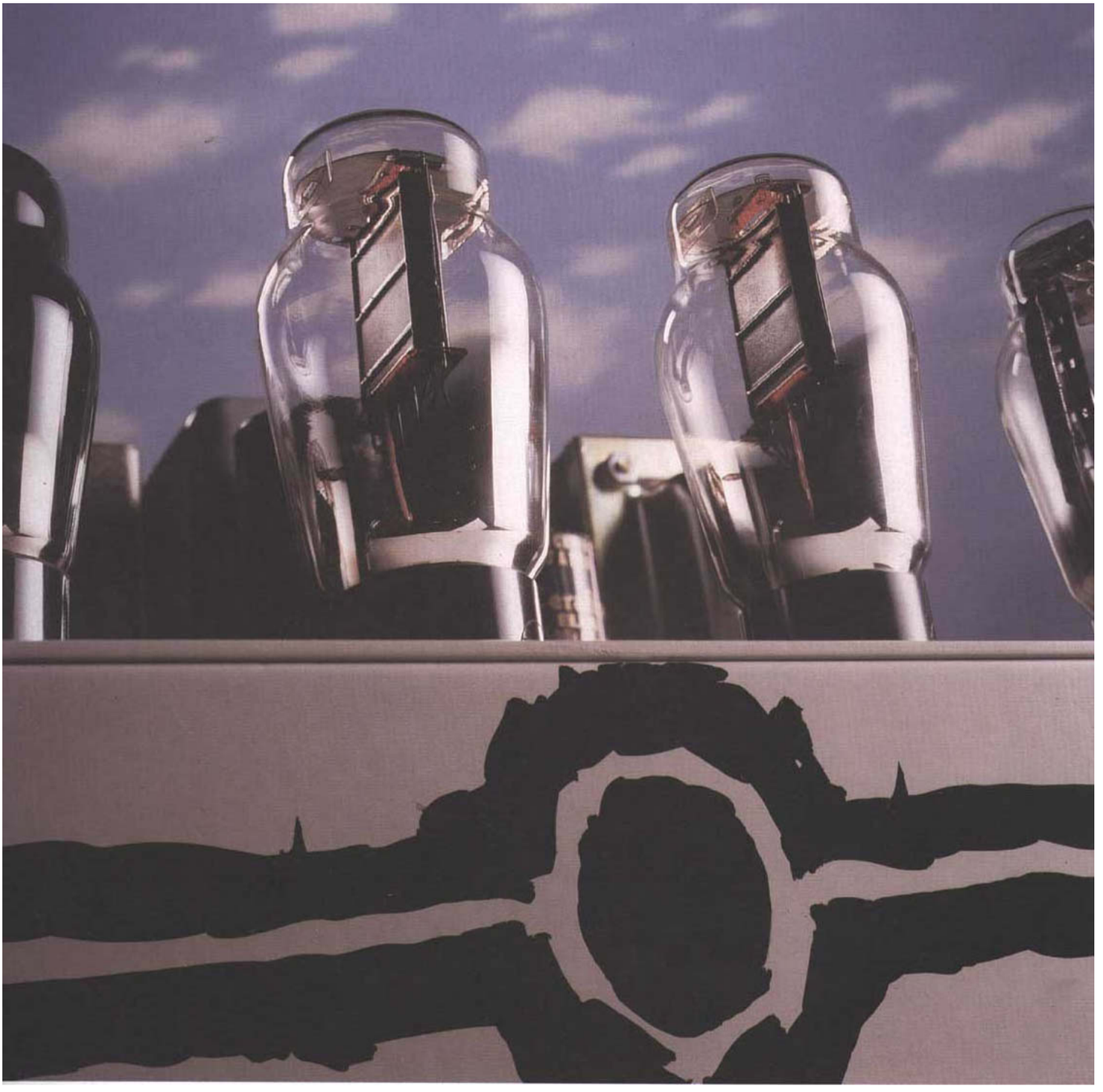
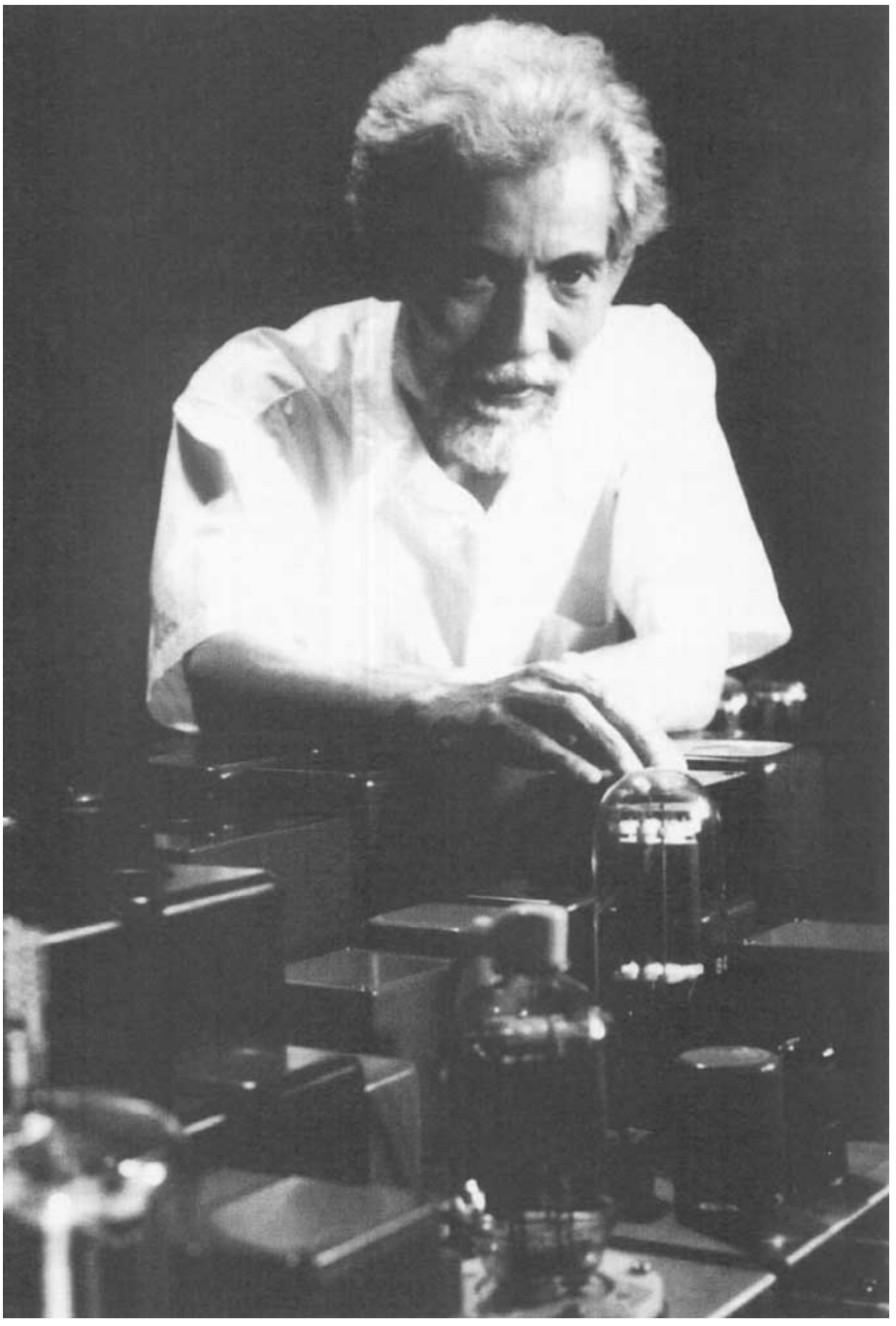
SOUND PRACTICES

THE AUDIO EXPERIMENTERS JOURNAL FIVE DOLLARS



Visionary Experimenter Dreams Issue 13

Direct Heating with the SAKUMA SYSTEM



by Susumu Sakuma

My old friends, VT25/801A push-pull preamplifier and PX4/PX4 SE power amplifier began singing "Manha de Carnaval" from *Black Orpheus* with a Lowther PM6 unit.

Under the misty spring sky, in my dimly-lit restaurant *Concorde*, I lean against the brick wall. A cooling breeze through the window brushes my eyes.

I see a scene over the breeze— that summer day when I made the amplifier, the 845/845 push-pull monaural power amplifier...

My two friends work in the lane outside the *Concorde's* entrance punching holes in an aluminum chassis. They have to finish the work before the noon hour, because it is very warm in the summer afternoon and the entrance must be clear for guests to have lunch.

A wood plank on two beer crates is my workbench for chassis construction. One guy drilled and another filed the holes smooth, wet with sweat. I bring cold Japanese tea to them.

A few humble tools and the workshop under the blue sky. Simple circuit design and old style devices, transformers and triodes. I have made my many amplifiers with these elements.

