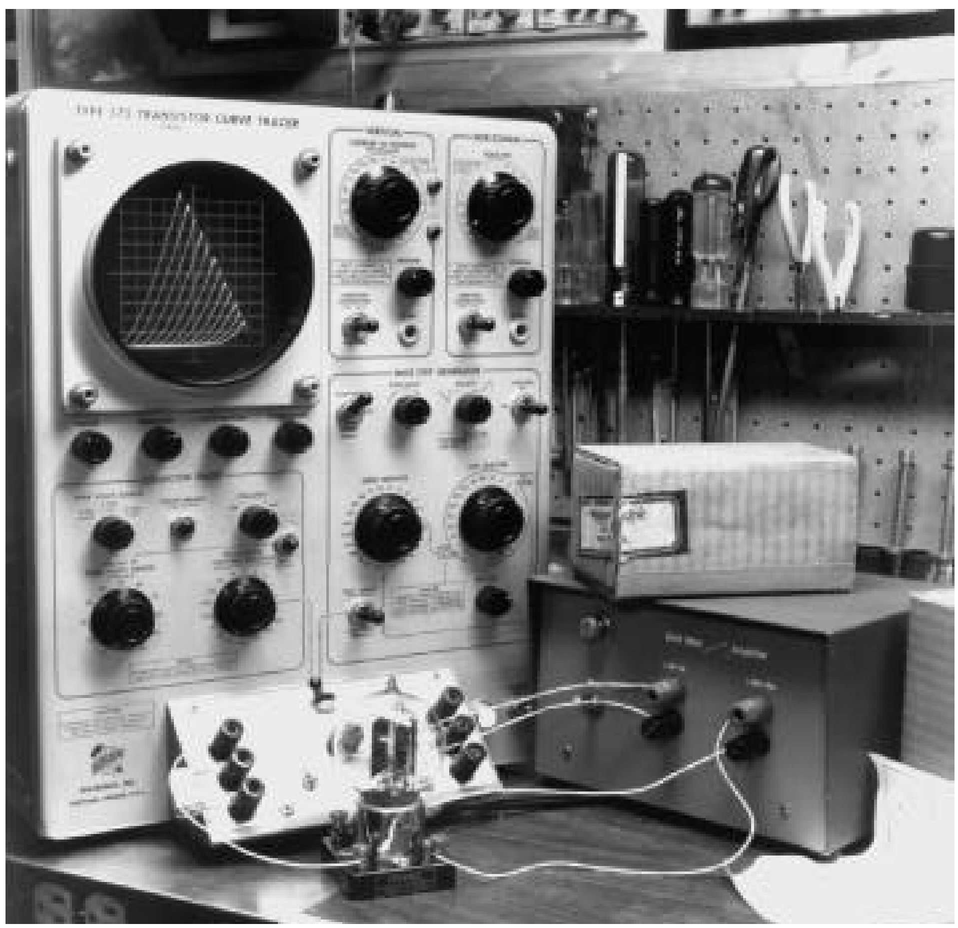
Tektronix made the model 575 and sold many more of them than 570s. Since the 575 is itself full of vacuum tubes—forty, with only two transistors—it is considered obsolete and is readily available on the surplus market. It closely resembles a 570. Availability, price, similarity:all of these suggest that the 575 deserves a closer look. More bad news/good news: the common 575 is quite unsuited to tube curve-tracing after all. But...it can be adapted.

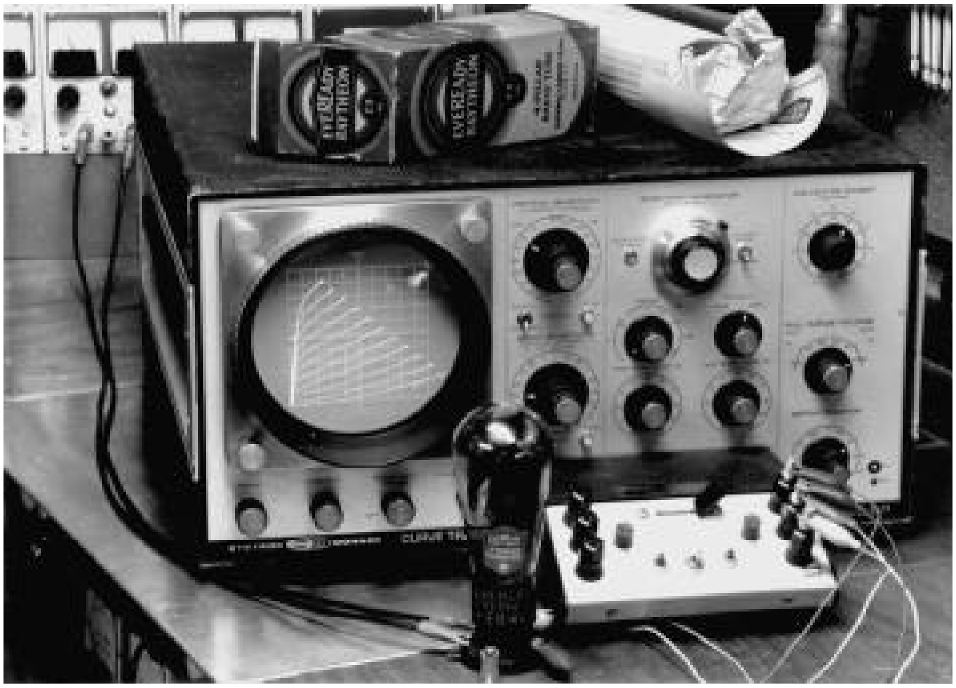
A stock 575 has two major faults: collector (plate) voltage and base (grid) drive. Plate supply is limited to 200 volts, about half of which is lost in the load resistor. Tektronix offered the "122C" modification to rewire the plate supply transformer to a bridge rectifier and obtain 400 volts. A completely new switch assembly was supplied, along with several trimmer capacitors to compensate for stray capacitance in the plate transformer. The horizontal volts per division switch got three additional ranges, up to 200 V/div or 2kV total (originally 200 V total; not much point going to 400 V plate supply if you can't see it on the CRT). A low-current 1500 VAC supply was added for checking peak reverse ratings of diodes, and even a new front panel came with the kit. While these changes could be made piecemeal without the official kit, it would be quite a project.Already-modified 575s are not rare, and command little premium over the stock instrument; they can be identified by the stamp "MOD 122C" next to the model number.

As originally configured, the 575 puts out current steps, as many as 17, of up to 200 mA each. To produce voltage steps, it feeds the current steps into a one-ohm resistor to ground, so it will provide 200 mV steps, or 3.4 volts total. This is not nearly enough to bias most tubes to cutoff. FETs were unknown in the mid-1950s when it was designed, so there was no requirement for more voltage. It is possible to use an external resistor of 10 or 100 ohms and get more voltage from the same current steps, but the internal supply voltage is only 15 V, so the amplifier runs out of headroom at about 10 V. Ten steps of 1 volt each are quite possible, though.

Evidently what is wanted is an external amplifier to increase this waveform to 10-volt steps and 100 V total, enough to bias a tube over its entire range. Such an amplifier has been described in a Linear Technology application note* and is not difficult to build, given a well-stocked junk box. I even used my 575—for its original purpose!—to select matched pairs of the high-voltage transistors needed.

The 400 volt plate supply of a modified instrument, although closer to 500 V at today's higher line voltages, is still none too much. Since you need a load resistor in the plate circuit (these are built into the 575 and selectable by a rotary switch), about half of the plate supply voltage is lost in the resistor.





Looking at the family of curves, the load resistance appears as a diagonal line on the CRT, extending from 400 V on the X axis to 400/R on the Y axis. This line is the upper boundary for any curves. The 570 was rated for 500 V, and probably gave more.

The 570 also had its own heater supply, and a variable regulated DC source for pentode screens, but these are easy enough to obtain externally. What is not so easy to duplicate is the switching for alternating between two tubes:

The 570 had them in parallel all the time, transferring the grid drive from one tube to the other while simultaneously connecting the "off" grid to -300 V.

The 575 switches both the base and collector, and has no source of -300 V available even if you wanted to do a massive rewiring. Also, if you build a transistorized step amplifier for grid drive, it will probably not appreciate having -300 V applied to its output even momentarily, but the Linear Technology application note does describe a version using a 12BH7 output device which can easily withstand such treatment.

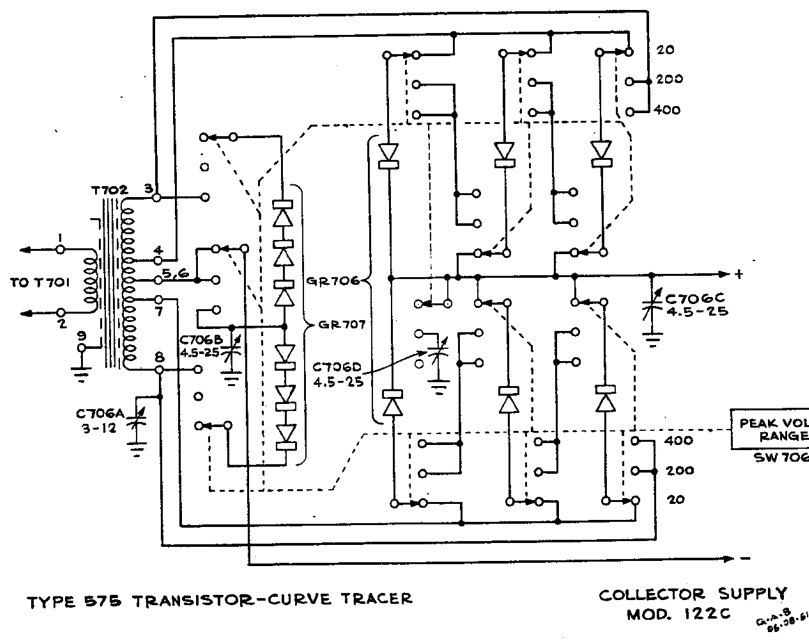
Neither will any of the transistor models provide both negative and positive steps simultaneously. A variable offset could be built into the step amplifier, however.

Tektronix 575s are generally reliable and long-lived. As with any Tektronix scope of its vintage, clean the switches, replace any black plastic molded paper capacitors with color stripes, and replace at least the final high-voltage filter capacitor if not all of them, before adjusting any calibration pots.

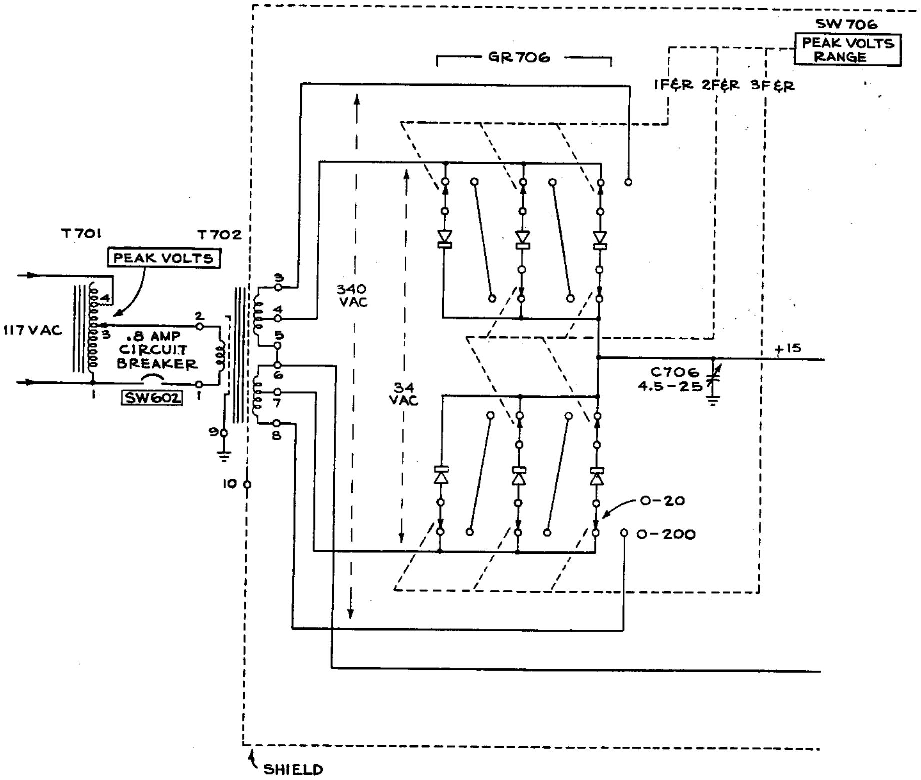
Tektronix had the curve-tracer market to itself for many years: the 575 lasted in the catalog from 1958 (or earlier) to 1971. But in 1967 Fairchild Instruments jumped in with a much-improved model 6200B, all transistorized, and capable of 35 volts of "grid" (base, gate) steps. Unfortunately Fairchild was poorly-run at that time, kept afloat by its semiconductor division profits, and its advertising budget and sales reps were no match for Tek's. Once Tektronix countered with a pricier but many-splendored model 576 in 1968,few people chose the Fairchild. Systron-Donner purchased the 6200B design and parts stock in 1969. The 6200B because of its orphan status sells for a lot less than a 576 but is capable of supplying 1000 V and will do a fine job on most tubes, with no modifications. The transistor socket/switching assembly looks awkward, protruding from the front panel, but can be unplugged.

