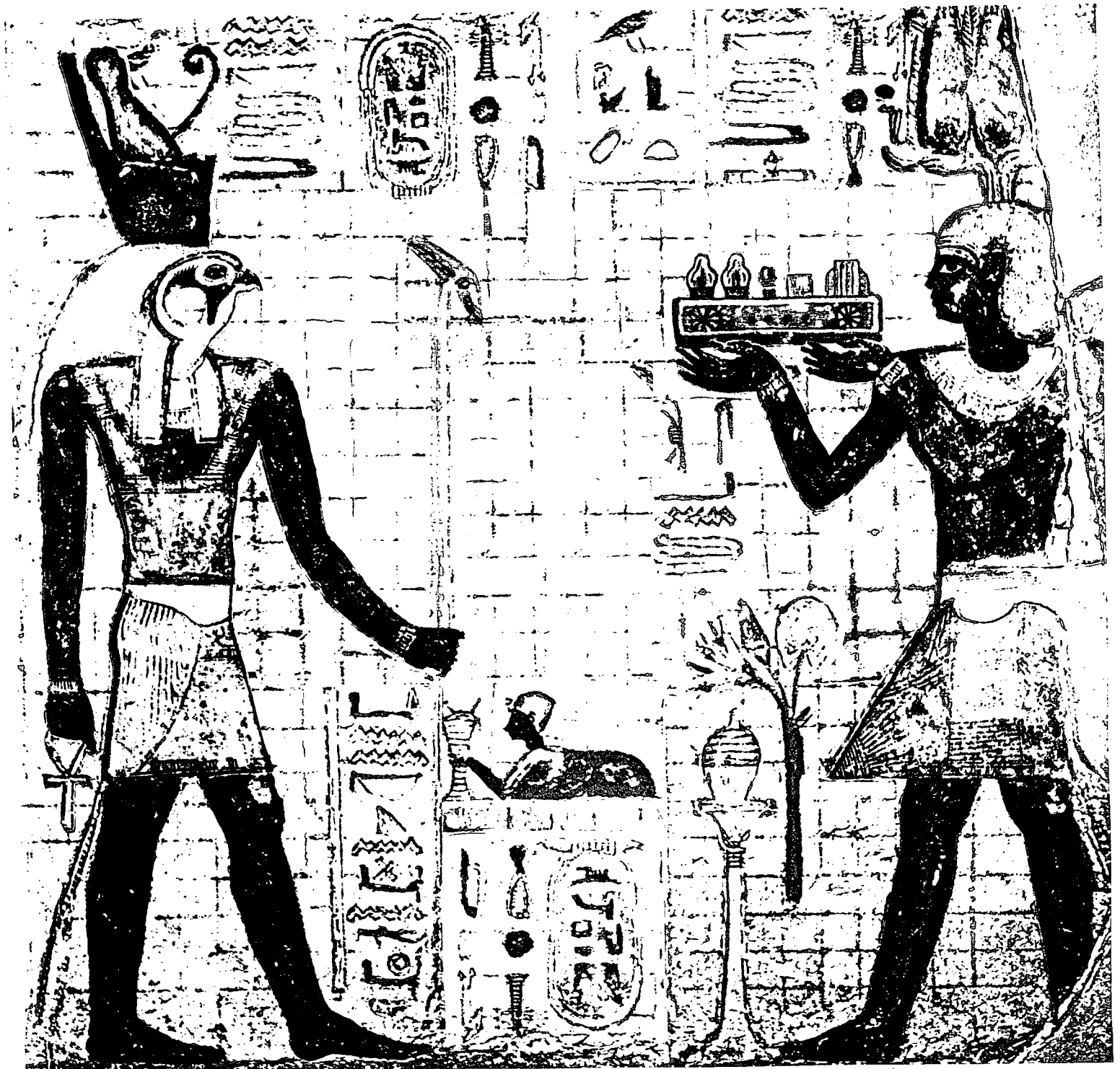


# SOUND PRACTICES

A JOURNAL OF AUDIO TECHNOLOGY

SUMMER 1993

FIVE DOLLARS



Old and New Technologies

Vol I: #4

# Sound Practices

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This publication exists to encourage audio experimentation and to promote the exchange of related information. Opinions expressed are those of the authors and may not reflect the opinions of any other person or entity.

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## Summer 1993 Contents

Development of a 211 Amplifier.....	3
No-Nonsense Line Conditioner.....	8
The Classic Williamson-1993 Style ...	10
Siren Song Update & Tweaks .....	16
Casual Reactions .....	17
Classic Designs:	
The Onken Enclosures .....	20
Analog Control Panel IV.....	22
Altec VOT Speakers for Hi-Fi .....	26
The Core Issues: To Pot or Not?.....	32
From the Archives:	
Electronic Phono Facts .....	35
Reader's Forum .....	36

... AND MUCH MORE !!!

## Fellow Travellers

In an age when the upward march of progress is taken for granted in most fields, more and more audiophiles are embracing obsolescent vacuum tube technology. The advance guard even seems to be moving further and further back in time, reviving and reassessing circuits which first came to light in the 1920s!

The sonic rationale for keeping the filaments lit is certainly apparent to readers of this publication and discerning audiophiles in general. Although largely abandoned by the "serious" engineering community, vacuum tube technology refuses to die because users still consider it useful and appropriate.

For most enthusiasts of other obsolescent technologies, everyday functional utility is of secondary importance. Antique radio collectors treasure old radios precisely because such things are not being made or used anymore. Although some collectors do fire up their sets occasionally, simply having them and saving them for posterity is usually more important than using them. They are historians.

Indeed, many old broadcast radios are evocative and appealing works of period industrial art which engage both the eye and the mind. Even to the most crazed vintage audiomaniac, a shelf loaded with old EICO amplifiers simply doesn't have the visual impact of a display of art deco radio sets.

For the most part, the beauty of tube hi-fi gear (vintage *or* modern) remains hidden until it is turned on. There are some "collectors" out there, but tube audio, even vintage hi-fi, is primarily use-oriented rather than ornamental or historical. Vacuum tube audio is a living art.

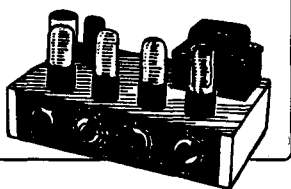
There is, however, another segment of the classic radio world that *uses* tube radios. A growing community of amateur radio operators (hams) is rediscovering the great communications radios of yore. They have character, they're easy to work on, and many are fine performers from a practical standpoint. Of course, most hams think the vacuum tube went out with men's hats — but there are quite a few around who really know how to have a good time with a technology that the mainstream gave up on decades ago.

There are contrary old timer hams out there who never did trust those darn silicon "three legged fuses". For some of these characters, the way to build a transmitter is to run a surplus metal 6L6 at 150 W dissipation inverted in a bucket of transformer oil so it won't melt down. If it worked well in 1953, it should still work in 1993. They've been around long enough to know that the laws of physics don't change that fast. But many of the "hollow state hams" are younger than the transistor. They see something in the glow of a tube that you can't buy at Radio Shack today.

They recognize the value in the idea of building your own gear and fixing it when it breaks. They are idealists, trying to capture the romance that radio once had, a quantity lost in today's world of LCD/LED lit microprocessor controlled "rice boxes". Compare a McIntosh MR-71 to a Panasonic tuner and you get the general idea. "Real radios glow in the dark," they say. They are right!

In this issue you will meet a few of these fellow travellers. You might also cross paths with these guys at swapfests or at the local surplus outlet. You want 2A3s for a single ended amp and they want 'em for the modulator deck of their WW II BC-610 transmitter. Hams are the *other* hollow state homebrewers, the other guys who read tube manuals in the bathtub, the other hobbyists keeping the orange glow burning. They are just like us — only the frequency range is different. We all recognize that real classics are always new.

## New Products



### SCOPE IT OUT

Perhaps the ultimate compliment on build quality is "Built like a Tektronix scope"—an accomplishment which very few products realize. *Oscilloscopes: Selecting and Restoring a Classic* provides over 370 pages of information on classic tube-era Tektronix instruments. Author Griffiths was a Tek service engineer for many years and his study displays a healthy respect for and intimate knowledge of these fine products. The book provides useful restoration hints, valuable advice for the flea market scavenger, and a useful glossary of 'scope terminology. An essential reference for the Tektronix fan. Available from the author for \$19.95. ISBN: 0-9633071-5-0

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### CHIMERA kyrie 211 AMPLIFIER

The kyrie is not your typical Wal-Mart single-ended 211 monoblock. One distinguishing factor is the attention lavished on the power supply. The voltage amplifier and the output stage are fed by shunt regulated supplies using an EL-34 and 211 respectively. Great pains were taken to ensure super low noise and low impedance power supplies are used for every tube's filament and plate supply — guess that explains why these babies are such a heavy load to tote.

Unweighted S/N ratio is over 100dBV below full output. Full power bandwidth is 11 Hz to 24 KHz with zero feedback. 100 pounds/15 Watts/\$5500 per side. The sound is said to be summarized by its name, which means "Lord have mercy!"

Read all about this innovative design in this issue of *SP!*

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### 300B SINGLE-ENDED AMPLIFIERS

Eddy Electric announces a line of directly heated triode amplifiers designed by Herbert Reichert. Design goals are simple and elegant — uncompromised electrical and aesthetic realization and vivid musical reproduction.

The REICHERT amplifiers are purist realizations of the legendary 300B SE topology. Eight years of experimentation and development preceded the final circuit and layout. A hand-wound custom transformer built to Eddy Electric specifications was commissioned from MagneQuest for this family of amplifiers. These amps deliver 7 watts of pure beauty into 4, 8, or 16 ohms.

This completely modern design is available in two versions. The COPPER version (\$4700) uses a pure copper ground plane and an "all natural" selection of the highest quality parts including non-inductive wire wound resistors, paper-in-oil capacitors, and Kimber Varistrand wire. The SILVER version (\$5900) has a pure silver ground plane, Kimber hyperpure silver wire, Teflon coupling capacitors, and Black Gate decoupling capacitors.

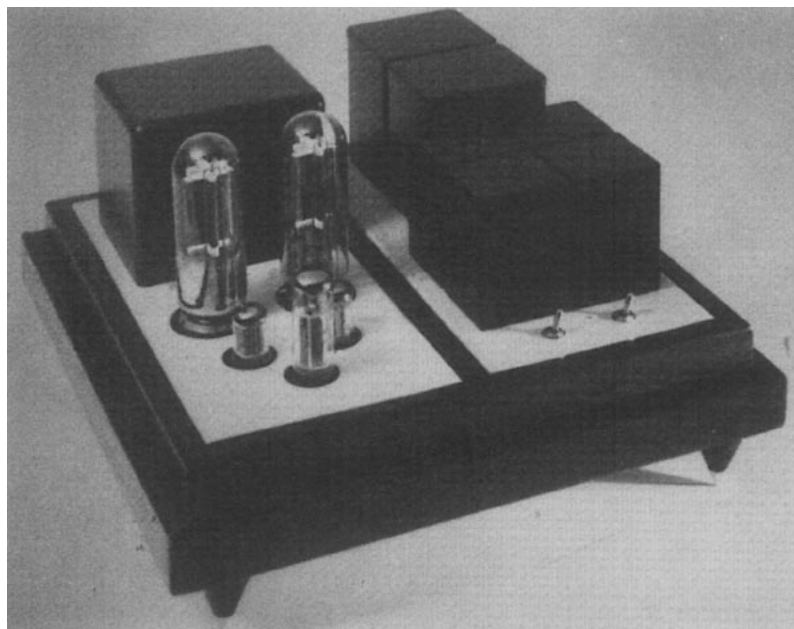
Both versions are hardwired and handcrafted to artisanal standards by Herbert Reichert. These amplifiers are pure Class A designs and employ no negative feedback. Handcrafting allows Eddy to offer a lifetime parts and labor warranty.

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# DEVELOPMENT NOTES ON A SINGLE-ENDED 211 AMPLIFIER

Dennis Boyle  
John Camille

Chimera Laboratories



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## Foreword by Dennis Boyle

In 1992, after over thirty years of building and modifying audio equipment, I decided to build a "test mule" single ended 211 amplifier to see what all the "fuss" was about. John Camille agreed to do some analysis and testing of the original prototype. At the time John was involved in preparing an article on a tube amplifier project and he had a very nice 8417 push-pull parallel triode amp put together. We listened to both amps in his system and the rest is history. After 40 years of push-pull audio, John was really "fired up" by the sound of a single triode. We decided to put our heads together and see where a dedicated single-ended design effort would take us.

After countless revisions and listening sessions, that "test mule" evolved into an amplifier that has converted a lot of "down home" fellow audiophiles. This collaboration blossomed into the founding of Chimera Laboratories and the commercial release of the *kyrie* 211 mono audio amplifier.

My background is in manufacturing operations and industrial design. I like things simple and I like equipment to look as good as it sounds. John has a broad and extensive technical background in military electronic, test and transmitting equipment and he is an ex-fighter pilot and "Top Gun" flight instructor. Where he comes from, sound design and reliability are key. His heroes are Tektronix, Hewlett-Packard, and Collins. For fun, he likes to design low-noise VHF/UHF receivers and do a little ham operation. Lately he spends a lot of time restoring and upgrading precision test equipment and adding audio test equipment to his RF test lab. He jokes that with just another \$500K worth of test equipment he will be able to measure to the degree of precision claimed by many audio periodicals. He is precisely the kind of guy you want to have on the team if you're out to do some "serious" design.

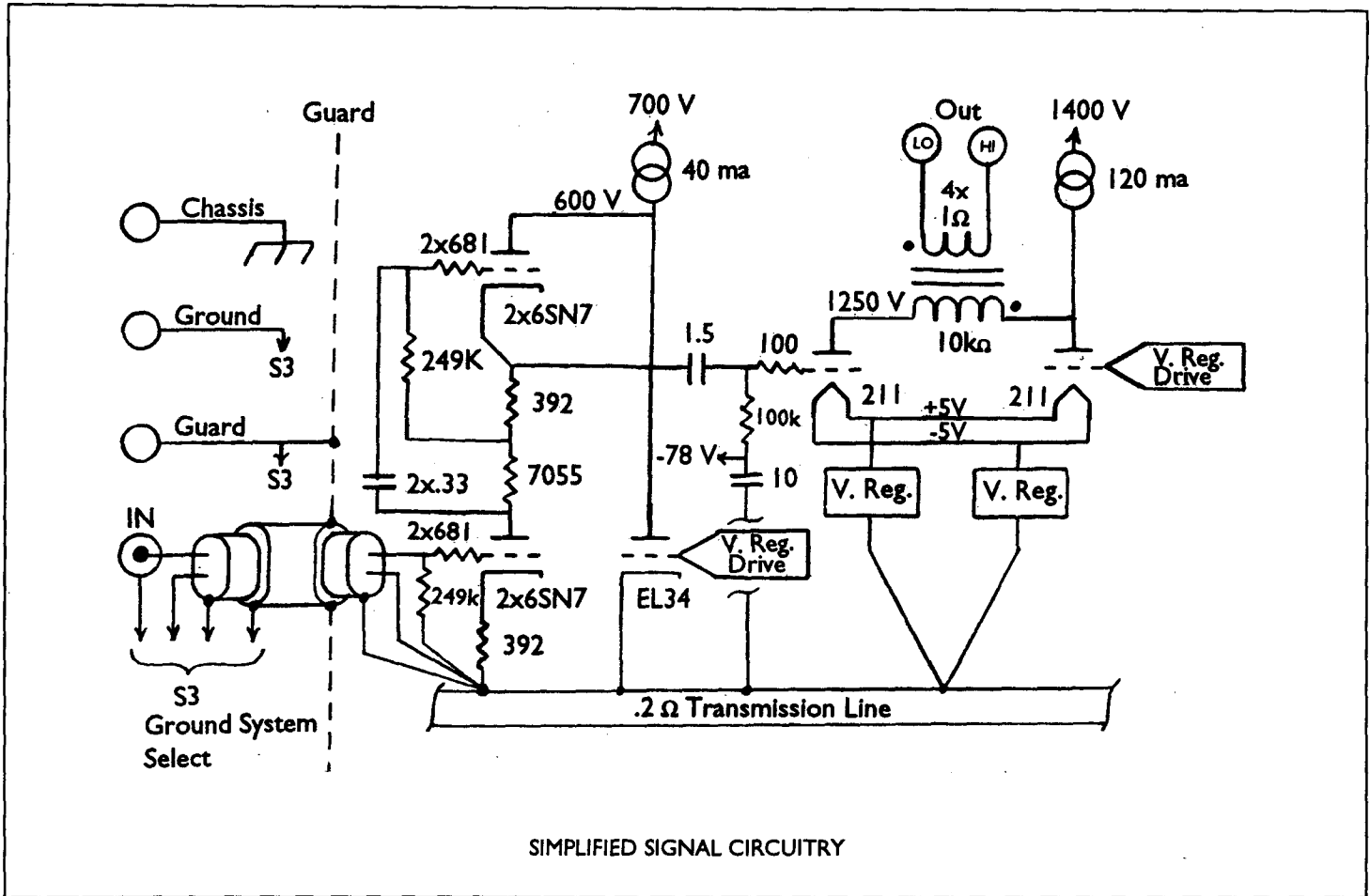
As it turned out, John's insights on layout and wiring, grasp of design principles from disciplines other than audio, and his meticulous attention to detail complemented my "plug it in and try it out" approach in the design of the 211 amplifier.

John and I feel that the circuits and concepts we finally ended up with should be made available to the audio community for evaluation and discussion. Audio design is a blend of science, component selection, execution, intuition and luck lubricated by lots of sweat. There is a tendency to use proven "classic" circuits and rely on component selection and execution to provide excellent sonic performance. That's the way the "old gray test mule" started out—simple design and good parts. As we progressed in the development program, we learned a lot that made significant improvements in sonic performance. We hope that this article will stimulate further experimentation and open some healthy discussions that will ultimately provide new paths to honor the music.

## Design Notes by John Camille

Development of a single-ended 211 amplifier was started here at Chimera Laboratories early last year. The list of design goals included realism, resolution, repeatability and reliability. Our primary objective was to produce an amplifier that would fully exploit the excellent linearity of the 211 transmitting triode. We also wanted the amp to have excellent attack and very strong bottom end performance.

Sonic purity and reliability were to hold equal weight during the development process. When sonic challenges required an increase in circuit complexity, we maintained an appropriate level of derating of components in order to preserve overall reliability.



Early on, we adopted an aggressive Mean Time Between Failure (MTBF) goal of 10,000 hours of operation at an ambient temperature of 38°C (100°F). This reliability goal would include the tube complement as well as other relatively short-lived components, such as electrolytic capacitors. Inclusion of tube life in a reliability goal of this type is uncommon in this day and age of running tubes to the limits of their specifications. However, we believed that proper treatment of tube start-up, operating and shutdown parameters would provide an amplifier with a lifetime equivalent to the premier tubed test and transmitting equipment built in the 1950s and 1960s. Solid state devices are also operated at very conservative ratings with maximum junction or chip temperatures of 80°C to minimize bonding stress between a device's substrate and package during start-stop cycles.

Sonic strides were relatively large during the early stages as the more obvious problems were solved. As the design matured and we got smarter, changes became smaller and more systematic. End game changes were of the "snake oil" variety. Lately, we have been experimenting with component and wiring substitution.

I must admit, based on careful listening, that "theoretical nonsense" such as hookup wire construction can and often does have a real sonic impact. The difference between hyper-annealed copper and silver is audible even though the path length is measured in inches. The change is non measurable because it would be buried in the noise at levels 60 to 100 dBV below the noise floor. However this effect shouldn't be surprising when you consider that many "old

time" radio-telegraph operators could pull signals out of the noise even better than the first phase-locked loop detectors which could lock onto a coherent signal buried 20 to 30 dB into the noise floor. The ear/brain interface is a wonderful thing and it is fun trying to fool it with our puny efforts.

### Topology Overview

The signal amplification circuitry at this stage of development consists of a parallel pair of 6SN7s stacked in the so-called mu-follower configuration. The 6SN7 stack drives a single-ended 211 operating in Class A1. An EL-34 is used as a shunt regulator for the 6SN7 stack B+ of 600 VDC. An additional 211 is used as a shunt regulator for the 1250 VDC B+ supply for the 211 output tube. Thirteen other regulated DC supplies provide heater, filament, bias and other control voltages. Transmitting style control circuitry provides sequenced, soft-start turn-on and sequenced turn-off for the various supplies. In addition, various voltages and currents are monitored by an interlock circuit that will shut down the system during serious fault conditions.

The development of each of these circuits has a story that will be broad-brushed below. As in any blank sheet development project, the real story is not in the final result but in the hundreds of trials that were *unsuccessful*. However, time and space do not allow coverage of each trial, test setup and results obtained. Suffice to say, we probably know many more methods that do not work than those that do.

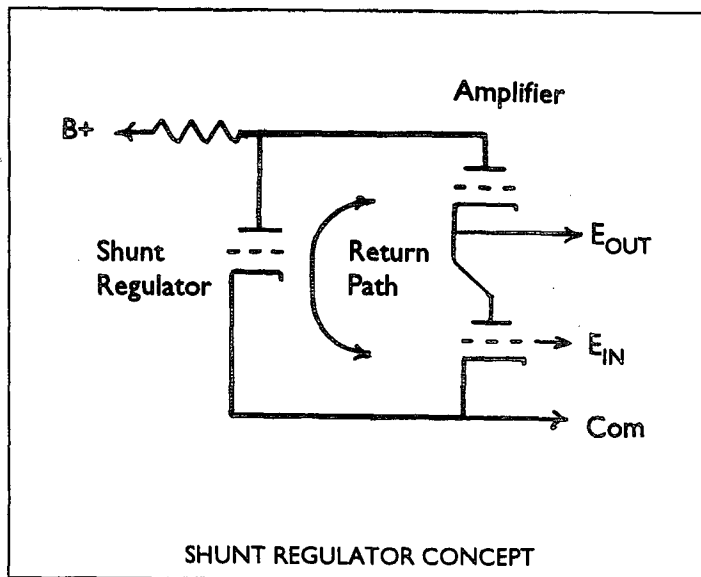
## Voltage Amplifier or Driver Stage

The voltage amplifier (VA) stage must provide approximately 150 volts peak-to-peak drive to the 211 grid for full Class A1 input. This drive level, in itself, is not excessive until one considers the 211's grid-to-plate capacitance and the Miller Effect multiplier.<sup>1</sup>

This grid/plate reactance, in parallel with the various real and dynamic resistances found in the 211 grid circuit, result in the need for approximately 0.5 W of peak drive power in order to achieve a reasonable bandwidth. The typical "cookbook" VA stage cannot provide this power with any degree of accuracy resulting in poor dynamics and sonically detrimental distortion effects.

### Trial and Error

We conducted empirical trials of dozens of low output impedance tube/topology combinations based on various octal triodes, including a number of cascode or stacked variations plus cathode follower configurations. Initially, we had high hopes for high transconductance triodes but listening results were typically poor—even though the "specs" looked very good. Along the way, we made a number of critical discoveries about the sonic effects of the power supply. Essentially, the VA must be decoupled or isolated from the power supply to a *much* greater extent than we ever anticipated. Also we determined that the upper plate in a cascode stack or the plate of a cathode follower must be returned to ground through a very small AC impedance in order to truly make it "sing." The conventional use of bypass capacitance produced a muffled signature. This finding led to another development effort we will cover in more detail later, the shunt regulator.



The shunt regulator provides a short, direct signal path to ground, and with proper implementation, a low AC impedance. This unconventional approach is rarely seen in tube equipment because it is inherently very inefficient—the regulator consumes as much power as the regulated circuit, *more* in our implementation.

Another discovery made during experimentation with stacked voltage amplifiers was that a significant amount of "trash" was being coupled from the upper tube's filament to the cathode sleeve and thereby into the signal path. The cure was to provide a highly

decoupled floating DC supply for the filament. Again, this problem will be discussed in more detail later.

Through continual experimentation and listening tests of low impedance drive stages, we eventually settled on the mu-follower configuration. We felt that the mu-follower offered the best level of sonic performance compared with other stacked configurations, all of which bettered the cathode follower to our ears.

During the above sonic trials, after blowing the dust off of a lot of tubes we ultimately came full circle to the "tried-and-true" 6SL7/5691 and 6SN7/5692. We initially selected the 5691 for optimization in the mu-follower configuration. Two of these tubes, with both tube sections tied in parallel, would swing just enough current to drive the theoretical 211 grid load to somewhere around 50 kHz. The 5691 combination was, indeed, able to drive the 211 grid to 35 kHz in the "brass-board" and eventually to 46 kHz in the prototype. The prototype had a slightly better component layout plus an in-house design, low capacitance 211 tube socket. In order to achieve the required drive levels, it was necessary to bias the 5691s to the maximum permissible plate dissipation.<sup>2</sup>

During later listening tests of the first "real" prototype, the inevitable tube "switcherama" began. Eventually, we plugged in a pair of 5692s and everything seemed to fall into place. Even though the 5692s were biased well down into their nonlinear region with the existing 5691 biasing, they sounded as smooth as the 5691s and had much greater attack on the low end. Triangles and bells now really sparkled on the high end and "rim shot" detail was greatly improved.

The second prototype was set up with proper biasing for the 5692 combination. Each tube in the stack was operated at a quiescent plate potential of 227 volts and a combined plate current of 18 mA. Plate dissipation under these conditions is slightly below the recommended operating point and well below the operating maximum (4W versus 7.5W). This operating point is centered in a sizable area of operating conditions that exhibit the same distortion level, thus minimizing aging effects.