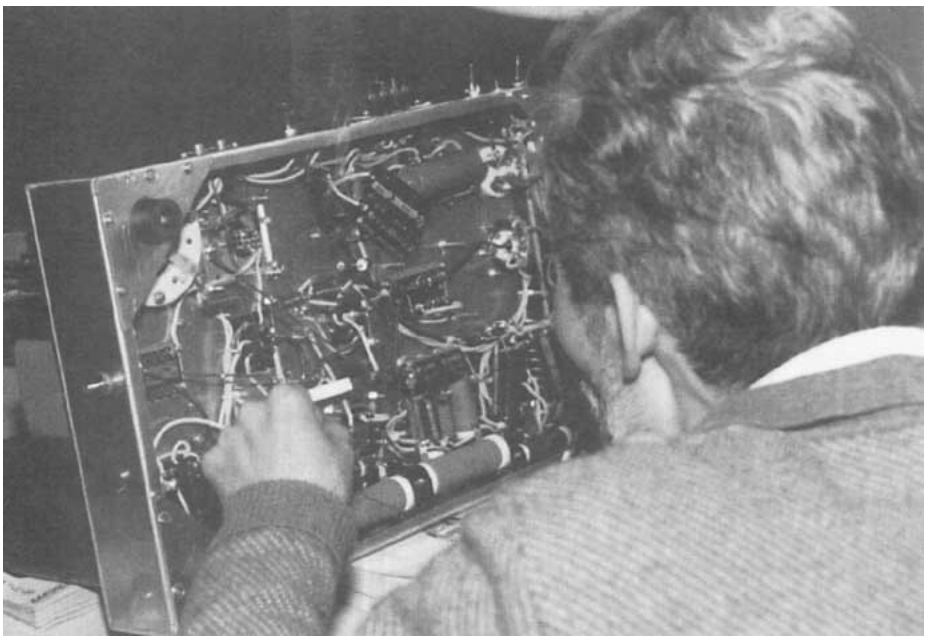
Can the engineers in the clean room with air conditioner and computers make amplifiers which can tell us the passion of the players and convey the strenuous efforts of the composers?

Design Concept

The schematics show you my concept in power amplifier design. I use the same tube for driver and output.

I made PX4/PX4 SE power amplifier, RCA50/RCA50 SE power amplifier. Their tones are clear and powerful. Through listening, I discovered that the driver's tone contributes the greater part of the amplifier's voice. An excellent power tube demands a similar level of quality from its driver. Few driver tubes can sing along in beautiful harmony with a good power tube.

I also made 300B push-pull/300B push-pull power amplifier. Before this, I didn't have the impression that the 300B tone was very elegant. But the special tone of the 300B push-pull driver/300B push-pull output power amplifier taught me the true *Western Electric* sound.



About "Unusual"

Certain "unusual" aspects in my schematics present mysterious contradictions and may raise doubts in some minds. You may say this is not a *volume control* but rather a *tone control* because it interacts with my *intentionally mismatched* input transformer.

But who has such doubts among those who have attended my audio concerts in Japan and Europe?

I understand that your doubts are grounded in accepted theory. I know this because I had to work through the barriers of convention myself. Now I assert that theory in electronics reference books took my favorite music from my life for a long time.

I think an amplifier builder should consult with himself and his amplifier before asking the reference books and authorities.

It is only after much cut-and-try that I find my best matching point for audio. The tube manual is like a telephone book. It gives perfect numbers. It is useful to make it possible to speak with a girl— but we cannot see her beautiful face from the mere telephone number.

To get the best sound from a tube, even if the proper match is 5K, we will try 7K. And we try these "mismatched" values with input transformers and other parts.

When you finally find the best operating point for the tube, you get the girl's address.

A few days ago, my friend, an experienced craftsman, painted the chassis in dark brown. I begged Kuniko, my wife, to cover the chassis with a soft cloth so the fresh paint won't be damaged.

I want to mount the parts soon but this big chassis, 65cm wide and 35cm deep, absorbs all the power from my body and heart.

For five days I have worked and listened to music, watching the chassis in repose on a round table. I keep the chassis like a wine. This is the most important technique of my craft.

There are two key matters in building amplifiers and audio systems.

One is to recognize the value of family and one's many friendships.

The other is inducing cooperation between human and machine.

After many hours of listening to music together, the chassis seems to recognize "who I am." It turns from mere sheet metal into the chassis for my amplifiers. I can then imagine the perfectly built amplifier. This moment is the end of my design, my planning, and yesterday's me. Now I must play my self ad lib.

It is easy to build from a reference book or from a magazine. But we cannot make the amplifier better that way. When I make an amplifier, I listen and listen to music so as to find 'what I need' in my imagination. Once I find that, the amplifier design and building are very easy. I take a screwdriver and mount all transformers and other parts in about one hour.

Parts

All transformers are made by Tamura of Japan.The custom-made STU-001 is expected to become a standard Tamura item. The other custom transformers were made to my order and are not likely to become catalog items.

This amorphous core interstage transformer (DC150mA) was a collaborative effort based on two years of listening tests. Tamura's good quality ITs enable me to use the same type of tube for driver and output.

Although Tamura ceased production of the 5k:20k 150 mA driver transformer because of high manufacturing cost, you can substitute a STU-5K (DC80mA), which is sold only by Sun Audio, the Tamura distributor in Japan.

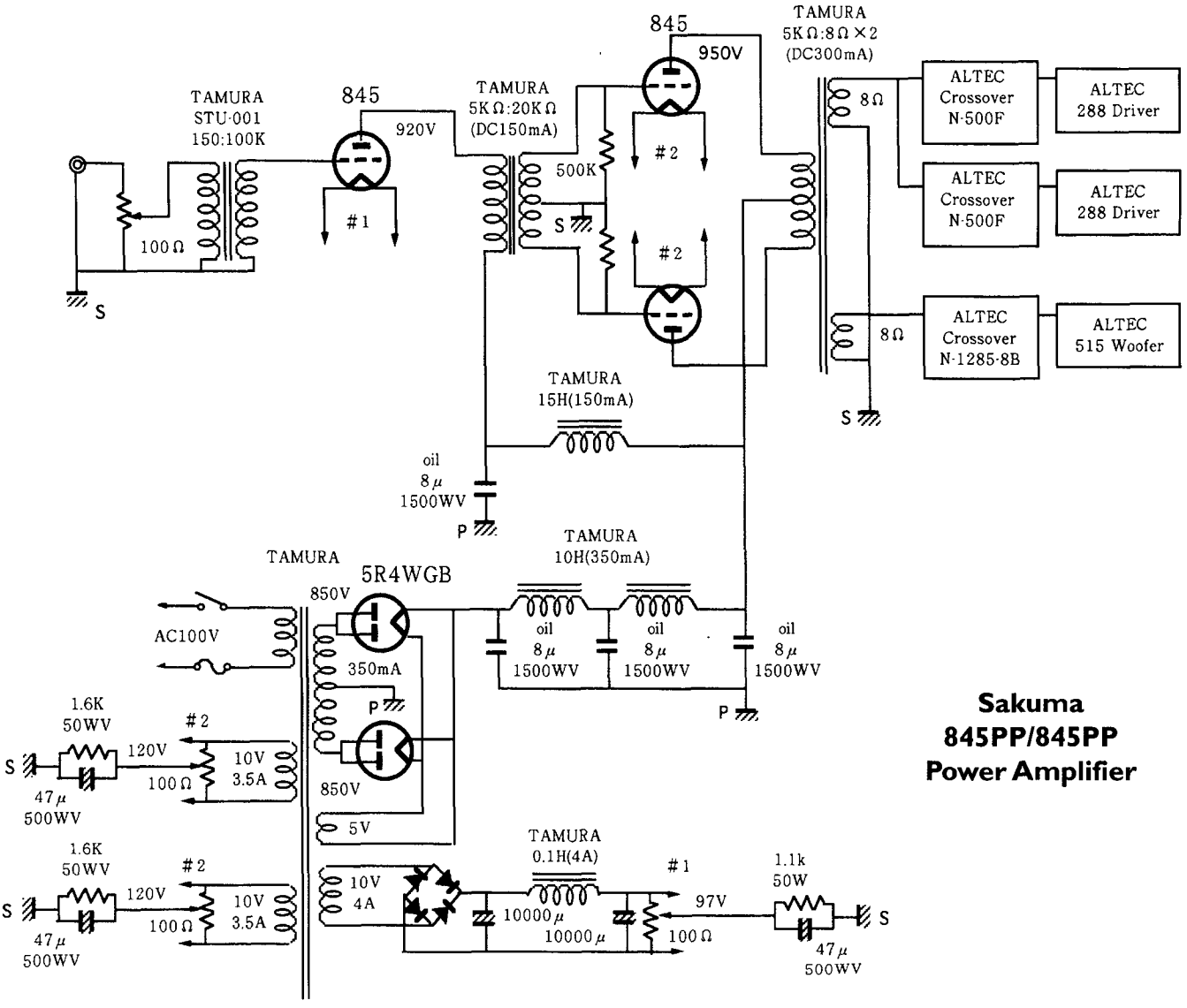
Let me explain about amorphous cores. There are three kinds of audio transformers: Si-Fe type, Ni-Fe (permalloy), and amorphous. Amorphous is composed of Fe-Ni or Fe-Co, but it is not an alloy. It has no regular crystals of metal. Physically, it is like glass and quite brittle but Tamura got around this with special manufacturing technology. The other challenge that Tamura had to overcome was that amorphous material saturates even more easily than permalloy or pure nickel, so here again special techinques were employed.