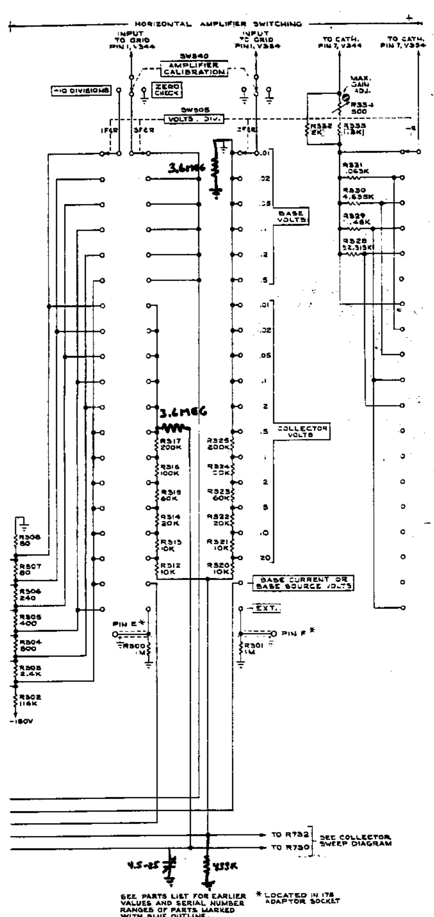
If you're lucky enough to find an affordable one, a 576 should work well too.The later model 577 is not as good for power tubes because of the lower plate (collector) current range, and of course the present model 370 is out of sight for hobbyists. The 370 will drive an external plotter, but otherwise the only permanent record from any of these curve tracers is from a scope camera and Polaroid print, at a dollar a shot. A manually-operated plotter has some real advantages here;see S.P. #11, pp.26-27.

All of these curve tracers are intended mainly for plate-family characteristics, plate current plotted against plate voltage for fixed steps of grid bias, the usual curves given in tube manuals. Often the transfer characteristic is more useful in predicting linearity of a particular tube over a certain operating range: plate current plotted against grid voltage for a fixed plate voltage.** On the plate-family plot, linearity is indicated by equal spacing between successive lines, a difficult thing to see. While it is possible to get a crude approximation of a transfer curve on a commercial tracer, a simple homemade device is much better, such as



TYPE 575, MOD 122C





the design published in Vacuum Tube Valley, issue no. _

*Application Note 18, available from Linear Technology Corp., 1630 McCarthy Blvd.,

Milpitas CA 95035-7487

**See S.P. #7,pp.24-25 for transfer curves of various 300Bs taken with a Tek 370.

And thanks for the original tip on the L.T. application note.

fig _

Partial schematic of the Tek 575 horizontal range switch. Adding two 3.6 megohm resistors will increase the volts/division ranges by ten. This is effectively what the Mod 122C did.

figs _

Partial schematics of the original and modified collector-sweep circuit in the Tek 575. The Mod 122C added an entirely new switch assembly, and two more rectifier stacks to turn this into a bridge. No doubt a single modern bridge rectifier could replace this entire business, though the front-panel markings would be wrong.

fig _

Tektronix 575 Mod 122C, with grid-step amplifier, running curves on a W.E. 205D.

fig _

Systron-Donner (Fairchild) 6200B/P (programmable) running positive-grid curves on a triode-connected 46.

Alan Douglas

Box 225

Pocasset MA 02559

SRPP POWER

The search for the best way to get five watts out of a 6AS7

by Flemming Madsen

I am an electronic engineer and teacher here in Iceland. I began experimenting with audio about 30 years ago, beginning with Voigt pipes and transistor amps. For the last 13 years, I have been concentrating on tube amps, mosfets with tube drivers and direct drive electrostatic speakers.

The SRPP project in this article began as a sound check on a Class A2 driver for a Svetlana 811-10/572-10 amp intended to drive my 7´ high, 1.5´ wide full range electrostatics. I needed a driver with about 50 mA current capability and at least 50 V RMS. The easiest way to get this is using a pass tube like 6AS7 or its equivalent, the 6080.

I had good experiences using 6080 tubes in a PP amp for the electrostatics. The tube is very rugged. I have driven it for every day in 2 years now with max. dissipation but at higher voltages than recommended and no failures have come up so far.

To check out the sound of the driver, I built an amp with 6SL7 and 6AS7 in SRPP using output transformers from a scrapped Dynaco Stereo 35. This amp lived in my workshop for about a year. Everyone who heard that amp was surprised how good it sounded. It had powerful rich bass and clear engaging midrange. The amp was built using metal film resistors and both electrolytics and polyprops in the signal path—in other words, an amp built of crap.

I always tell my students that building tube amps will save the world, and I try the best I can to let them get the bacterium *highfideli-itis*.

One day I woke up to the fact that my student were making a horrible mess of some measurements on the lab table. It looked like a certain kind of Italian food. Then I could do nothing else but ask (in reality I *roared*) "what in h…. can we do to teach you work more systematically?"

They answered as a chorus:"What about building a tube amp?" I warned them, "But it will cost you money." I saw a lot of work planning it. "That's all right, we will pay," they answered. So, there was nothing I could do other than begin thinking about a project that was easy to build, good sounding, and cost next to nothing.

Soon I built a prototype around the SRPP 6AS7 amp in the workshop, putting a 6SN7 preamp in front of it with relay-controlled input switching. The original idea was to control the input switching with TTL logic, but in the end only one out of nine worked. The fact is that *logic is crap*—every tube freak knows that!

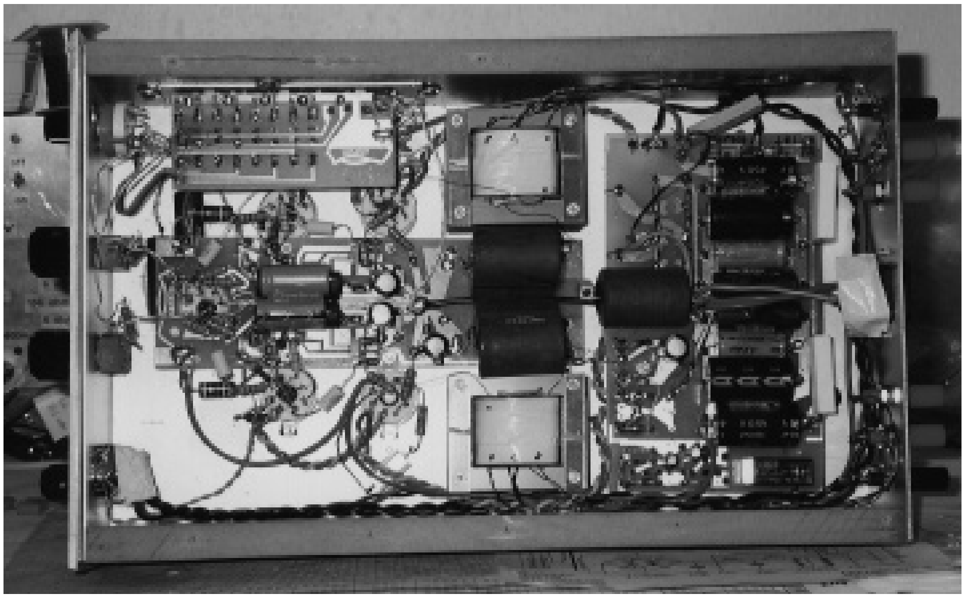
We ended up with a simple switch to control the relays, and it has the added benefit that the switch remains in the same position as you left it last time you used the amp.

You can copy the amp as described below or use it as a platform for experiments. In the process of describing it, I will relate some of my experiences and insights about amp building to you.

But, remember I am not god—I only sound that way when I come forward with my opinions. You must be a critical reader, make your own decisions, and listen critically to *your* results before you'll get an amp that matches your equipment. That costs a lot of sweat and tears, but in the end you will have learned a lot.

Don't expect to be satisfied—if so, you would be the first that had been cured of perfectionism. Here you have a chance to get into tube amp building at low cost. Our amp cost about $430. All the items were gotten from four different companies. Most of the parts from Circlewood London. A little from ELFA Sweden. The tubes from Billington. The transformer iron and forms were provided by the local transformer maker. I will make a list on the Internet together with the PCBs and other drawings of the amp.

The platform described here is easy to change to other kinds of output stages with around maximum 15W power capability. The power supply is good and easy to match tubes from 2A3, 300B, EL519 and 6C33B, providing enough current for them all. Of course, you have to change output transformers to match the output tubes. You also must have separate windings for the filaments if using directly heated triodes.



If this is your first project, then it is best to follow the description. You can always upgrade later and would be much better prepared for it.

Input Stages

The input switch is built on a PCB with integrated phono plugs and DPDT relays controlled with 5V from the heater supply. The diodes over the coils are there to kill clicking noise. The way the input plugs and relays are mounted on the board, the signal path is as short as possible. The advantage with relay switching is that you don´t have the usual long cabling to a switch of often questionable quality. Good switches don´t come cheap. The relays are cheap and hermetically sealed.

Templates of the PCBs used as well as some wiring diagrams are available on www.soundpractices.com/srpp.html in PDF format.

There are two volume controls, one for each channel. It is difficult to get stereo volume pots that actually match. I think that we DIYers end up buying the crap that factories do not want, and pay 10 times more for it! Two volume pots is simpler and better and costs less than a stereo volume pot and a balance pot. I like the two volume control system best. You can get used to using two controls very fast.

The volume control is made as a voltage divider with a fixed resistor in series with the potentiometer. It sounds better that way. The signal goes through a good resistor (carbon composition or Allen Bradleys). The cost is a loss of gain but often this is not a problem.

I think that components shunting signal have lesser impact on the sound than components that the signal goes through. Logically, it is strange, because the current goes through both the shunt and the series items. As we know, a lot in the hifi scene remains unexplained, therefore if you feel it is better, let it be. At least you will feel better about it.

Have your own philosophy, be thoughtful about it, and don´t let anyone mix into it.

A good example about philosophy is how it is possible to build good gramophones with light and stiff materials with a little damping. Alternatively, build it heavy with materials with a lot of damping. Both kinds can be good sounding. But don´t try to mix the philosophies! If you damp the light built one the sound dies. Lightening the heavy one makes it resonate.

Before you modify hifi equipment, you must figure out the philosophy behind the construction. You can try make the light phone stiffer or improve damping of the heavy one. If you try the opposite, the sound will change radically and in most cases for the worse. If you hear big differences, then there is something wrong. OK… I think it is time to come back to the amp project.

The preamp tube is one-half 12SN7 for each channel. It is a plain plate-coupled connection without a bypass cap on the cathode resistor. It is possible to change the sound a bit by changing the plate resistor. For more body, try 12k and for lighter and more liquid sound, use 27kΩ. Anything between is also usable and largely a question of taste and speakers.