Full power bandwidth of this stage was now 250 kHz and the sonics were well into "goose bump" territory. Inexplicably, a later change to a garden variety 6SN7WGTA rewarded us with greater apparent speed and much better apparent dynamic range, even though the measured performance did not change. We still haven't uncovered the reasons why the highly touted 5692 sounds very slightly lacking in inner detail when compared to the 6SN7. [This was a great disappointment for me. I had been hoarding Red tubes for years, even kept a few on my night stand—Dennis]

<sup>1</sup> The grid-to-plate capacitance of a common cathode amplifier is increased significantly by a phenomenon called "Miller Effect." Very roughly, the static  $C_{g-p}$  is multiplied by the AC gain of the stage. For the 211, the  $C_{g-p}$  (14.5 pF) is multiplied by the amplification factor (12) to about 170pF. Consult texts for a proper understanding. This effect also explains why simple pentode to triode conversions rarely work well because of the greatly increased load capacitance.

<sup>2</sup> The 5691 is rated for 10000 hour service at a recommended design center that occurs around *one-half* the maximum dissipation.

## VA Characteristics

Measured output impedance of the VA stage is less than 600 ohms (430 ohms) and full power distortion (approximately 150 Vpp) was 0.4% (-48 dBV) throughout the 20 Hz to 20 KHz range. Distortion numbers at 1 W equivalent output are approximately twice as good (0.2%/-53 dBV). These distortion numbers are comparable to many systems using feedback. Out-of-band distortion (20 kHz to 100 kHz) rises gently to 0.3% at 100 kHz. A 0.3% bump in distortion also occurs at the 70 kHz self-resonant frequency of the output transformer where the worst case load exists. The VA stage has over 6 dBV of headroom in that it will drive a pseudo-grid (non-clipping) dummy load to 350 Vpp. Clipping is nicely rounded when a real world 211 grid is driven into the positive region and the amplifier sounds perfectly acceptable when driven to the 30 W level—well into Class A2 operation.

The VA stage and its voltage regulator are unconditionally stable at all plate voltages between 0 VDC and 700 VDC. Inductive and capacitive speaker loads reflected back through the 211 output stage cause minimum change in VA wave form. Also, parasitic oscillations could not be induced under any operating conditions up to an input overdrive of 60 Vpp of sine, pulse or triangle waveforms! Swept input waveforms between 0.003 Hz and 1 MHz produce no spurious products, an attribute of no global feedback.

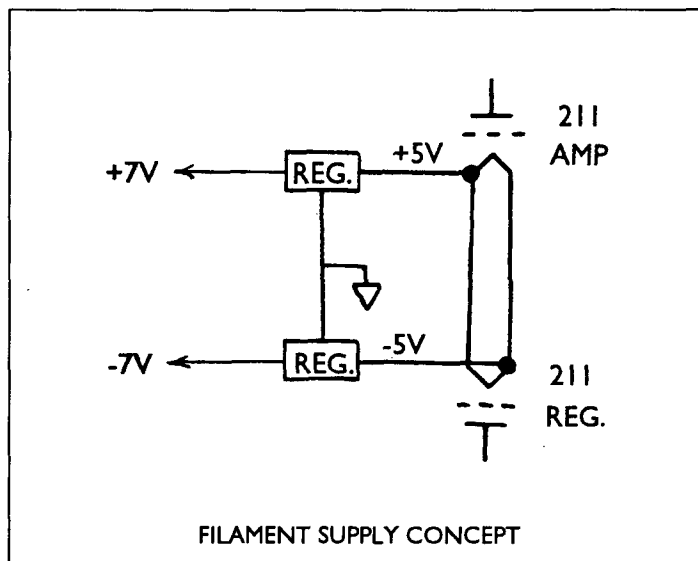
## 211 Power Amplifier Stage

We originally thought that the 211 power amplifier (PA) stage would be a "piece of cake" since all one had to do was "light the fire" and add B+. We assumed that a stage operating at the planned power level would be immune to the normal problems associated with low-level stages. However, this was *not* the case.

We discovered that numerous artifacts from existing "cookbook" power supply topologies would show up in the output signal. Thus, the story of PA stage development is primarily one of power supply refinement. Simply put, we determined that the 211 output stage must be supplied with highly regulated and very clean power for the best sonics and to provide a good signal-to-noise ratio (SNR). Otherwise, the PA stage seemed to process "garbage" as well as it processed the desired signal. In more polite terms, the 211 SE stage had a poor power supply rejection ratio (PSRR).

We also learned that the 211 does not really "come alive" until the B+ is raised above 1200 VDC and the "after-burners" kick in around 1250 VDC. This presented an interesting engineering challenge in building a low-noise HV supply. Being of single-ended design, the amplifier has none of the noise canceling effects of push-pull designs. B+ and bias supplies must be filtered and isolated to the same extent as the low-level stage supplies.

We encountered another set of surprises in working with the 211 filament circuit and here we feel that we made a very significant degree of sonic progress. Conventional AC and DC filament supplies force the entire audio signal return path through the filament winding and other power supply components to ground. In addition, it was virtually impossible to bring both ends of the filament to the same AC impedance (to ground) over the amplifier's bandpass when using conventional approaches. This factor led to a symmetrical design using two regulated 5 VDC power supplies operated in a center-tapped series arrangement providing +/-5 VDC at the filament terminals.



The much lower AC impedance of the regulators shunt a majority of the signal current to ground, thus bypassing the majority of power supply "nasties." This filament supply topology produced one of the most significant sonic improvements during the amplifier's development. Additionally, each improvement in regulator speed and in lowered dynamic impedance brought forth better sonics. The prototypes presently operate with LT1083-5 chips as the regulator element. This device has both a very low output impedance and an extremely low noise figure that measures several times better than other regulators.

We suspect that there is room for further sonic improvement in the 211 filament supply area. We are presently working on a dual shunt regulator using MOSFETs driven by video amplifiers. An order of magnitude improvement in dynamic impedance with an additional 6 to 10 dBV decrease in filament noise current appears possible.

## 211 Power Amplifier Stage Topology

The 211 PA stage development was, as mentioned earlier, a power supply problem. Otherwise, the topology was relatively simple. A grid bias of -75 to -80 VDC was delivered to the grid through a 100 K resistance. Bias is adjustable to set the plate current within a 50 to 60 mA range. Listening tests have shown that there is no advantage in increasing plate current over the prescribed 60 mA. No detriment in sonics is detectable as the plate current is reduced to 20 mA. However, such a large reduction in plate current would reduce the maximum power output capability and dynamic range would suffer on speaker systems with sensitivities of less than 100 dB SPL. Since 211 emitter life is more a function of plate voltage (ion bombardment) than reasonable plate currents, plate current is set at the specified 60 mA for maximum Class A1 dynamic range.

The heart of the 211 PA stage is of course the output transformer. The core and winding are about the same size and weight as a typical 500 W push-pull output transformer or a 1 KVA isolation transformer. The multiple interleaved primary has an impedance centered around 10K ohms at 20 Hz. Primary inductance is over 100 H at a current of 60 mA. Saturation effects are not visible on the full power output waveform above 20 Hz. 3 dBV bandwidth is 11 Hz to 24 kHz at full output. At normal listening levels, core saturation effects are not visible down to 5 Hz.

Secondaries are brought out of the winding stack with individual leads that tie-off to an array of insulated terminal posts. This arrangement allows strapping for output impedances between 0.5 ohm and 16 ohms. Strapping of these windings is done by soldering suitable busses across the appropriate terminal posts. Screw-type, quick-connect strapping schemes were discarded because of possible sonic degradation with age in high humidity locations due to galvanic action. This decision was also in keeping with an overall design philosophy precluding mechanical connections within the amplifier.

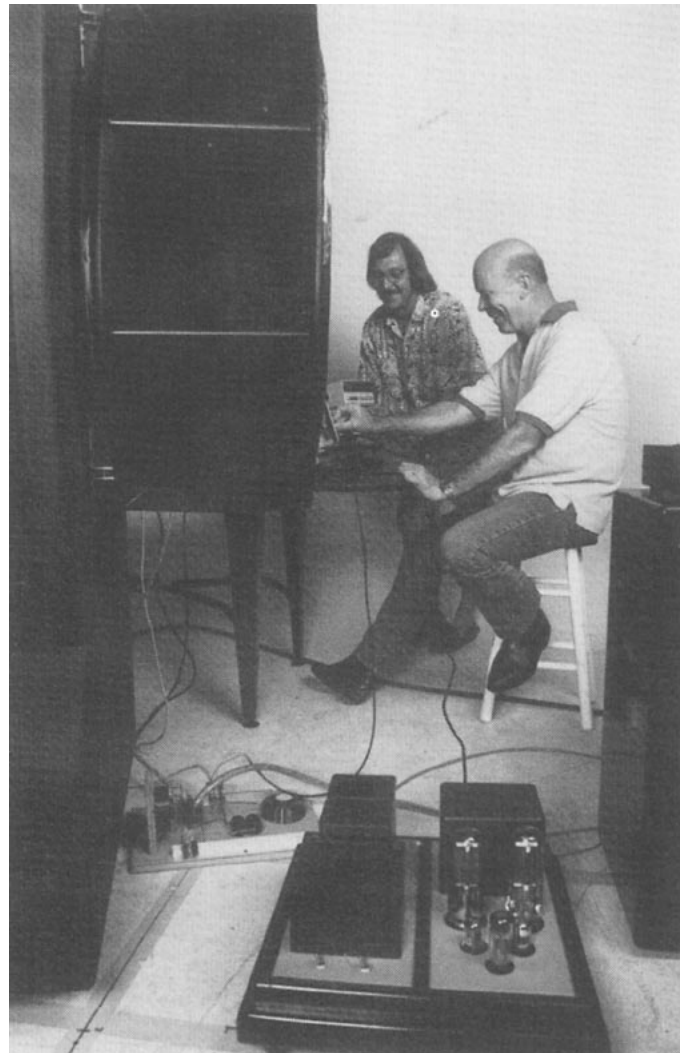
### Conclusion

To some, the whole concept of building a 100 lb. monoblock in order to experience 15 Watts of single-ended sound might seem a bit "obsessive"—however, listening to it can ruin your happy life with push-pull tube amps or transistor amplifiers.

We are nearing completion of the development program on these amplifiers. All the midnight hours, the thrill of discovery, the adrenaline rush to complete something for testing, have been replaced by a deep sense of satisfaction every time we light the fires to listen.

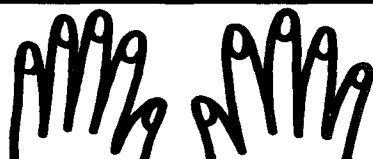
The prototypes have been running for over 6 months in their current configuration. During that time they have not required any adjustment or tinkering of any kind and they simply ignore any planned or accidental destruction testing. There has been a steady stream of "audio fanatics" knocking on the door of the converted movie theater that houses Chimera Labs. Many carry in amplifiers and other gear for evaluation. We even hosted a few visitors who flew in from Europe and the Far East. It usually takes only a few minutes to compare amplifiers. The *kyrie* prototypes just don't seem to have any sonic signature. They don't color or erase the music at all. One "golden ear" found that they were too accurate—his "holy grail" is a system that would make all recordings sound *good*. The *kyrie* tells it like it is.

Chimera Labs is only a few minutes from the Dallas-Ft. Worth Airport, so on your next layover c'mon over for some fine Texas chili and some mighty good listening—don't forget to bring your favorite "system killer" record or disc.



John (foreground) and Dennis testing custom X-over for a theater-style horn system using a modified RCA PL-304 bass horn with Altec 802 driver on a well damped 329A horn.

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# A no-nonsense line conditioner

by Mike Vans Evers

**WARNING:** *This project, like many others, involves working with voltages and currents that can kill you or burn down your house with you in it. So please, please don't attempt it on your own if you aren't well beyond the beginner stage.*

I hope that it comes as no great surprise that line filters will improve the sound of your audio system. I'm not going to try to prove it to the skeptics. I'll just nod in agreement and congratulate them when they DO discover the benefits of less noise filling up the blank spaces in their music. Line filters have been around in commercial use for several decades, primarily for keeping RFI/EMI out of computers and other digital equipment. Tice, API, and others have made versions that are application specific for audio that, according to many thousands of users, do a good job.

I have been making line filters for several years. Until May of this year, they were just another "something else" that I researched and then built. They were used in recording and playback systems for pro audiophile recordings. Other people had heard improvements, but I hadn't taken the time to do a serious 'before and after' listening test. When I did, I can tell you that it was a big eye opener! To make a long story short, line conditioners and power cords are what I "do" now.

This isn't the high-class design that I'm presently marketing, but it is a DIY design that is effective and fairly easy to build. It will help clean up some of the noise that the power line is "powerless" to prevent from grunging up your sound. I measured attenuation at 1 MHz of 50 dB for the first section, 70 dB for the second, and over 80 dB at the digital outlet.

I tested the frequency response of one of the power transformers that I used as a

choke in this project. It was flat from 20Hz to 2MHz; then its response tilted UP and it peaked at 5MHz! Scary, yes? Electronics, both passive and active, are full of self-resonant passive components. *All passive components, especially transformers and capacitors, resonate. Unwanted RF noise can play havoc with your electronics.*

The filter elements that I've selected are easy to find used or surplus. If you can't find a local source try Fair Radio Sales in Lima, OH. They should have something that will work, and for a great price. Corcom-type filters can be had from most surplus outlets, including Hosfelt Electronics at 1-800-524-6464.

A high-end audio magazine recently published an article focusing on a line filter that used a choke as its only element. Yes, this approach will work, but there is a price to pay. A mention was made about loss of dynamics and this is the direct result of the AC and DC resistance of the choke. To keep from repeating this mistake, my DIY line filter uses multiple stages and doesn't use series elements that can adversely affect the 60 Hz impedance of the line in the mains supply to the power amplifiers.

The line filter's duplex outlets are mounted to 4" X 4" metal covers that mount to 4" X 4" extension-type bottomless metal electrical boxes. These boxes are then mounted to a wooden box that contains the main filter elements. Use a piece of copper wire to daisy-chain the green screws together. The metal electrical box parts are available from many sources. The line cord's line, neutral, and ground wires are connected directly to the outlet that your power amp will use, thus minimizing the AC/DC resistance. The white-jacketed wire is "neutral" and connects to the silver-colored screw terminal. The black-jacketed wire is "line" and connects to the brass-colored screw terminal.

The first filter element is 2-4  $\mu$ Fs worth of 2000V oil capacitors. This is wired from line to neutral across the first outlet. Underwriter's Laboratories says DC rated capacitors for across-the-line use should be rated at least 1500 VDC. I like to exceed UL ratings, hence my selection of 2kV caps. A 25 amp-125 VAC fuse is wired in series with the capacitor. The fuse will blow if lightning causes the filter/surge protection elements to short. The high value is necessary because derating is necessary when dealing with the micro-second, high-amperage current pulses associated with lightning induced surges. The MOVs are protection against surges and should be wired through fuses because the failure mode for MOVs is to short-circuit.

The next element is the high amperage, dual secondary transformer. This gets wired as a common-mode choke with one secondary winding in series with the line, and the other secondary in series with the neutral. Both secondaries have to be wired in-phase (see "how to" diagram on pg. 9). The primary will not be used and should be well insulated with electrical tape to prevent accidents. There will be some leakage between the secondaries and the case of the transformer, so ground the case.

The third element is 2-4  $\mu$ Fs of 1500-2000V oil capacitors. This voltage rating can be slightly lower than in the first stage because transient spikes will be reduced first by the MOV across the first filter element and second by the choke. Two or more duplex outlets across this filter will provide power for preamps, tuners, analog tape decks, etc.

An optional fourth filter element will further clean up and isolate "things". A surplus Corcom-type filter can be wired to the third filter element or, if you already have one, a Tripplite can be plugged into one of the outlets across the third filter element. Surplus filters come in many shapes, sizes, and amperage ratings. If you are not ignoring the convenience of digital and have a CD player, then almost any Corcom-type filter will work. If you have an extensive video set-up, then use a 3-6 amp filter, or use a Tripplite plugged into one of the outlets wired across the third element. Mount the surplus Corcom-type filter to the wooden box. Use two filters if you have both digital and video. This keeps the one from interfering with the other, and both of them from interfering with your analog.

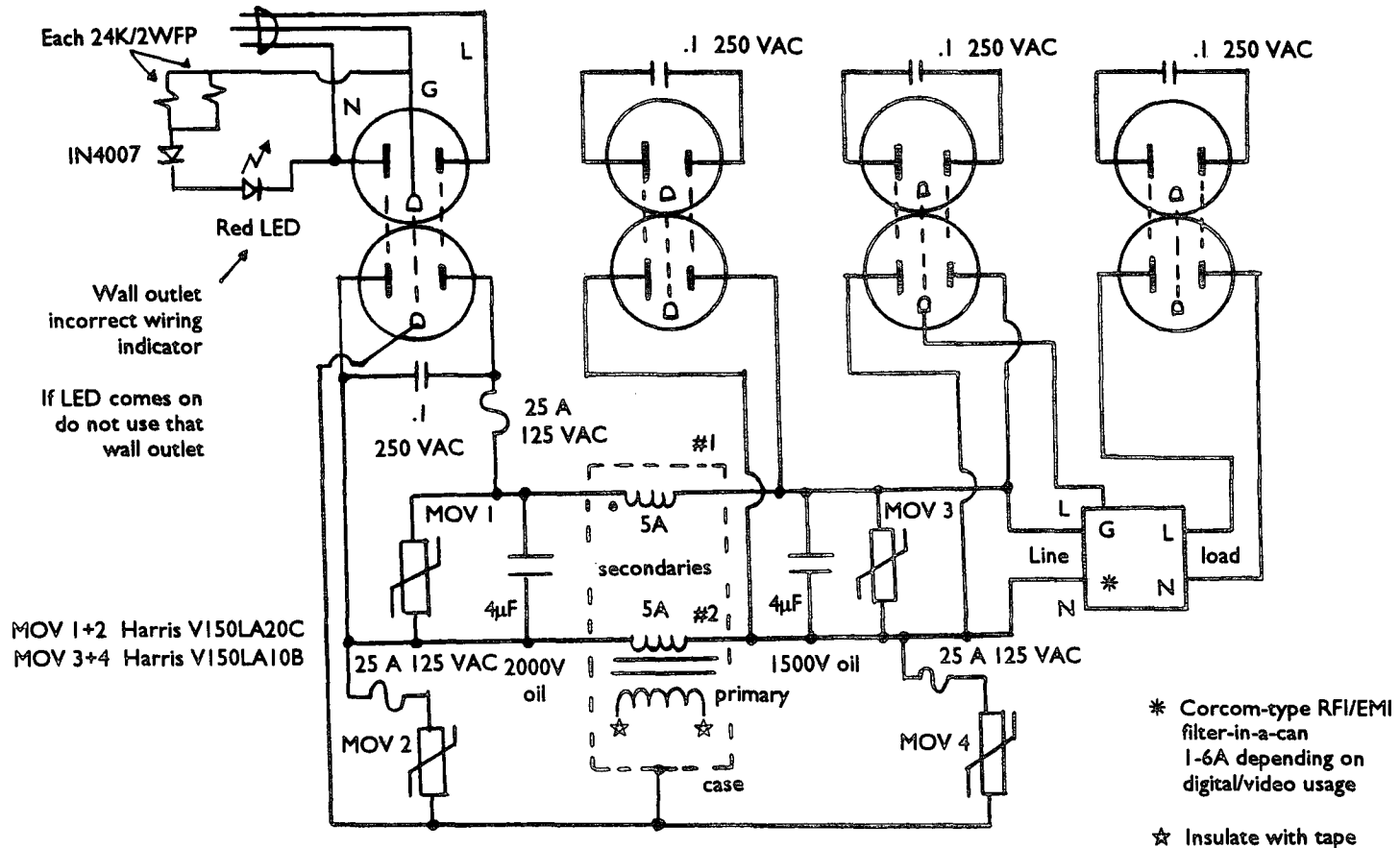


Fig. 1— SCHEMATIC OF LINE CONDITIONER

That completes the description of the placement of the major filter elements. A 0.1 µF 250VAC UL approved capacitor should be wired directly across each outlet. Wrap the leads CCW around the screw terminals. Tightening the screws will then tend to loosen the tension on the capacitor leads,

rather than pulling the leads off the capacitor.

A voltmeter test should now be carried out. A low-Ohms or "continuity" setting should be selected. Use the probes to try all combinations of an outlet: line to neutral, line to ground, and neutral to ground. There should be no continuous low-impedance reading or continuous "bee-eep". If there is, start at the last outlet and disconnect its wires and re-test. Do this until you find and correct the problem. A momentary low-impedance reading or short "beep" may be noticed when checking the line and neutral. The key word is "momentary." As the 4 µF cap charges up, the beep or the low-impedance reading will go away. This is normal and is to be expected. It's also a good way to tell if you remembered to put in a fuse.

Next, check for continuity between all the tall slots (neutral) of all the outlets. Do the same for "line" and ground.

Install and enjoy.

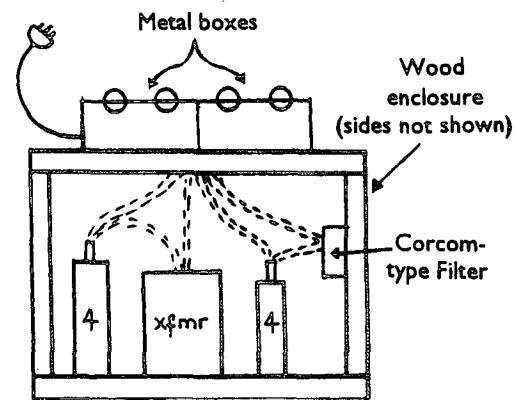
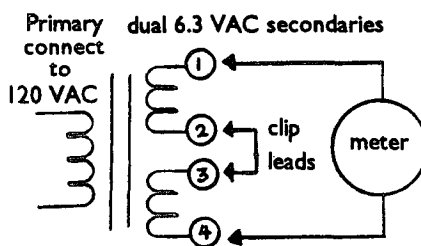


Fig. 2 — SUGGESTED LAYOUT

Parts Sources:

Fair Radio Sales  
PO Box 1105  
Lima, OH 45802  
419-223-2196

Procedure for finding the in-phase ends of the filament transformer secondary



If meter reads approx. 12.6 V, use 1 & 3 as input

If meter reads approx. 0 V, use 1 & 4 as input



# The Classic Williamson 1993 style

by Bill Kleronomos KDØHG

*A hollow state traditionalist says "Up Your Ongaku"  
to all you puny single ended triode freaks*

By way of introduction, I'll say I've been a ham for almost 30 years now, and the world I come from is one not too unfamiliar to most readers of this rag. Having rejected the premise that operating modern soulless, bell and whistle festooned imported ricebox radio appliances has nothing to do with what real ham radio is about, my shack contains nothing but the radio world's equivalent of your classic audio gear of the 30s, 40s and 50s.

Those of you impressed by death dealing instruments of destruction would be awfully impressed with the 450 pound, 7 foot high rack mounted plate modulated kilowatt transmitter I completed several years ago. There's nothing quite like the ceramic, silver and steel hardware required to generate vast amounts of RF energy, and there's nothing like sitting back in an easy chair, squeezing a microphone's switch, and watching a pair of tantalum anode glass tubes with three kilovolts coursing through them lighting up with a white heat reminiscent of Flash Gordon's atomic furnace.

But I digress. Some time back I became obsessed with the idea of constructing a stereo amp for use in the family living quarters as a consequence of upgrading my preamp and CD player. Having only recently discovered the parallel world in the other dimension of hollow state audio in the last two years (via *Glass Audio* and *SP*), my level of sophistication is perhaps not as refined as those of you who live, breathe, and eat single ended audio and perhaps also despise the concept of inverse feedback.

So let me put it another way: the amplifier I'm presenting in this article is nothing more than two single ended amps, connected in a manner that allows only one amp to work at any given instant. It is not really "push-pull"! If you hate inverse feedback, that's OK. You only need to omit one component to dramatically increase distortion products, noise, and reduce the damping factor, gain flatness and bandwidth.

I had no desire to reinvent the wheel during my quest for a high performance amp design, and I don't have the luxury of enough

spare time to spend months or years tweaking a circuit in search of perfection. I wanted a darn good, solid, reliable unit that used no exotic or expensive tubes that we could just sit down and listen to some good tunes on. One circuit that kept popping up during my research of good old designs was the one by D.T.N. (Theo) Williamson.



Bill and his mighty homebrew 1 KW plate modulated AM ham radio transmitter—304TL triode modulated by push-pull 810s. The modulator deck is good for 700W of audio at 5% THD!

The Williamson amp might very well have been built by more home constructors than any other over the years, and nowhere in the literature did I ever find any suggestion that it sounded "bad" or had any outstanding sonic deficiencies. If thousands were indeed built or purchased by people of all levels of sophistication, acoustic taste and with the use of innumerable types of preamps and speakers with few complaints, who can argue with success? I challenge any of you engineering geniuses out there to design a product that thousands will praise and few will pan over a forty year period. By any measure, doing so would be considered a success in design. So it is with the Williamson.

Let's take a few minutes to look at the history of this classic amplifier design. Theo Williamson was a young man in his 20s who worked as a tube development engineer in the English laboratories of the Marconi-Osram (M-O) valve company. Sometime during the mid-1940s he became intrigued with the idea of developing an essentially distortionless amplifier and spent many hours of his own time in pursuit of this goal.

At that point in history, the best amplifier designs used a push-pull pair of triodes or pentodes with an inverse feedback loop that ran from a plate of one output tube back to the input stage. It was recognized at the time that factors such as imperfect coupling and imbalances between the halves of the transformer primary and core generated distortion were significant contributors to distortion and lack of gain flatness in an amplifier's design, but attempts to control these problems by including the output transformer within the feedback loop caused nothing but trouble when a large amount of feedback was used. The reason for this is that at the extremes of the audio range phase shift occurs in both the output transformer and in a conventional amplifier's circuitry; at some point the phase shift becomes significant enough that the amplifier will become unstable or oscillate. Williamson was perhaps one of the first to realize that a good amplifier needs to be designed on a holistic basis with the output transformer considered as part of the design, not as something hung onto the back end of an otherwise sound product.