I find the amorphous core to be excellent throughout the frequency range, however, its extremely clear sound requires color and power elsewhere in the amplifier. Some builders who tried amorphous cores say the low frequencies are weak. My answer is simple— their grief comes not from the amorphous core but the poor quality of the parts used elsewhere in the amplifier.

The output transformer's core is also made of amorphous strip material. It has two secondary windings for separate outputs for drivers and woofer, to bring out the powerful and clear sound of the Altec speaker system.

Capacitors are Nikkemi or Nichicon make. Resistors are cheap metal oxide-type.

I always use wire meeting Japanese AC code for the speaker cable and general-purpose hookup wire inside the amplifier. I use Belden wire for power supply, filament, and signal line.



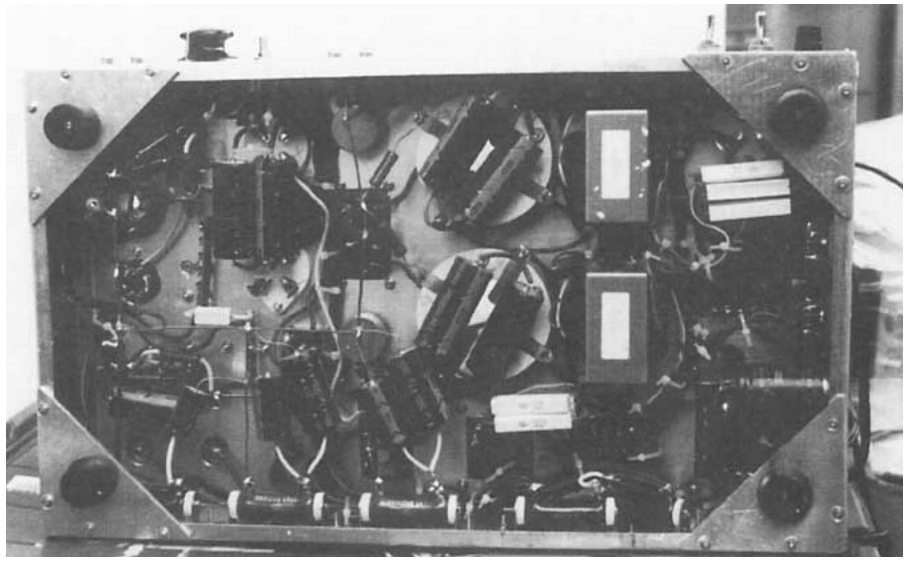
Sakuma
845PP/845PP
Power Amplifier

Wiring: The Two-Point Earth Method

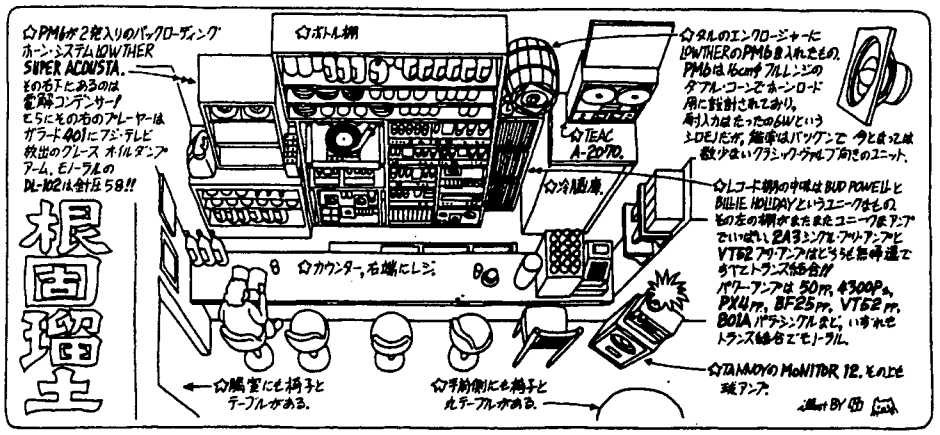
I use the two-Point Earth Method to reduce AC hum. With this method, I don't need DC heating of the final tube's filament.

Please observe the schematics again. The earth symbol with "S" refers to "earth of Signal." "P" is as "earth of Power supply."

I use heavy bare copper wire with a diameter of more than 3mm for the main earth buss. The signal earth buss is connected to the input terminal and the other end is connected to speaker output terminal. This line connects with the chassis at one point near the input terminal.



Underside of a Sakuma amplifier illustrating ground buss technique. Wiring of signal earth buss is visible to left of amplifier.



Bird's -eye view of one corner of the Restaurant Concorde sound system The Lowther PM-6 is mounted in a wooden beer barrel hung from chains

The power supply earth line connects with the chassis at one point near the power transformer.

All ground points are connected to the signal earth line. However, don't connect the end of earth line with the chassis before finishing all wiring and soldering. When the wiring is finished, touch the probes of the tester to the chassis and the earth line. If the tester shows no current, then you can connect earth line to chassis.

Unfortunately, if the tester indicates current, you must search and correct a short somewhere in the circuit.

Many amplifier builders bundle and tie the wires together. A lot of noise and AC hum results from this practice. Although the inside of my amplifiers are not beautiful like the rich catalog pictures of commercial products, my amplifiers don't need DC current for the output tubes!

The picture of the underside of one of my amps above shows you the wiring technique. Although this is not the 845 amplifier discussed in this article, it will serve to illustrate my method.

Throughout the time I am wiring it, the amplifier rests on the round table. This table is the best spot in the *Concorde* restaurant to enjoy both food and sound.

Customers sit at this table. They eat and drink with little notice of this monster amplifier laid before their noses.

I don't mind, because their frank criticisms have made my sound. It is easy to earn five stars on my food but it is very hard to get even one star for audio!

Sound report

My system is monaural. I use a Garrard 401 motor and Denon DL102 monaural cartridge mounted on an oil-damped tonearm for phono reproduction.The DL-102 cartridge is designed to output mono signal from a stereo LP, so it does not endanger modern LPs. It is used at AM broadcast stations for this purpose.

To obtain a mono signal from CD and DAT, I made up a converter using some transformers, capacitors, and resistors.

I chose my VT25/801A push-pull preamplifier to drive the new 845 amplifier. The 801A has a uniquely beautiful character in the high frequencies, which I think would combine well with the 845's rich and powerful midrange.

First I listened to Duke Jordan trio playing "A Night in Tunisia" and "Summer Time." I lost my words...

The sound appeared suddenly as if an apparition and the audio system vanished. This amplifier destroys a wall between me and the jazz players. In Art Blakey's solo drumming in "A Night in Tunisia" and in Jordan's piano in "Summer Time," I see their philosophy of life.

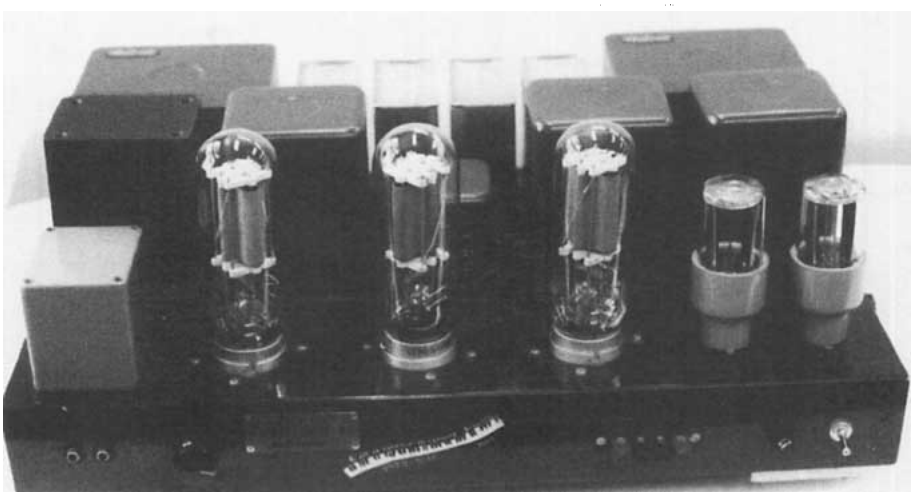
The amorphous core transformer has powerful and speedy bass. The 845 is very powerful. But the most important goal is not 'power,' but 'energy' and 'frame of tone.' The only way to get Energy and Frame is to mount many transformers, although I can't tell you a scientific reason for this.

845 driving amorphous core transformers can shade the sound of music. I see the human story in the bright and shadow of 845's tone.

To use an example from the painterly arts, Rembrandt's expression through light and shadow is marvellous. Most figures on his canvas reside in darkness. Lighted figures he draws only partially. Our eyes are initially drawn to the lighted part, but to recognize Rembrandt's theme, the darkest areas need to be searched. Darkness is silence; this darkness includes many subtleties to which we must listen. Darkness makes us search our imagination.