You can also try bypassing the cathode resistor with 220µF/10V HQ electrolytic, it will give more punch and a more massive sound.

I used the 12SN7 because of my experience of the amp in my workshop with a 6SN7 SRPP preamp. The tube sounds thinner plate coupled than in SRPP. It is alright if your speakers are not too bright. Perhaps it is better to use 6SN7 and step the heater voltage down from 12V with a 10Ω/10W resistor.

Then you have the choice of a lot of different brands of tubes and they differ a lot in sound. I like the ones with the triangular plates best, the 6SN7WGTA from RCA, for example.

With bright sounding speakers such as Lowthers, I would try the 5687 as preamp. It has a more full-bodied sound without losing the details. The plate resistor would be 7.5k–12k/5W and cathode resistor 330–390Ω/1W. The step down resistor from power supply changed to 6.8kΩ/5W. I have not tried it, but I think it would be a better preamp in this kind of system. Be aware of the different pin connections when you use this tube.

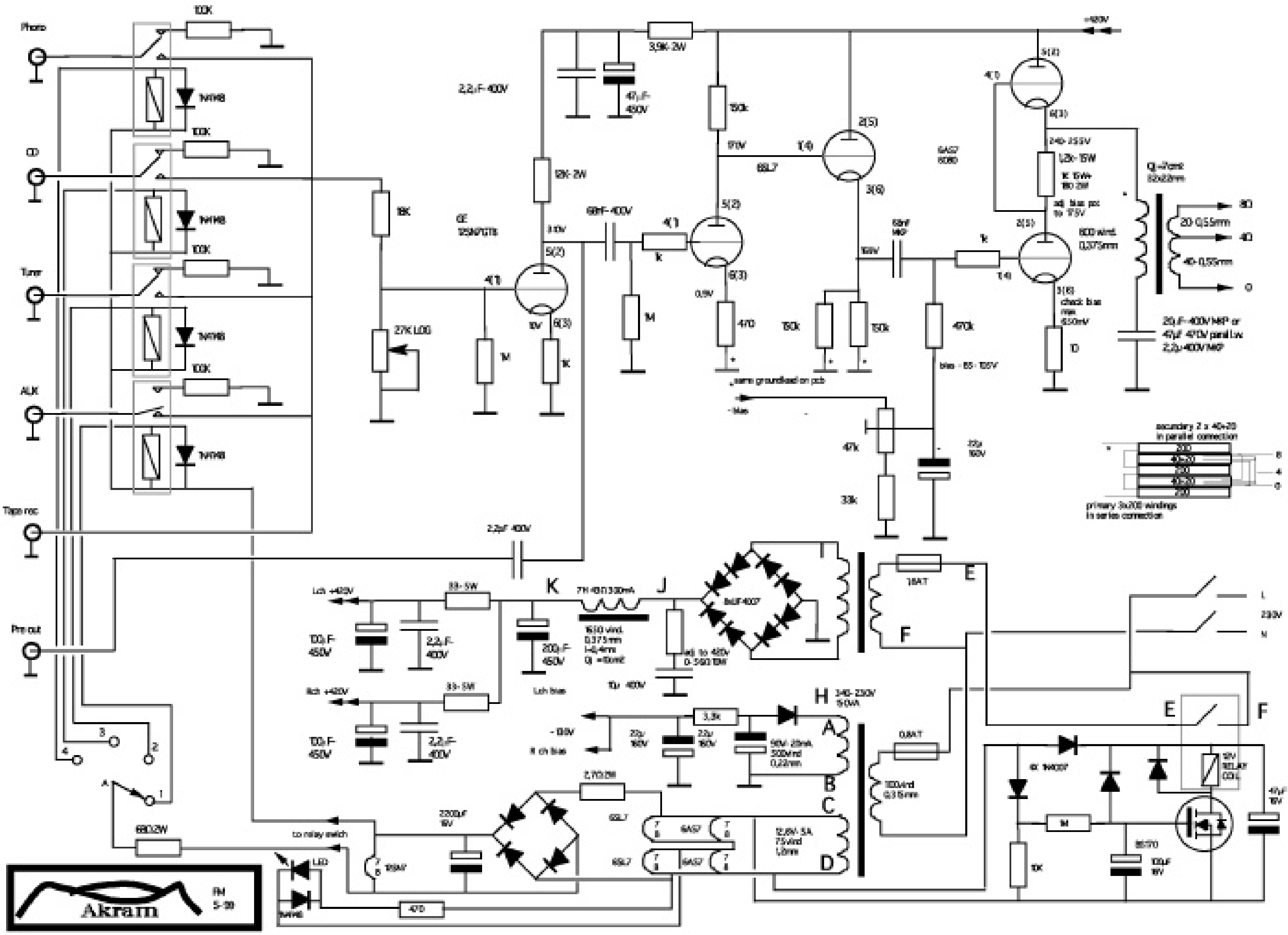
Don’t try 12AU7—OK, it is full bodied, but dull and lacking details and a very sloppy bass. I think that a lot of that talk about tube sound with sloppy bass and rounded creamy sound is because of that tube. It was widely used for many years.

I have made a preamp output on the amp, but it is not capable of driving any length of cable. Connecting anything deteriorates the sound on the outputs. Actually, it would be better to use the jacks for an extra input.

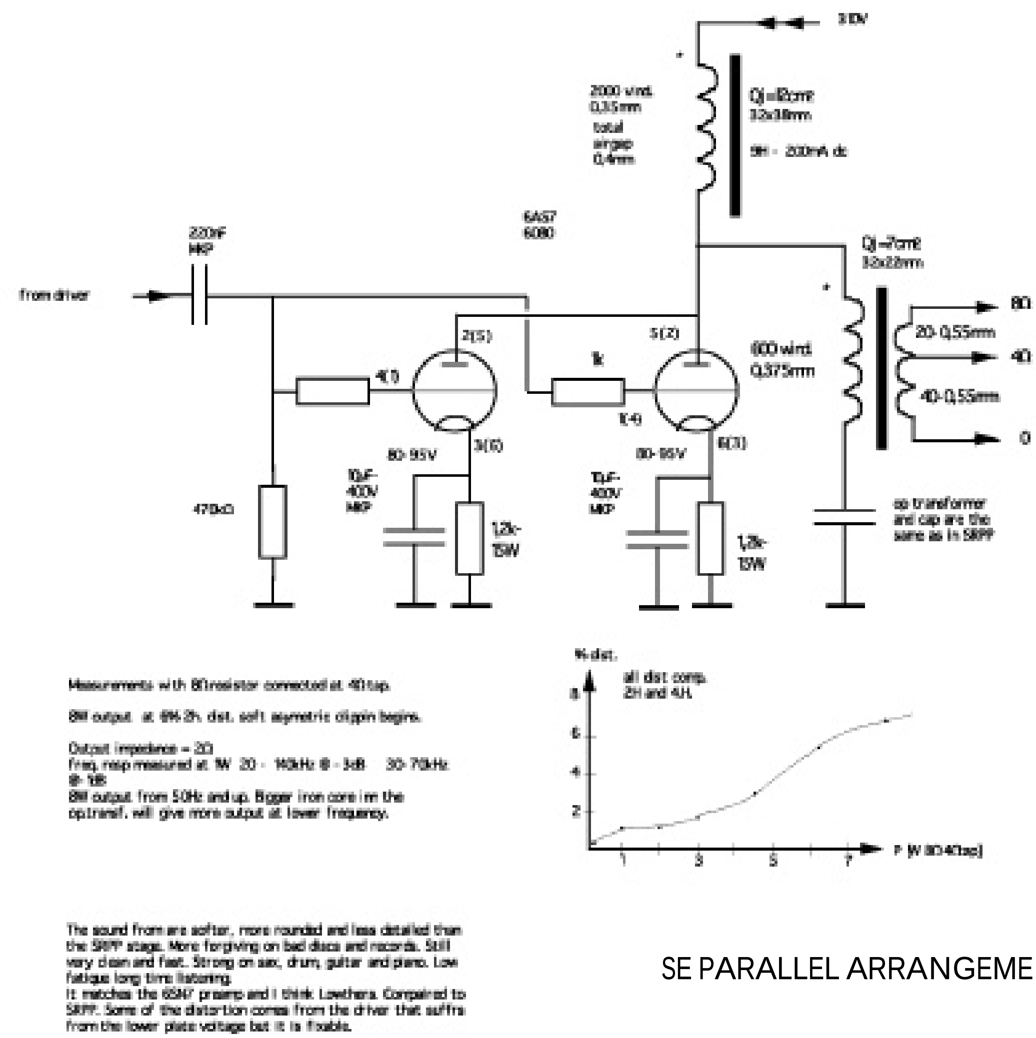
Or use it as output from the output tube to drive a separate bigger power stage with, for example, 572-10s. I am thinking about trying this out. Perhaps a description on that later. With such a stage it would be possible to wake up normal 88dB cigarbox speakers, from the so called “high-end class.” Wonder why it is called high-end? Were the constructors high when they made it? Or perhaps they tried to high-end their income by manufacturing these undynamic speakers with such high power requirements?

Driver Stage

It is my experience that voltage amplifiers make much more of a footprint on sound than current amplifiers. Therefore,



Phono
CD
Tuner
AUX
Tape rec
Pre out
100K
1N4148
18K
27K LOG
1M
1K
6E
12SN7GT8
2,2μF-400V
3,9K-2W
12K-2W
47μF-450V
68nF-400V
150k
170V
6SL7
470
6AS7
6080
1k
470k
47k
33k
+420V
Lch +420V
Rch +420V
100μF-450V
2,2μF-400V
200μF-450V
Lch bias
R ch bias
- 130V
3,3K
2200μF 16V
470
680,2W
LED
to relay switch
Akram
FM
5-08
A
B
C
D
E
F
H
J
K
230V
L
N
12V RELAY COIL
1M
10K
4X 1N4007
BS170
100μF 16V
47μF 16V



SE PARALLEL ARRANGEMENT

the driver stage and preamp contribute at least 70% of the sound from a triode amp. It is from here by far that most of the voltage amplification comes from. The output tube has little voltage gain compared to the others in triode amplification. The primary stages are mostly responsible for the outcome of the amplifier.

To get enough drive to the power tube, the driver must have high voltage gain. The output tube requires about 70V RMS drive with little distortion. The 6SL7 is good for this. I love the 6SL7— it is fast, clean, and not too clinical.

First I tried SRPP driver with 1kΩ cathode resistors. It sounded fine, but the tube gods don't like putting identical couplings after each other. SRPP 6SL7 is a little rounded but not too much. Also, 6SN7 is fine (very clean) in SRPP but you will lose about 10 dB of voltage gain compared with the 6SL7. It would be worth trying 6SL7 preamp and 6SN7 driver, let me know if anybody tries it.