Williamson's answer was to design an output transformer of exceedingly high specifications and quality and to minimize or eliminate the use of bypass and coupling capacitors in his amplifier's circuitry to minimize phase shift. The basic structure of his amplifier is well known: four all-triode stages consisting of DC coupled voltage amp and phase splitter, and push-pull driver and output stages. Williamson was able to minimize phase shift over many octaves with his simple design and so it was possible to incorporate a degree of overall feedback sufficient to reduce distortion to far below audible levels in the tents of a percent range. The 22 year old Williamson had succeeded in designing an amplifier that had measurable performance far better than anything else available in the mid-40s.

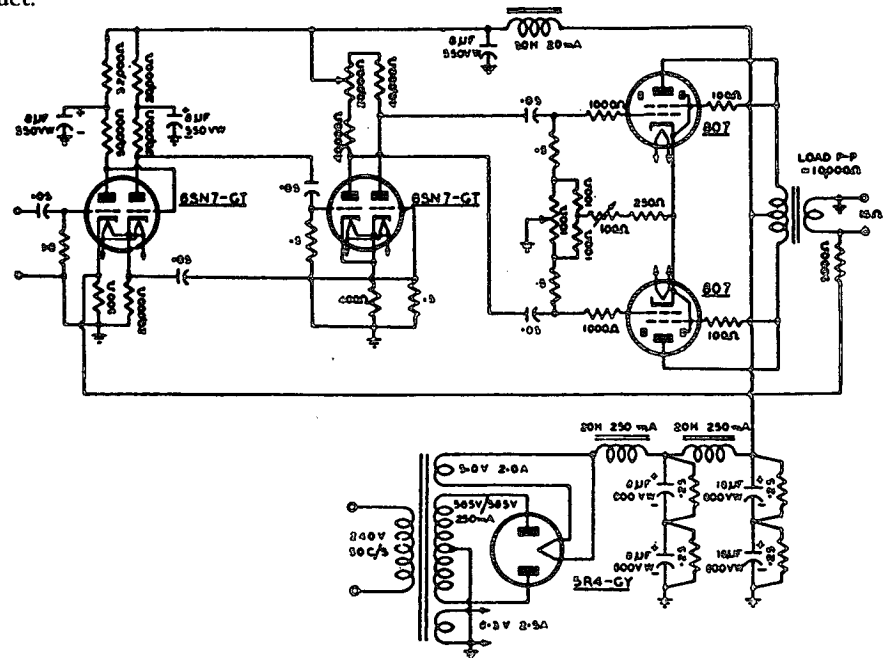
I wondered just how good the basic Williamson design could be if one used more modern and better performing tubes and components than were available in his day. The main drawback of

the Williamson design for my application was its power rating of around 20 watts when using a pair of 2A3s or triode connected 807s. I have to share my living quarters with two energetic preschoolers, a wife and all the accessories that are attached to same, and I don't occupy an 8,000 square foot chalet at the foot of Aspen Mountain. So, for reasons of size, I gave up my homemade bass reflex/horn enclosures years ago in favor of a pair of large Advents, which still ain't bad on-axis speakers but need more watts than your typical surplus high school gym speaker and P.A. horn robbed from a police car hermaphrodite system used by many with their puny overpriced SE amps.

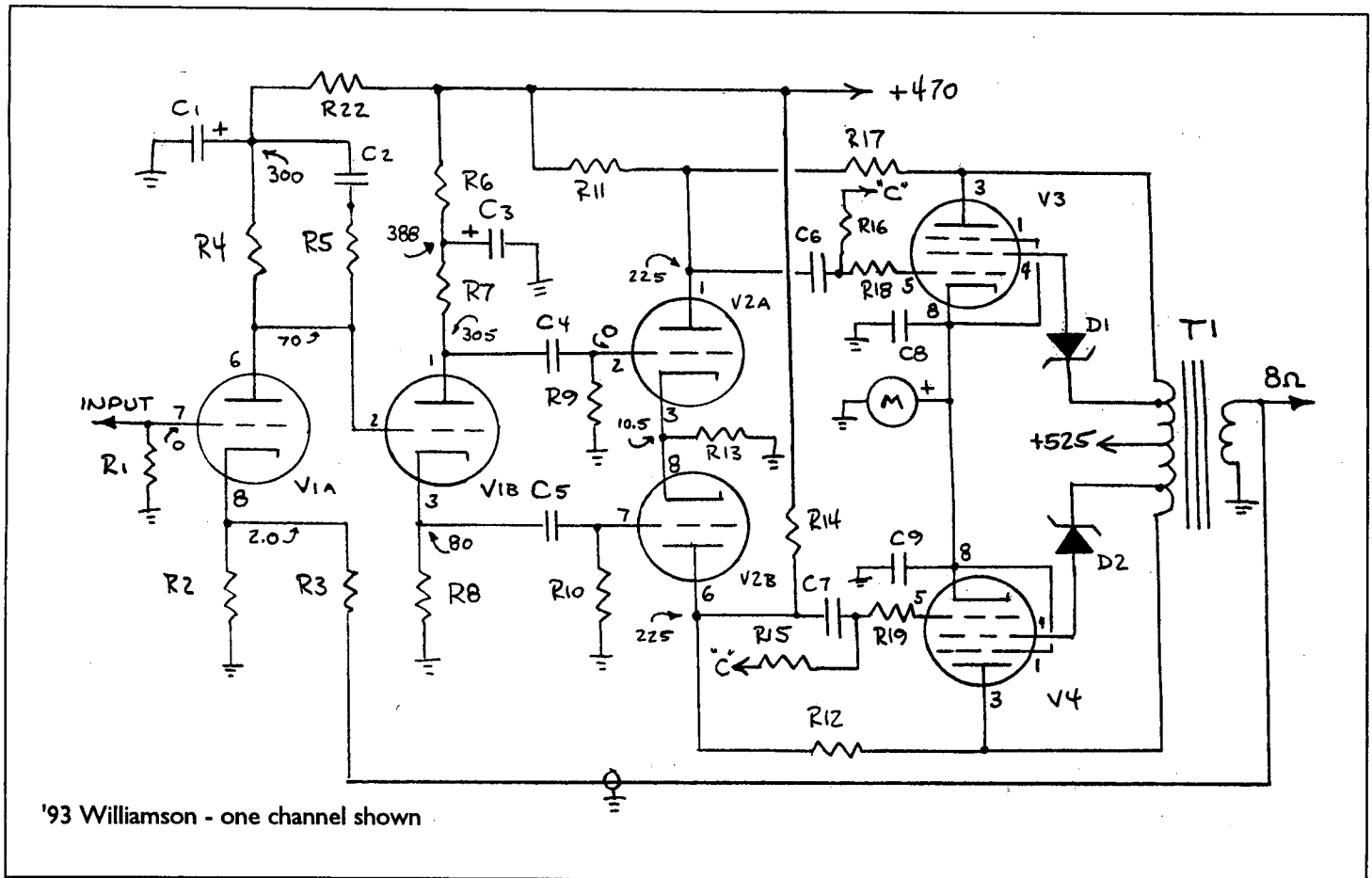
Somehow when I think of your typical SE amplifier, I'm reminded of a Yuppie-French-Whole Earth restaurant in Boulder I ate at once when my \$19.95 plate arrived with more white than food visible and my wife telling me how wonderful my "delicate portion" was in presentation. For me, single ended = All-American 5 tube table radio; a mental block I suppose, and all I'll say on the subject. Just so you know where I stand — now gimme that chicken fried steak, *garçon*.

The answer to my power requirements was the well known ultra linear output stage a la Dynaco. I certainly wasn't the first to utilize a Williamson/Hafler hybrid as I'm aware of at least one published design from the mid-50s, and it looked like a good deal.

One area of improvement I wanted to pursue during my bench test phase of the project was the replacement of the originally specified 6SN7 amplifier stages. One interesting article I found was one published in Audio Engineering of August 1952. The author of the article suggested the replacement of the 6SN7s with a 12AY7 preamp phase splitter followed by a 5687 driver stage. I didn't care much for the idea of using the fairly hi-mu 12AY7 and I really didn't like the 5687 for being an industrial tube. "What?," you say.



Original 1947 Williamson



Some time back *Electric Radio* magazine (for vintage radio enthusiasts) published an interview with the designer of the Collins KWM-2 HF transceiver. This radio, for the uninitiated, was designed to be a no-compromise military and top of the line radio for embassy, government and amateur use in the late 1950s. The article went on to say that the Collins engineering team called in representatives of the American tube manufacturing companies, told them about the project and their tube needs, and asked them to suggest the absolute most reliable tube types for the application. What special developmental military types could they use?

The answer they got from the tube engineers might surprise you. The Collins staff was told that the most reliable tubes made were the one made in the largest quantities — your standard TV and radio tubes. RCA, GE, and Sylvania had garnered so much experience and feedback in making these types of tubes and were so far up the learning curve that durability and reliability on a percentage basis were excellent. Yes, some military numbered equivalents of civilian tubes received extra tests on a sample basis,

but were the same tubes sold at your corner TV store, and by and large those special industrial types made in relatively small quantities had no more longevity than your standard types.

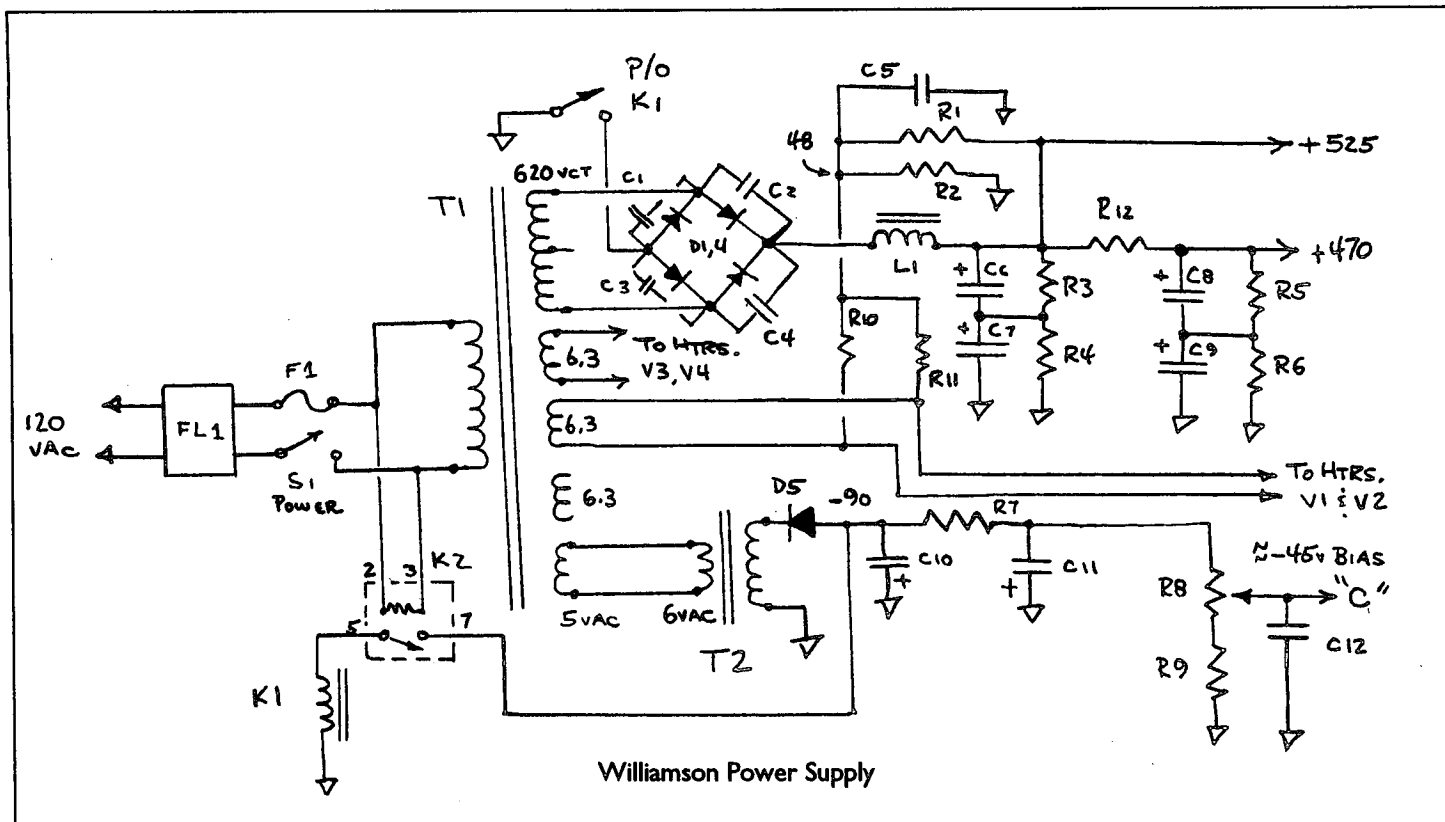
Is a 5692 truly a better, longer lasting, more reliable tube than a 6SN7GTB, or does all the extra internal mica and hardware assembled by more inexperienced production lines create more potential points of failure? Do the tubes in preamps really need the extra internal bracing to withstand a 500g shock? Are a lot of industrial tubes being used for pragmatic reasons, or just snob appeal?

In any event, there's nothing wrong with using the originally specified 6SN7s, but I did want to refine the circuit in my own individual way. After several evenings studying my RCA HB-3 tube manuals and laying out some loadlines I decided to use the 6DJ8 for the amp/phase splitter and a 12BH7 as the push-pull driver stage. My logic behind selection of the 6DJ8 was that its a low noise tube, originally designed for use in cascode VHF amplifiers. Other advantages are that it uses a rigid frame grid, which would

theoretically tend to minimize microphonics, and the amplification factor at 33 was lower than that of the 12AY7, allowing more signal level headroom at the input.

The 12BH7 was chosen for its low plate resistance, high plate voltage rating, and once again, low amplification factor and subsequent ability to handle large signal voltages. In class A amplifiers the total harmonic distortion is almost directly proportional to the output voltage being delivered as a percentage of maximum output capability. In other words, big output voltage capability = lower distortion.

On my bench, the Williamson dual 6SN7 combination was able to produce a maximum peak to peak output voltage swing of about 110 volts at about 5% THD. The 6DJ8-12BH7 lineup was able to put out in excess of 250 volts P-P before clipping at a measured THD of 2.9%. At the 40 volt P-P level, the approximate operating level in the complete amplifier, I measured a THD near .35%. The revised tube lineup was significantly better in all respects and I decided to go with it.



Williamson Power Supply

A note on tweaking the above described stages. I plotted a dynamic characteristics curve for the 12BH7 and selected a nominal value of 950 ohms for the common cathode resistor. It is possible to achieve somewhat lower values of THD in the completed amplifier by reducing the value of this resistor to around 750 ohms. The downside to doing this is that I observed a small ringing type of oscillation on a portion of low frequency

(about 20 hz) waveforms in breadboarded amp and only with certain brands of tubes when I used this lower resistance value. I decided to err on the side of stability and not worry about inaudible differences in measurable parameters. If you're a natural tweaker, here's one place to play.

The selection of output tubes was an interesting project in itself. While waiting for my

output transformers to arrive I set up a test jig using the breadboarded preamp-driver described above, a 450 volt bench supply and an output transformer salvaged from a junked Fisher 50A. And I mean literally "junked." I found what would have been a decent 50A tossed in a dumpster by someone cleaning out a garage full of so called electronic junk. Unfortunately dented and bent by its unceremonial flight, I managed to save the carcass by doing a quick dumpster dive before the trash truck hauled it away. From what I've heard, this maneuver is the principal means of parts acquisition by this magazine's publisher. [ed.— Just stay off my turf, punk.]

The tubes under test were connected as pentodes since the transformer had no screen taps, and I logged their relative power outputs at the onset of clipping as well as generated THD. A sampling of the tubes I tested follows:

Sylvania 5881	50 watts
Sovtek 6L6GC	36 watts
Sylvania 6550	66 watts
GE 1614 (metal 6L6)	41 watts
RCA 6CA7/EL34 (UK)	50 watts
GE 8417	68 watts
Telefunken 6CA7/EL34	47 watts

**Parts List - Williamson Amp**  
(one channel)

- C1, C3 - 10uf/400V electrolytic or polypropylene
- C2 - 820pf/300V mica or polystyrene
- C4, C5 - .01 uf/500V "Vitamin Q" or polypropylene (matched to 1% or better)
- C6, C7 - .25uf/500V "Vitamin Q" or polyprop. (matched to 1% or better)
- C8, C9 - .1uf/100V tubular

Note: All resistors are metal film or metal oxide film unless otherwise noted. All resistors of like values are matched to within .5% with use of a DVM.

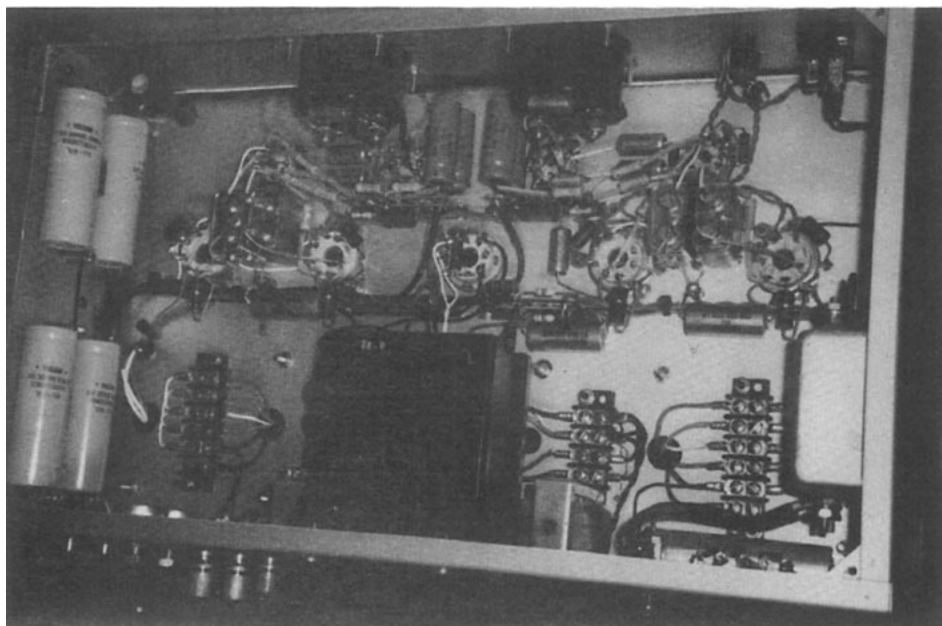
- D1, D2 - 75V, 5W Zener diode for Ep of 500; 100V for plate voltages near 525
- R1 - 47, 1/2W
- R2 - 470, 1/2W
- R3 - 3.92K (for 8Ω), 2.4K (for 4Ω), value is  $1200 \sqrt{\text{output}Z}$

- (Feedback resistor)
- R4 - 47K, 3W
- R5 - 4.7K, 1/2W
- R6-R8 - 22K, 2W
- R9, R10 - 220K, 1/2W
- R11, 12, 14, 17 - 100K, 3W
- R13 - 950, 1/2W
- R15, 16 - 100K, 1/2W
- R18, 19 - 4.7K, 1/2W
- R22 - 33K, 3W
- M - 300mA DC panel meter
- V1 - 6DJ8/6922
- V2 - 12BH7A
- V3 - 6CA7/EL34, 6550, 6L6GC, KT66, KT88, etc.
- T1 - multimatch output xfmr screen taps at 40% to 50%

**Parts List - Power Supply**

- T1 - 620VCT "surplus" power xfmr from H.P. scope, Similar rated xfms suitable
- T2 - 115V to 6.3V filament xfmr
- F1 - 5A fast blow
- L1 - 4hy, 500mA filter choke

- FL1 - surplus "Corcom" EMI filter, 10A rated
- K1 - SPST power relay, 90VDC coil
- K2 - Amperite thermal delay relay, 30 sec., 115V (115 NO 30)
- D1-D5 - 2500 PIV 300mA diodes
- C1-C4 - .005/3KV disc ceramic
- C5, C12 - .47uf/200V "Vitamin Q"
- C6-C9 - Mallory TCG capacitor, 180uf/350VDC
- C10 - Mallory TCG capacitor, 21uf/250V
- C11 - 35uf/250V electrolytic, low leakage type
- R1 - 470K/2W carbon composition
- R2-R6 - 47K/2W, 5% carbon composition
- R7 - 2.2K/1/2W
- R8 - 20k linear taper
- R9 - 4.7K/1W carbon film
- R10-R11 - 390/1W carbon film
- R12 - 2K, 10W wirewound



Underside of amp

The winner and runner up in the battle of THD were the RCA 6CA7 and the Sovtek 6L6GC. I decided to use the 6CA7 for their great performance as well as the fact that I had acquired quite a few matched sets from shopping at flea markets during those dark days of the 70s when tubes were considered worthless by the unwashed masses. The selection of proper operating bias is interesting in itself. At the above 450 plate volts, the 6CA7s produced the best overall distortion at an idle current of about 110 mA per pair. My finished amplifier, on the other hand, has a plate voltage of around 530 volts. At this higher plate voltage, the best overall idle current setting was around 70 mA, using the previous value of over 100 mA caused surprisingly higher levels of THD at all output levels, and the tubes were really cooking at near max plate dissipation. Idle current set on the low side made for lower THD at higher power levels, conversely, higher idle current decreased distortion at low levels. It appears that optimum idle current is inversely proportional to applied plate voltage. Or, perhaps an optimum level of idle current differs between pentodes configured as such or in the UL mode of operation.

An unusual method of applying screen voltages to the tubes is used. Instead of the usual dropping resistors, I used a set of 5 Watt Zener diodes for special benefits: screen voltage is always held at or below manufacturer's recommended values regardless of screen current. Distortion products are

materially lower because of the stiffer screen supply provided by Zener regulation—this is especially true for the EL-34 pentode with its wider ranging screen current than usual beam power tubes. And less screen voltage requires less bias voltage and therefore less peak signal voltage from the driver at max. output. Bench tests with EL-34s and 6550s in the output sockets confirmed an approx. 20% reduction in THD when the original dropping resistors were replaced by Zeners.

The use of a 10 to 20 ohm two watt resistor in the common cathode lead of the output tubes seemed to have a beneficial effect in lowering distortion products, but inconsistently so, being dependent on tube types. Again, you tweakers out there could play with this addition; I chose not to use this refinement in my own amplifier.

I made one final change to the original Williamson design. R12 and R17 provide an additional feedback loop directly around the output tubes. I found that with certain bias settings and certain brands and types of tubes, a tiny amount of crossover distortion became evident near maximum output. I'm uncertain as to the cause; it may have been a result of the interaction of the output transformer with the rest of the circuit, or by the tubes transitioning from a pure class A to class B operating level. The added feedback loops completely eliminated any trace of this problem and as a bonus improved overall THD.

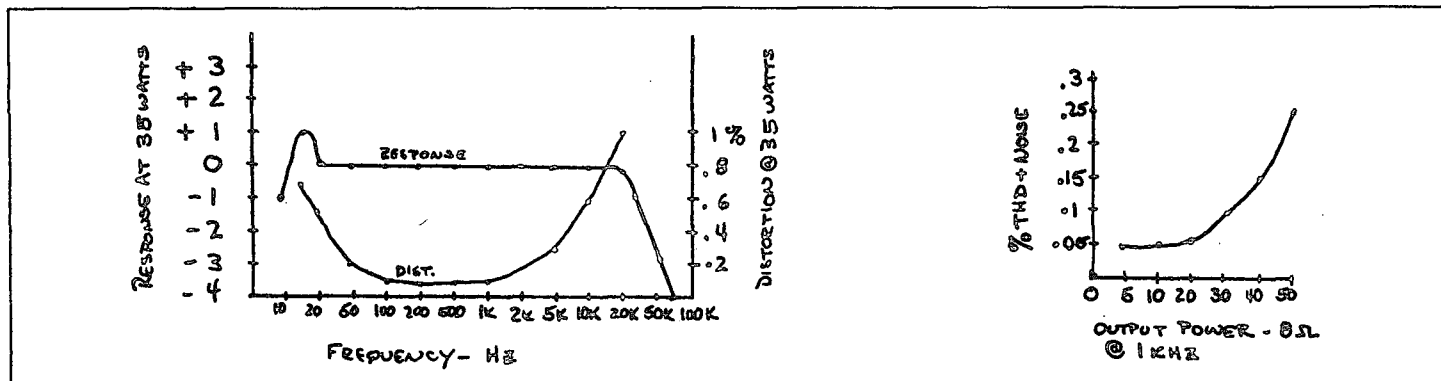
The decision-making process in the selection of output transformers was easy. I chose to use the Magnequest MQ-431 with screen taps at 50%. Unfortunately, I can't offer the results of comparison tests with other makes and models in my application, but the end results were pretty good. And I haven't heard anyone say that Mike makes a lousy sounding product!

Some comments on the chassis are in order. I originally thought a steel chassis was going to be required due to the weight of the top mounted iron. After looking over a number of catalogs I found that Premier Metal Products of Bronx, NY makes a line of 11" x 17" aluminum chassis substantially thicker than those made by Par and Bud. I was not disappointed; the finished product is very rigid and chassis flex isn't much more than would be experienced with a steel chassis.

Since the amplifier was destined for use in the family living quarters, I paid some attention to cosmetics. I had a metal finishing shop polish and apply a grained finish to the surfaces, then I had it hard clearcoat anodized. For a final touch I milled out a couple of chunks of dark hardwood, applied an oil finish and attached them to the chassis sides with the use of a couple of small wood-screws and some Liquid Nails construction adhesive. Several months later I added a small muffin fan and several ventilation holes in the bottom cover. This is important to prevent the buildup of appallingly high temperatures inside the chassis

As far as component selection goes, I didn't engage in what I perceive to be the excesses of anal retentive audio engineering. Most resistors are standard off-the-shelf metal film or metal oxide types matched to within .5% and operated at substantially below rated power. Based on the glowing reports here in *SP* for their sonic quality and proven reliability I used paper in oil capacitors for coupling in the signal path—Sprague Vitamin Qs and Clorinols. Again, these are run at a substantial voltage derating for longest life inside a hot chassis.