Amplifier builders seem to think that clear and "accurate" tone can express the essence of music. I need non-analytical tone in reproduced sound. I aspire to Rembrandt's interplay of light and shadow, to evoke memories both happy and sad.

My audio life is to make emotional shadows from sounds. Hints are found in the many transformers. I draw the contrasts



with transformers and tubes. I hope the amplifiers will be my portrait.

Ending

I come back to myself when the Lowther PM6 unit tells me the end of LP.

I go to the player and lift the arm.

As I return the LP to the shelf, I notice a book resting there. That small volume, "Opium" by Jean Cocteau, has greatly influenced me and my audio life.

I read again.

"When I record my poets, I dislike the notion of taking a picture of a voice. I notice there is a problem. If this problem can be solved, the recordings will turn from being the camera for our ears to become a new tool for our hearing. Then this new tool promises us new surprise future.

The machine's hard voice is not same as my voice and is the result of the co-operation with human and machine.

Don't admire machine. Don't regard machine as tool which we can control easily. And create with machine."

I close the book

It is evening by this time

Midnight

Heavy rain

It seems to destroy
my poor restaurant

I stare at the new 845 pre-amplifier which I am building

Solder is burning my fingers

The lines twist about

Something holds its breath
behind me

My ears are full
with the sound of beating rain

Blue eye of tube looks at me

I look at it back

All walls bear down on me

I lost my being

Nuance 845

by Adnan Arduman
Istanbul, Turkey

Deciding to go for it...

"What would you like to achieve in life?" was an out of the blue question that my wife asked me two years ago. How should a Turkish citizen, living in Istanbul, 43 years old (41 at that time), mechanical engineer, representing and distributing Carrier Air Conditioning equipment in Turkey for many years, an Audiophile tube and Music lover and the president (this year) of Istanbul Hi Fi Club reply to this question? Although not very uncommon, the question struck me as if I was hearing it for the first time—maybe I was hearing it for the first time!

"I want to design and build my own tube amplifier," was my reply, "but unfortunately I have to wait my retirement." She suggested that I should consider starting it at that very moment (she is a therapist!!). Her following arguments were convincing enough and the idea so attractive, I agreed.

First I contacted my electronic guru friend (who builds his own marble speakers) and asked him if he would volunteer to teach me just enough electronics to achieve my project. He gladly accepted, gave me several books and suggested I subscribe to both Glass Audio and Sound Practices [*...but not necessarily in that order —ed.*] and buy all past issues, which I did. After much reading, lessons from my friend, my realization of the analogy between tube curves/load lines and the pump curves/system curves I'm used to working with in my job, the inner workings of amplifiers eventually began to make sense to me.

Thanks to the great influence of SP magazine I've decided to build a single ended amp (the concept of SE or PP was totally new to me). For a beginner SE amps were easier to understand and to conceive, apparently had a magical mid-range, were unheard of here in Turkey, in other words it was a "Mystery Cafe". My intuition (which played a major role throughout the project) also said: SE.

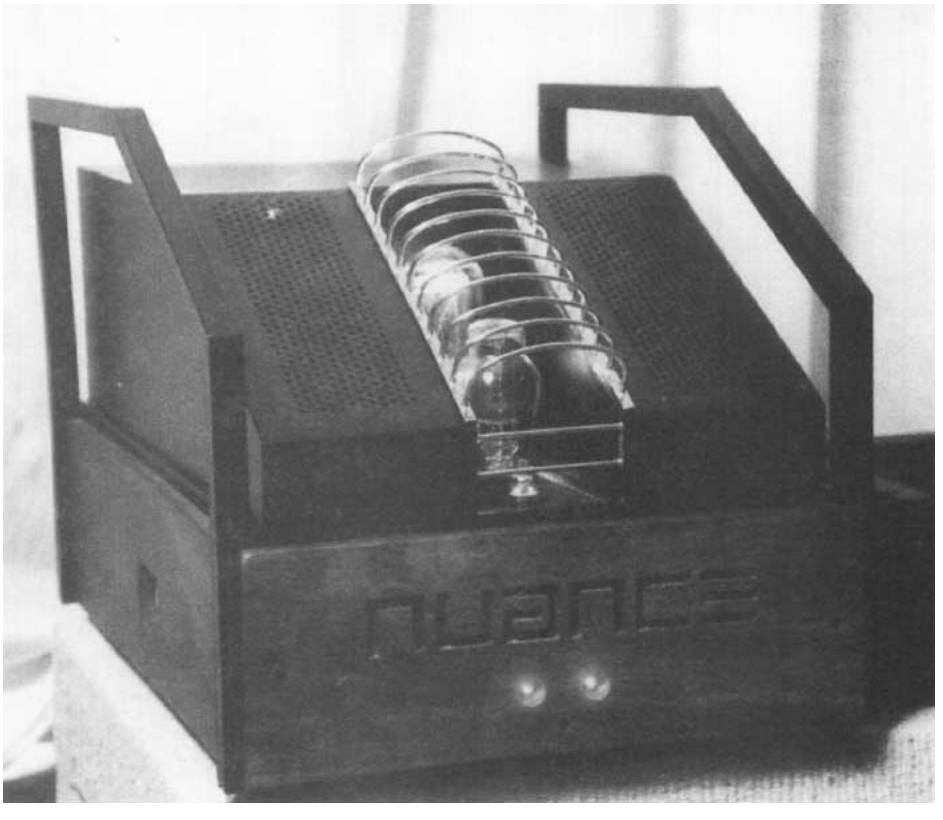
The whole point of the project was to improve on the sound of my existing push-pull ARC Classic 60 amp; here again my intuition said that only a "cost-no-object" SE amp would be able to achieve this goal. It had to be as purist as possible (no parallel tubes) and capable of driving a relatively wide range of speakers.

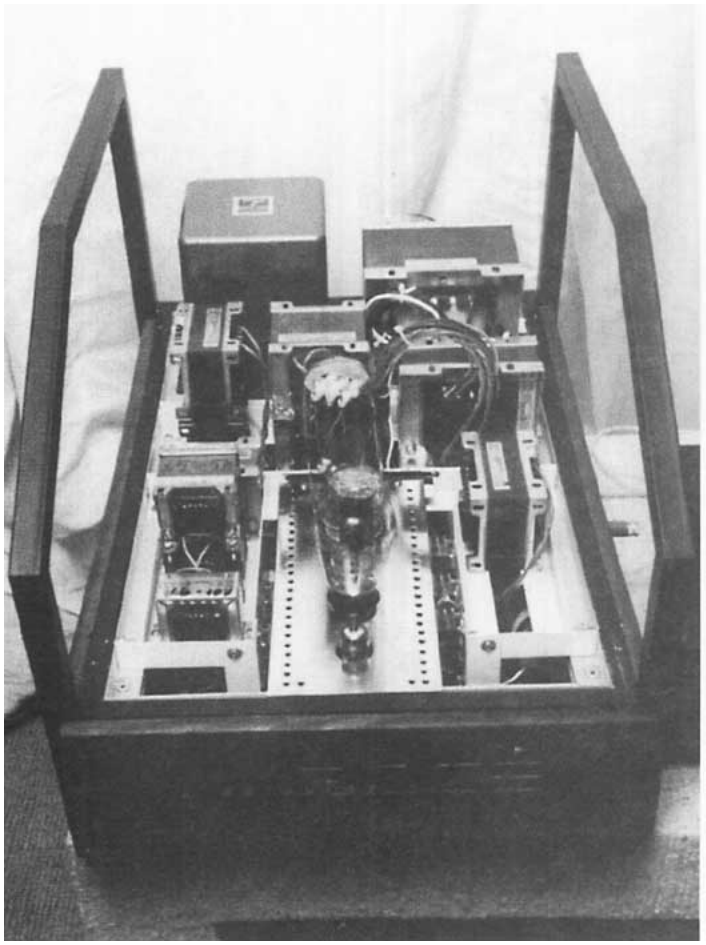
I chose to build a single 845 tube, driven by 300B with a SRPP configured 6072A at the front end. Separate power supply circuits for each tube and mono design would be adopted. Gordon Rankin's article ("A Single '807' Amplifier", issue #2) was a great help for starting my calculation and design.