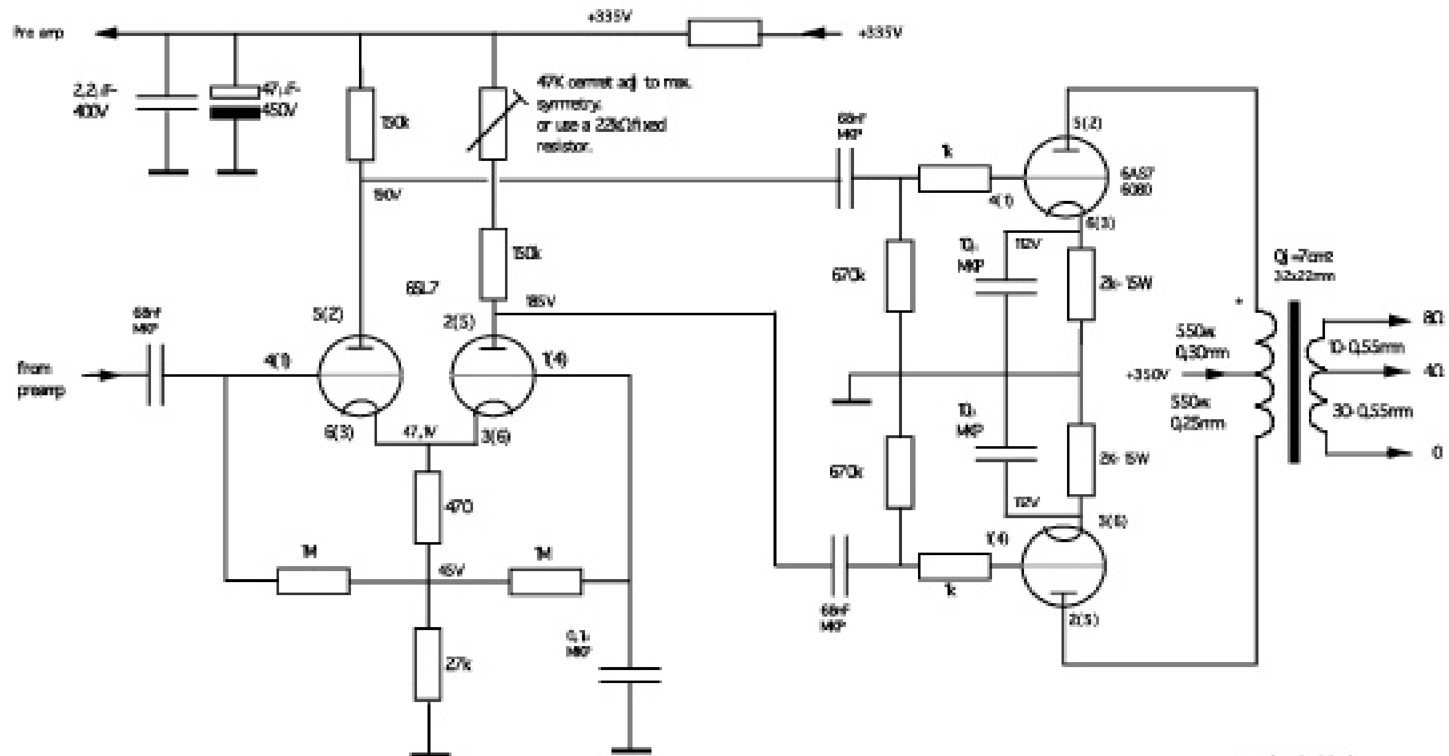
I also tried SRPP 12AX7 in my workshop. Actually, I have the choice with a switch, so that I could compare different hookups. It is fine but, as with 6SN7, there are big differences between brands. Some sound almost as dull as 12AU7 (bah) and some are fast and powerful (Sovtek WXGTA).

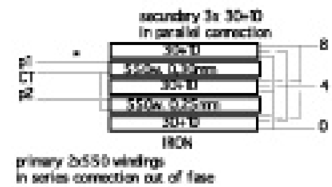
In the end, I chose a plate-coupled 6SL7 DC connected to a cathode follower to get good voltage drive and lower output impedance. I decided not to connect two SRPP stages after each other. The good priests say it is not wise and sometimes, like it or not, you have to listen to the tube gods. They say weaknesses will accumulate.

I am not sure this rule is entirely appropriate here because of the different tubes and very different working conditions. The output tube is heavily loaded by the speaker impedance and the driver is lightly loaded by the very high input impedance of the power tube paralled with a 470kΩ bias resistor. The sound is crisper with plate load/cathode follower. By trial and error, I selected the plate and cathode resistors and ended up with 150K and 75kΩ. That made the lowest distortion on the output and a fast, clean, and crisp sound that matched the 92dB Voigt pipe speakers most of my students have. On my Focals, I find it a bit cold, but the sound is not far from a 2A3 I made for a friend.

For coupling caps I ended up using Wima MKP10 polyprops. Later I tried Audio Note aluminum foil/paper in oil but I was surprised how little difference they made. To excuse my bad hearing, it was difficult for me to compare the cap because of the long break-in period of the paper and oils.

The coupling caps are small, 68nF pp and



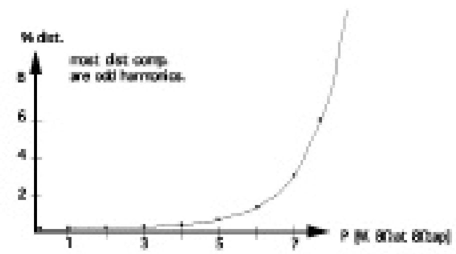


Measurements with 8Ω resistor connected at 8Ω tap.

8W output at 6% dist. soft symetric clippin begins.

Output impedance = 1,6 Ω.
freq. resp measured at 1W 18-55kHz @ -3dB 40-28kHz @-1dB
8W output from 50Hz and up. Bigger iron core inn the outransf. will give more output at lower frequency.

The sound are a bit like the paralled. But very much normal and rather borring. Not crisp as SRPP and not forgiving and euphoric as SEP, not anything it just plays as it is said to do.
The amp is much more complicatet to make than parralled , I dont think it is worth it. Take a look at the distortion curve, it is very saleable. One more time PP looks well on paper but the sound from it dont live upp to it. Specially if you have the other concepts to compare with.



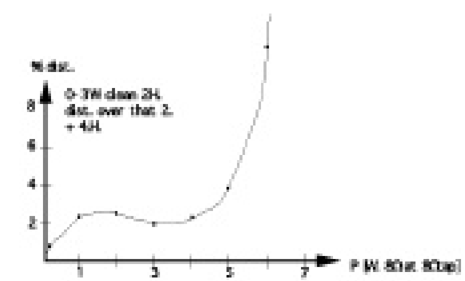
Measurements with 8Ω resistor connected at 8Ω tap.

5W output at 5% dist. soft symetric clippin begins.

Output impedance = 2,4 Ω.

freq. resp measured at 1W 10-55kHz @ -3dB 22-35kHz @-1dB
5W output from 30Hz and up.

The sound are fast crisp airy dynamic with tight bass.
Lot of ambience and room. The amp is sensitive to bad records and cds.
Strong points are snare drum, hi hats, discs, trumpet.
Sax and violins are a bit thin. I think that 5687 preamp will much better than 6SN7.
Strange distorsion curve. High second harmonics but very constant over a big powerrange. Perhaps its the secret of suprisingly good sound compared to the distortion rating. You dont get tired of listen to the amp.



PUSH-PULL ARRANGEMENT

47nF AN, compared with normal practice. This is because I wanted a small amount of filtering—together the coupling caps make a high pass filter of about 10Hz. There is no reason to force the power tube to pump too much subsonic audio from warped records into a transformer that will just eat the current without transferring it. The low frequencies, although not audible, will modulate higher frequencies in the power tube and the power supply will be heavy loaded, so you will get nothing instead.

In the beginning, I did not like this driver because of the two stage configuration. But, in reality, SRPP and my follower also are two stage amps. But you don´t see it as easily. The cathode follower is just put on top of the plate coupled stage. I never tried my follower in this amp. Long ago, I gave it up. It has never sounded right for me. It eats detail compared with SRPP.

In most cases, I like the SRPP best. The sound is clean and human and doesn't change a lot with the working point. In other words, when the tube gets old and tired you won´t hear it very much. The shunt regulated push pull is an easy and forgiving friend to work with. I prefer it in all amp stages from line level and up. While it works for me, I also know that other DIYers have had bad experiences with the SRPP.

Output Stage

The output stage is plain SRPP with the lower half DC biased. The 1kΩ resistor in the grid of the lower tube is to prevent the tube from oscillating. I am not sure if it has to be there. I have not had problems of that kind, perhaps because I always use a grid stopper resistor and always try to make all wiring as short as possible.

The bias voltage is fed to the tube through a 470kΩ resistor. The bias voltage differs a lot from tube to tube, also the halves can differ substantially. This is one of the biggest problems with the 6AS7 and other pass tubes.

In the school project, we had the opportunity to swap tubes so that everybody got tubes that were fairly close in bias voltage. It is preferable to have the bias voltage high to get the highest power from the tube. A tube with higher bias voltage tolerates higher drive voltage before it will eat the upper half of the drive signal with the grid to cathode diode. Higher bias also means more current swing with less input.

In my circuit, the upper half of the tube works as a current source that tries to help the lower tube to draw current. When the plate on the lower tube goes higher, the grid of the upper one also goes higher (less negative). Therefore the cathode follows the grid and the upper tube opens up more for the current through it.

The voltage gain of any SRPP is about the same as mu, in the case of 6AS7, a voltage gain of about two. That is very low, and to make bad worse, under load I have measured input and output voltages to be the same, a voltage gain of only one. Therefore, the 6AS7 as SRPP output tube is only a current amplifier—and therefore has much less impact on sound than you would think.

The 10Ω in the cathode of the lower half, has two different purposes. First, it makes current measurements easy. Voltage across the resistor divided by 10 is the idle current of the tube. Secondly, if the tube should short circuit or lose bias, the resistor will blow up and stop further destruction in the amp and power supply.

The output signal from the output tube is AC coupled through a cap to the stepdown transformer. The cap is put in the ground connection of the transformer. I chose this connection because it's my experience that harsh (lifted highs—subjective not measured) sounding caps in series with signal sound dull when used as decoupling caps. In the amp here we have two harsh sounding polypropylenes in the signal path of the voltage amplifier stages. If my theory is right, it must be fine to use a harsh sounding pp in the decoupling of the output transformer, to balance the overall sound. At least I hear it that way. But perhaps it's because I think it is right. Psychology and hifi have a lot in common. No answer is absolutely right, and there are different theories about the same problems.

I have used 47µF electrolytic paralled with 2.2µF MKP. I also have tried 2 x10 µF paralled. I expected better top end and worse bottom. But again the break-in time of the change spoiled the direct comparison. I must admit I can't remember small sound differences for days or weeks. After that long of a time, I only can say whether I like the change or not. It becomes, as always, a matter of taste. Try it yourself and make your own responsible choice. Life is not meant to be easy.

Output transformer

The SRPP output stage has an measured output impedance of about 200Ω. Therefore, a matching impedance between 800-1kΩ would be about right. The primary-secondary ratio should therefore be √ (800/8) or 10 to 1. The old Dynaco transformers I began with had about that ratio, when the 8Ω tap was used as secondary and the primary was taken between the two screen grid taps. The amp worked fine with the Dynacos. The bottom was very powerful but the top-end lacked a bit of air. I think you can use many different push pull transformers in this amp, both old and new ones. However, I prefer to wind the transformers myself.

In the school project, we wound our own transformers. It is by far the cheapest route and easier than many think. I also think that it is good to learn how.

There is a lot of fuss about the difficulties of transformer winding. Very true, it is difficult to wind an Ongaku transformer with 16kΩ primary impedance at 20 Hz (127H and pr/sec= 45/1), a lot of DC current through it, and to insulate for 3000V DC on the primary. Oh yes, that costs a lot of work and skill. I think it would be cheaper to buy that kind of transformer, compared to the work required winding it.

But, come on, we can wind a transformer with no DC current through it, a 10:1 ratio, and a primary inductance about 10H. That will give you 800Ω at 12 Hz. Our homemade transformers perform well. They measure <10Hz– 120kHz within -2dB. We used M6 iron from the local transformer supplier. The core was 32 x 22mm (Qj = 7cm2). The windings were interleaved 5 times. In other words, 3 primary windings series connected and between them 2 secondary windings paralled. See the specs and wire dimensions in the schematic.

Our transformers perform better than the Dynacos in the treble but not in the bottom end. When measuring the amp, 20 Hz sine waves have distortion when the output voltage exceeds 3 V into 8Ω. More iron will cure that problem.

Next spring, when my students build an amp, I will double the iron core. The bigger core will store more energy for the bottom end. The E and I laminations are put into the coil 5 and 5 together, making a little air gap in the core and linearizing it. The sound will be lighter and less mechanical, and the break-in period much reduced.