Internal chassis wiring was done exclusively with stranded silver plated teflon wire. Not for any alleged sonic benefits, but because it still looks good after being cooked during the soldering process. AC heater wiring was tightly twisted in an electric drill to minimize hum coupling into the signal path. Ceramic/silver contact mil surplus tube



sockets from my ham junkbox were employed throughout — because they look cool.

Since I can't run a shielded teflon insulated power cord all the way to the local power plant, I used a surplus Corcom double pi-section EMI filter to reduce line noise and rectifier destroying transients. A line cord cut off an old toaster was used for the rich sonic texture only a rubber appliance cord can provide.

A set of high voltage ceramic capacitors was used across the rectifier diodes to prevent a clicking type of noise that has been reported in the literature when a choke input power supply filter is employed. Apparently, this noise is created as the rectifiers go in and out of conduction during the AC cycle, and has been observed in both solid state and tube rectifier circuits.

An Amperite thermal delay relay that operates a second, heftier relay allows the tubes to warm up prior to the application of plate voltage. As a protective feature, I chose to use a surplus relay with a 90 VDC coil that will only operate and enable the high voltage supply if bias voltage is present. No bias, no B+. As it should be.

As per common practice, the 6.3 volt heater line is elevated to about 45 VDC via a voltage divider off the main B+ line to minimize hum. Don't omit C5, the heater line signal bypass capacitor; it's important in minimizing hum and noise.

### PERFORMANCE

Aaah! The best part! I hooked up my bench equipment and thoroughly went over the completed amplifier. (For reference: H-P 200CD, Eico 378 generators, H-P 331A distortion analyzer and Tek 547 scope with 1A2 plug-in) Some of the results are shown graphically above.

Several of the specs come out better than initially expected. In addition to the remarkably flat response shown on the graph, the THD and IMD are far below the levels considered to be excellent in many competing designs and an order of magnitude better than commonly achieved in your typical SE amplifier. Certainly, if it is distortion products that explain in part an amplifier's "color", this amp should add no audible modifications of its own to the program source other than the sonic integration effects of the tubes and other components. Other measured specs are quite good: hum and noise output of .0005 volts RMS, giving a S/N ratio or dynamic range of 92 dB. Channel to channel gain matching is within .1 dB. When fed with a 5 KHz squarewave and driven to near full power, rise and fall times are close to 1.5 uF, an indication of both successfully minimizing stray circuit capacitance and even more so, the high quality of the Magnequest transformers.

So enough with scope jockeying! How's it sound?

As a point of reference, the rest of my system consists of a mid-1950s Knight AM-FM tuner (modified), an older Dual turntable using a Shure V15 type III cartridge, Rotel 955AX CD player, Hafler DH-110 preamp and a set of recently refoamed Large Advents. I put the Williamson in line and played some vinyl and CDs my wife and I were both familiar with — some Mozart piano, Sting, K.D. Lang, Stevie Ray, Lyle Mays, and Lyle Lovett. After listening for a while, my wife's first comment was, "How'd you get it to sound so good?" And indeed it did.

Now, I can't compare this amplifier with any other in terms one might use in wine-tasting, so I won't. The most immediately noticeable difference was on CDs, where that well known upper midrange harshness typical of digital program sources was

largely gone. The overall texture was smooth, detailed, and tight — not tight in a restrictive sort of way, but more in the manner of a good Latin band where all the percussionists are perfectly in time and sync. In fact, a major positive point was its ability to accurately reproduce the sounds of percussion instruments, including drums and piano. Percussion? Piano? I was now able to clearly hear the sound of hammer on string, then the resulting instantaneous tone in a concert piano instead of just a tone appearing out of nowhere. You can hear the impact of stick on drum head, not a sound like a baseball bat on fiberglass outhouse. Much as smells can bring on a powerful sense of *deja vu*, I had the same feeling of remembrance at the subtle nuances of sound one only hears at a live performance. On some CDs, the playback apparatus seemed to tangibly disappear, leaving only the musicians. I don't claim to be a musical sophisticate, so I really can't describe it in more esoteric terms such as coloration and texture as I commonly see presented in the literature. Luscious? Gimme a break!

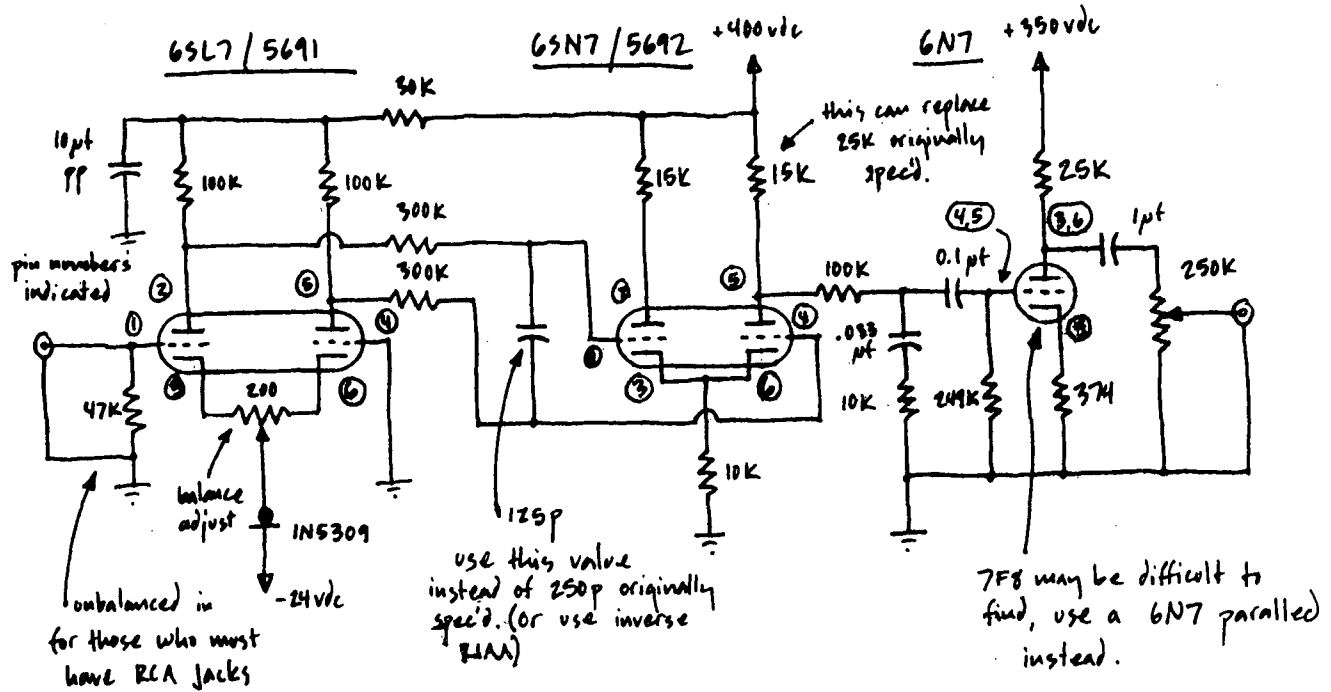
I will say that I was able to achieve what I considered a satisfying tonal texture with a minimal twist of the Hafler's tone controls. And I found that the louder I play this amp, the better it sounds., i.e. it cranks!

After some thought, I now believe that an amplifier's supersonic response and risetime are significant considerations in achieving excellent transient performance and realism, given a program source that's capable of delivering it. In other words, it takes a darn "fast" amplifier in terms of risetime to accurately reproduce the sound of a hammer striking a metal plate, and this Williamson delivers.

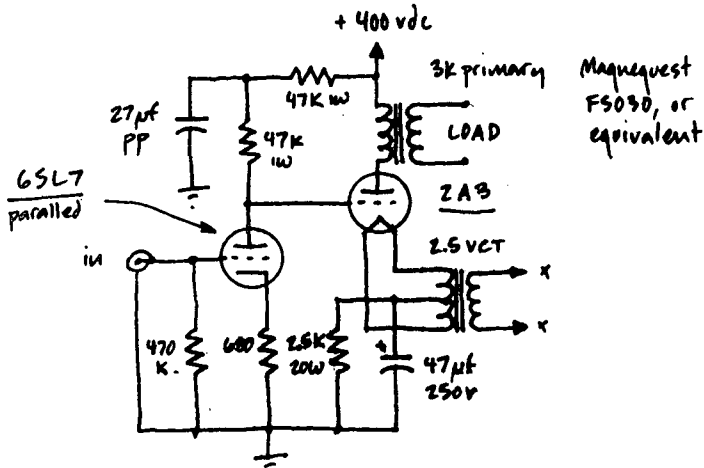
So, I've joined the ranks of those thousands who over the years have duplicated this classic design and are eminently satisfied with the results. You might be too.



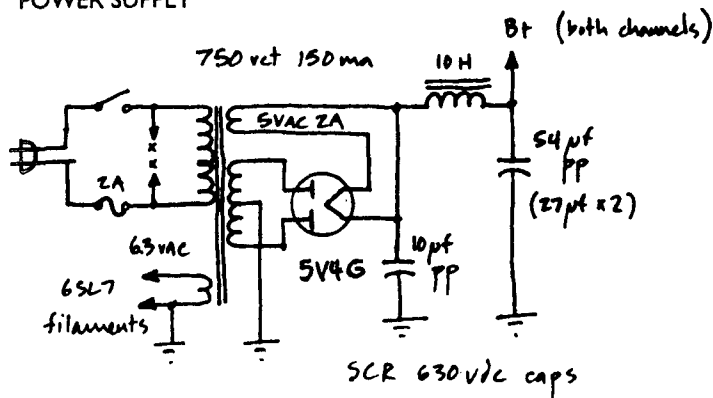
# SIREN SONG PREAMPLIFIER - MODS & TWEAKS



MORRISON MICRO 3.5W TRIODE AMP



POWER SUPPLY



Thanks to reader communication and insights gained from continuing experimentation, here are a few updates and tweaks for the Siren Song preamp circuit published in SP #3.

I included a balance control in the cathode of the first differential stage. Adjust for equal plate voltages on the 6SN7/5692. This will get you real close to AC balance with a minimum of hassle and test equipment. You could switch to a 1N5311 (3.6 ma current source) for a small improvement.

A few changes are proposed in the RIAA network to tighten up the equalization. If you're really anal about absolute phono EQ perfection, use an inverse RIAA network to tune out any deviation from the ideal curve. Results with the above changes will be close enough for the average hedonist.

Several readers wrote that 7F8 tubes can be difficult to find. Also, after testing a few dozen 7F8s in the circuit, I found that a few specimens went into unprovoked oscillation. I now suggest that you use a 6N7 instead of the 7F8. The 6N7 is a great tube which is both common and inexpensive. I'm surprised it isn't used more in modern audio. If you can locate a pair of 5694s, a classy industrial-grade relative of the 6N7, I highly recommend that you give them a listen.

The Micro 3.5 W amp is as simple as it looks. It's a perfect partner for your Siren. Build it as proposed and it will work great. Given the ultra-simple direct coupled signal path, the output trans will determine the ultimate sonic performance of this amp. Excellent iron = excellent results. Build it and enjoy!!

J.C. Morrison  
Fi, NYC

# Casual Reactions

by Herb Reichert, Eddy Electric

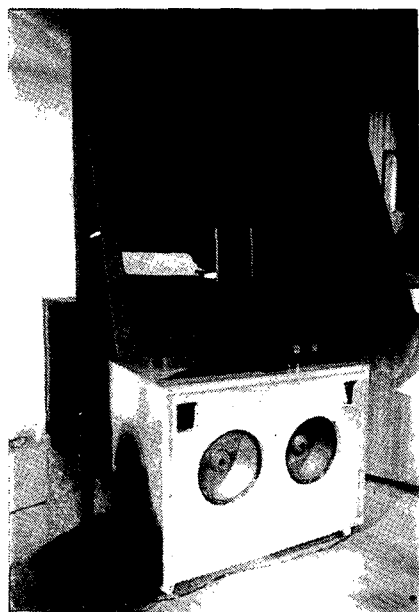


## ULTRA FI HORN SYSTEMS

The vast majority of American audiophiles that I meet are unfamiliar with the sound that a good horn system provides. In fact, most seem to believe that *there is no such thing as a good horn*. Most have heard only damaged, overdriven, and poorly installed P.A. horns at the stadium or disco. A few remember hearing vintage Electro-Voice systems or Klipschorns driven by early transistor or aging, out of spec tube amps. We have all had bad horn experiences and nothing is as painful as a really awful horn system. If you have only heard nasty horns, you might find it hard to believe that a good horn system can be the best speaker PERIOD.

## TRIODEMANIA 93

Samedi 15 mai 93  
de 14 h à 19 h



- SUN AUDIO
- AMPLIFICATEUR 300B LEGEND (transfo Partridge)
- Réalisations Amateurs (PX25 - 845 - VT52)

En écoute sur le prodigieux système  
ONKEN-WESTERN

Only a small handful of American enthusiasts have heard the kind of carefully engineered and lovingly installed triode-powered horn systems that the French and Japanese have been listening to. I have been lucky; my French and Japanese friends have helped me to develop a system of this kind. Building it was one of my most rewarding audio projects ever.

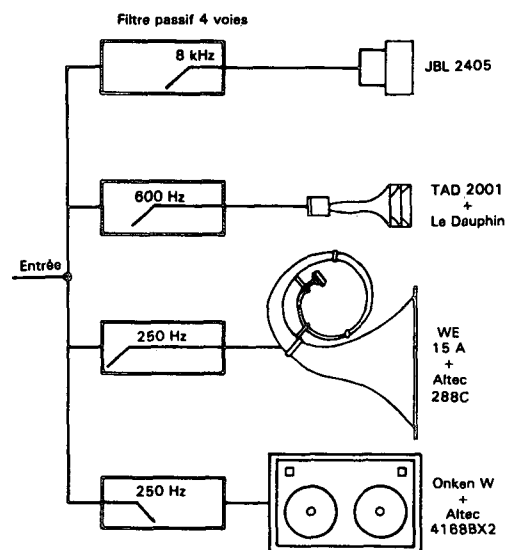
Although there is a lot of room for the individual touch in design of horn systems, a few classic components have achieved worldwide recognition. A typical Asian or European horn system consists of either an Onken or Altec V.O.T. bass cabinet with Altec 515, 416, or 414 drivers. These two low frequency systems are of such quality that they provide the foundation for nearly all the "ultra-fi" horn systems in Asia and France.

The "Petite Onken" enclosure for the Altec 414 12-incher is very popular in smaller European homes. At 40 Hz, Jean Hiraga measures .8% THD @ 100 dB/1m with this combination. It measures only 34"h x 18"d x 25"w. A larger Onken box for 15" woofers is also very popular in Europe and Japan.

The V.O.T. based systems have less bass extension but play with more veracity and power in the 100-500 Hz band and are therefore most favored by lovers of large orchestral works.

There is a much wider range of choices for quality midrange. The Altec 511/811 horns with appropriate compression drivers or Altec multicellular horns with 288 drivers are universally popular entry level midranges. Everybody has their favorite tweaks for these old stand-bys. Well financed triode maniacs in France favor the Onken SC-500 sand-filled wood horn or its look-alike, "Le Dauphin". These are used with the TAD 2001 or Onken OS-500 compression drivers. In Japan, the TAD wood horns or home-made equivalents are commonly used with a wide variety of TAD, Altec, WE, or JBL drivers. Here again, the best systems tend towards wood horns with compression drivers.

### Système Onken/Western/TAD/JBL



Triodemania '93 hosted by *La Maison de L'Audiophile* in Paris— Onken W enclosure for 2 Altec fifteens, Western Electric 15A wooden "ram's horn" with Altec 288C compression-drivers for the midbass, and a Onken-style wooden horn for the midrange. *Incroyable!*

Audiophile horn systems are usually three-way setups. Above 5000 Hz, the rich guys use the renowned Onken OS-5000 and everybody else does the best they can. The French prefer the JBL 2405 "slot" tweeter and Japanese like tweeters by Fostex and Gauss.

The Europeans prefer passive crossovers and one pair of "Legend" 300B amps or other fine triode amps, while the Japanese universally favor bi- or tri-amplification.

None of this equipment is compact or inexpensive. An all-Onken system could easily cost \$10,000! But the build quality and durability are of the highest standard and the level of sonic refinement such systems provide is impossible to achieve otherwise.

It takes love, patience, and cash to build one of these exotic "ultra-fi" systems. Unless you've heard one, you are going to have to trust me when I tell you that these systems do not sound like ANY horns most Americans have heard. In my experience, these combinations can be more vivid, more detailed, far more dynamic, and less easily confused than the typical U.S. high-end setups. This is the type of system for which the Edgar midrange horns are designed.

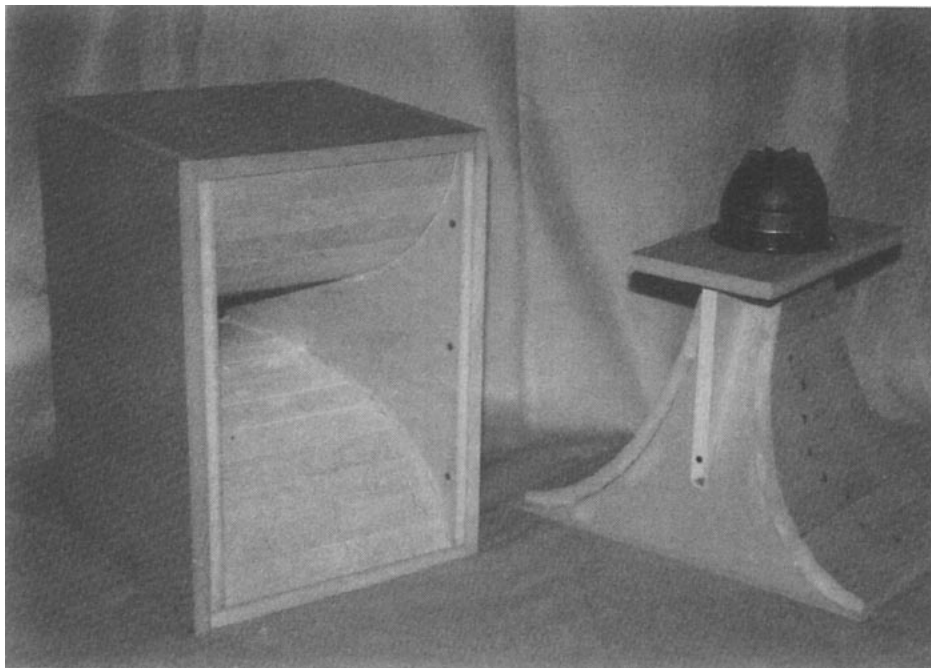
#### THE E-HORN

When I drank, I couldn't keep a secret at all. Now, after eight years without a drop, I can only keep a secret if it is totally boring. So, I have to tell you that a scientist from Torrance, CA has made some break-through discoveries that could radically change the reputation of the horn in American "high-end" audio -- at least for those of us fortunate enough to live in something larger than an Airstream trailer or a NYC "studio" apartment.

Bruce Edgar is a contributing editor for *Speaker Builder* and a space scientist by day. He has been working on refined horn designs for a number of years. His current portfolio includes five midrange horns that take the horn out of pro-sound, past hi-fi, and on to the world of "ultra-fi." They are cone-driven horns made from wood which are based on a Tractrix expansion, the only flare which provides a spherical wavefront.

Each of the five horns was designed around a specific, commonly available cone or dome driver from companies like Dynaudio, Focal and Polydax. The driver is fastened onto the back of the wood horn. The complete units have sensitivities in the 100-105 dB/watt/meter range. They are four octave devices, covering the 400-5000 Hz band. They are remarkably small for their LF cutoff rating. One 300 Hz horn I have on hand is only 18" wide and 11" deep.

Dr. Edgar's philosophy is "Ultra-fi for the people." He is a supporter of home construction and a hobby builder himself. Aside from writing for *Speaker Builder*, he is often involved with DIY speaker contests and the like. The Edgarhorn is meant as a DIY project, although Bruce does sell some horns he makes in his garage wood shop at very reasonable prices.



Bruce Edgar's 250 Hz tractrix horn for the Dynaudio D-54 driver.  
Measures only 11" H X 21" W X 13" L

With people like Bruce Edgar supporting creative home audio, the real state of the art is in the domain of the experimenter and not in a color ad in an audio magazine.

The sound from these wood horns is so smooth, detailed, and undistorted that when a friend and I first listened we thought something was wrong. We both kept looking at each other saying, "This is very strange." However, as the piano player rolled back and forth past middle-C we looked at each other and froze. It was startling—and right!

At this point we both realized it was not the Edgar horn that was strange, but every other speaker we had heard to date. Our initial reaction was that this was RIGHT and we both knew it. The distortion we have come to accept from loudspeakers has been reduced in the Edgarhorn to such low levels that, after experiencing music through them, other audiophile and professional speakers sound fuzzy, grainy, and opaque in comparison.

The two most outstanding traits of this driver are its complete lack of artificial character and its grainless, dynamic presentation. These are rare qualities, found only in the very best loudspeakers. Additionally, these speakers require only a few tube watts to play ANY type of music at extremely high SPLs. What more do you ask?

Compared to the IRS-Vs, the Divas, and several Euro-style ultra-fi systems I got to hear around New York, the Edgarhorn presents music in a smoother, more relaxed, and "cleaner" fashion. With the Edgarhorn and a pair of homemade Onken or recycled Altec V.O.T. bass modules and a JBL 2405 or Polydax PR-120 tweeter, create a world class loudspeaker system at a small fraction of the usual cost. A clever music lover who is handy with a saw and screwdriver could conceivably build a IRS-V beater and hang out with the Ultra-fi horn crowd for under \$2000 !

Where's the caveat? My only disappointment is that the Rolling Stones sounded a lot more 'rough and ready' on my Altec 1005/288Cs. All the little peaks and ringing in these horns add some excitement to live rock recordings that the Edgar wood horns do not. But that's a special case., In general, the Edgars throw a gentle, even light on the performance that just makes you want to keep on listening. It appears that a cone driven horn may have advantages over a compression driver for small room systems. Listener fatigue is simply not an issue.

So for now, I tell you these horns are wonderful, perhaps as good as it gets, but you can't just substitute them for your present midrange in most systems. My early experiments have shown that because they are horns, because they are sensitive (efficient), and because they are very low distortion, creating a complete system or integrating them into an existing system can be challenging. In short, it's hard to find a low end that is good enough in the ways that the Edgarhorn is good.

Finding six more octaves of this quality is what I hope to do myself. Dr. Edgar's low frequency horn designs, the "Monolith" 40-400 Hz horn and the 50 Hz "Show" horn, might be the ticket. Stay tuned for a detailed report on the "Show" horn and a bi-amped Onken/Edgarhorn system I'm building.

If I have succeeded in developing a "high fever" in some of my readers, I am sure you will be writing Dr. Edgar and experimenting without waiting for me—here are a few tips worthy of consideration.

First, if you choose a direct radiator or Onken bass enclosure: BI-AMP. Padding the mid-horn down 6-9 dB to match the efficiency of these bass units makes the speaker sound dull and lifeless. The same amount of padding makes compression type drivers sound bright, grainy and harsh.

If you use a passive filter, use only a first-order device. The mechanical rolloff of the horn on the low end will give you a steeper effective slope on the bottom and cone mass induced roll off will take care of low pass on the top end. A high quality series capacitor is all the crossover you should need with the Edgar mid. Use another series cap for the tweeter and you're in business.

If you don't want to bi-amp, use a horn below 500 Hz. One of Dr. Edgar's other designs might be perfect. I'm using an Altec 825 (A-7 low end) with 515s in combination with the Edgar-horn in my system.

One last note; don't just pile this stuff up. If you want to experience the tremendous focus and detail of this driver you must tie them down and damp them. I recommend separate, sand-filled enclosures for the mid and high units. I then recommend mounting the mid and high units on separate spiked and sand-filled stands. This creates a three-piece full range speaker with exceptional mechanical isolation that the truly fevered can arrange and "time-align" to taste.

If you're traveling along the path outlined in this article, please write me care of SP and share your discoveries.

#### References:

*Speaker Builder*, One/1986, "Edgar's Midrange Horn"  
*Speaker Builder*, Two/1990, "Bruce Edgar's Show Horn"

*Speaker Builder* (forthcoming) "The Monolith Horn"

Hiraga, Jean "*Les Haut-Parleurs*", Editions Frequences, Paris.

Distributed by Eyrolles, 61 Blvd. St. Germain, 75240 Paris, France.

Contact: Bruce Edgar, PO Box 1515, Redondo Beach, CA 90278

ed. note - It's true. The Edgarhorn is indeed special. After a few weeks listening to a pair of custom E-horns designed to work with my favorite 8" cones—Altec 755As and Lowther PM-6s, what was left of my Altec and WE theater gear collection went up for sale. Sure the Edgarhorns require care in set up but something like an Altec horn system is *much* more challenging to get right in a smallish room. At least, I personally never got a compression driver system with metal horns tweaked to the point where I was 100% happy. With the Onken/416A LF system and a Gauss pro tweeter, I had *la musique* after only two days of playing around with the E-horn—with no machine work or heavy lifting required.

The Edgarhorn doesn't sound like a speaker at all—at least not like any other speaker I ever heard. The E-horn is destined to become the reference standard for midrange purity. Although I don't have much patience for whining Audiophile criticism, I must admit that it is unsettling to listen to a midrange that doesn't provide anything to complain about.