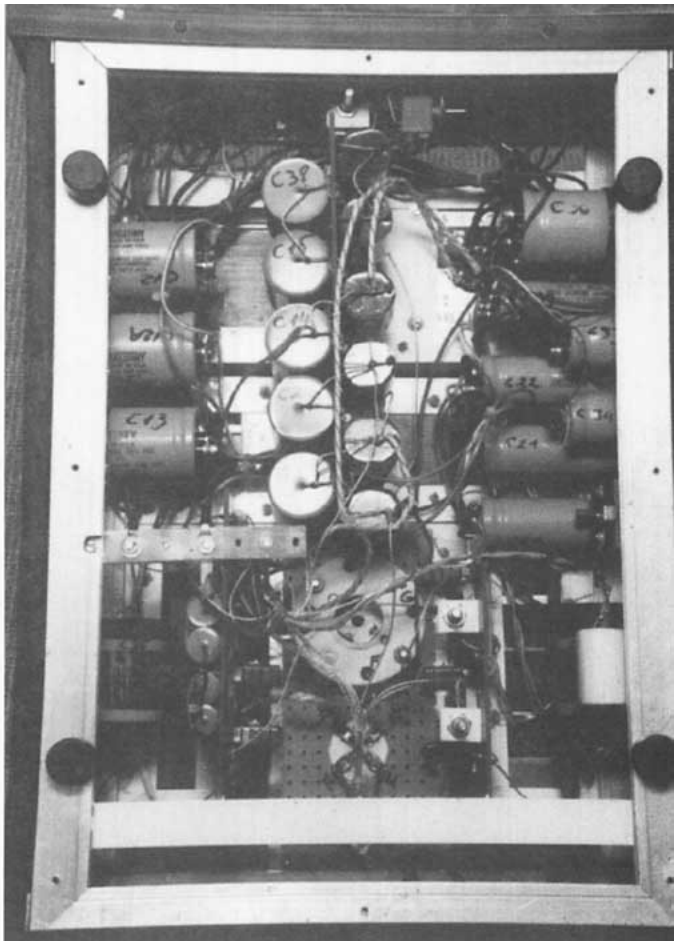
After finishing my preliminary calculations and circuit schematic, I contacted Allen Wright (author of *The Tube Preamp Cookbook*) for consultancy. He suggested that I use "choke input" filters instead of the originally drawn capacitor input ones. "As you aim a cost-no-object amp you should have the best filtration, and choke inputs will give you a much better result if you have space and money to spend. Thus, you may as well use solid state diodes as their switching noise will be filtered by the chokes. It is also the solution adopted by Cello," was his argument to defend the choke input.

He suggested to split the first choke to two and place one to positive and one to negative leg after the bridge in order to filter the whole of the mains trash. Verifying what he had mentioned with the *Radiotron Designers Handbook* and cross checking it with my guru friend, I applied his suggestion to the point and used three chokes per tube (in total 9 chokes per side!).

The same purist philosophy and intuition was in use when it came to selecting and







Top and bottom views showing constructional details of Adnan's Nuance 845 single amplifier

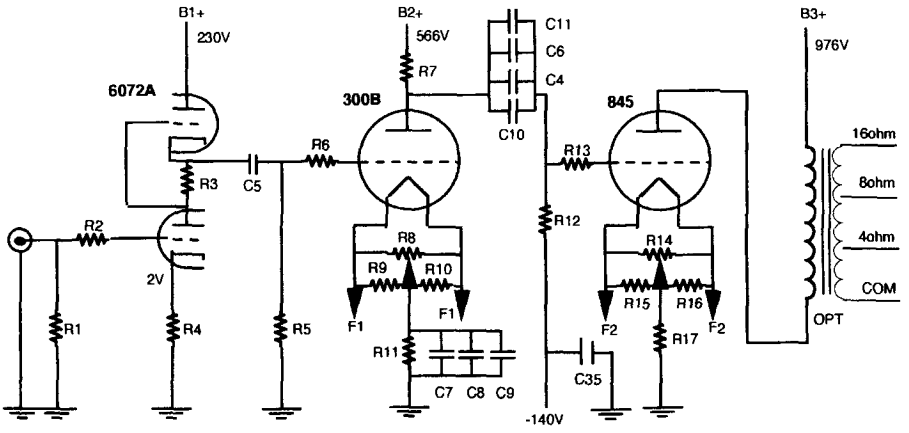
ordering the components: I used TANGO X-10S OPT (best of TANGO for 845 tubes), Gold Aero tubes, Caddock, Vishay, Holco resistors, Hovland Caps on the signal path and MIT bypassed SOLEN's elsewhere, Kimber AG cable on all signal paths, SOWTER mains transformers and inductors.

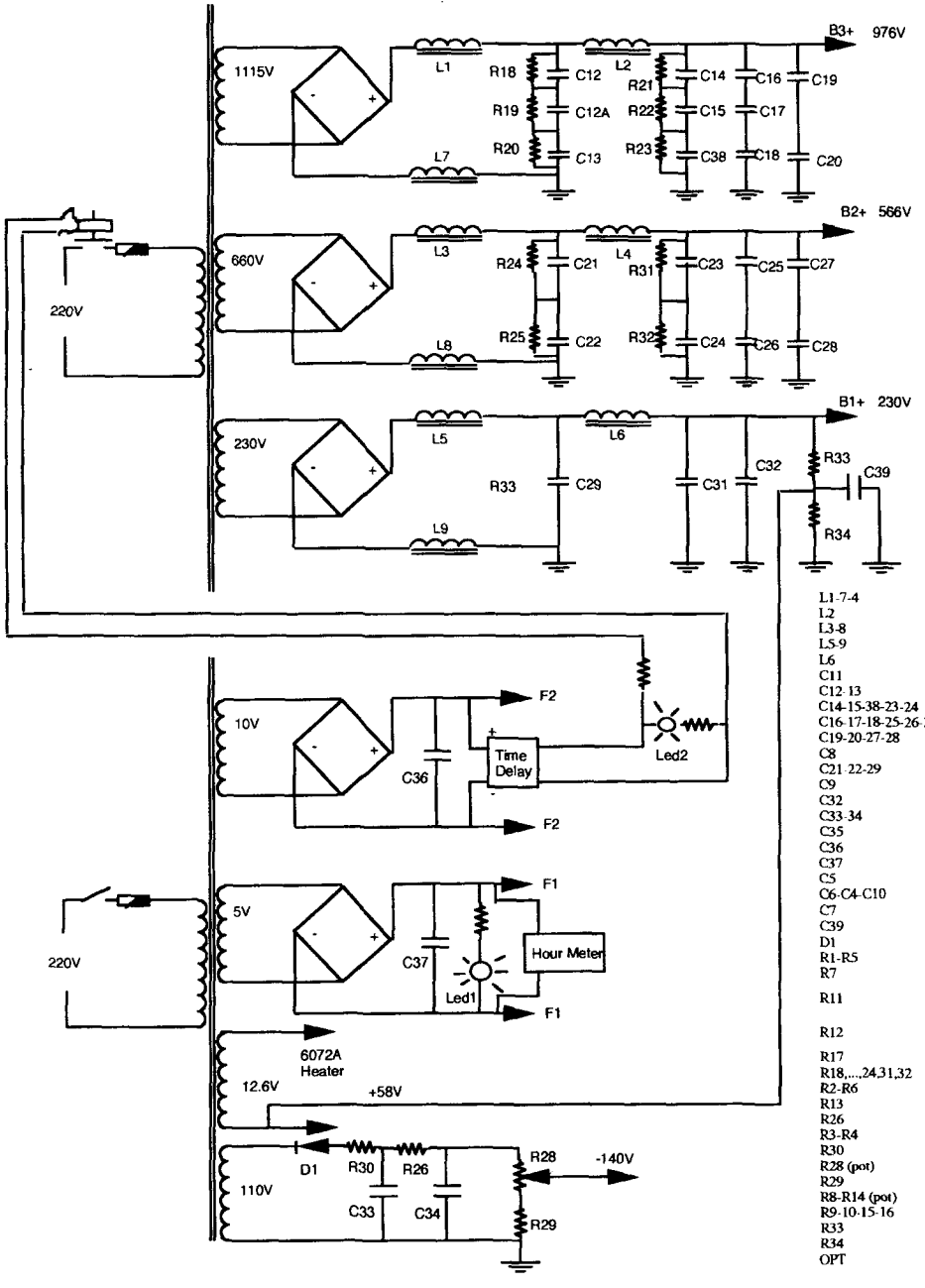
Since I had very good results picking up more detail and extension on the top end) when I tried bypassing the 250 uF electrolytic input capacitor of my Quad 63 speakers, I decided to bypass all capacitors As a unique touch, an LCD display hour meter is included. This would be useful to indicate the burn-in times and give me an exact statistical idea about tube life.

On paper everything looked fine but the most difficult part started when I received all these HUGE components. How on earth I was supposed to assemble them? It was going to be monstrous!

After a few days of acute depression followed by a heavy meditation period I decided to take everything to our company's workshop and get the help of our technicians for the chassis design and construction.

Nuance amplifiers looking good in their natural habitat, the Arduman listening room.