I always use non-magnetic brass screws and insulate both sides of the transformer with fiberglass PCB. It is best not to use pots and frames made of scrap iron from old cars. At least, if you use this crap put thick cardboard or PCB spacers between them and the iron core. Don't forget to isolate the brass screws. Any connection between the sides produces loss in the transformer, and it is the last thing you want in an audio transformer. If you don't do what I suggest, you will end up with an amp that looks nice but sounds mechanical and compressed. Fellows, the choice is yours.

Perhaps later I will write an article on transformer winding, derived from an old Danish book I found. It is easy and the transformers work well using the modern materials of today.

Transformers are far from perfect on the test bench, but it is surprising how little impact they have on the sound. Caps measure near-perfect compared to transformers, but have a lot more impact on the sound than anyone should expect. Nature is strange.

Power Supply

The power supply is very plain. No tube rectifier is used in order to hold the costs down. It is much simpler to use a bridge rectifier. Only one winding is required for this, you must use additional windings for tube rectifier. In our project we recycled transformers that we had been given from an aluminum plant nearby. Therefore, we have two power transformers one for plate supply and one for heater and bias.

The high voltage rectifier is built around 8 UF4007 diodes, an ultra-fast equivalent of 1N4007 1000V/1A diodes. I series connected them two in each branch so that they can withstand 2 kV in reverse. Really, it is not necessary, but I like it better because if one gives up, the other can do the work alone.

I remember waking up in the middle of the night when a diode in my old Dynaco power amp had given up, the power transformer overheated, and all the black stuff in it had began to boil. It stinks, I tell you—I get bad feelings thinking about it today, 15 years later!

The output voltage from the transformer is 340V@600mA, more than enough. But remember at the place where overkill is a must, a bigger power transformer is always better. After rectification, the voltage is decoupled with a 10µF MKP/400V cap, in series with it is a 10W resistor between 0 and 56Ω. It allows adjustment of the output voltage from the supply by changing the resistor. With no cap, the supply gives out about 300V and with 10µF it gives about 450V when the amp is loading the supply.

After the adjusting cap is a 7H choke @300mA. The airgap in the choke is adjusted with 2 sheets of ordinary writing paper(80g-m2 paper is 0,1 mm = 4 mil), it will make an airgap that is 0,2 mm. The paper is placed between the E and I laminations. All the E blades are together at the same side, then the two sheets of paper cut in size, and then all the I iron together on top.

It is easier to screw the choke together if you apply about 10 V dc to the coil. Then the magnetic field in the iron core will hold the choke together while you are working on it.

After the choke are filter cap banks made of two 100µF@450V caps paralled. After that, the left and right channels are isolated with 33Ω/5W resistors and then decoupled once more with 100µF paralled with 2.2µF MKP, one for each channel. The preamp is further decoupled by 47µF paralled with 2.2µF after the 3.9KΩ voltage dropping resistor feeding the preamp tube.

The bias supply is rectified with only one diode UF4007. One is enough because the bias draws next to nothing in current. But it is preferable to decouple it well to get rid of garbage and noise from the AC power lines and switching noise from the rectifier diodes. Any noise on the bias voltage line will be injected directly into the drive signal of the output tube.

The heater supply is also very plain. Output tube and driver are heated with AC. Left and right channels are series connected to the 12.6V output of the transformer. The preamp tube is heated with 12VDC after rectification. I hard wired the bridge rectifier and cap directly on the preamp tube to get as little switching noise as possible. The lead length between the rectifier and the cap is nearly zero. The output voltage is adjusted by the 2.7Ω/2W resistor and it also compresses switching noise by lowering loading currents to the 2200µF cap—it takes a longer time to load the cap, therefore the rise time of the noise goes down, and it is easier to get rid of by decoupling.

The control voltage to the input switch is taken from the heater supply and stepped down to match the 5V relays. It may be necessary to adjust the resistor if you use different relays than I did.

The power supply is mounted on a PCB. I like best to use it upside down. The advantage is that you don't have to loosen the PCB every time changes are made. The only thing to be careful of is that it is strongly advisable to mount the caps at least 2 mm over the copper foils. The insulation is not made to withstand 450V constantly for years with a lot of heat.

You can get the PCB design on the net. I have used this power supply PCB for years in all kinds of tube amps as a universal assembly like the input switch PCB.

On one side of the PCB there is a little timer connected to a relay that switches on the plate transformer 1-2 minutes after the heater and bias. This is done to protect the caps in the power supply from more than 450V in the start up period. The power tubes also will last longer, the cathodes will not miss electrons in the start up when they are too cold to emit enough electrons to provide high currents. This is also called cathode stripping.

Don't forget to phase the power transformers correctly. Measure the AC voltage between earth and the chassis. When you get the lowest voltage you have found the right connection to the power line, so mark the cords with live and common. If you have not done this already, you must do it with all your equipment one at a time, they must not be connected together, and the ground lead must be disconnected while you do the measurements. By doing this you minimize the ground currents between all your equipment. Soundstage improves and the sound gets cleaner.

Practical things

The amp is built on an anodized aluminum plate. The template will be on the net in PDF 1:1.

The power transformers and choke are placed on top of the chassis together with the tubes. The output transformers are under the chassis. The sides are made of 16 mm MDF form and the front plate of 4 mm aluplate. The text on the front is made with dry transfer symbols.

All the ground connections are star-grounded. To make life easier, I made a PCB to mount between the tubes with all the ground connections and space for bias components. It too is available on the net.

Use a loose power cord and a connector so that you have the opportunity to switch power cords. Make them yourselves. Thick braided wires work well. You can get inspiration in *The Cable Cookbook* from Allen Wright. It is a must-have book.

Use good wiring between the input switch, volume pots and preamp tube. It is best to use twisted wires. Or better yet, silver foils from Allen Wright. I don't like shielded cables—they eat the soundstage. Make the connections as identical as possible for left and right channels. That also enhances soundstage. I have placed the input switching board in the front of the amp to make signal paths as short as they can be.

After finishing the amp, apply power in steps. Begin by checking the power supply without any tubes in the amp. Adjust the bias voltages to –90V, check the heater voltages and high tension. Put in the tubes and adjust the plate voltage on the lower power tube to 180V. Check the voltage across the 10Ω cathode resistor—it must never exceed 0.7V. If it does, you may have to lower the supply voltage by adjusting the resistor in series with the 10µF power supply cap. Readjust the amp after an hour when everything has gotten hot.

Let the amp play music, or better yet, use an XLO burn-in disk for at least two days and finish up with the demagnetizing tracks on the disk.

Use two 10Ω/10W resistors as a dummy load for the break-in period, to protect cat and neighbors while you are at work. You can listen to the amp after a short time but the full break-in period is much longer, so be prepared for changes for the next month at least. Let the amp play as much as possible. It is not enough to just have it on, it must play signal to become softer with time.

Also fix the absolute phase before you listen critically, again using the XLO disk. This disk is one of the best things the high-end guys have come up with. I can't live without it.

I have not investigated silver foil wires for the loudspeakers but I use copper foil 5mm wide made of foil from the local transformer supplier. He uses the foil for electrostatic screens between primary and secondary windings in power transformers. Strip down the foil and insulate it with a good tape and you have a good and cheap speaker cable.

Somebody might ask, "Why SRPP instead of a cathode follower?" I thought the same way and even tried it, but got only about 2 watts from it and much worse overall performance. I dropped it without thinking about why it performed so badly. I think I must have done something wrong, but I don't care.

The distortion of the SRPP amp is clean 2nd harmonic to about 3V output and then the amp gives more and more 3rd harmonic until clipping begins at about 6V into 8Ω.

Some tubes gives 5.5V before clipping and others about 6.5V. I have a pair of RCAs that give 7V. The performance is about the same as 2A3s are capable of. The sound doesn't differ much from a 2A3 SE amp ("Baby Ongaku" with home-wound transformers) I compared it with.

Close at last

To complete this article, I will give you alternative connections of the 6AS7 power stage with the component values and a brief subjective description of the sound and the measured performance.

The differences in sound are not very big but the power performances and measurements differ a lot. I tried to let some of my fellow patients with a high degree of *highfideli-itis* make comparisons in an AB listener test of three different amps: SRPP, push pull Class A, and paralled SE parafeed. On nine different records every amp was named best amp three times!

But there were problems with the preamp. I used one of the 12SN7s as preamp into all the amp inputs at the same time. We knew that the preamp wasent that great and, what's more, it did not have capability to drive all the tested amps at the same time.

So, I will not put to much authority in this formal "test." Instead I will give a brief subjective description of how I find the long term sound from the different coupled outputstages, together with the data and distortion curves.

Another thing is that AB tests seem to magnify small differences compared to long-term listening. Perhaps records, gramophone, amplifier, speakers and the soul of the listener must be burned-in together before anybody can make critiques of anything.

OK, we are back again to a combination of psychology, perfectionism and engineering, blended with religion and an expensive world-wide disease nobody can, or even tries, to cure, called *highfideli-itis*.

So, make your own choices and don't expect to be fully satisfied with the sound of your equipment. If that happens, then you are getting old…start making yourself a coffin out of your VOT speakers!

Not Your Father's Dyna Mod...

Retrofitting the Push-pull Pentode Classic for Single-Ended Triodes

by Ross Lahlum

Psst…wanna buy the world's heaviest ST-70?

This project began as a quick experiment to find out what all the commotion was regarding DHT SE triode power amplifiers. I had a Dynaco Stereo 70 chassis with good iron,which I had planned on using sooner or later with an Audio Research upgrade from an old *Glass Audio* article ca. 1978. I never finished it, however, putting the whole project aside for several years. Last year I stumbled across some UTC HC-116 parallel feed chokes (150H at 16 mA) and bought them & put them on the shelf. At the time, I didn't really see a use for a choke at such low current.

Then somebody on the JoeNet (Grover Gardner) suggested the 46 as a nice driver for a P-P 2A3 amp I was building. People also started talking about the 46 as a lower-cost alternative to the 45 in amps in the 1 - 2 -watt class. The 45 is known for its musicality & sweetness, and the 46 is more or less a 45 with a screen grid added.

The 46 was designed by RCA as a dual-purpose tube. A pair configured as high mu triodes (both grids tied together) in push-pull Class B could deliver up to 20 Watts, while the same tube, with grid #2 tied to the plate, could serve as a Class A triode driver for the push-pull pair. Experimenters in the late '90's found that by connecting the screen to the plate, one could get a triode even sweeter sounding than the 45. Plus, they work well even at low plate currents of 20 mA or less. Check out the plate curves. These tubes are pretty linear even at low plate currents.

So I bought several 46's & got to work on a parallel-feed 46 amp using Dynaco iron. Please note that this is NOT a Stereo 70 mod (I had to tell Joe that so he'd agree to publish the article). I used Stereo 70 iron because that's what I had. You could pull this off with a wide variety of PP OPT iron, including all manner of Fisher, Eico, Knight, etc. amps. You're best off with OPTs that have a primary impedance between 4K & 8K. The 46 has a plate resistance of 1700 ohms, so a good rule of thumb is 2–3X that. Lower Z will get you more power, but also more distortion. If you go higher, you'll lose some power but distortion will improve.