I am really glad that I tried Edgar's midrange horn. The only problem is that now I strongly desire horn loading down to at least 100 Hz. Hey, Bruce. . . where's my *mid-bass* horn?

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# CLASSIC DESIGNS

## THE ONKEN ENCLOSURE

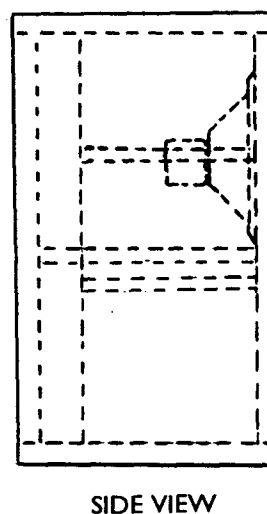
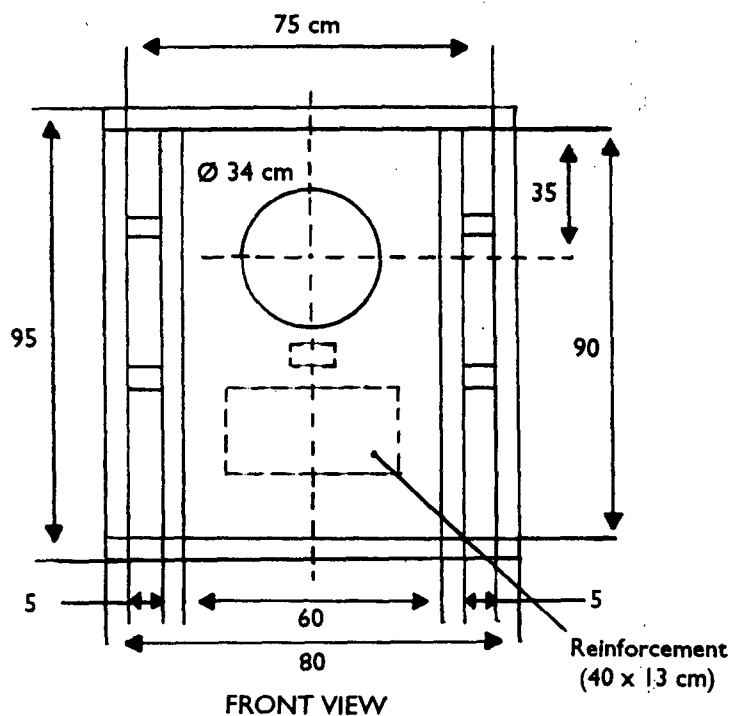
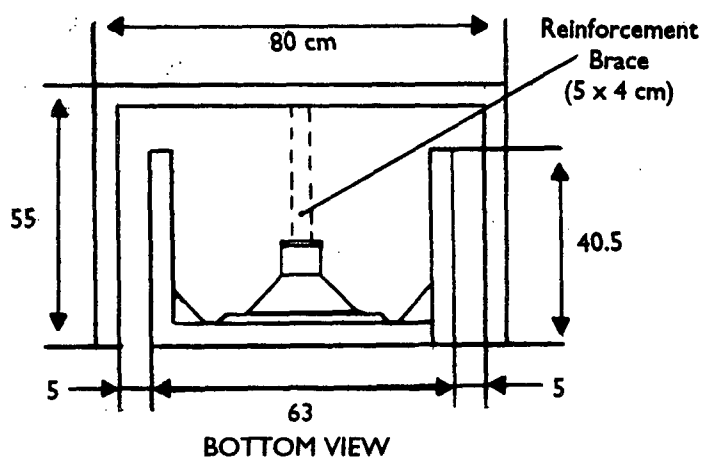
"Onken" is not exactly a household name among Western audiophiles. But for those in the know it represents one of the ultimate refinements in modern audio. Despite their rarity and great expense, the Onken transducers are among the few modern speakers that have achieved cult status worldwide.

Founder Eijiro Koizumi brought the finely crafted Onken transducers onto the market in Japan in the early Seventies. The Onken drivers and speaker enclosures, designed in consultation with an acoustics professor from Tokyo University, received wide critical acclaim among advanced Japanese audiophiles. Unlike the many Japanese supermania creations which go completely unrecognized outside the local audio community, Onken was to enjoy an international destiny.

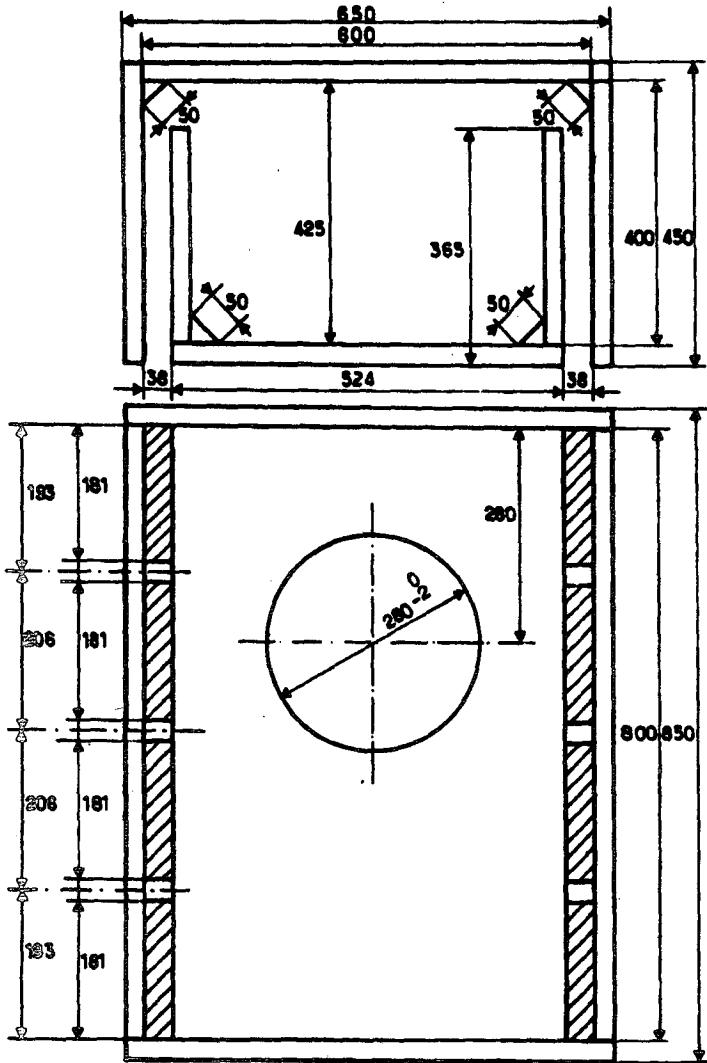
The man responsible for the wide diffusion of the Onken system was Jean Hiraga, a Franco-Japanese engineer and journalist who wrote for *Revue du Son* and edited the pioneering journal *L'Audiophile* from its inception in 1977.

Hiraga lived and worked in Japan as a correspondent for *Revue du Son* during the era of the ascent of the Onken. His role was to act as a broker between the Japanese and French audio cultures. He was the first and most influential contemporary spokesman for triode amplifiers and horn speakers in the Western Hemisphere.

In one of the premiere issues, *L'Audiophile* promoted the Onken bass enclosure, a design derived from a Jensen design of 1938, as an answer to the difficult question of what to use for a low end with high resolution horn midrange speakers.



The classic ONKEN enclosure for the Altec 416-8B



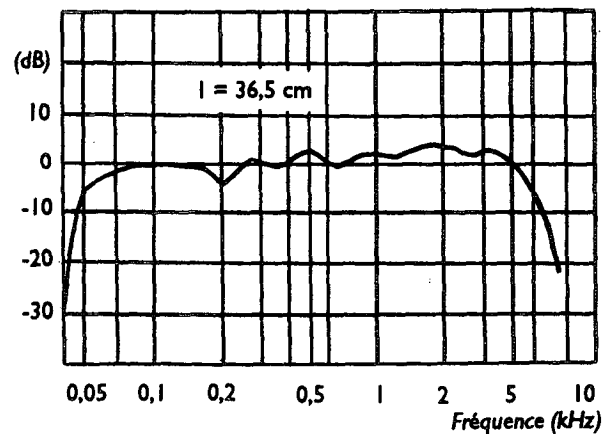
The "Petite Onken" for the Altec 414-8B.  
A front-to-back brace should be added as in the 15" enclosure

Finding a quality low end for your horn system can be a real challenge, as many independent experimenters have discovered and Hiraga had one solution. Based on listening tests, *L'Audiophile* suggested the Altec 416-8B as a suitable replacement for the scarce and expensive Onken woofer in the original 15" bass cabinet.

In September 1982, *L'Audiophile* published the plans for a smaller Onken enclosure designed by Koizumi in 1976. It became very popular in Europe, as it had in Japan, due to its reduced size and for its ease of setup and tuning relative to its big brother. This smaller Onken box is known as the "Petite Onken" in France and by its original name "IP Ultra-Bass" in Japan. The 12 inch Altec 414-8B was used in this cabinet. Subjective and measured performance is generally on par with the larger Onken.

During the Eighties, the French loudspeaker manufacturer Focal recommended Onken-derived enclosures for several of their LF drivers, including the 10C01. The "Onken-Mahul" Focal bass system differed from the classic Onken in that it had ports on all four sides of the box, rather than only on the sides. The unique Focal plaster "Egg" two-way system was utilized as an HF system with the Onken-Mahul box.

Thanks to construction plans published in *L'Audiophile*, the Onken designs were and are widely reproduced by advanced hobbyists and craftsmen who cater to the audiophile elite. As always, selection of materials is a critical aspect of the art of audio design and in this regard there is no equivalent to the original Onken. The Japanese version used exotic pressure treated one-inch plywood and carefully selected long-fiber wool for damping. The *L'Audiophile* articles recommend one inch (2.5 cm) marine-grade plywood and argue that wool stuffing is indeed the best choice.



Frequency response of  
Petite Onken/Altec 414-8B

If you choose to recreate the Onken box, the finishing touches are up to you. However, between the French and the Japanese, all likely variations have been tried. *L'Audiophile* suggests building these designs "*sans aucune modification*"— probably well founded advice. By all means, rear mount the driver; do not blindly follow conventional audiophile wisdom and attach the driver from the front!!

The Onken enclosure is renowned for its natural, articulate, and detailed low end. Although there are bass systems which have greater extension and bass horns with more "slam", the Onken ranks high in terms of subtlety and finesse. In terms of pedigree and mystique, Onken is in a class of its own among modern loudspeaker systems.

# Analog Control Panel IV

A line level preamp with direct coupled servo output

by Gordon Rankin, Wavelength Audio

Of all the equipment that I go through, the pre-amplifier is the most stable component in the chain. Perhaps this is because a pre-amplifier requires less maintenance, but it seems that after I find one I like it stays there. Now that we have broken out of a constant loop of amplifier projects (thanks to Vinny Gallo), maybe I can finish that line level pre-amplifier everyone has been hounding me for since *SP #1*.

Line level preamps have been gaining in popularity over the past decade because you can get great digital performance at reduced cost over a phono-equipped unit. If, like me, you're still into vinyl, a separate phono stage such as J.C. Morrison's Siren Song from *SP #3* can easily be added if black disc playing capability is desired. I love my Linn but I am also totally into digital. My modified CD player and my DAT get as much airtime as my turntable.

I call this pre-amplifier "The Analog Control Panel IV." It's "IV" because it is my fourth commercial preamp effort and there are coincidentally four tubes in the circuit. This design is based on feedback and suggestions from numerous individuals and draws on various cool ideas I have been tinkering with for the past few years.

My design criteria were as follows: The unit should be easy to build with generally available parts. It should be simple enough to build without a math degree, (. . .not that math is boring or anything) but novel enough to strike interest in heavy duty technotypes.

Reader Mike Somers recently asked me why I never give up any of my hot

design secrets in print. Well, okay Mike, for added excitement I will reveal one of my favorite design tricks—my servo controlled DC coupled cathode follower strategy.

We are going to break this project up into two articles. This one will deal with the electronics of the gain/buffer stage and in the next installment we will look at switching and volume control implementation.

For maximum versatility, we will include a "direct input" which skips the gain stage and selector switch, going directly to the input of the buffer. So if your digital source is already riding high on gain, you can choose the direct link for shortest signal path. You can then use the gain stage to match the level of your tuner or other lower output source to your digital source level.

## GAIN STAGE

I have been searching for a good single stage non-inverting gain block for some time. The differential amplifier is well suited for the task. A nice feature of this circuit is its minimal parts count and availability of both in-phase and out of phase output at the same level.

The gain stage of this project is a simple differential amp using the 6922, a boss version of the perennial favorite 6DJ8. The Sovtek 6922 is a fine high transconductance audio tube, try it! The cathodes are fed from a current source based on a MPSA05 transistor. Each side of the diff amp runs at 4 mA so the current source is set to deliver 8 mA. The calculated gain of each section is just over 10, just what we were looking for for 20 dB. Actual gain is around

12.5 for the Sovtek 6922 and 11.2 for the Sylvania 7308.

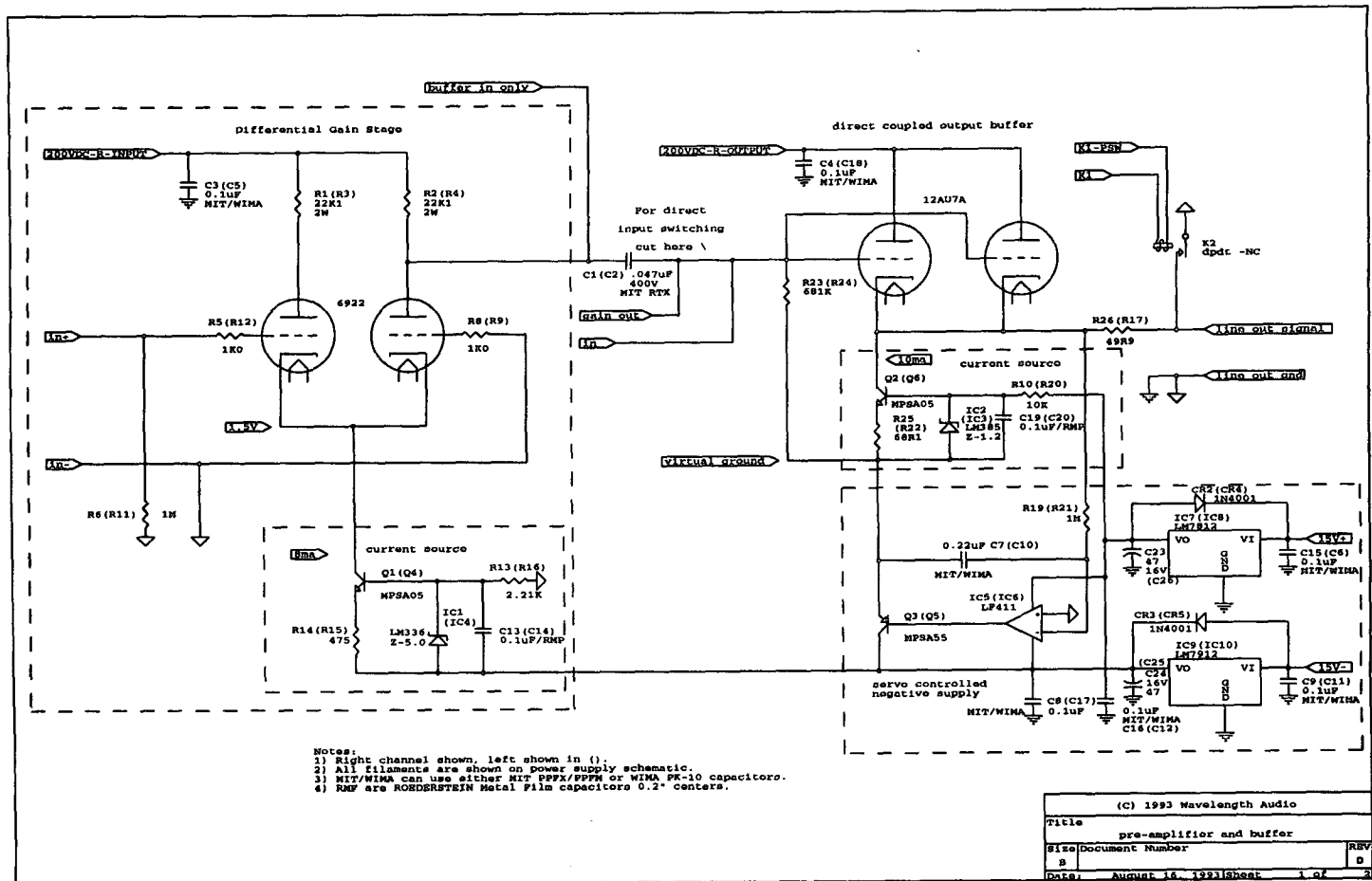
A differential stage gives us both inverting and non inverting outputs. I use the non-inverting output. Many high end units invert polarity, perhaps because designers wish to minimize the number of gain stages. I have an ethical problem with this. *Maybe* there is no sonic difference, *but* . . .

As J.C. Morrison noted in *SP #3*, the power supply interface of the differential is optimal because each half of the differential draws opposite current. We will use separate supplies for input and output buffer in each channel for better regulation and isolation. Cool so far, but wait till you see the buffer/output section.

When I first got started with Wavelength Audio, I was strictly solid state. I didn't really "find myself" however until I converted to tubes. Dedicated tube purists might object that the output stage has some solid state principles in it. However the audio path only traverses the 6922 and the 12AU7. We're using solid state here for control circuitry for convenience. We could do all this with tubes at a great increase in cost and complexity with no operational advantages whatsoever. Solid state devices are a great resource for many applications and I don't hesitate to use them where appropriate.

## THE BUFFER

A cathode follower was chosen as a buffer because it requires only a single stage, it has good output capabilities, and the gain is close to one—0.95 in this instance. The trick to getting a



cathode follower to sound good is simple—the cathode must see an extremely high impedance so that it only drives the load and not the cathode resistor. A current source will give us the high impedance we want. Also, as the cathode impedance increases the gain approaches unity.

The main problem I have with tube pre-amplifiers is those huge DC blocking caps required on the output of the cathode follower section. I think it was Walt Jung who argued that "the best capacitor is no capacitor at all." NO capacitor can get complicated but many designers recognize that the lower the value of the cap, the better the sound. Output caps on cathode followers usually need to be high value units.

We are using capacitor coupling on the input to the buffer, but since the input impedance is extremely high (up to 2.2M can be used as a grid resistance for the 12AU7A), we can use a good sounding small cap. Let's keep the grid resistance to 681K for the paralleled

sections and use a 0.047 uF cap. If you don't need flat response to 5 Hz, a 0.033 uF cap will get you down to -3 dB @ 7.1 Hz.

Instead of using a large DC blocking cap at the output, we can employ my trusty servo design. I used servos in several of my discrete transistor/FET circuits to correct for zero DC offset instead of using a big nasty cap to block DC and the sonic results were excellent—so let's try it here.

A servo is simply an error amplifier. The voltage seen on the input is subtracted from the reference (ground in this instance) and applied on the output to compensate for the error. The performance of a servo is further enhanced by a low pass filter to limit the frequency range to approximately DC. Using this technology, we can keep DC on the output way down in the nanovolt range.

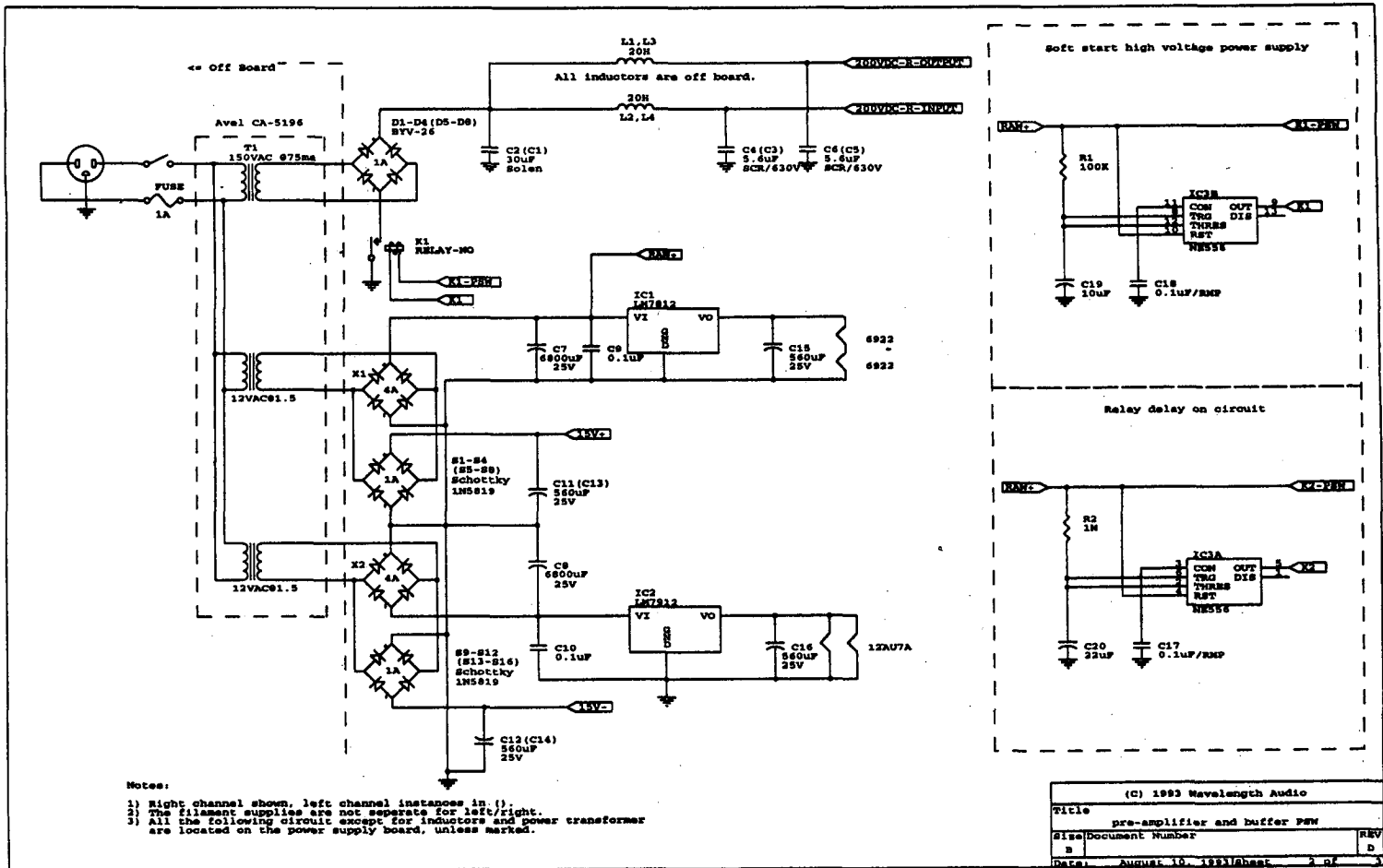
I chose an LF411 for the servo because of its extremely low offset voltage, high input impedance, and low drift. One

method of direct coupling is to control the negative grid bias through the servo. However, this approach would require a really high grade power supply since variations in the supply voltage can show up on the grid and act like signal.

A more simple way of doing it is to bring the cathode down to zero volts. We will use a negative servo as shown on the schematic. The MPSA55 in the servo provides an even lower output impedance than the already low output Z of the LF411. The grid resistor of the 12AU7A and the current source are attached to a "virtual ground."

The power supply board also uses an NE556 timer to delay the high voltage and to clamp the output (using relay K2) until the servo and the tubes warm up to prevent pops at turn on. When K2 closes at power up, the servo actively corrects for DC offset on the output. When the system is warmed up, the relay opens and music appears at the output. The servo is great because there are no adjustments to make. Plug in a





Notes:  
 1) Right channel shown, left channel instances in ().  
 2) The filament supplies are not separate for left/right.  
 3) All the following circuit except for inductors and power transformer are located on the power supply board, unless marked.

different brand of 12AU7 and off you go—no changes, no problems. The servo will automatically correct for any variety of 12AU7A within a bias voltage range of -5 to -10V (-7.5V typical, -8.5 for the Gold Dragon)

### PCBs

That is, Printed Circuit Boards, not the deadly stuff in oil caps. It might be true that the best of all possible worlds is point-to-point wiring. If you plan on building this preamp from scratch, go ahead and wire it that way. However, over the years there have been many great sounding products on PCBs. Using a PC board greatly simplifies construction and with proper attention to layout and design, the end results can be excellent.

I lay out my boards using PC software. The important thing here is to find a package that will handle curves well. The performance of a board can be compromised by squared off traces. You want curves that have either rounded corners or trimmed to 45 degree angles, otherwise radiation can

become a problem. A square corner will radiate at the tip, causing bleed over and crosstalk with other traces. The size of the traces is also a consideration. For analog circuits, the trace should be at least 25 mils wide. The PCBs for this project use 50 mil traces for the signal and control circuits and 100 mils for the filament leads. I use two layer boards so I can layout all the components without breaking up the traces with jumpers.

The circuit is split into a power supply board and a signal board. This is for isolation and to provide the option of housing the power supply in a separate cabinet if desired. The power supply board carries all supply components except the power transformer and inductors. The signal board holds all of the gain and buffer components and the regulated +/- 12 V supply.

The signal board starts at the front with the 6922 gain stage and works its way back to the output section. The board is split down the center with a Roger's Q-strip for a quasi-star ground

configuration. The strip has two conductors of high quality copper. There are takeoff points for signal ground and power supply ground. They are joined at only one point at the ground connection from the power supply.

### POWER SUPPLY

The power supply is "dual mono" all the way back to the power transformer, which is shared by both channels. Two power transformers could have been used, I suppose, but for a reasonable economy measure I choose to employ only one. The four legs of the HV supply are very well decoupled after the shared transformer.