Nuance

845 SE Amplifier

by

Adnan Arduman

L1-7-4	6H / 200mA	Sowter
L2	12H / 200mA	Sowter
L3-8	3H / 200mA	Sowter
L5-9	5H / 40mA	Sowter
L6	10H / 40mA	Sowter
C11	0.01µF - 1600V	Hovland
C12-13	450µF - 450V	Mallory Type CGS
C14-15-38-23-24	47µF / 400 V	Solen
C16-17-18-25-26-31	6µF - 400V	MIT - PPMFX
C19-20-27-28	0.022µF - 600V	MIT - RTX
C8	5µF - 400V	MIT - PPMFX
C21-22-29	380µF - 350V	Mallory Type CGS
C9	0.01µF - 600V	MIT - RTX
C32	0.01µF - 600V	MIT - RTX
C33-34	200µF - 250V	Mallory Type CGS
C35	120µF / 400 V	Solen
C36	50000µF - 16V	Mallory Type CGS
C37	21000µF - 16V	Mallory Type CGS
C5	0.47µF - 600V	Hovland
C6-C4-C10	0.47µF - 600V	Hovland
C7	150µF - 400V	Solen
C39	20µF - 400V	Solen
D1	1A / 1000V	1N4007
R1-R5	274K - 1.0W	Vishay - VTA52
R7	3 x 1K0 - 20W	Caddock MP-820
R11	2 x 330R - 20W + 1 x 100R - 20W	Caddock MP-820
R12	1 x 10K0 - 3W + 1 x 4K7 - 3W	Caddock MS-223
R17	1R0 - 0.3W	Vishay - VTA55
R18,....24.31,32	300K / 3W	Matsushita
R2-R6	1K0 - 1.0W	Vishay - VTA52
R13	100R - 1.0W	Vishay - VTA52
R26	510R / 1W	Holco H2
R3-R4	1K21 - 1.0W	Vishay - VTA52
R30	220R - 1W	Holco H2
R28 (pot)	10K / 5W	RS 163-151
R29	20K0 / 7W	RS 156-030
R8-R14 (pot)	100R - 2W	RS 162-776
R9-10-15-16	56R - 7W	RS 156-181
R33	75K - 3W	RS
R34	25K - 3W	RS
OPT	10K - 40W	Tango X-10S

The chassis is constructed from aluminum profile. Magnetic elements on my amp were banned like smokers on a US domestic flight. For the finish only black painted brass and wood are used. Soldered joints were made using WBT Silver solder and ground lines are connected in star fashion. Signal inputs are made from the sides in order to shorten the signal cable runs inside the amplifier.

The two monoblocks are built in mirror symmetrical fashion to allow both signal inputs to face each other and the hour meters to look to the exterior.

It took me two years to finish and test everything. The test results came out wonderfully with a perfectly symmetrical sinus at the output which gives approx. 25W on 8 ohm fixed load before clipping.

I also had to find them a name. NUANCE came to my mind as a very appropriate one: NUANCE is what gives the emotion to Music and meaning to life. It was lucky and surprising for me to discover that no such brand name was used by anybody else. Its model designation would be Op.65, 65 being my wife Eda's birth year. She was the one who initiated, supported and encouraged me at every level of the project.

The subjective listening results are also very satisfactory: silky, full bodied midrange, trebles detailed and free of harshness or edginess, extended and fairly controlled bass (if not on par with best solid state and/or push-pull gear). Nothing seems tiring at any duration. Maybe as a result of this (or because of the increased pleasure) I noticed that I am now listening to Music for longer periods.

I can comfortably declare that I achieved my goal of bettering my ARC Classic 60 amp which sounds thin or lean in the mids like a solid state compared to NUANCE. Furthermore, the ARC seems to be less involving and less musical. Subjective tests were carried out using ProAc 2.5 speakers.

One of my "golden eared" friends declared that it was the most musical amp he had heard to date and another one (who builds kits) suggested I write about my project in *Sound Practices* as he thought it was a success story.

So here I am. It's a pity I can only transmit the story but not the sound but anybody who is willing to visit my wonderful country, Turkey, is most welcome to my home for an audition. For appointments kindly contact the undersigned.

Adnan Arduman
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Visit the Istanbul Hi-Fi Club Website! http://www.iHiFi.org

Casual Reactions

by Herb Reichert, Audio Note NYC

The Dream I Want

If your ears see,
And your eyes hear,
Not a doubt you'll cherish —
How naturally the rain drips
From the eves!
Bujutsu Sosho

Sound Practices is really a lifestyle publication, like *Low Rider* or *Chevy World* and the editor is really a lifestyle consultant. And you know what? That really is a picture of me in the drawing above my column. That's me in one of my dream lifestyles. I haven't started wearing a bow tie but right now I'm sitting here, smoking my pipe and listening to 1/4 track tapes on a Revox G-36. I want to be the calm poet listening to the voices in the wind.

I believe you are what you aspire to be and the only way to discover your aspirations is to travel a few untraveled roads. Me? I have chosen to find my future self by following the various paths that music and art lead me down. Lately, I have been exploring alternative source material like tape and 78s and I have a good feeling about where it is leading me.

Sound Practices appeared at the dawn of the alternative hardware revolution. Its program is to encourage new ways of thinking about audio engineering and new ways of listening. For me, this magazine is the magazine of suggestion. Here is an idea, take it and run. Then get back to us. Tell us what you have learned. Now I am beginning to think it is time to reconsider WHY we build audio components.

I believe that now is the time to take a holistic view of the audio design process. The tea ceremony of playing tapes and discs, the processes of developing more effective amp/speaker combinations, the creation of a beautiful audio installation, the laying down of wires! To build a shrine in your home. To install your speakers and light them effectively. You didn't know this? The lighting of audio components and the lighting of the listening room are every bit as important as the circuits you choose. Home building must be a complete conception!

If you are to pursue the Ultra-fi DIY aesthetics suggested in *SP*, don't do it to build boxes to save money, build a temple for music! Try to see the home construction of hi-fi in architectural and artistic terms. Create a secret place: a tree house or a monastery. Use your time, your skill, your personal resources, to create a magic world. Aim for intensity of experience. Don't just go in the basement to isolate yourself, use these ideas to connect yourself to the forces and laws of nature. Use these projects to broaden your intellectual and social horizons. Use these suggestions to unleash the artist and scientist within you.

The home builder is the only one that operate on this level. The big audio companies cannot compete with a man inspired to reinvent himself.

There are three processes that make the music hobby. First the creation of the playback system and the integration of this system into the home environment. Second, the selection and acquisition of the music software. Third, the tea ceremony of listening.

To be successful at building an amp or speakers, I maintain you must PICTURE, in your mind, how you will look and how you will feel playing discs. I mean how it will feel to put the disc on/in the player. I mean how you think you will look in the room lighting, standing in front of the player and between the speakers. I mean try to imagine how you will feel putting on the disc and sitting in the chair, dreaming and carrying on, in the new world you have created. This is your time machine, your sanctuary. This is your religion. You are the wizard, the movie director, the conductor, the mad scientist! When you create your own music system, you create your own new culture. I really like the feel of playing 78s. It takes me somewhere.

If I could be remembered for only one contribution to audio it would be this: How the system looks, how the electronics and speakers interface with your room and lifestyle, how they are placed and how they are lit, is THE most important thing you can consider when planning a home building project. Please don't just build a box full of tubes and stick it on the carpet of your living room.

Create a PLACE to go. Create a personal RITUAL. Integrate the process of soldering with the process of listening. Do not separate the process of building and planning from the process of living. Let the gluing and soldering lead you to notice the birds singing and the wind in the leaves. Create a hi-fi that reminds you to listen to the rain falling.

I can only speak for myself, but nearly thirty years of building audio has forced me to finally reflect on the why more than the how. For me, audio is about becoming a more peaceful, cultured and reflective man. It is simply a process. In my dreams, I see myself as a lone Zen scholar sitting in a little wooden boat, fishing and painting pictures. When I get tired, I take a nap!

My daily reality is somewhat different. I talk on the phone, I pack boxes, I do bookkeeping, I solder a little but I rarely get to sit, puff my pipe and listen to music. When I do, I really, really want it to feel special. I want to go somewhere and be someone new! The few hours I get to be alone and listen and dream must (for now) be a tangible and rewarding substitute for what I really wish I could be doing.

My personal explorations in audio are motivated by a strong desire to make my musical moments...transcendental. It is a path. The act of placing a 78 on a Thorens 125 and listening to Fritz Kreisler play Paganini, in tones that make me cry, is as close to the Zen poet's lifestyle as I can get...for today. This is why I pursue basement audio.

For each of us it will be different. I think my friend J.C. time travels, becoming the early 'dark lantern' alchemist one day and the future cyber-poet the next. For my friend Rio, it is sexual. He wants to lay his head on the breasts of Julie London before he falls asleep. For others the path is about connoisseurship, becoming a person of

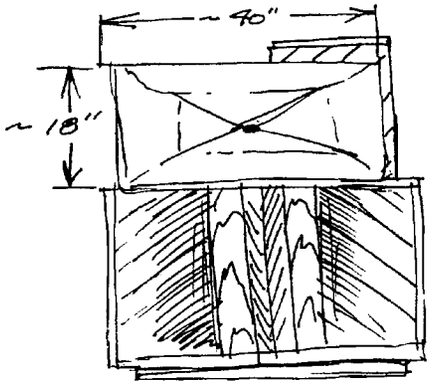
higher appreciation and deeper sentiment. Any reason or plan is good. A magazine like *Sound Practices* can open doors and give you a peek at what's outside the house you are living in, but you will have to choose which path you walk down first.

Uchida Makes a Transition

In issue #11 I took you to the den of Uchida. We had miso soup and 755As. I promoted April Audio.