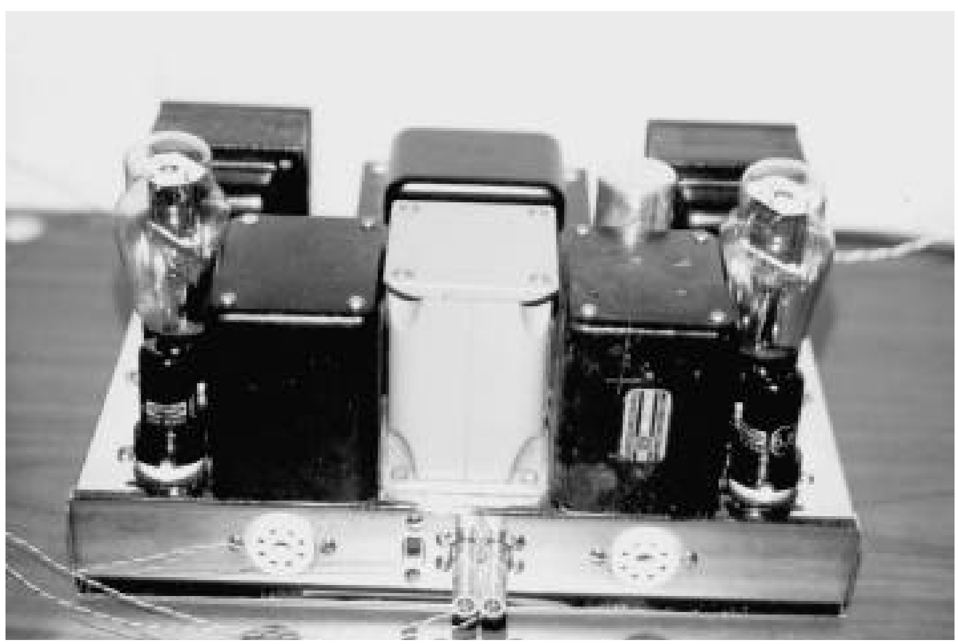
The Stereo 70 OPT is 4300 ohms, center-tapped. By using the full primary (just put some heatshrink over the c.t. so it doesn't touch anything!), you're at about 2.5X the plate resistance - just about right! I wasn't too concerned with power because this amp will be used with horn tweeters once I get the horn system put together; but with parallel feed the –3 dB point is about 15Hz on the low end,so it sounds great with efficient full-range speakers.

Mind you,if you're going to use this amp for tweeters only, you don't even need to pop for parallel-feed chokes. Just run the plate current right through the OPT iron. God forbid, you say, you're not supposed to do that! Well,you're not,because the core will saturate at low frequencies. But keep it low enough, and the amp will work, even though the low frequency cutoff point will be raised. That's what I did at first, just hooked the thing up to the OPT & ran DC through it, because I was impatient…and that's when I heard the DHT SE sound for the first time.

Whoa! Never heard that kind of sound before... Yeah, the bass was thin, and I couldn't crank the volume, but there was something really special there. So then I hooked up the DC feed chokes & the bass came in like gangbusters. But hey, if it's a tweeter amp, who cares? Save your money, build two sets of amps, and biamp!

I ran the amp for a while at 20 mA standing current and found that I was only getting about 600 mW of power, so one day I decided to push my luck with the UTC chokes. Although they are rated at 16 mA for 150 Henries, I reasoned that, due to the low plate resistance of the 46, I could afford to pay the penalty of lower inductance for higher current.

Judging by the DC resistance , I figured i'd still be safe running them at 30 mA. So I went ahead and kicked the output current up to 30 mA for a higher operating point. Now the Po went to over 1 Watt, I got to a more linear part of the curve, and a higher operating point, and as a result the amp got more punch, detail and sweetness (i.e. less grunge on peaks).



Of course, if you buy your own plate loading chokes you will have the freedom to choose your standing current. Based on my results, I would recommend running the tubes at 30 mA. I did try even higher current, up to as much as 40 mA, but did not notice any improvement past the 30 mA point. You don't really need 150 henries, you can get by just fine with 50 or 60 H. Magnequest has a nice line of plate loading chokes that I plan to try on my next amp, using a larger output tube like a 2A3 or a 300B.

I'll digress for a minute & talk about how I'm setting up my crossover for the biamp horn setup. My line stage has a transformer-coupled output. It's got a 26 DHT similar to Tom Ronan's line stage but instead of an RC-coupled output I used a Triad HS-54, which has a 20K primary & a 600 ohm secondary. No DC is allowed on the primary, so I used a constant-current FET to supply the plate with about 5 mA and cap-coupled the OPT. Again the 2 to 3X tube plate resistance rule-of-thumb applies. The data sheet shows that with 135 volts on the plate and a standing current of 5.5 mA, the 26 has a plate resistance of 7600 ohms. 20k is 2.63 times that, so we're in a pretty good region for distortion vs. power.

Since my line stage has a 600 ohm output, I got some Daven 600 ohm variable attenuators & went to town. If you look around at UTC iron, you'll soon learn that the price can be sky-high for some of the more popular items like LS-series & A-series input & output iron. But there are a lot of oddball parts floating around, too, that are of excellent quality, but since the applications are obscure, the price is correspondingly low. A ham friend actually gave me an LS-30 mixing transformer, and, as luck would have it, I soon stumbled across several more.

Since the LS-series are built like a brick outhouse, I thought they'd make good interstage trannies, but,because they have windings of 600 & 200 ohms, the primary is just too low for a plate load, so they sat on the shelf for a while, until I started thinking about a crossover. What's cool about mixing transformers is that they have multiple secondaries. You can take the output of your linestage, split it in two, and build a crossover using one winding for the highs and one winding for the lows.

Follow each side of the crossover with a 600 ohm variable attenuator, and you're home free with a passive adjustable crossover that sounds great! Since it's 600 ohms it's easy to design the crossover modules and you can build a variety of crossover modules to play around with & get the frequencies you want.

Voltage Amplifier Stage

The first stage of the amp uses a 6J5,a wonderfully linear and musical medium-mu triode, especially if you treat it right.This tube has a very straight and evenly-spaced set of plate curves at around 8 mA and 160 volts, so I decided to use a constant current source to keep it right there. The constant current source serving as the 6J5 plate load is a shameless copy of John "Buddha" Camille's Constant Current Source (CCCS) as described by the boys at Electronic Tonalities. I tweaked it just a little to get the voltage & current I wanted on the 6J5, and to use transistors I had on hand.

You can use this or some other CCS, or if you want to keep it simple, just use a plate load resistor, setting the value to get the right voltage on the grid of the 46. The CCS does do a nice job of keeping the voltage amp linear, and you get the full mu of the tube since the plate load is effectively over 1 megohm. To picture what a constant current source does, look at the 6J5 plate curves. Instead of drawing a load line the way you normally would,intersecting B+ on the X-axis and plate current on the Y-axis, just draw a horizontal line at your plate current. (*see sidebar*)

You can see how this keeps you in a very linear region. Tube purists may balk at this, but believe me, there is no mechanical solid-state sound in this stage! It is just very sweet and crystal clear. When you stop & think of it, little or none of your signal will be touched by those transistors, because the impedance is so high. An added benefit is the excellent isolation provided from the power supply; the voltage amp is very well decoupled from the next stage and its neighboring channel.

I figured a good place to build the current sources would be on the two octal tube sockets Dyna so thoughtfully placed on the front of the Stereo 70. One LED is centered in the keyhole, which has a nice visual effect when the amp is on. You can use whatever you want, but I had some extra ceramic octal sockets, and chose them for purely aesthetic reasons. (When you make your own stuff, you can do whatever you want!)

You'll need to heatsink the MJE350. I fabricated a clip from a terminal lug, and used one of the tube socket screws to anchor it. Be sure to electrically isolate the MJE350 from the chassis - that heat spreader is also the transistor's collector.

I used another trick that's been bounced around on the JoeNet to finish off the voltage amp stage. I wanted to avoid a big cap in the cathode, but I needed the full gain of the 6J5, so I put a 3.6 volt NiCd battery in the cathode circuit. This puts the tube in self-bias, with the cathode at a very stable point, and maintains a very low impedance to ground at the same time.

The NiCd battery pack I used was a 3-button-cell cordless phone battery pack I picked up at the local Batteries Plus store. I've since seen these in some of the surplus catalogs for less money than I paid. The

How to calculate L & C for parafeed

It's not hard to figure out what values to use for the plate loading choke and the DC blocking cap for a parallel feed arrangement. You already know the value of L.

I'll use 150 H for this example, but if you're building from scratch,you'll probably use a choke with a lower inductance, say 50 or 60 H.

To find the value of C, simply plug & chug with the old standby equation

$$Fc = 1/(2 \pi \sqrt{LC})$$

If we use a 2 uF cap in series with our 150 H inductor, we get a -3 dB cutoff frequency fc = 9.19 Hz.

That ought to be low enough! Now suppose you're doing this with a 50H parafeed choke. You'll get an fc of 15.92 Hz with a 2 uF cap, still OK.

Now the above is actually a bit oversimplified, because it does not account for the inductance of the output transformer, which in effect is in parallel with the DC feed choke. Push-pull OPTs generally have fairly high primary inductance, so this does not present a big problem.

For example, let's say my OPT has an Lp of 80 H. I haven't measured it,but that's a typical number for this type of OPT. Then we just plug the parallel value of the two inductances, or 52.2 Henries into the equation, with a resulting fc of 15.6 Hz. (I actually measured a -3 dB point of 18 Hz on this amp, but I know I lost some inductance in the DC feed choke when I cranked the current above the rated 16 mA.)

Calculating R values for the CCCS

In the CCCS, R4 sets the current output, while R3 is sized to accommodate the B+ the current source has to start out. The value of R4 is given by Electronic Tonalities as

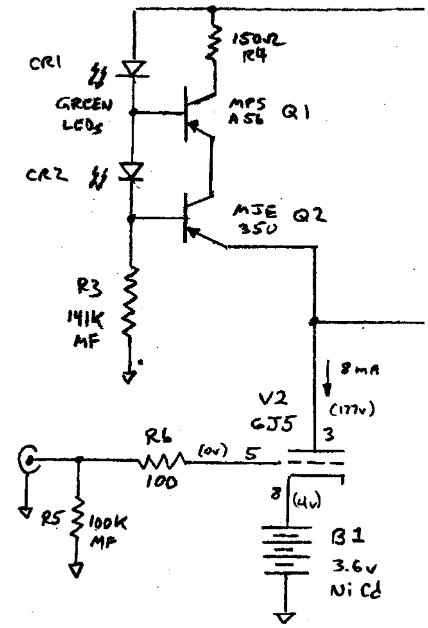
R4 = 0.95/Ip

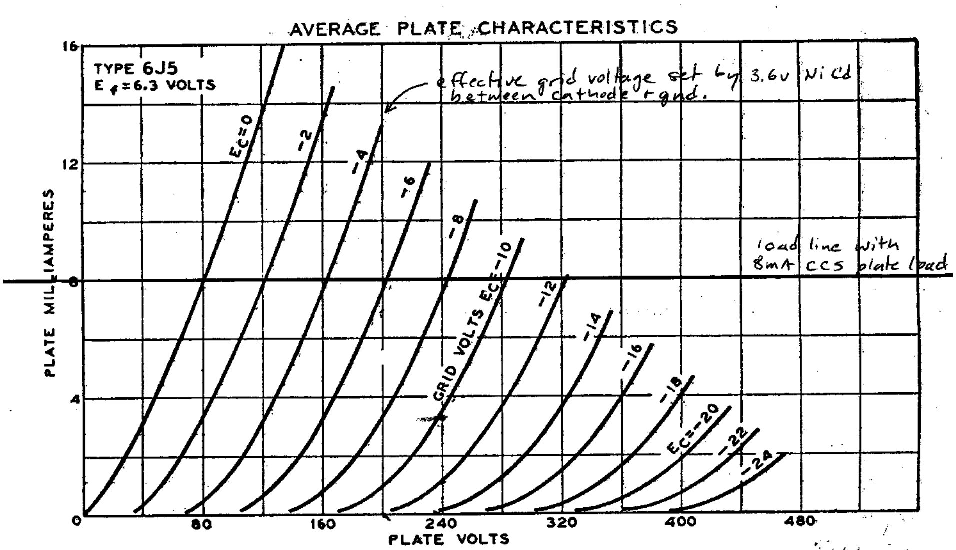
Or 119 ohms for 8 mA. I used a 120 ohm resistor, but ended up with 10 mA; I raised it to 150 to get the 8 mA I wanted.