The power supply uses all fast recovery diodes for rectification—except in the filament supplies which use full wave bridges. The diodes of choice for the low voltage are Schottky rectifiers and for the high voltage, fast recovery epitaxial diodes.

Let's look at the power supply in three parts: filament supply, low voltage and high voltage.

### Filament Supply

In pre-amplifiers, a nice regulated DC supply for the filaments will keep the noise floor down on the gain and output stages. The 6922 has an extremely low noise floor with a clean DC heater supply. A 4A bridge is used to rectify the AC input voltage, which is fed to a 6800 mF cap followed by plus and minus 12V regulators. The plus side runs the 12AU7A filaments in parallel and the minus 12V side is used to heat the 6922s.

### Low Voltage

The AC is rectified by Schottky diodes and filtered on the power supply board. Additional filtering and regulation is provided on the signal board. The idea of putting the LV regulators on the signal board is to avoid long leads between the regulator and the circuit it powers for low noise and lowest output impedance. Since current demand is low (about 25 mA), we can use LM78L12 and LM79L12 regulators. They are bypassed with high frequency capacitors. The LM7X12s are followed by the current sources and the servo supplies so they will work fine here.

### High Voltage

The AC input is rectified by fast recovery epitaxial diodes of the BYV variety (available from General Instruments and Philips—Digi-key stocks Philips). The supply turn-on is delayed for 20 seconds so that the heaters will have time to heat the tubes. This will prevent cathode stripping and promote longer life for the tubes. The output of the discrete rectifier bridge goes to a pi network consisting of a 20 mF polypropylene cap, a 20 H choke, and a 5.6 mF poly cap. Two such filter networks are provided for each channel: one for the 6922 stage and one for the output stage. The supply leads are bypassed at the signal board with high frequency film capacitors.

### Fast Diodes

Before I got started on a project with (count them!) 24 diodes, I did some investigation to find the right parts. Corey Greenberg's second *Stereophile* article on the BUF-03 buffer generated a lot of hoopla on "fast" diodes. I sought some advice from John Schlesiner of Precision Audio, a diode design expert by trade. He claims that the reason that

fast recovery diodes provide better performance is their ability to 'disconnect', providing better isolation between power transformer and filter capacitor. Ideally, the rectifier should conduct to bring the cap reservoir up to voltage initially, then it just tops off the potential drained from the supply caps each cycle. The faster the diode the better it can connect and disconnect from the circuit.

Schottky diodes have basically zero reverse recovery time and work great for low voltage rectification. The problem is that they only come in low voltages (60 V max.) so we can't use them for the high voltage section. For HV applications, fast recovery epitaxial diodes are the best available. The BYV variety switch faster than 35ns, much faster than the standard 1N4004 variety.

This circuit will provide over 5 V RMS at the output and an output impedance at 1kHz (sine wave) of 350 ohms. Bandwidth is from 10 Hz to over 100 kHz (-1dB).

For listening tests, I wired the unit up direct with a 250K ALPS pot and a single set of inputs. I used my DAT as a D/A converter, a pair of Wavelength Audio Cardinal Mk.II 300B SE amps, and the Taddeo Arpeggio loudspeakers. I also added Tony Taddeo's excellent Digital Antidote to the audio chain toward the end of my preamp audition program and I found that it provided an apparent increase in resolution.

Anyone who knows me will tell you that I'm not inclined to talk about the way equipment sounds in poetic terms. In short, this preamp has the sonic attributes one expects from a quality tube unit in terms of imaging and soundstaging. Thanks to the direct coupled output it provides the quick and punchy bass of a great solid state unit without the dry or harsh character that often plagues non-tube electronics.

### SOURCES

Analog Control Panel IV kits and parts:  
Michael Percy  
Box 526, Inverness, CA 94937  
415-669-7181 voice  
415-669-7558 fax

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# ALTEC "Voice Of The Theater" Speakers For Hi-Fi

by Jeff Markwart  
and John Tucker

Several years ago, while auditioning components for an overall system upgrade, Bill Fisher of Friendswood, Texas, suggested that I consider horn loaded speakers. The following weekend, he gave me a demo of his classic Altec Lansing A7-500W-1 Magnificents. The Magnificents are a furniture cabinet version of the A7 small "Voice of the Theater" system with a 500 Hz horn.

It was immediately apparent that these imposing boxes did a number of things very well compared to the majority of speakers I had been evaluating. Positive characteristics included:

- huge, effortless dynamics
- fast, controlled midrange transient response
- dramatic presence
- midrange clarity
- natural, open sounding bass
- high efficiency

I was hooked. Before long there was a pair of A7-500 Utilities in my front room running on a pair of 6B4-G push-pull triode monos I built. John Tucker stopped by for a listen and soon Altecs appeared at his house also. Over time, however, John and I became aware of a number of shortcomings inherent in the stock A7. These included:

- midrange and treble distortion on program peaks
- treble ringing
- lack of soundstage/imaging
- lack of clean bass
- lack of deep bass
- lack of system balance at lower SPLs
- crossover region colorations
- requirement for a low system noise level

The following paragraphs suggest some practical remedies for these limitations. We were impressed with the results of our

experiments but we feel they only approach the limit of potential improvement. Some of these recommendations will not be appropriate or cost effective in commercial applications. Many of these recommendations apply to other Altec systems. Our goal was to optimize the A7 for full range, hi-fidelity use in relatively small, quiet, environmentally controlled spaces.

## NOISE, NOISE, NOISE!

A7s are extremely efficient. The typical A7 has a pressure sensitivity of 105 dB SPL (1W/1M). You may discover your system noise floor is clearly audible through this speaker. Hum must be 1-2 mV or less for woofer inaudibility; even less if there is any non-sinusoidal component. The compression driver can reproduce thermal noise in its bandpass quite readily, and this may have to be reduced so as not to be intrusive in a

quiet room (40-45 dBA). The following steps may be useful in achieving an acceptably low system noise level:

- use main amplifiers that have less than 1-2 mV of hum at their output with the input grounded
- eliminate system ground loops
- eliminate unneeded gain stages
- use stepped attenuators
- for unbalanced terminations, employ interconnects that use a shield as a drain
- upgrade stock speaker wiring, crossover wiring, and connectors
- upgrade stock internal wires between the compression driver binding posts and the diaphragm voice coil terminations
- clean all signal connection mating surfaces

These steps should result in greater usable dynamic range, lower harmonic distortion, an increase in low level program information, and better imaging. You promised to do this years ago, anyway, right?

## WHICH WAY IS UP?

The speaker can either be configured "inverted", with the H.F. horn mounted in the cabinet reflex port and the short bass horn closest to the floor, (Magnificent, A7-W, some Utilities - Fig.2), or "upright", with the H.F. horn on top of the cabinet and the reflex port closest to the floor (Fig.1). If the

## ALTEC A7 Systems

PERFORMANCE SPECIFICATIONS:	A7 SYSTEM	A7-500 SYSTEM
Power Rating:	30 watts	30 watts
Impedance:	16 ohms	16 ohms
Horizontal Distribution:	90 Degrees	90 Degrees
Vertical Distribution:	40 Degrees	40 Degrees
Frequency Response:	35-22,000 cps	35-22,000 cps
Pressure Sensitivity:	109.2 db (w/1 watt input at 4')*	109.2 db (w/1 watt input at 4')*
	124 db (w/30 watts input at 4')	124 db (w/30 watts input at 4')
Crossover:	800 cps**	500 cps***
Dimensions:	42" H } LF Horn 30" W } Only 24" D }	54 1/4" H 30" W 24" D
Finish:	Theatre Gray	Theatre Gray
Weight:	100 lbs. (Cabinet)	135 lbs. 142 lbs.

\* 109.2 db measured 4' from mouth of horn over warble frequency range 500-2,500 cps. (Ref: .0002 dynes/cm<sup>2</sup> for 1 watt input.)

\*\* N-800D furnished; Adjustable in 4 steps of 1db \*\*\* N-500 D furnished; Adjustable in four steps of 1.5 db

H.F. horn is removed from the port for upright mounting, the reflex port area must be reduced from approximately 375 to 220 square inches. The upright configuration is superior for bass projection and tightness, overall imaging, and a seamless blending of the drivers.

### CAUTION: DIPS AHEAD

Each speaker requires crossover phase alignment of its two drivers for lowest distortion and best imaging. Altec recommends locating this point by: 1) positioning the driver voice coils in basic vertical alignment and then, 2) adjusting the H.F. driver/horn position (connected electrically out of phase from the woofer) to achieve the greatest observed dip at crossover on a real-time analyzer measuring speaker reproduced pink noise. A dip of 6-8 dB should be attainable. Reverse the H.F. connections when you finish securing the horn and the drivers will be in-phase at crossover.

### ACOUSTIC MUD & OTHER FINDS

The stock bass cabinet contributes significant amounts of unwanted acoustic energy to program material. Reduce these vibrations by stiffening the box with external veneers or laminates and adding internal panel bracing of 2X2s or 2X4s glued and screwed on edge. Dampen the internal flare of the short horn with contractor's epoxy, tar, insulating foam, or other suitable material. Install braces between the short horn flares and the sides of the box. Brace the port boards with diagonal hardwood 1X2 glued and screwed on edge. These actions will eliminate the muddying distortions caused by cabinet radiations in the mid and upper bass.

Altec cast aluminum horns ring like the Liberty Bell. They need to have damping material applied to their exteriors until a knuckle rap produces only a "thunk". Use tar, Soundcoat, layers of latex paint over sand, lead, sand filled enclosures, or other suitable material. This will eliminate the treble ringing of the H.F. horn that is a major source of listener fatigue.

All air leaks in the box should be sealed. A common problem seen in many older boxes is a gap that appears along the bottom edge of the short bass horn flares.

### SO MANY CHOICES, So Little Time

There are two basic families of compression drivers applicable to the A7 — the small 1" throat type and the larger 1.4" variety. The

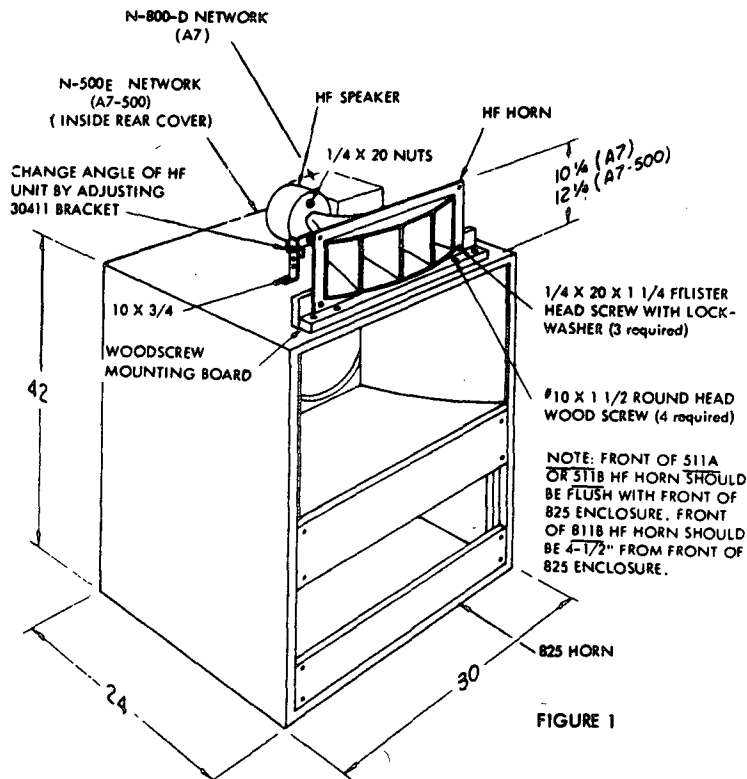


FIGURE 1

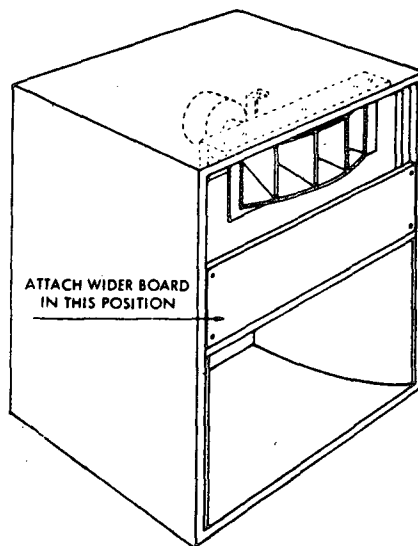


FIGURE 2

### UPRIGHT AND INVERTED A7 CONFIGURATION

one inch family includes the 802, 804, 806, 807, 808, 902, 908, and 909. The one and a quarter inch type can be either a 288, 291, or a 299. There have been many cosmetic and performance changes over the years in both families.

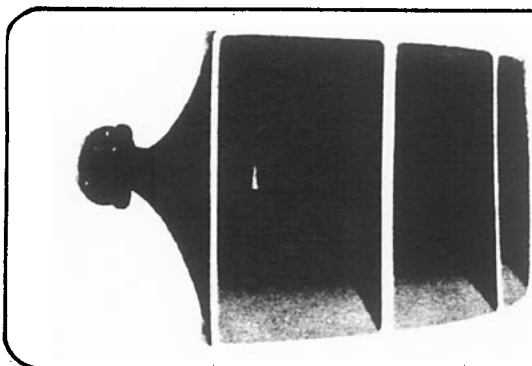
#### Generalities:

- Older units (pre 1980) use Alnico magnets; later units use ferrite
- Older units (pre 1977-79) use a machined metal phasing plug; later

units use the plastic "Tangerine" phasing plug

- Older units have a bronze throat screen attached to their mounting gasket; later units have a bronze or stainless screen sandwiched between the phasing plug and throat
- The 1 inch drivers bolt to the 511 or 811 sectoral horn directly; an adaptor is required to connect 1 inch drivers to larger sectoral, multicellular, or constant directivity horns designed for 1.4 inch drivers

## ALTEC 311-60 AND 311-90 SECTORAL HORNS



The Altec 311-60 and 311-90 are the newest sectoral horns in the Altec line. They are designed for use in sound systems where a low cutoff and uniform control of the projection angle are required. These horns are treated with "Aquaplas", a patented sound deadening material, to assure freedom from resonance and ring. They are designed to operate with an Altec 288C, 290E or 730C Driver Loudspeaker through the proper receiver attachment. Use of an Altec N-500C Network or 15045A 70-volt matching transformer will provide driver protection. Both horns feature a 300-cycle cutoff frequency, and the sound pattern, controlled by the sectoral expansion, is 60-degrees horizontally for the 311-60, and 90-degrees for the 311-90. Vertical distribution for both horns is 40 degrees.

Many experimenters prefer longer, lower cutoff horns over the stock 511/811

- 1.4 inch drivers bolt directly to the large sectoral horns and to various throats of the multicells or CDs

Three types of diaphragms exist for Altec compression drivers:

1. Aluminum: low power handling; best transient and high frequency response (288, 802/902, 804/806)
2. Pascalite: high power handling; transient and high frequency response slightly less than aluminum. (299, 909)
3. Symbiotik: high power handling; poorest transient and high frequency response of the three. (291, 807, 808/908)

There are two basic families of woofers applicable to the A7 — the large magnet 515 series and the less efficient 803/416 variety. There have been many cosmetic and performance changes over the years in both families.

- Early units (515, 803A) use light, stiff cones with 40-45 Hz resonant frequencies and 16 to 20 ohm voice coil impedances
- Later units (515B and later, 803B/416A and later) use heavier cones with 25 Hz resonance and 8 or 16 ohm impedances
- Older units use Alnico magnets; later units use ferrite

### DETAILS, DETAILS

Whether you choose small or large format compression drivers, eliminate the throat screens. These screens prevent bugs and other debris from entering the compression

drivers in unattended or hostile commercial environments. Although light and thin, their construction has a polarizing effect on visible light. Remove them from the gaskets on older models; on later units cut an "x" across them with an Exacto knife, then grasp and remove them with a hemostat or large pair of tweezers. These "bug" screens are responsible for the bulk of midrange and treble distortions on program peaks, softening of treble leading edges, midrange colorations, H.F. signal attenuation, and phasey images that are hard to localize. Altec compression drivers sound excellent with these throat restrictions removed.

Whether you choose small or large format compression drivers, use aluminum diaphragms for best home sound. They are available in 8 or 16 ohms impedance for the 1" units; 8, 16, 24, or 32 ohms for the 1.4" types. Their only performance limitation is power handling, but this should be of little concern for Hi-Fi use unless you plan on producing constant, ear-shattering output levels. If you do, use the Pascalites.

Whether you use passive or active crossovers, stay at 500 Hz and employ a relatively long horn with a low cutoff frequency for best performance and sound. The 1" drivers will fit the larger sectorals, multicells, and CDs via throat adapters from Altec. A long horn with a low cutoff will provide more effective throat loading in the crossover region than the stock 511 horn. Consider 311s or 329As. The 329A resembles the 311 pictured above but with reinforcing bars instead of sectors.

Altec 500 Hz crossovers are excellent sounding units. Most are straightforward 12

dB/oct, parallel L/C, Butterworth types that were designed for 8 or 16 ohm loads. A few models (e.g. N500C and E) had their component values set for 12 ohms. Replace the stock wiring and capacitors in these units with your favorites to improve their sound. We measured the stock capacitors in several Altec crossovers and found that some had drifted in value considerably.

Still higher performance can be obtained by bi-amping the A7. I've listened through various solid state and tube crossovers employing 12, 18, and 24 dB/oct slopes and feel they all offer performance advantages over the single amp/crossover per speaker configuration. My favorite is the 24 dB/oct Linkwitz/Riley.

If you like to hear information above 10-12 kHz, opt for the 1" drivers over the 1.4" units. No contest here - tics on 802s sound like pops on 288s; leading edge attacks are razor sharp on 802s, softened on 288s. The 21216 adapter is a current Altec part which will allow the use of 1" drivers on horns designed for 1.4" drivers. Jobber price is around \$75/pr.

The midrange sounds cleaner on drivers that use the machined metal phasing plug. Distortion that is noticeable through a Tangerine plug on steady tones or program material is not present on the metal units.

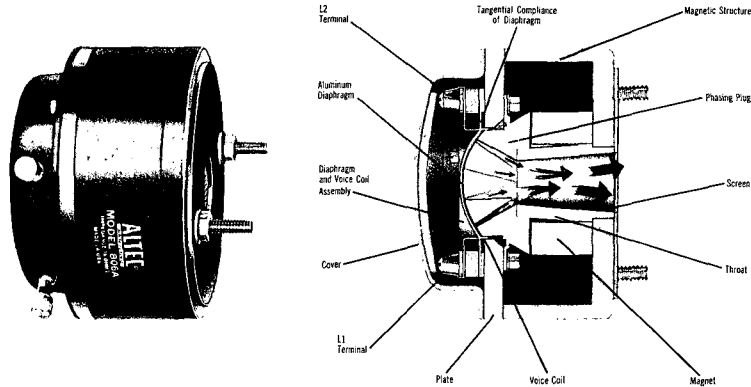
We prefer 416 type woofers in the A7 for the best overall performance in a Hi-Fi application. Use the 515 for low frequency augmentation.

(Continued on page 31)

# 802D & 806A Driver Loudspeakers

802D  
806A

ALTEC 802D  
806A



## SPECIFICATIONS

	802D	806A
<b>Power:</b>	30 watts (with N-500D or N-800D Network)	30 watts (with N-500D or N-800D Network)
<b>Frequency Response:</b>	500-22,000 cycles	500-22,000 cycles
<b>Pressure Sensitivity:</b>	111.7db* at 1 watt; 126.4db at 30 watts	109.5db* at 1 watt; 124.2db at 30 watts
<b>Impedance:</b>	16 ohms	16 ohms
<b>Voice Coil Diameter:</b>	1.75"	1.75"
<b>Application:</b>	HF Driver unit for wide-range, two-way studio 'Playback' Systems	HF Driver for wide-range, two-way, studio 'Playback' Systems
<b>Protection:</b>	N-500D Network and 511A or 511B horn for 500 cycle crossover N-800D Network and 811B horn for 800 cycle crossover	N-500D Network and 511A or 511B horn for 500 cycle crossover N-800D Network and 811B horn for 800 cycle crossover
<b>Magnet Weight:</b>	1.2 lbs.	13 oz.
<b>Flux:</b>	15,250 Gauss	13,000 Gauss
<b>Dimensions:</b>	Diameter: 4 1/2" Depth: 3 3/4"	Diameter: 4 1/2" Depth: 3 1/4"
<b>Weight:</b>	7 lbs.	5 lbs., 11 oz.
<b>Finish:</b>	Altec Green	Altec Green
<b>Accessories:</b>	511A, 511B, 811B Sectoral Horns; N-500D, N-800D Dividing Networks; 70.7v transformers	511A, 511B, 811B Sectoral Horns; N-500D, N-800D Dividing Networks; 70.7v transformers

\* (Ref. .0002 dynes/cm<sup>2</sup> measured with warble frequency 500 - 2,500 cycles, 4' from mouth of 30" trumpet)  
Note: For Multicellular Horns use Altec drivers 730, 288 and 290 types.

### PROFESSIONAL 'PLAYBACK' SOUND SYSTEMS BROADCAST & RECORDING STUDIOS • BALL ROOMS AUDITORIUMS • SCHOOL & CHURCH MUSIC ROOMS MUSIC HALLS • THEATRES • NIGHT CLUBS DANCE STUDIOS • WIDE RANGE MUSIC SYSTEMS

The Altec 802D and 806A High Frequency Driver Loudspeakers are designed for all professional PLAYBACK applications requiring outstanding reproduction of sound over an extremely wide frequency range at substantial power levels. Such conditions are readily fulfilled with unusually high efficiency and exceptionally uniform response from 500/800 (dependent on the dividing network and horn employed) to over 22,000 cycles.

When used in conjunction with the Altec 511A, 511B (500 cycle) or 811B (800 cycle) sectoral horn, the N-500D (500 cycle) or N-800D (800 cycle) network, and the 414, 515, or 803 low frequency loudspeaker, the 802D and 806A furnish the realistic reproduction demanded by all major broadcasting stations, recording studios, theatres, auditoriums and music halls.

Both the 802D and 806A transducers utilize a voice coil of notably large diameter (1 3/4") edge wound with aluminum ribbon and coupled to a large 2 1/4" aluminum diaphragm having tangential compliance. A mechanical phasing plug (i.e., pole piece), having two exponential acoustic slots, is utilized to provide the proper phase relationship between the sound emanating from the center and outer edges of the diaphragm and voice coil assembly, thus insuring maximum high frequency reproduction while maintaining a smooth overall response. Either driver is capable of uniform, peak-free reproduction to a point far above the range of human hearing. The entire diaphragm and voice coil assembly of the 802D and 806A is field replaceable; no special tools or skills are required.

For full range systems utilizing low frequency loudspeakers of relatively low efficiency, located in non-reverberant areas having moderate ambient noise levels, the Altec 806A driver proves a perfect match. (Such conditions would be analogous to the average listening room or smaller broadcast and recording studio). In instances wherein relatively high ambience is present, and where maximum efficiency of both vocal speech and music must be reproduced with greatest clarity, the heavier magnet weight and greater flux density of the 802D are preferred. The 802D represents one of the finest high frequency transducers manufactured by Altec; the 2 db greater efficiency (over the 806A), coupled with the same precision accuracy of minute production tolerances, make the 802D the industry standard for laboratory and professional usage alike.

These factors, together with the all-important Altec criterion of engineering experience, combine to produce the 802D and 806A high frequency loudspeakers of virtually matchless quality and limitless application.

## Features :

- 500-22,000 Cycle Response
- Smooth, Peak-Free Response
- Extremely High Efficiency
- Low Distortion
- Faithful Reproduction
- Aluminum Diaphragm with Tangential Compliance
- Edge-Wound Voice Coil
- 30-Watt Capacity
- Compact — Easily Installed
- Field Replaceable Diaphragm & Voice Coil Assembly



From 1966 Altec Specifications for Engineers and Architects

## ARCHITECTS' & ENGINEERS' SPECIFICATIONS

### (FOR ALTEC 802D):

The high frequency driver loudspeaker shall utilize a 2 1/4" diameter aluminum diaphragm having tangential compliance, coupled to a voice coil of edge wound aluminum ribbon having a diameter of 1 3/4". The voice coil gap shall have a flux density of at least 15,250 Gauss, produced by a magnet having a weight of 1.2 pounds. A machined phasing plug, which also serves as the pole piece, having two exponential acoustic slots shall be utilized to provide the proper phase relationship between the sound emanating from the center and edges of the diaphragm and voice coil assembly, thus insuring maximum high frequency reproduction while maintaining a smooth overall response. The entire diaphragm and voice coil assembly shall be field replaceable without requiring special tools or skills; this shall be interpreted to mean that the speaker shall incorporate self-centering dowels to insure proper spacing and alignment of the diaphragm and voice coil assembly.

The HF driver loudspeaker shall produce a sound pressure level of at least 111.7 db with 1 watt input and 126.4 db with 30 watts input at a distance of 4 feet from the mouth of a 30" trumpet when a warble band of 500 to 2,500 cycles is used. Single frequency measurements shall not be acceptable under this specification. The frequency response of the HF driver shall be uniform over the range of (SPECIFY):

500 to 22,000 cycles, when used with the Altec 511A or 511B sectoral horn and N-500D dividing network, 800 to 22,000 cycles, when used with the Altec 811B sectoral horn and N-800D dividing network.

Any high frequency driver loudspeaker not meeting all of the foregoing requirements shall not be acceptable under this specification.

The high frequency driver loudspeaker shall be Altec Lansing Model 802D.