Well, I am sorry to say Uchida is not here for the spring rain in New York City. He died just after the article was published. Uchida was the Cheshire smile behind the Triode movement in New York. He was a good teacher and an inspiration. He was a great friend to any kind and genteel music lover. He galvanized a circle of alternative audio people and he reminded us never to get too technical. I wish I were more like him.

From the Backwoods



Yet another way to play strings (and kick butt) with a few watts

by The Baroda Bard

Pressing toward musical ecstasy with a two-way and a woofer

I've been playing with horns in the world of pro audio since my employer, Electro-Voice, got into the business circa 1974, later to become a major player beyond all the grand originals (Western Electric, Altec, JBL, Stephens, et.al.). I've hooked up and voiced more two, three, and four-way horn systems (sometimes mixed in with direct radiators) than I can shake a stick at. In auditoriums, trade show demo rooms, hotel rooms, mono, stereo. . .

I've never had much trouble making them sound enough like music to want to bring one home to my stereo someday. Someday. Right now I'm listening to a system at home that I've been working on since November 1994. See the pictures and the system diagram below. We are having a blast and the emotional chills are abundant.

My buddy Will calls the system "nouveau retro hi-fi." It doesn't look anything like Lowther cones, Altec multicells, A7s or A5s, Tannoys, Klipschorns, EV Patricians, or WE goodies, or the modern Eurythmies and Edgarhorns. All of the above are relatively mainstream now. What I've been listening to with so much pleasure and excitement is the way of only me and Ray and Takane-san in Tokyo. Essentially discovered beyond my living room, perhaps never to be discovered, which is OK.

The system is multiamped, horn-loaded from 80 Hz on up, and is easily powered by a few watts– and not just for Haydn string quartets. To give an idea of the territory we're working in, we have closed out late-night parties with the 80 rank Sanfilippo Wurlitzer, 32 foot stops and all, at the same 108 dB broadband maximum long-term average level I measured in the hall.

Or how about Hank Williams, Jr. doin' "Ain't Nobody's Business" at 112 dB? And the system isn't even topped out yet. As for the string quartets, *they* top out at 79 dB maximum average level experienced in the sixth row.

I got into the SE 2A3 thing because I didn't want to pay the 300B price, but come on with 45s, 300Bs, or any old PP thang you found in Grandma's attic. I have a few 20 to 30 W push-pulls that I put to good use and they work fine, aside from being total overkill in the watts out department.

I like an occasional, very robust pipe organ with my cognac, so there's a high-efficiency (97 dB 1m/1W) vented direct-radiator covering 25 to 80 Hz. This is an EV DL15W 15" woofer in a 3.2 cubic foot box tuned to 28 Hz, a so-called B_6 alignment that requires an underdamped (Q=2) high-pass filter at 28 Hz to flatten the overall system frequency response. You can get the same response without EQ if you double the box size and maintain the same tuning frequency.

Basically, it is a Thiele-Small on the computer style design, which takes a lot of power relative to horns. I use an old pair of Mac MC40s on loan as low bass amps.

So, here's my current recipe for approaching musical ecstasy with horns in stereo, using only a few watts.

1— Keep it basic, cinema-style

Two-way configuration, 500 Hz crossover. Compression driver and horn above 500 Hz. Fully horn loaded cone driver under 500 Hz.

The big bass horns are a creation of my late very best friend Ray Newman, who died suddenly in February of 1996. Total surprise to me and I wasn't prepared to learn how much I depended on "talkin' to Ray" and slipping his latest LF horn design into the old system. This prototype pair of horns develops a whomping 106 dB 1W/1m and is solid from 80-500 Hz using EV DL10X 10 inchers.

See John Stronczer's article in Issue 11, *Voice of the Theatre Chez Nous*, for an excellent treatment of horns and woofers that sound like music. It was very much a pleasure to see some real speaker basics outlined. Bottle heads interested in getting into speakers should take heed!

2— Select a big, dead-stiff HF horn that loads the driver pretty much like an old-fashioned, straightforward exponential horn but with constant dispersion over its operating range of 500-20,000 Hz.

Horns with this characteristic are called "constant directivity"(CD) horns. These devices have a bad name in some audiophile quarters. John Stronczer, for one, rightfully warns against modern CD horns with abrupt flare rate changes and non-optimally sized mouths, including too small.

Indeed, constant directivity is not a natural thing for a speaker to do, even though horns can be designed to produce this characteristic. Often in the world of pro sound, driver loading performance is compromised to achieve the desired directional results, with associated detrimental sonic effects.

I believe that given the realities of typical listening room acoustics, controlling the angle of radiation with stability across the frequency range – say over angles of 90° x 40° or 120° x 60° –creates an "open" or "transparent" quality that is very revealing of a stereo recording's inherent character.

A side benefit is being able to step out of the magic listening position, say to finish dinner in the kitchen alcove, and still being able to hear most of what you hear in the magic spot.

Electro-Voice developed the first CD horns in the early 1970s, which otherwise behaved like the best classic exponentials before them. The EV HR9040 and

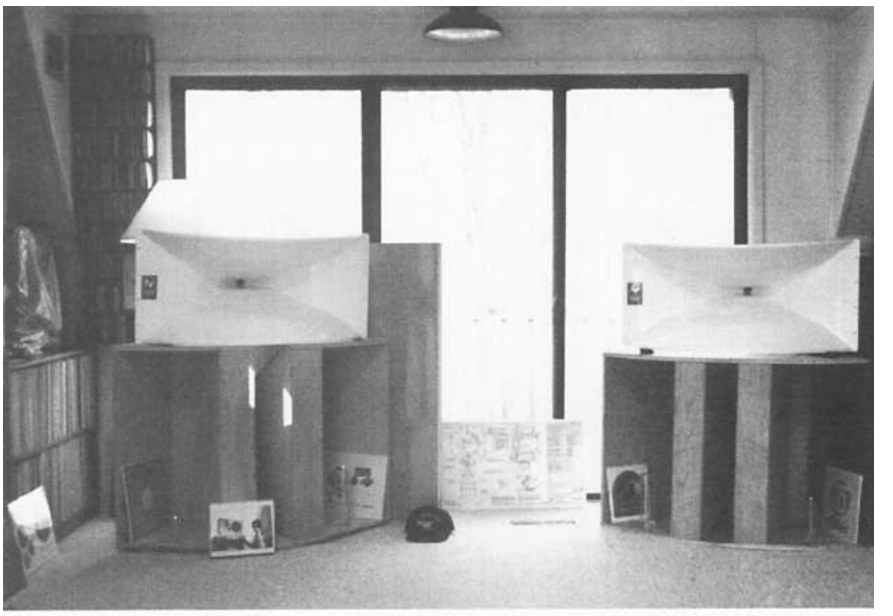
HR9040A (c.1974-85) offered extraordinarily constant 90° x 40° dispersion across the bandwidth without messing up the driver load.

Technical proof is in the very uniform impedance vs. frequency response, suggesting a lack of bad-sounding mouth reflections. The sine wave response curve was also very smooth, without the up and down nasties that most advertising departments like to keep hidden in the closet.

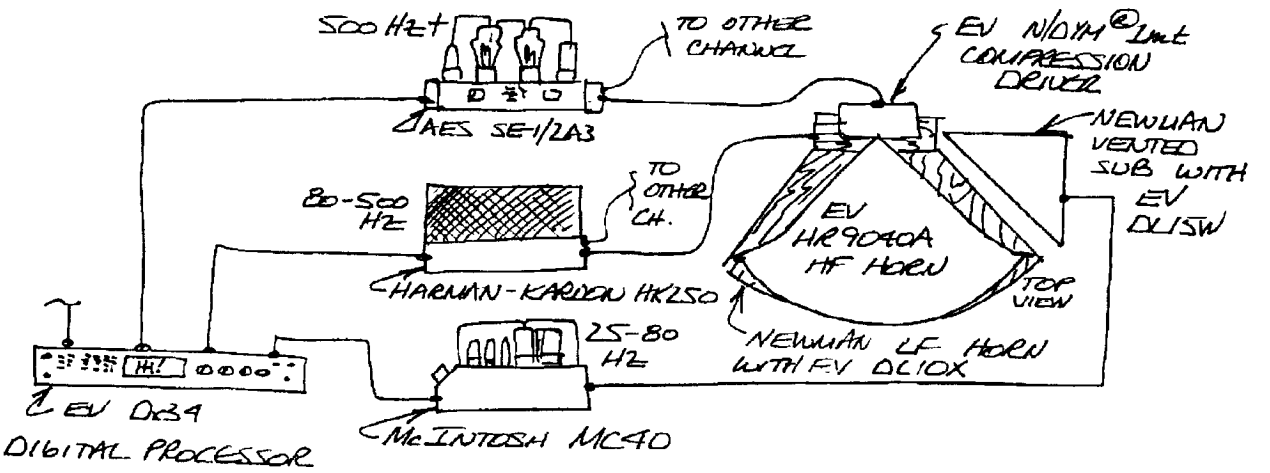
Executed in brilliant white fiberglass, the smoothly sculpted shape of the HR9040A is a sight to behold from the listening position. Its physical presence is even more substantial than the 1505B multicell—overall dimensions of 17" x 40" x 23" hwd for a huge mouth area of nearly five square feet!