The value of R3 is given as

R3 = VB+/0.002

Or 175k for a B+ of 350 v. Again, I had to tweak this to 141k to get the current & voltage I wanted. Some day I'll run this through PSPICE to get a better understanding, but for now, it does the job quite well!





constant current source keeps the NiCds in a low trickle-charge state, 8mA, which saves you from having to worry about overcharging the battery. Don't worry about the infamous NiCd memory effect here. The battery's sole purpose in life is to take a charge & stay at the same potential. The only current drawn out of the battery will be during self-discharge, when the amp is turned off

Power Amplifier Stage

The 6J5 is DC coupled to the grid of the 46. Here's another advantage of using a constant-current source. Along with the benefits of linear operation of the preceding stage, the grid of the output tube is set to a fixed value. We still need a cathode resistor, however, since the filament is going to be a couple hundred volts above ground. The cathode resistor is actually comprised of three resistors, bypassed with a 50 uF metallized polypropylene cap. The first resistor is a 5K 25 Watt wirewound. Don't worry about inductance here - it's bypassed by the cap. The next resistor is a 2.5K 5 watt pot, which is used to set the plate current. The bottom resistor is a 100 ohm 2W wirewound, which is there only to provide a measurable voltage drop to use in setting the bias. It's smart to use a 1% or better resistor here, but if you don't want to, the concept will still work as long as you know the exact value of the resistor; the voltage drop times the resistance is your plate current. For example, to set the plate current to 30 mA, we adjust R8 so that we get 3 volts across R9, since 3v /100 ohms is 0.03 amperes. I brought leads out from the current sensing resistor to two spare pins on the front panel tube socket for easy access.

Of course, the plate is supplied B+ through the DC feed choke. The plate is also connected to one side of the output transformer primary. The other side of the primary is connected to a DC blocking cap. The value of this cap is set to 2 uF for good low frequency response. (See sidebar.) At first I connected the other side of the cap to ground, but then just for fun, I tried connecting it to the center tap of the filament transformer, to get it as close as possible to the cathode of the tube. This opened up the sound of the amp quite a lot,so I'm going to leave it that way.

Power Supply

The power supply is a straightforward LCLC design,with a couple of twists added to protect the tubes.

The 46, after all, is an antique radio tube, and they just don't make them anymore. Therefore we want to extend its life as much as possible. Many studies over the years have shown that a major cause of early tube failure is excessive filament voltage, and in DHT power tubes, the filaments are also heavily stressed by the initial current surge caused by the filaments' lower resistance when cold. There's a 105 ohm wirewound resistor in the primary of the two 2.5 volt filament transformers to drop the output voltage to 2.5 volts.

Eventually I will replace this with a negative-temperature-coefficient (NTC) thermistor to protect the filaments from high initial turn-on current. These are available from Digi-Key, although most of them have a much lower on resistance. This configuration is a little different in that I am trying to put the thermistor in the primary rather than the secondary. This has two advantages. First you only need one thermistor. Second,you preserve the center-tap balance of the secondary by not putting anything else between it and the filaments. The 6J5 filaments are also protected by 1 ohm resistors between the filament transformer and the tube filaments. This keeps the filament voltage at 6.3 volts.

The rectifier is a GZ34 for slow warmup. Again, this is to protect the tubes. We want the filaments to get up to temperature before voltage is applied to the plates to avoid cathode stripping. There is an arrangement in the power supply to prevent cathode stripping at turn-off as well. The power switch is a DPDT, with the spare pole being used to connect a resistor between the B+ and ground when the unit is switched off. This bleeds off the B+ before the filaments cool off too much. A fair amount is dissipated in the resistor, but only for about a second, so it never really heats up that much. Consequently a 5 watt wirewound will be adequate.

The GZ34 is connected to a single 10 Henry choke. This should be a fairly large choke, rated for 100 to 150 mA. Next comes the first filter cap. I used a large aluminum electrolytic in an FP-style can because there's a cutout in the chassis for it. This is followed by a separate 10 Hy at 55 mA choke for each channel. These just fit underneath the chassis in the two rear corners. Following these are two 10 uF metallized polypropylene caps per channel. This arrangement provides very good filtering,and allows us to use reasonably small caps to the plate supplies to keep the amp sounding fast.

Grounding is done with a strip of copper EMI shielding tape stuck onto a strip of teflon. A nice wide, low-impedance ground bus is the result. This also is a major contributor to the amp's good transient response and high-end sweetness. There is a separate ground bus for each channel. Both are tied to the chassis at just one point, the ground lug of the aluminum electrolytic cap.

Room for improvement

There's always room for improvement. I decided to leave the amp in its current state for a while to get accustomed to its sound. That way I'll be better able to discern subtle changes when I get back to tweaking it. I must admit, though, at this stage I just like it more every time I listen to it. Perhaps it's still breaking in. Maybe that just means it's too soon to start applying tweaks.

There are some deficiencies, however, which I want to correct eventually. First of all, I don't really have enough voltage across the plate of the 46. This is noticeable on less efficient speakers, particularly on musical peaks where the amp just runs out of steam. It's not a terribly objectionable sound; it's basically just a much higher amount of 2nd order harmonics.

That's an advantage of SE triodes without feedback. Really, the amp sounds great on small ensembles, acoustic jazz, chamber music and especially small vocal ensembles.

Designing passive 600 ohm crossover modules

There's a nice reprint of a 1969 AUDIO article in SP Vol. 1 #3, which you should have if you're any kind of self-respecting DIY-er! (1) We'll just suppose you don't feel like digging it out from under the pile of parts and test equipment on your bench. Here's a brief synopsis:

We will be using parallel, m-derived filters. We'll use m = 0.6 for constant impedance over 85% of the transmission band.

Our impedance in & out is 600 Ω.

Crossover frequency: 500 Hz.

Attenuation at crossover: 3 dB

Slope of attenuation: 12 dB/octave

The L.F. filter is comprised of a series inductor, L1, followed by a shunt capacitor, C1. At the output end, we'll put a 600 ohm "L" or "T" stepped attenuator to vary the L.F. output.

The value of L1 is calculated as follows:

L1 = (1+m) Ro/2 pi fc Henry,

Where Ro = 600Ω, the filter's characteristic impedance, and fc = the crossover frequency.

This gives us L1 = 305 mH. You can make one of these yourself if you have some toroid ferrite cores and some magnet wire. Toroids are available from many surplus sources. There are reference materials available on many manufacturer's web sites that allow you to compute the number of turns needed on a given core to get the desired inductance. Arnold Magnetics and Micrometals are two I've used.

For example, take a look at www.grouparnold.com/products/powder/pdf/MPP4-8.pdf for powder cores, and http://www.grouparnold.com/products/wound/pdf/chapter10.pdf for tape-wound cores. Micrometals has a downloadable inductor design program at www.micrometals.com/software.html.

Of course, the best way to finalize your inductor is to measure it on an impedance bridge. If you like to experiment with passive components, it's well worth having one such as the General Radio 1650A, or ESI 650A. They can often be found at hamfests or on ebay.

Ok, so now that we have the inductor, let's figure out the value of the cap, which is:

C1 = 1/(2 pi fc Ro) Farad, or (5.3E-7) Farads X (E-6 uF/Farad) = 0.53 uF

which you can build up with the right combination of parallel capacitors.

Here, too, an impedance bridge comes in handy for getting the final value just right. If you have a lot of caps in your junk box you can get this value by paralleling a 0.47, 0.047, 0.01 and 0.0033.

Now we'll design the H.F. filter. This is comprised of a series capacitor, C2, followed by a shunt inductor, L2. The value of L2 is

L2 = Ro/(2 pi fc) Henry, which works out to 191 mH.

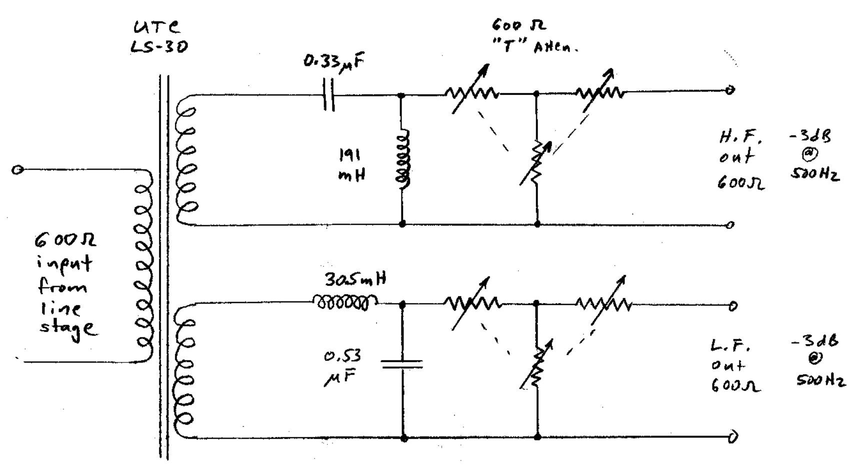
C2 is given by

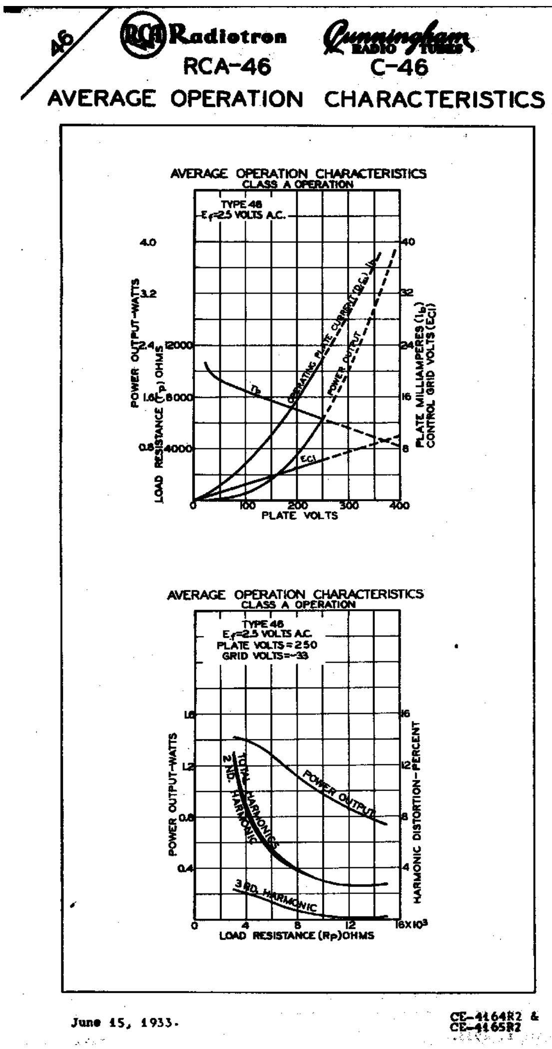
C2 = (1/(1+m))/(1/(2 pi fc Ro)) Farad, or 0.625 times the value of C1, or 0.33 uF, which is, fortunately, a standard value.

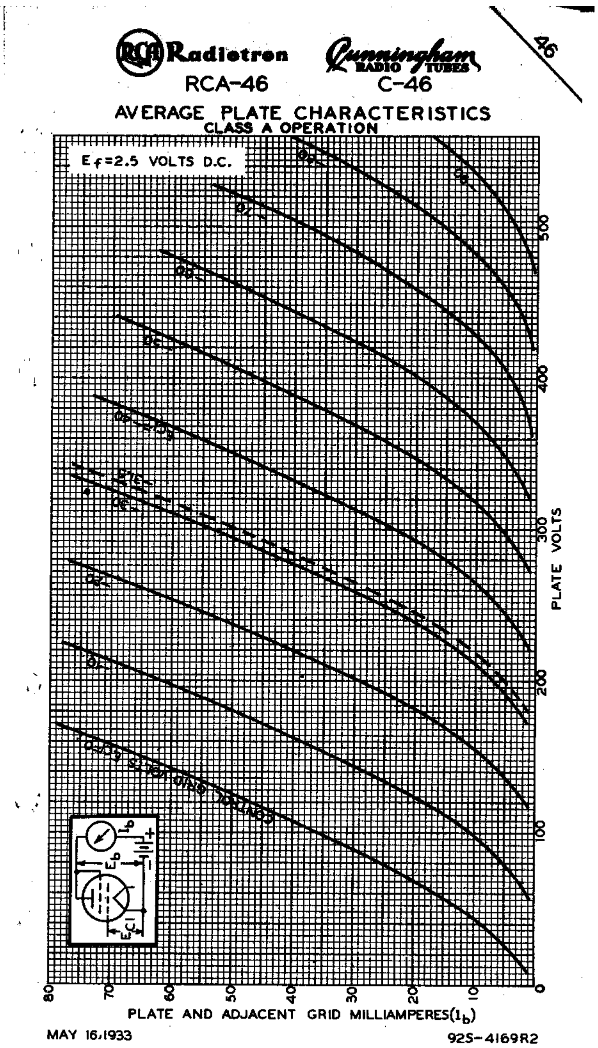
Again, since the output is 600 ohms, we can put a 600 ohm attenuator at the output to set the level wherever we want.