### (FOR ALTEC 806A):

The high frequency driver loudspeaker shall utilize a 2 1/4" diameter aluminum diaphragm having tangential compliance, coupled to a voice coil of edge wound aluminum ribbon having a diameter of 1 3/4". The voice coil gap shall have a flux density of at least 13,000 Gauss, produced by a magnet having a weight of 13 ounces. A machined phasing plug, which also serves as the pole piece, having two exponential acoustic slots, shall be utilized to provide the proper phase relationship between the sound emanating from the center and edges of the diaphragm and voice coil assembly, thus insuring maximum high frequency reproduction while maintaining a smooth overall response. The entire diaphragm and voice coil assembly shall be field replaceable without requiring special tools or skills; this shall be interpreted to mean that the speaker shall incorporate self-centering dowels to insure proper spacing and alignment of the diaphragm and voice coil assembly.

The HF driver loudspeaker shall produce a sound pressure level of at least 109.5 db with 1 watt input and 124.2 db with 30 watts input at a distance of 4 feet from the mouth of a 30" trumpet when a warble band of 500 to 2,500 cycles is used. Single frequency measurements shall not be acceptable under this specification. The frequency response of the HF driver shall be uniform over the range of (SPECIFY):

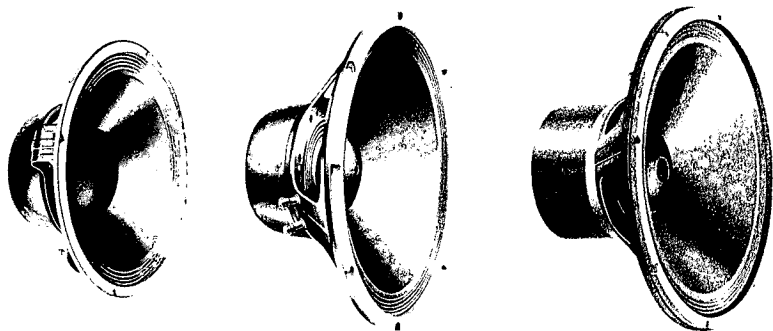
500 to 22,000 cycles with the Altec 511A, 511B sectoral horn and N-500D dividing network, 800 to 22,000 cycles with the Altec 811B sectoral horn and N-800D dividing network.

Any high frequency driver loudspeaker not meeting all of the foregoing requirements shall not be acceptable under this specification.

The high frequency driver loudspeaker shall be Altec Lansing Model 806A.

# 414A, 416A, 515B L. F. Loudspeakers

414A  
416A  
515B



414A

416A

515B

## Features

- Heavy Alnico V magnet
- Edge-wound voice coil
- Rugged construction
- Smooth response
- High efficiency
- Low cone resonance
- Low distortion
- High power capacity
- High linearity

### LOW FREQUENCY SPEAKERS FOR WIDE-RANGE, TWO-WAY SOUND REINFORCEMENT SYSTEMS • OUTSTANDING AUDIO REPRODUCTION FOR THE LARGEST CONCERT HALL, THEATRE, AND AUDITORIUM SYSTEMS • PROFESSIONAL 'PLAYBACK' SYSTEMS • BROADCAST AND RECORDING STUDIO MONITORING

Altec low frequency loudspeakers are designed for use in the finest recording and broadcast studio 'Playback' systems as well as providing outstanding reproduction of the lower audio spectrum when used in two-way systems for the largest theatres and auditoriums. Utilizing heavy Alnico V permanent magnets, rugged, die-cast frames, edge-wound copper ribbon voice coils of the largest practical diameter, and exceptionally compliant cone suspension, these LF transducers combine the advantages of long-term operation with unparalleled response throughout the entire audible bass frequency range.

The smooth response and exceptional linearity of each loudspeaker is achieved by means of strict adherence to precision design and manufacturing tolerances. The axial retention of the voice coil, in a magnetic field uniform over the full excursion, assures the clarity of bass reproduction at high power levels. The low cone resonance, when coupled to a properly designed Altec enclosure, eliminates virtually all 'doubling' or self-generation of unwanted harmonic components.

The Altec 414A, with a range exceeding 30 to 4,000 cycles, is an outstanding 12-inch LF transducer—ideal for use in institutional and entertainment systems of moderate size and coverage area. The power rating of 25 watts makes the 414A, singly or in multiples, an excellent choice in two-way systems utilizing Altec high frequency drivers and sectoral horns.

The Altec 416A is a 15-inch low frequency loudspeaker of professional quality, chosen to complement the finest broadcast and recording studio monitor systems (such as the Altec A7 and A7-500) in addition to providing the critical listener with superb bass reproduction for all wide-range public address, sound reinforcement and theatre or auditorium systems.

The Altec 515B, with its exceptional low frequency response, high efficiency and ability to faithfully reproduce the lowest audio frequencies at unusually high power levels remains the unchallenged leader in the largest and finest two-way systems throughout the world. When used in conjunction with the Altec 288C HF driver, N-500C dividing network and multicellular horn of the desired size and coverage angle, the 515B becomes an integral part of the identical Altec 'Voice of the Theatre' loudspeaker systems currently employed by the majority of the largest and finest theatres, auditoriums and concert areas.

# ALTEC 414A, 416A, 515B

## SPECIFICATIONS

	414A	416A	515B
<b>Power Rating (Continuous):</b>	25 watts	30 watts	35 watts (50 watts peak)
<b>Frequency Response:</b>	30-4,000 cycles	20-1,600 cycles	20-1,000 cycles
<b>Pressure Sensitivity:</b>	99 db (SPL at 4' from 1 watt*)	99 db (SPL at 4' from 1 watt*)	103 db (SPL at 4' from 1 watt*)
	113 db (SPL at 4' from full 25 watts)	114 db (SPL at 4' from full 30 watts)	118.5 db (SPL at 4' from full 35 watts)
<b>Impedance:</b>	16 ohms	16 ohms	16 ohms
<b>Cone Resonance:</b>	30 cycles	25 cycles	25 cycles
<b>Voice Coil Diameter:</b>	3"	3"	3"
<b>Magnetic Assembly:</b>			
<b>Magnet Weight:</b>	1.8 lbs.	2.4 lbs.	4.4 lbs.
<b>Magnet Type:</b>	Alnico V	Alnico V	Alnico V
<b>Flux Density:</b>	10,000 Gauss	12,000 Gauss	14,750 Gauss
<b>Construction:</b>			
<b>Frame (Basket):</b>	Structurally-reinforced cast aluminum	Structurally-reinforced cast aluminum	Structurally-reinforced cast aluminum
<b>Cone:</b>	Molded Fibre	Molded Fibre	Molded Fibre
<b>Cone Suspension:</b>	High-compliance cloth surround with mechanical resistance	High-compliance cloth surround with mechanical resistance	High-compliance cloth surround with mechanical resistance
<b>Voice Coil:</b>	Edge-wound copper ribbon	Edge-wound copper ribbon	Edge-wound copper ribbon
<b>Diameter:</b>	12 1/4"	15 3/4"	15 3/4"
<b>Weight:</b>	15 lbs.	17 1/2 lbs.	26 lbs.
<b>Mounting:</b>			
<b>Mounting Hole Diameter:</b>	10 1/4"	13 1/4"	13 1/4"
<b>Mounting Bolt Centers:</b>	4 holes, equally spaced, on 11 3/4" centers	4 holes, equally spaced, on 14 1/4" centers	4 holes, equally spaced, on 14 1/4" centers
<b>Loudspeaker Depth:</b>	5 5/8"	7"	7 3/4"

The Altec 414A, 416A, and 515B low frequency speakers may be used to greatest advantage in wide range, two-way systems with the addition of the following Altec components:

**HF Drivers & Horns:** 802D & 806A (with 511A/B or 811B Sectoral Horns)  
288C & 290D (with Altec multicellular horn having proper cutoff frequency and distribution pattern)

**Accessories:**  
Altec Loudspeaker Enclosures: For 414A: 612B, 614B, 618B, 622B, 855A, 858A, 859A.  
For 416A & 515B: 612B, 614B, 825A, 855A, 856A, 857A, 858A, 859A, 210, 410.

**Dividing Networks:** N-800D (800 cycle crossover)  
N-500C (500 cycle crossover)  
N-500D (500 cycle crossover; for use with Altec 802D & 806A HF Drivers)  
\*414A = EIA rating of 52db at 30 ft. from 1 milliwatt  
416A = EIA rating of 52db at 30 ft. from 1 milliwatt  
515B = EIA rating of 56db at 30 ft. from 1 milliwatt

## ARCHITECTS AND ENGINEERS SPECIFICATIONS

### 414A

The low-frequency speaker shall be 12" in diameter and shall have a minimum pressure sensitivity of 99 db (spl at 4 ft. from 1 watt) measured on axis. The voice coil shall be approximately 3" in diameter and shall be of edge-wound copper ribbon operating in a magnetic field of at least 10,000 gauss derived from an Alnico V magnet weighing 1.8 pounds minimum. Speakers with smaller voice coils or round wire windings are not acceptable under this specification. The free-air resonance of the speaker shall not be greater than 30 cycles and it shall have a continuous power rating of at least 25 watts. Frequency response of the speaker shall range from 30 to 4,000 cycles. Any low-frequency speaker not meeting all of these requirements shall be deemed unacceptable under this specification. The speaker shall be Altec Lansing Model 414A.

### 416A

The low-frequency speaker shall be 15" in diameter and shall have a minimum pressure sensitivity of 99 db (spl at 4 ft. from 1 watt) measured on axis. The voice coil shall be approximately 3" in diameter and shall be of edge-wound copper ribbon operating in a magnetic field of at least 12,000 gauss derived from an Alnico V magnet weighing 2.4 pounds minimum. Speakers with smaller voice coils or round wire windings are not acceptable under this specification. The free-air resonance of the speaker shall not be greater than 25 cycles. The speaker shall have a continuous power rating of at least 30 watts and shall have a frequency response from 20 to 1,600 cycles. Any low frequency speaker not meeting all of these requirements shall be deemed unacceptable under this specification. The speaker shall be Altec Lansing Model 416A.

### 515B

The low-frequency speaker shall be 15" in diameter and shall have a minimum pressure sensitivity of 103 db (spl at 4 ft. from 1 watt) measured on axis. The voice coil shall be at least 3" in diameter, of edge-wound copper ribbon, operating in a magnetic field of at least 14,750 gauss derived from an Alnico V magnet weighing 4.4 pounds minimum. Speakers with smaller voice coils or round wire windings are not acceptable under this specification. The free-air resonance of the speaker shall not exceed 25 cycles. The speaker shall have a continuous power rating of at least 35 watts and a peak power rating of at least 50 watts. Frequency response shall be uniform from 20 to 1000 cycles. Any low-frequency speaker not meeting all of these requirements shall be deemed unacceptable under this specification. The speaker shall be Altec Lansing Model 515B.



## WHO STOLE THE DEEP BASS?

Nobody. The stock A7 cabinet cannot efficiently produce deep bass due to the relatively high box resonance created by its low port area to internal volume ratio. If you increase the ratio (hopefully by decreasing the port area - not enlarging the box!) the rise in electrical impedance will degrade the bass smoothness, efficiency, and transient response that the A7 is famous for. The solution to this dilemma is to find a subwoofer that can be blended seamlessly with the A7 "sound". We couldn't find any.

We became interested in adapting the Karlson Enclosure to this task after Bill Fisher related an anecdote about the ability of this mid-50s design to produce significant low frequency output from a relatively small volume. The story went something like this: A mysterious source of energy was shaking things off the wall in the juke box repair shop. It was eventually traced to infrasonic turntable rumble being reproduced by the shop's Karlson test speaker!

The Karlson is a folded pipe configuration that drives its bass output through a tapered, exponential slot with both front cone radiation and a chamber driven reflex port. A pair of K-15s were soon acquired for experimentation. While John applied his professional level of carpentry skills to the modifying and refinishing tasks, I busied myself with tuning, impedance and response testing, and bandpass filter design.

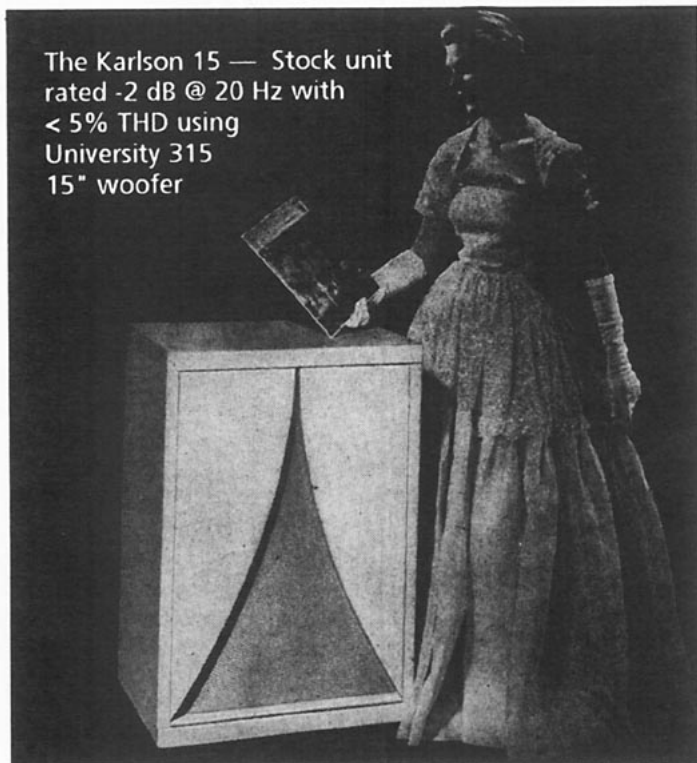


Photo from 1956 advertisement

Specific modifications applied to the Karlson Enclosure for 15" drivers included:

- Altec 416 or 515 woofer with 25 Hz resonant cone installed
- Stock reflex port replaced with two 3", 90 (degree) PVC elbows.
- Enclosure tuned to 30 Hz
- Active bandpass filter implemented; centered at 30 Hz with -3 dB points at 19 and 45 Hz; 12 dB/oct skirts. (Requires 12 to 15 dB of boost above line level at 30 Hz for good subjective blending with A7s)
- Carpet piercing spikes attached to cabinet

The Karlson adaptation adds seamless balance to A7 based systems when reproducing music and movie soundtracks containing deep bass. The Karlson, like the A7, is easy to drive — a Mac 40 works well.

## FINAL MIX

The performance that results from carefully optimizing the small Altec VOT speaker for Hi-Fi can be truly stunning. The remedies that we have suggested here can be applied to the thousands produced since 1947, including the current production A7-8G system. If you don't think a speaker can have explosive dynamics, wall-to-wall imaging, a seamless midrange that just won't quit, incredibly low distortion, a sweet, airy, top end, and do all this *without a hint of strain*, you haven't driven a good horn system lately!

Footnotes:

- <sup>1</sup> Ted Uzzle, "Polarity and Phase", Application Note AN-9, Altec Lansing Corp., 1986.

## RESOURCES

Factory reconing service is available for most Altec woofers. Your local reconing service might be competent to replace cones but Altec has equipment to remagnetize drivers, a procedure often required after 15 or 20 years of service to restore full performance. Contact Altec Service Dept. for more information.

Altec Lansing Corporation  
P.O. Box 26105  
Oklahoma City, OK 73126-0105  
405-324-5311

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## About the Authors

Jeff Markwart and John Tucker work for Aerospace firms supplying Space Shuttle and Space Station engineering services to NASA at the Johnson Space Center in Houston, Texas. Their terrestrial pursuits include design, construction, and modification of sound equipment for use in musical sound reinforcement and hi-fidelity audio.



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# The Core Issues:

## To POT... or NOT?

### The myth of potted transformers

by Mike LaFevre, MagneQuest

*"The Core Issues" will examine the function, construction, design and operation of magnetics for audio applications. This series will combine practical advice in the form of useful "rules of thumb" with enough pure theory to give us some concept of how these magnificent devices work. This column is not an academic engineering tutorial, but rather a guide to becoming an informed consumer.*

This installment of the Core Issues will explore the benefits and disadvantages of "potting." Given a choice, 99 out of 100 audiophiles will, any day of the week, pick a potted transformer over one that is not potted. What lies at the heart of this strong preference among audiophiles? Is it simply a case of judging a book by its cover?

Am I just being hopeful or is it true that end users are sophisticated enough to realize that you can't make a silk purse from a sow's ear and that there will be some "pretenders." Plainly speaking, transformers that are poor performers create a strong illusion of being a quality transformer when potted in beautiful cans.

In this article I plan on digging beneath surface appearances. I will challenge the notion that potted transformers are inherently better than nonpotted transformers. In fact, I plan to boldly argue for the opposite, which is to say that I will present a host of arguments in favor of not potting transformers for sound performance reasons in the majority of consumer applications.

#### MARKETING

"Hi-fi packaging." Have we come full circle? I can remember in the mid-1970s reading in the underground rags (they were then much truer to the spirit and real concerns of the

burgeoning audiophile community) that the entrenched giants, and especially the Japanese mega-corporations, were "ripping off" the audiophile.

The argument was that there was a lot of sizzle and very little steak in product offerings. Most of the money spent in manufacturing the product went into faceplate, the idiot lights, and the overall physical packaging. The strategy: Make it physically sexy and alluring and they will buy. The underground argued that manufacturers should be more concerned with what's in the box and what comes out of the box rather than the size and overall appearance of the box. Good common sense. But have we come full circle?

As many readers are aware, contemporary hi-fi packaging makes the antics of the 1970s players look rather modest and restrained. In today's "high end" market, a disproportionate share of resources is dedicated to "packaging" of many contemporary products. I lost count some time ago of the number of "high-end" manufacturers who told me openly or in confidence that they spend more money on the box that they put their transformers on (or even the can they put the iron in!) than they do on the transformers themselves.

We get stainless steel cans, lacquered cans large enough to hide a small Hyundai in, and cavernous deep-drawn tombs which have been designed to house large volumes of air and/or potting compound in addition to the transformer. All for the sake of impressing you, the consumer.

#### ECONOMICS

Since I brought up the issue of cost, let's explore this a little further. Although it may seem counterintuitive to most readers,

sometimes transformers are potted because it is actually cheaper overall, than the other options available to the designer or manufacturer.

On some cost-constrained products, it is cheaper to use a less expensive grade of laminations, a smaller core section, and/or less ambitious copper package, knowing full well that, for instance, your heat rise will be excessive and your regulation poor but that you can bail it out by potting the unit.

There are many different types of potting compounds and formulations available. Some formulations are specifically designed to dissipate heat. The trick here is that, when potted, the "too small" transformer has a much larger cooling surface area. The effective cooling area can be greatly expanded by putting the unit into a larger can and selecting a compound that is effective in pulling the heat way from the core — the best analogy is that of a heat sink. This "Band-Aid" approach has utility in situations where space is at a premium, such as in aerospace work, but definitely doesn't belong in audio.

There are other applications for which potting saves labor and expense. If your end user demands a high degree of "fit and finish", sometimes it is less expensive to forego the steps necessary for it to look good in bell end caps and simply put the unit in a can. Unfortunately, some units are potted because the last thing the manufacturer wants you to see is the quality of workmanship and/or the materials that went into your unit. If housed in bell-end caps, it is much easier to directly view and evaluate the quality of care and evidence of workmanship expended on the unit. It's much harder to hide your work when the transformer is displayed in bell-end caps.

#### GOOD REASONS TO POT

I trust that it is obvious that not every company that has ever potted a transformer did it for pure marketing reasons and/or for marketing impact. Let's take a look at some engineering derived arguments in favor of potting transformers.

There are some lamination shapes and sizes for which there exist no commercially available bell-end caps and/or L-shaped brackets with which the transformer can be both held immobile while simultaneously providing a means with which it can be attached to a chassis. C-core laminations, for

instance, do not have any bolt holes drilled through the laminations. You simply cannot put a traditional bell-end or L-bracket on this type of lamination. While other mounting hardware has been developed that would allow a C-core based product to be mounted without potting it, it is generally preferred to either pot it in a can or bury it in a chassis where the end user cannot go exploring with his/her fingertips, since many of these coils carry lethal voltages.

Safety is almost always a good reason for doing something. But practical reasons prevail in cases where no other good alternatives exist. Such was the case for the famous Acrosound transformers. Their outputs were built on a punched lamination with appropriate mounting holes. But their unusual size and shape meant no one offered bell ends for that lamination type. The most practical choice was to pot the transformer.

Another valid reason for potting is challenging environmental conditions. This particularly applies to mil-spec transformers. A transformer built for Uncle Sam's militia must withstand many perils, including salt spray, fungus growth, extreme temperature cycling, vibration, shock, drop tests, etc. (For a more complete treatment of the special requirements imposed on transformers going into the military, please review *The Core Issues in Sound Practices #1*).

Unless you plan to expose your precious transys to environmental evils, you are unlikely to require the protection offered through Mil-spec packaging—or at least not for these reasons.

Uncle Sam was a big enough buyer that many companies competed for this business as either a prime contractor or a qualified subcontractor. Triad, for example, had a line of audio transformers called the HSM series which met the stringent requirements of Mil T-27 (which addresses almost exclusively packaging issues). Its "S" series employed the same coil and core as its HSM series counterparts minus the mil-spec packaging. Both the S-146A and the HSM-186 enjoy the same specs on paper. The S-146A costs less because it was in bell-end caps.

Another often cited advantage of potting transformers is that a potted trans seals out moisture and dampness. In the past, say 30 to 40 years ago, this may have been a strong

argument. At that time, many of the insulating materials for inside the transformer were organic materials like cotton and kraft paper; even the magnetic wire coatings were much more adversely affected by moisture and humidity since they too were largely based on organic chemicals.

Many of the premium materials used in transformers today are inherently non-hygroscopic. This is a fancy way of saying that they will not absorb moisture. Teflon, for instance, is pretty much impervious to moisture. You can dunk it in a bucket of water and for all intents and purposes, it does not absorb water. Most of the materials favored by today's constructors such as polypropylene, polyethylene, nomex, kapton, ultem, mylar, etc., are non-hygroscopic. Voltage breakdown due to arcing or tracking caused by the presence of moisture is rarely a problem in modern transformers.

In fact, many of the different types of transformers made today, including many of the toroids and bobbin-wound units, are not impregnated at all nor are they potted. Yet they still survive and function day in and day out.

#### NOISE

Another reason cited in favor of potting is that a potted transformer will be less noisy by eliminating mechanical vibrations which can originate within the core itself or in the lamination stack. The potting proponents are mostly right. If the proper potting materials and methods are used, it is possible to quiet down a noisy transformer. But here again this is treating the symptom and not the cause. True, it is important to minimize mechanical noise in a trans but I prefer to address this potential problem right from the beginning.

Mass-produced transformers are frequently wound on formers which are larger than the nominal core dimensions. This is done to make it possible to machine stack the core with an automatic laminator (which reduces production costs) and to minimize the possibility of the laminator jamming as the stacking nears completion. The little bit of "slop" built into the stack height is then filled by wedging the coil and the core with a maple or phenolic wedge shaped spacer. This is intended to tighten the interface between the coil and the core and keep this interface quiet and chatter-free.

If you carefully construct your coils and do a good job in laminating the stack, you can build a trans that is eerily quiet without the aid of potting. This requires that the coil be wound with proper tension on the magnet wire, that even winding lengths be maintained, and that the coil be laminated with care and patience to completely fill the stack. Proper hand winding almost always results in a higher "K" factor than machine stacked coils. Squaring of the laminations also decreases the incidence of stack-induced hum. Choosing a high-grade lamination with low losses also decreases the magnitude of stack noise. Even the insulating material's physical properties will, if suitably chosen, aid in preventing noise that is generated within the coil by the passage of current through the conductor. There is not a lot of magic here—just old fashioned trial and error, attention to detail, and the desire to do it right.

#### PERFORMANCE CONSIDERATIONS

So far, I've demonstrated that potting is not necessary in most applications given intelligent design choices and careful building techniques. Now the astute reader might ask, "What harm is done by potting?" This question brings us to the crux of the debate. For if potting a transformer has no drawbacks and doesn't impose any penalties on the performance of the transformer, then why not pot?

There are costs associated with potting. First and most obvious is that in most designs the potting will add to the sale price of the unit. But as dedicated audiophiles, who cares?! So, let's not even count this as a potential disadvantage of potting. We are all after pure performance, right?

And it is purely in the performance realm that I wish to challenge the notion that a potted transformer is somehow inherently better than a non-potted unit. In fact, the reverse is true—potting *always* imposes some penalties on the performance of transformers. Most of my comments directly apply to audio output transformers or other types that must pass wide bandwidth audio signals. However, many of the same arguments also apply to power supply transformers.

First and foremost, every time you pot a transformer in a can, you increase its capacitance. I am fond of pointing out to customers that potted transformers have all the essential ingredients of a capacitor.

Look at it this way: a capacitor is a simple device which has at least two conductors (or plates), a dielectric (insulation), and an AC voltage potential (or differential) between the two plates. So, let's look at our potted trans. The coil, or parts of it, have an AC voltage potential above ground (the signal voltages from your output stage), while the case or pot is at AC ground potential.

In the void between the pot and the coil is a potting compound which is nothing more than an electrical insulator. Like all insulators, it has the ability to store an electrostatic charge. This charge (capacitance) is like all other capacitances; it tends to exhibit (to a greater or lesser extent, depending on the insulator) markedly nonlinear behavior. Its dielectric constant, which is a measure of how much potential capacity it can store, changes with both temperature and frequency. The dissipation factor, a measure of a capacitor's ability to dissipate a stored charge, of an insulator also is nonlinear with temperature and frequency changes.

Of course much research has been done on the effects of capacitors, and I need not rehearse the litany of gremlins associated with the electrical functioning of capacitors. We all know the woes of capacitors—when we use them we try to select the best—but when there is no real need for them, wouldn't pure performance considerations dictate that we not use them?

To make matters even worse, coils are made up of a multitude of winding layers, each having on either end a voltage different than that above it or below it, so that when you pot the coil there may be several dozen points at which there is a discrete voltage potential between the coil and the potting assembly. You can actually measure the increase in capacitance of the transformer before potting and after potting. Also note the increase in the exciting current, the decrease in permeability (in many cases) and the decrease in the resonant frequency of the transformer. It's not a pretty picture.