1. Another good reference is Attenuators, Equalizers and Filters, by Howard M. Tremaine and George K. Teffeau, Howard K. Sams Photofact Publication AET-1,1956.

Also it's well worth having a copy of Reference Data for Radio Engineers,published by ITT in many editions over the years.







But there are times you wanna rock out, let's face it! I might try raising the B+ by putting a not-too-large cap in front of the first filter choke. There is a range of input cap values, I'm guessing around 0.5 to 1 uF, where you can raise the B+ substantially while retaining the sonic advantages of a choke-input filter. It's also possible that this design is less sensitive to the power supply design due to the isolation provided by the DC feed choke in the output stage and the CCCS in the input stage. If I were building this amp from scratch, I'd use a transformer with a higher plate voltage.

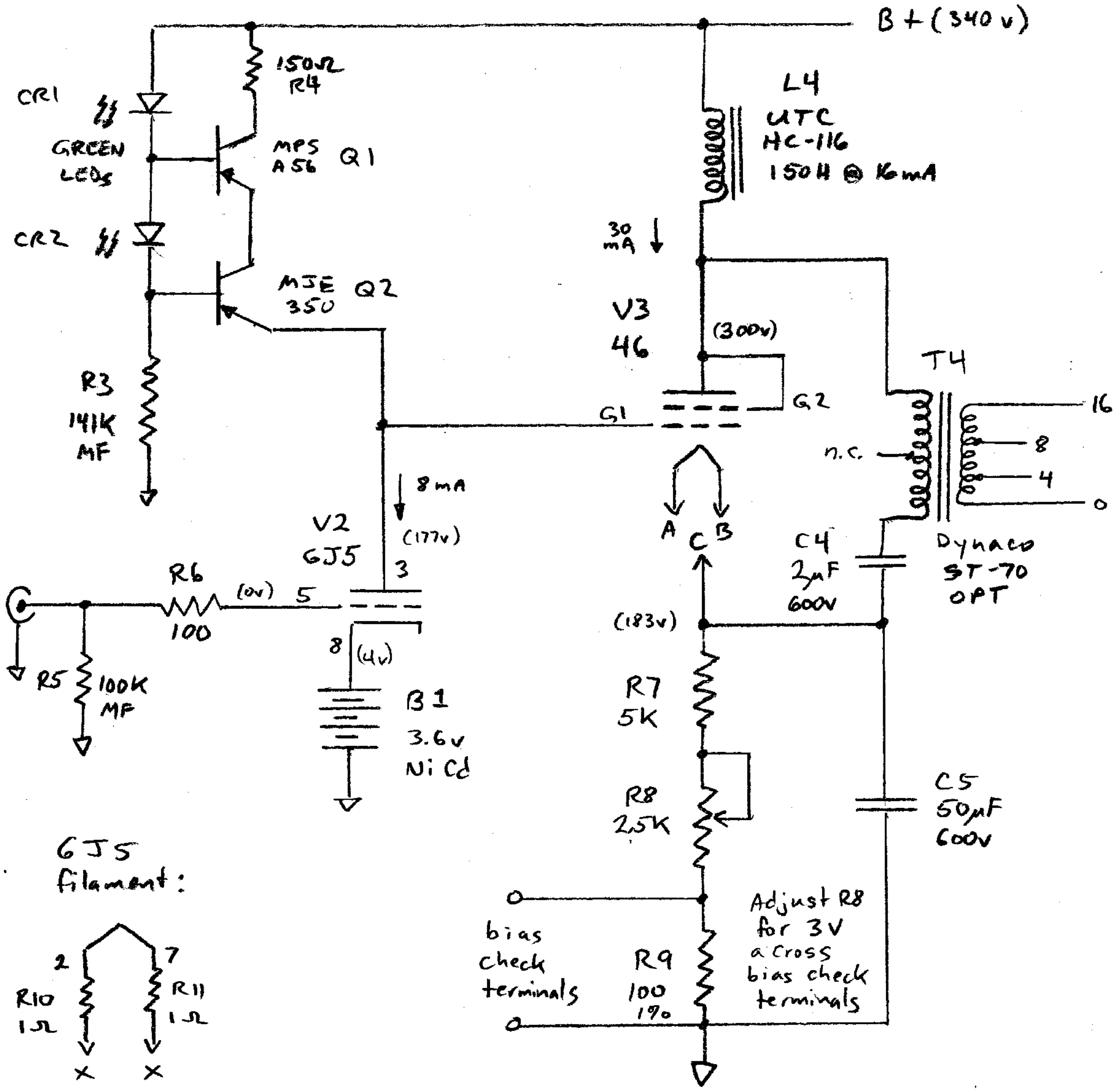
Another thing I want to try is to adjust the CCCS on the 6J5 plate to get the voltage a little lower. This will change the bias to the 46 grid,and allow the cathode voltage to go lower. The effect of this would be a higher plate-cathode voltage.

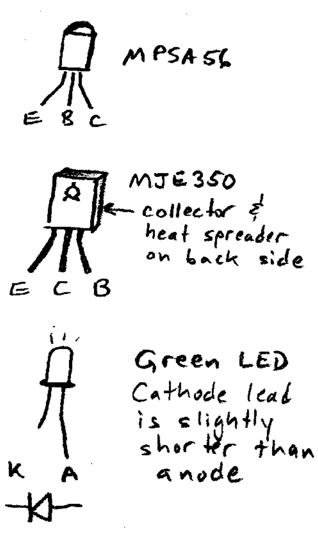
Second, there is a small amount of hum audible if you put your ear right up to the speaker. I believe that running the 6J5 filament off a DC supply will lower this hum substantially. It should be easily done with a couple of Schottky rectifiers, a filter cap, and an LM317 regulator. I might also try configuring the regulator as a current source. Schottky rectifiers are preferable because they produce much less switching noise than your garden-variety silicon rectifiers like the 1N4000 series. After all, any noise they produce will be reflected back into the power transformer, and could get into the signal path through the plate supply.

The Sound

What initially struck me about this amp was its open, natural sound and great frequency extension at both high and low ends. Perhaps this is because it's using a DHT in the output. I've heard criticism of DHT SE amps' lack of punch and a solid bottom end. Well,this amp has the punch! I believe this is due to the parallel-feed arrangement. Keeping DC current out of the output transformer allows a higher inductance, which helps the low-end response. Also I have to admit that these output transformers are high-end overkill for a one watt amp! Of course if a bigger transformer is better, then how much is too much? Who cares if the amp weighs more than most 100 Watt solid state amps? Who even wants to listen to them anyway?

So far I am very pleased with this amp, and I can heartily recommend trying your own version of this with any kind of push-pull iron you have sitting around. The most important thing is to get started on something. A very wise older engineer I once worked with had a saying I will always remember: "Don't wait until you think everything is perfect, just build something now &start testing it!" That's what I did here—and I'm glad I did. Let's keep those soldering irons in their heated state!





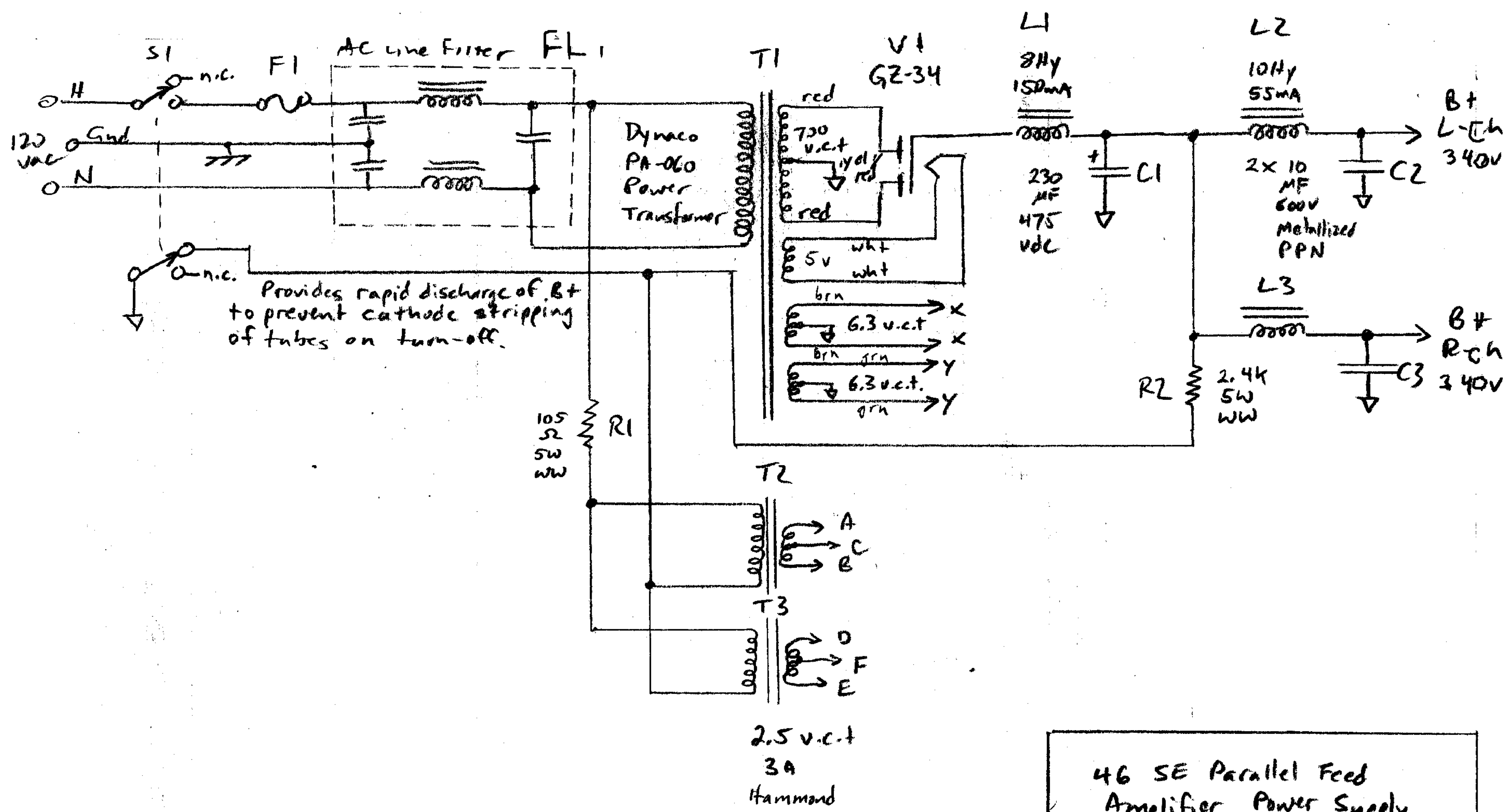
Notes:

1. R10 & R11 are set to adjust 6J5 filament to 6.3v.
2. Adjust R8 for 30 mA plate current, as measured across R9, 1volt = 10mA
3. Mount Q2 to chassis using iso-pad to prevent shorting collector to ground.
4. All grounds are connected to copper tape ground bus. This is connected to chassis by one wire to electrolytic can gnd.

46 SE
Parallel-Feed
Amplifier

(one channel shown,

rev. 1 11/17/99 R



46 SE Parallel Feed Amplifier Power Supply