The resonant frequency of a transformer is that spot where the inductive reactance equals the capacitive reactance. Adding capacity to a coil will always result in this junction occurring at lower and lower frequencies in proportion to the additional capacitance added. The first or lowest resonant frequency of an output transformer is a measure of its useful frequency extension.

Above the resonant frequency many transformers will show a sharp falloff in frequency response and will exhibit markedly more ragged phase response. All things being equal, you want that resonant frequency to be as high as is consistent with good overall design practices. This is especially important in push-pull transformers which utilize global feedback. Potted transformers always pay a price in the diminution of extended high frequency response and the "quality" of their response range.

Surprise, surprise. On the bottom end of the frequency range, potted tranny's often also pay an additional sonic penalty. An important performance consideration in the design of transformers is to keep the exciting current as low as is practical. While I'll be covering exciting currents in more depth in a later installment, suffice it to say that the exciting current component can be thought of as the energy necessary to set up a magnetic field in the iron core of the transformer.

The grade of lamination, its thickness, and the quality with which it is stacked all have an impact on the amount of exciting current consumed by the transformer. For now, think of increased exciting current as being "wasteful". The ability of a transformer to deliver clean, undistorted power into low frequencies is inversely proportional to its exciting current.

In addition to the lamination material used, how the laminations are handled and housed affects the magnitude of exciting current and, hence, its bottom end performance. Many methods and materials used in potting transformers can have an adverse effect on this parameter. If potting compound "creeps" in between the laminations you will get reduced stacking factor (K factor), the measure of how void-free the stack is. If it is not 100% filled by laminations, then the stack will work harder because of increased magnetic reluctance (i.e., the magnetic correlate of resistance).

If you do anything to the laminations that reduces their permeability, you also increase the exciting current of the unit—for example, if you hammer or otherwise exert a lot of force to "square" the lams. Many of the materials used to pot transformers have such great compressive strength when they cure (and shrink in the process) that they exert great pressure on the coil and laminations, thereby distorting the coil and

decreasing the permeability of the iron. This is especially true with nickel-based lams. The worst offenders are modern epoxies and polyurethanes. Incidentally, these materials also have high dielectric constants and very poor dissipation factors—other good reasons to avoid them.

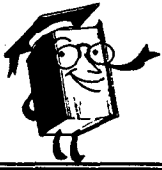
Impregnating a coil with an insulator like wax or varnish also increases exciting current. I learned of this phenomenon while studying drawings in the Peerless archives. They tested the magnitude of exciting current before impregnation, after impregnation, and after potting. The exciting current always increased after each step. The before and after figures typically varied by 20 to 25%! Magnetic materials are so sensitive that even the type of hardware used to keep the laminations together will have a measurable impact on exciting current. Non-magnetic materials are best, obviously.

The moral of the story is the less you handle the cores, the better. Less processing, better and more careful workmanship in construction, and less dependence on after the fact "cures" results in better overall performance of the transformer.

Let me issue a few quick disclaimers before the arrows start to fly. The editor has promised me a safe haven. [*ed.- No way! You're on your own, dude.*] Low-level input transformers made with very high permeability nickels usually require potting for satisfactory performance. Here the "cans" are usually multiple units, one tucked into the other, made from mu-metal and interspersed with copper shields. This is necessary to shield the very sensitive nickel from stray magnetic fields. Even the smallest magnetic field can have detrimental effects in some low-level applications. Such small fields would have zero effect on silicon based laminations whose initial permeability is high. A steel pot or steel bell-end cap will provide about 10 dB of magnetic shielding if you are nervous about this. Aluminum, however, is useless for shielding.

There may be other specific applications in which potting is necessary or beneficial. What I have tried to demonstrate in this article is that there are always costs imposed on performance in ALL potted transformers. In the case of high-level audio output transformers, the costs far outweigh any of the alleged benefits of potting.

Till next time. . . happy listening!



# from the archives

## ELECTRONIC PHONO FACTS

by Maximilian Weil

*An audio pioneer, founder of Audax company, provides a timeless statement on what Hi-fi is all about. Reprinted from an Audax brochure of the mid 1950s.*

OF THE HUNDREDS of letters received by the writer from day to day, it is astonishing to find that a large percentage is from readers who are in no way connected with the field of electronics. In some way, they have gained a working knowledge of audio equipment and are more critical in selection of apparatus.

Of the many questions in the field of sound reproduction that such letters contain, the most frequent ones are answered here.

It was back in 1935 that "high fidelity" became the talk of the industry. At that time, the Radio Mfrs. Assn. issued a definition of high fidelity as — "equipment capable of reproducing frequencies to 7,500 cps or over." This was most unfortunate, as it made *wide range* and *high fidelity* synonymous. Since then, audio equipment has been built to kilocycles and more kilocycles.

On the one hand, the purchaser buys a high-fidelity audio system in the belief that the performance will be, as claimed, one of *fidelity*. That, to the purchaser, means *listening quality*. To the technician, on the other hand, it means wide frequency range in most cases.

According to the above definition, the technician is not misrepresenting, if the audio system is capable of reproducing a wide frequency range. At the same time, however, the purchaser is in the firm belief that he is buying *listening quality* performance. Accordingly, the deal is a sort of legal fraud, with both parties innocent of it.

Let us cite a few actual cases:

Mr. Smith, who had just bought a high-fidelity audio system on sales talk such as "crisp," "sharp as a razor," "you can hear the resin on the bow," etc., is much disappointed and disillusioned.

Says Mr. Smith, "It sounds very unpleasant. I decided to check up and went to a concert. At the actual concert, the music I heard was not 'crisp,' not 'sharp as a razor,' I didn't hear the resin on the bow and, what's more, I didn't want to." Smith then puts the treble-control to work, cutting off a lot of kilocycles for which he paid that extra money.

Take the case of Mr. Newman, who just paid over \$650.00 for a high-fidelity system. He is disappointed and complains. The seller answers, "This is 'high-fidelity,' you have to become used to it..." Mr. Newman says, "That's nonsense, no one has to get used to it when at an actual concert and that is the real thing, Mr. High Fidelity himself."

The term high fidelity, as used in connection with audio apparatus, has always seemed to me unfortunate. Why *high fidelity*? Sounds very much like the man who keeps emphasizing that he is *highly* honest — as though there were different degrees of honesty.

Here is a quick test: Compare two pick-ups A and B of different makes but whose wide-frequency characteristics are substantially the same. One will be found to perform with *fidelity*, with pleasing musical quality while the other will be harsh, strident, shrill. Yet, both have the same range. *Mere extension of frequency range does not, by itself, result in listening quality.*

The interchangeable use of *high fidelity* and *wide frequency range* is probably rooted too deeply by now. However, for the good of the audio industry, *high fidelity* should be redefined in order to stop continued misunderstanding.

*(From the archives of David Sarzer)*

## AUDIO NOTE UK OUTPUT TRANSFORMERS

15 W for EL84/ECL86/6V6 PP	9K-4/8 ohm	\$70
25 W for 2A3/300B PP	5K-4/8 ohm	\$110
25 W for EL34/KT66/6L6 PP	6K-4/8 ohm	\$100
50 W for KT88/6550A PP	6K-4/8 ohm	\$130
50 W for EL34/KT66/6L6 PPP	3K-4/8 ohm	\$130
50 W for 845 PP	6.8K-4/8 ohm	\$215
60 W for 6550/KT88/EL34 PP-UL !!!	4.3K 4/8/16 ohm	\$120
15 W for EL84/6V6 PSE 110ma	2.6K-4/8 ohm	\$125
25 W for 6L6/KT66 PSE 140ma	2.1K-4/8 ohm	\$150
25 W for 2A3/300B SE 90ma	2.5K-4/8 ohm	\$165
25 W for 2A3 PSE 130ma	1.25K-4/8 ohm	\$145
25 W for EL34/6550A PSE 180ma	1.5K-4/8	\$135
25 W for 211/845 SE 150ma	10K-4/8 ohm	\$210
50 W for 211/845 SE 150ma	10K-4/8 ohm	\$225
50 W for 2A3/300B PSE 180ma	1.25K-4/8 ohm	\$235
50 W for 845PSE 180ma	2.5K-4/8 ohm	\$265
75 W for 211/845PSE 240ma	5K-4/8 ohm	\$290

PP = Push-Pull, PPP = Parallel Push-Pull, SE = Single Ended, PSE = Parallel Single Ended. UL = 43% Ultralinear taps for Dyna Mark III, etc.

All primary impedances are calculated for Class A operation with the main consideration given to maximum dynamic power transfer and minimum distortion, rather than unrealistic steady-state conditions. All single-ended transformers are air gapped. All units have a frequency response well beyond the audible range, typically 20 Hz-40 kHz -1.5dB. All are E.I. cored with high grade silicon steel laminations and either end-

bells with flying leads or frames with solder tags.

Call, write or fax for a free Audio Note Component Parts Price List! We offer many unique and exotic items, including silver foil and paper in oil signal capacitors, ceramic/gold tube sockets, Black Gate electrolytics, MORE!

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# Readers' Forum

## MY WAY

Yo, Rap-Master Joe,

Just received SP 3 and I dig it the most. But, I do have a problem with what has become a more or less recurring theme in SP. To whit, the question of what hi-fi is all about. The basic theme at SP seems to be that hi-fi is about getting the sound that you like. And indeed, on the face of it, this seems an easy perspective to support. But let's look a little deeper. Let's do a little vertical thinking, and see what we dig up. In your reply to Frank O'Connell-san you say, "Hi-fi is always a LIE." Gee, lighten up Joe.

Well 'tis true I suppose, the original event will never occur in your listening room. There's a small matter of space and time, if you get my drift. Could be the performers are all dead, you know. But to me, the point is how close can you get to an accurate recreation of the event? Now, anyone who's seen a real sunrise can tell the difference between its blinding radiance, and the image of one that's been captured on film, and projected onto a screen. The distinction is that with the sunrise we have a daily reference. With music/audio it's a lot tougher; very few of us are lucky enough to get a daily dose of live music, though we'd all be healthier if we did. The SP rap seems to say, "If you don't know/like the original sound, then make it sound the way YOU like."

Let's drop the audio thing for a second. We're getting too damned sweaty about all this. Let's say we're talking about color slide photography: would you want a projector that showed your slides, be they good or bad, accurately? Or, would you prefer a projector that subtly deepened the blues and softened reds, resulting in dramatic blue skies and warm skin tones? You'd oooh and aaah at the pretty colors for a while, but in time you'd be looking for the truth.

The "My Way" approach to audio harms me not at all. Still, it's not high fidelity, it's "my fidelity". Yeah, I know. Someone else said it first; I just can't remember who it was. Anyway, me, I need fidelity. I want to know what recordings really sound like, and just how bad (or sometimes good) my slides look. If the world were filled with systems that always made their owners feel warm

and fuzzy, the recording process would never improve. We would all just bask in the warmth of a false audio sun, having no idea of the brightness of the real one.

But, like I said, it doesn't bother me. I'm just looking for you to be up front about it. Drop the hi-fi moniker and embrace you most favored colorations and distortions. Why not get yourself some tone controls, an equalizer (maybe one with lots of pretty lights?), some old DBX compressor/expander, a good ol' SAE pop and tick remover, and maybe a bass synthesizer. If you're bent on the damnation of fidelity, why not damn it good?

Man, I'll defend you. Just like I'll defend your right to wear plaid, vote for Republicans, bungee jump, watch hockey, eat pork rinds, buy polyester blend jeans, listen to show tunes, drink Diet Coke, and microwave a good steak. I'll be there for you. Just be straight with us.

The current audiophile correct attitude can, at times, be even less defensible: at January's WCES I heard some of the most blatantly distorted and colored sound that I've ever been victim to. Most of it erred on the side of brightness, it's true. But a lot of it was quite simply too pleasant. Rolled and rounded. Saxophones with no edge, trumpets without bite, or aggression. I mean, I played the trumpet for years; at a distance under 40' it can actually hurt. At the same time, I reject gear that adds its own detail. For example, virtually every Audio Research preamp that I've ever heard.

So where does all this leave you and me? Not far from where we've started, I'll wager. Still, I do maintain that everyone who's into hi-fi for the right reasons ought to be getting their RDA of real music, I don't care whether it's Arrested Development or Brahms. Just go hear it. Otherwise, it is all too easy to forget the sound, feel, and impact of the music that you love. The pursuit of high fidelity may indeed be a futile one, but it's still worth an honest effort.

Paul A. Cervantes  
The Audio Observatory

Paul, my man:

I hear ya'. You know what you want. You listened hard, you were honest with yourself about what you heard, and you defined what you're looking for. Now you're trying to get it. That's what it's all about.

Let's get a bit philosophical for a minute. By definition, there is only one kind of *perfect* fidelity. If it is *exact* reproduction, it's exact reproduction and that's that. But if perfect fidelity is impossible (or unattainable presently), then it seems to me that different

sounding systems can reach the same "level" of imperfect fidelity, even if they are imperfect in different ways.

So, if you can't get a perfect "10", I argue that it's okay to choose the "8" or "9" that you like. Let's say there can be a "slightly bright and edgy 8" and a "slightly warm 8". Of course, this line of reasoning gets away from the goal of perfect fidelity. But how do we choose among the flawed systems we all have to live with until "10" comes along?

Because a musical performance is a highly complex, multi-dimensional experience, fidelity has many dimensions. Every system does some things better than others and certain aspects of music are more important for a given listener than others. The thing I am trying to recapture is "emotional fidelity", as I'll call it for lack of a better term. Give me a system that will make me boogie, space out, ponder, or what ever the music wants me to do. I like an illusion of "person-to-person" communication, a sound that lets me relate on musician-to-audience terms. Few systems do it for me and I sometimes find it hard to find a common thread in "objective" sonic terms among those that do. However, when it happens, *I like the sound*.

Anyway, I consider it to be significant that as soon as somebody mentions "sound you like," card-carrying Audiophiles revert to the trusty 'warm and fuzzy' argument. Why can't there be a "sound you like" that is true to the original? Can't a listener actually have good taste and like a sound that approaches fidelity? Or are audiophiles *required* to suffer while listening to fancy reference quality systems that they don't really like much?

The big question is "Whose fidelity do you want anyway?" It's an issue of "reasoned choice" vs. being a high-end zombie. The quest for fidelity is mostly about understanding, exploring, and fulfilling our individual tastes, perceptions, and aesthetic values. Through our attempts to reach perfect fidelity, we can learn to know ourselves better and find expression for our personal values. The hi-fi quest is about the journey as much as the destination.

I'm right next to you looking for a "10". If you find it, let me know—call collect. In the meantime, I'll just fire up my trusty SE amps and live with an "8" or "9" that I like.

## RING DEM BELLS

I read Herb Reichert's "review" of the Audio Note caps and transformers in SP #3 with interest. "Wrought by a single hand", eh? I am more than pleased that Herb has noticed that, I think that when you hear more of what we do you will find that to be very true.

One comment that Herb made was closely the same as what we have found, that AC signals are electromagnetic "shockwaves". I think that there is more to that than most audio engineers realize. To give you an example, when I started looking at capacitors in 1979, we devised the following test:

Connect a capacitor over the output terminals of a stable power amplifier, then connect a frequency generator to the input, and set the volume level at about 1/4 to 1/2 volume. Then run a frequency sweep from 0-20/khz into the amplifier. All the plastic capacitors that I've tried sounded like small (very small) loudspeakers, the paper caps were almost silent. We employed sensitive listening devices like medical stethoscopes for these tests. The frequency at which a capacitor resonates under these conditions closely matches the colouration it introduces into the sound of the amplifier when used in the signal path.

This is not a finite, conclusive test by any means, but a good and quick way of disqualifying most contenders. On the subject of feedback, the electromechanical "shock-wave" theory may also have some mileage; when I have time over the next few months I shall run some tests and formulate some thoughts on this subject.

Peter Qvortrup  
Audio Note UK

#### KLIPSCH

Dear SP:

I just received the most recent issues of your magazine. I think they are wonderful and contain very interesting articles, ones we all have been looking for these days.

One thing I don't understand, however, are the negative references and reviews of Klipsch products, such as in Greg Boynton's "What About Horns?" in SP #1.

#### Department of Corrections

Changes to Issue #3

##### 6BX7 TRIODE AMPLIFIER (p. 11)

The 6.3 filament is shown grounded in two places in the schematic diagram. Choose ONE grounding arrangement.

##### READER'S FORUM:

Reply to O'Connell-san (p. 34)

The Silver Night is a *push-pull* amplifier (called *super-linear* by the designer) and not a parallel single ended amplifier as reported. This mental slip provides strong evidence for O'Connell-san's argument that Roberts-san has single ended triodes on the brain.

Mr. Paul W. Klipsch has been involved in the audio-industry for a very long time and has witnessed the evolution of sound reproduction from its beginning.

The Klipschorn has been in uninterrupted production since the 1940s and it is still recognized worldwide for its design and sound qualities. It is also the most copied loudspeaker in the world.

While the audio community kept pushing for change, and witnessed the introduction of the transistor, the direct radiator speaker, electrostatic and planar speakers, and so on, Mr. Klipsch continued to promote the horn-loudspeaker, making sure that horns were not forgotten.

So before selling it all to the Japanese, as happened with Marantz, McIntosh, etc., you should better appreciate your American heritage. We in Europe do.

I get very good results with the Klipsch La Belle, a 1975 model, which I use in combination with the L'Audiophile 300B Legend mono-blocks.

These French triode-tube kits are from the Maison de L'Audiophile, in Paris, and were designed by the famous Jean Hiraga. They use an original Western Electric 300B triode and the Partridge TK4519 output transformer, filter choke and power transformer.

As a pre-amplifier I use the McIntosh C 28, because it also has an independent center-channel output, for 3-speaker stereo. For your information, Mr. Klipsch has mentioned and favoured a 3-speaker-array in his "audio papers."

This can be done with 3 electrical true independent channels, as introduced by Bell Telephone Labs in 1934, or as a 2-track, 3 channel by means of a phantom circuit, where the center channel speaker is an acoustic mix of the left and right channels.

Enclosed is a Reference Listing from a German audio magazine, where you will find the Klipschorn ranked in the top category.

Henk B. De Ruiter,  
Giekerk, Holland

Dear Mr. De Ruiter:

Of all the correspondence we receive, some of the more passionate mail has to do with Klipsch. Many serious and experienced listeners swear by Klipsch speakers, particularly the Klipschorn.

Well, a group of us recently listened to a pair of Klipsch La Scalas powered by some small triode amps as part of a high efficiency speaker survey for SP #5. We thought

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they were really good. And, yes, we were  
somewhat surprised. Pleasantly surprised.

I came up with several untested theories on  
why the big Klipsches aren't favored by  
typical American tweak audiophiles.

- They never heard them (at least not with  
an appropriate low power tube amp)
- They are hopeless snobs and Klipsch  
speakers aren't fashionable in certain  
elitist audiophile circles.
- Klipsch are viewed as "old" designs and, in  
our culture, there is a tendency to break  
with the past and subscribe wholeheartedly  
to the illusion of "progress."

Of course, there are probably some who  
gave Klipsch speakers a serious evaluation  
and simply didn't like them as much as  
something else. To each his own. But, as  
you suggest, if more high-end types gave  
Klipsch speakers an honest chance surely  
many would find that they like them quite a  
bit.

Contrary to the stereotype you mention  
above, there are *many* in the US who value  
our classic products. Greg Boynton is certainly  
one—he studied every paper Klipsch  
ever wrote. He has the greatest respect for

Klipsch's work but he wants to time-align  
drivers 1993 style. He values solid contemporary  
practice as well as the classics. A  
good healthy attitude, I think.

Of course, the number of "historians" is  
small compared with the total US audio  
buying public—not to mention the total  
population. How many Europeans really  
care about classic audio gear, regardless of  
where it came from? There are individuals  
everywhere who recognize quality and it's  
certainly true here in the States.

As for the Japanese, I congratulate them for  
recognizing quality and getting a good deal  
on the purchase. There's still plenty left for  
the rest of us who know what is good. Sure,  
prices are higher thanks to Japanese interest—  
but that's life in a free market world.  
Looking on the bright side, North American  
and European enthusiasts can occasionally  
unearth a real bargain. Recently, I found a  
few nice Western Electric speakers for \$5  
each. That would *never* happen in Tokyo!

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# W.A.F.

by Joyce

## A DAY AT THE HAMFEST

So you married an audiophile. Your friends and family try to comfort you and say, "Look at it this way, you could have married a gambler or an ax murderer instead." But you know better. What, you ask yourself, could possibly be worse? Let me tell you, I know. You see, I didn't just marry an audiophile, I married a ham radio fiend.

Like some kind of modern day werewolf, my man looks like a regular audiophile by day, but come dusk he disappears into the attic with his radio and his antenna and turns into a *ham*. He's gone for hours every night and I don't know what he does up there, because all I've ever been able to hear is a lot of static, some loud crackling and maybe a few snippets of conversation such as "You're 59 Virginia, WX is sunny, running a HQ-792, QSL." Oh boy.

Audio may rule the day, but the night, the night belongs to Ham Radio. Unless, that is, the next day is a Hamfest Sunday, in which case he'll get up at the crack of dawn to reach a swap meet where he can rub shoulders with others of his kind and check out ham radio gear. You can imagine my shock when he asked me to go with him the other day, because, he said, he was actually going to get rid of some stuff (hallelujah!) and he needed someone to help him watch his stand. How could I refuse?

We drove for hours down winding country roads before arriving at the entrance of the Hamfest (a.k.a. the home of the local Agricultural Fair) where we were met by at least 20 members of the local Civil Air Patrol, all of them hams. The cadet selling tickets glanced into the car and sold us one ticket, "No charge for the XYL," he said, and waved us on to the parking area.

That's ex-young-lady in ham-talk, and just one of the many mysteries of the hamfest. It took my husband 46 seconds to unpack the car and abandon me to the unknown perils of selling radio parts and gear with a simple, "I'll be back." I am left alone to sell

four boxes of tubes, two boxes of radio parts I don't know what they are, a few miscellaneous drivers, transformers and books, and a classic 1960s Collins S-Line receiver.

By now it's 6:30 in the morning and a lot of people are starting to pass by. I sell a few tubes and parts for a buck apiece. Then an old man comes by and carefully checks out the Collins receiver. He lovingly opens the top, inspects the workmanship inside and turns towards me, "What's your husband's name? I think I sold him this receiver. What's he selling it for?" "Two-seventy-five," I answer, and the old man shakes his head. "Nice radio," he says, "I know, because I owned it," and walks away.

Maybe I'm not so good at this hamfest selling. I observe the guy next to me, who is hawking obsolete satellite receivers. He loudly calls to passersby, "Everything is five dollars, that's right, five bucks takes anything!" When a potential customer asks, "That's so cheap, do they all really work?" my neighbor doesn't miss a beat, "It's a fifty-fifty chance, sir. Maybe half of them work, half don't. But at that price, you could buy ten! The odds are with you. How can you miss with a deal like that?"

Finally my husband returns, and I tell him about the old man who came to look at the receiver and thought it once was his. But my husband says he got the Collins receiver in trade from Keith, who got it from Mike, who got it from Steve, who maybe got it from the old man. While I'm still trying to memorize the distinguished ancestry of our Collins receiver, my husband disappears, as mysteriously as he appeared.

For another hour, more hamfest characters come by, some to look, some to buy, and some just to chat. Steve, an old radio buddy stops by and I ask him about the Collins. Yes, he was the one who bought the radio from the old man, who then sold it to Mike, who, by the way, didn't sell it to Keith, but traded it to Dennis who owed Mike for some gear, but since Mike himself owed Keith from another deal, he was the one who sold the receiver to my husband.

I sell a few more items and am still trying to mentally sort out the Collins history when a voice over the public address system interrupts my thoughts, "Ladies, we remind you that Bingo is about to begin, free of charge, in the bovine pavilion. That's right, ladies, free Bingo courtesy of the Lyons Club."

A few more people stop by to buy parts and the old man reappears. He runs a proprietary hand over the Collins chassis and says, "Your husband still running around? When he comes back, tell him I'll give him 125 for it." and walks away. Another man stops to look at some parts marked 25¢. "Will you take 10 cents for these?" he asks. All of a sudden, playing free Bingo in the cow pavilion sounds like an excellent pastime.

My neighbor is still calling, "Five bucks takes anything!" A man stops by, takes a look at all the ancient tubes and parts I have for sale and asks, "So who died?" I am startled and just stare at him. The man steps closer and asks more loudly, "Who died? Whose estate is this a part of?" Nobody, I explain, it's my husband, he's into these things. But from the suspicious look on his face when he left, I'm not sure he believed me.

Another old timer checks out my wares and is about to pass on when he does a double take and picks up a silver painted transformer looking thing. A huge smile transforms his face. "You know what this is?" he asks. I've no idea. "I was a railroad man myself," he proudly tells me, "worked up and down the line in '38. This here's a W.E. repeat coil, used to use 'em everywhere." "Would you like one?" I ask. "Nah," says the old timer, and walks away, the smile still on his face.

My husband finally comes back to relieve me and I get a chance to look around the hamfest. Half an hour later when I come back, I'm just in time to see the old Collins radio man leaving with his newly reappropriated S-Line receiver. I notice a certain spring in his step. No wonder, I realize later. His radio went through five different hands, in three different states, and he not only managed to get it back, he also made some money on the deal!

Next I discover that my man has spent all of our profits. The car is once again packed to the gills. The money I got for the mysterious parts I've spent all day selling has been converted into other, equally mysterious parts. The back seat is now taken over by another large receiver, twice the size of the old Collins S-Line.

Believe me, the man is a maniac. A friend once said, "He would rather see a 5692 in a perforated tube shield than Cindy Crawford in a string bikini." I'm afraid the truth is even worse; I suspect he would rather see the 5692 in a string bikini.