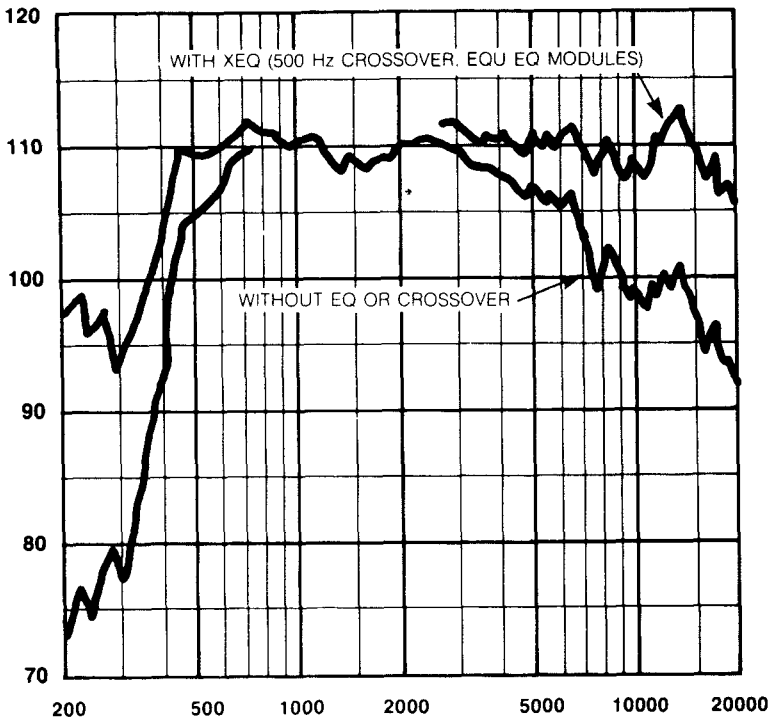
One benefit of the large mouth is the horn's ability to maintain its rated 90° horizontal coverage angle down to the crossover frequency of 500 Hz. A horn needs to be at least 27 inches wide to do this. Smaller horns can be 90° at higher frequencies, but at some point way above 500 Hz, they will "balloon out" and approach omnidirectional (360°) response as frequency decreases.

The HR9040(A) throat size is 1.3 inches and the flange has holes for EV 1.3 inch drivers and Altec 288s, 299s, etc. The



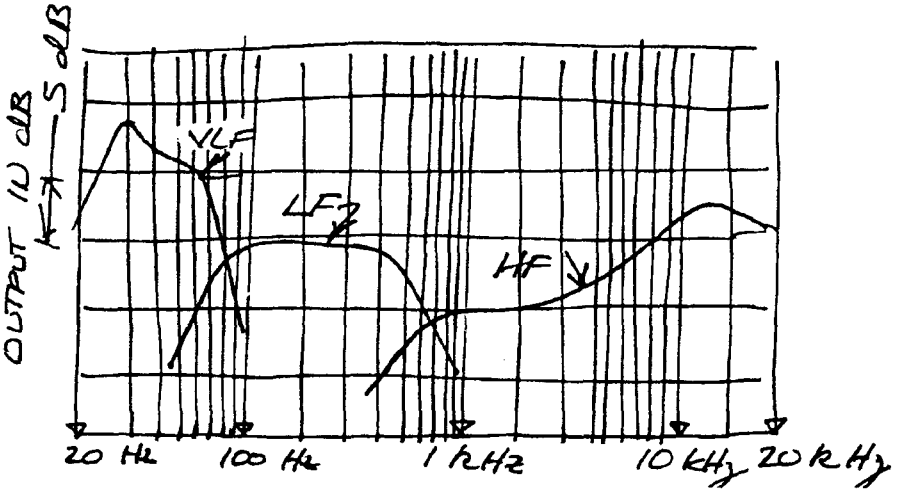
The Bard's "mostly" horn-loaded backwoods ecstasy system. Bass below 80 Hz is handled by a direct radiator 15" EV woofer.



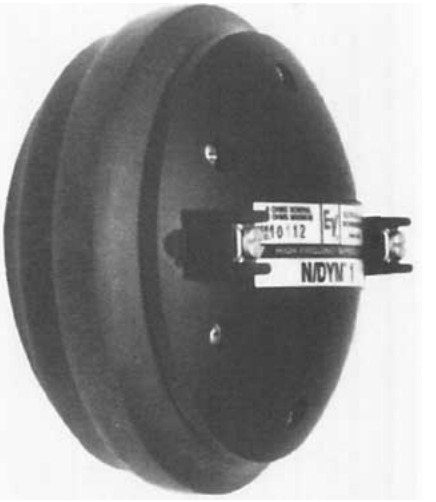


Unequalized axial frequency response of N/DYM-1 high-frequency driver mounted on an EV HP9040 constant directivity horn demonstrates a uniform 6 dB rolloff above 3000 Hz or so, close to the theoretical maximum.

Active or passive EQ can be used to obtain an essentially flat frequency response out to 20 kHz. Not being one to miss out on a good shortcut to musical ecstasy, the Bard uses the latest tool of pro sound, the digital signal processor.



Approximate digital EQ transfer function for a flat in-room response with The Bard's Backwoods Two-Way + woofer



Electro-Voice N/DYM-1mt
High-Frequency Reproducer

Neodymium alloy magnet system, titanium diaphragm with edge-wound aluminum voice coil.

Available in 8 and 16 ohm versions..

Minimum crossover frequency 500 Hz

Throat diameter 1.3 inches

Sensitivity 111 dB@1m/1W(500-5000 Hz on HR9040A horn)

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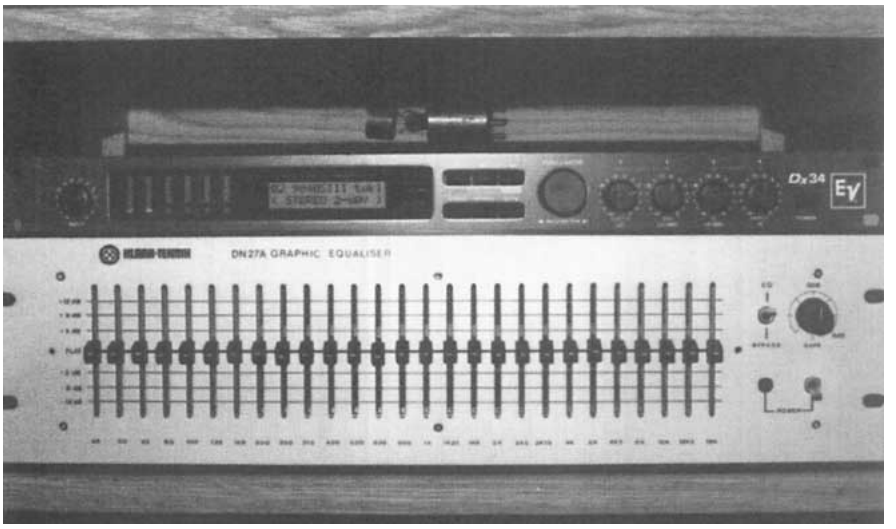
slightly different exit diameter of the Altecs (1.4 inches) is of no acoustic consequence.

I started out with a later-generation EV "small format" CD horn that I liked for pro applications and the Klipsch K-400 midrange horn. The small CD horn just didn't sound right, although the dispersion was great. The K-400 sounded very good but beamed like mad– a characteristic that, in the end, made me want to go back to my old speakers which didn't beam.

When I tried the big HR9040A, there was no contest. It was like removing a barrier in the room between me and the performer. Immediate, open, and right there.

The HR9040 and HR9040A are the same basic design but the "A" traded a vertical front stiffener for radial stiffeners and used a simpler-to-produce throat detail that had the side benefit of smoothing response a bit above 10 kHz. The story of the EV HR horns is contained in Don Keele's 1975 Audio Engineering Society preprint, "What's So Sacred about Exponential Horns?" Write The Bard c/o SP for a copy or e-mail me direct @ jlong2@compuserve.com.



The Bard's latest system uses two EV Dx34 digital signal processors for crossovers, parametric and shelving EQ, and signal delay for shaping loudspeaker response. The defunct de Forest Audion from the Bard's dad sits atop a single Dx34. The Klark Teknik DN27A one-third octave EQ was formerly used for the job.

3— Use a compression driver with performance close to the Newman criteria in acoustic power output vs. frequency.

One of the frustrating realities of all compression drivers is that the efficiency of a well-designed driver falls off at about 6 dB per octave as the frequency increases beyond 3 kHz. In short, there is no way around this phenomenon which is caused by physical realities like air squeezing through small slots and friction in the diaphragm suspensions (see Bard and Ray, *SP #7*). The best you can do with a real world speaker is 30% efficiency in the mid-band, dropping off with increasing frequency, and the rest of the power turns into heat.

The top drivers from companies like Altec, JBL, EV, TAD and so on perform at a level approaching this theoretical maximum. In order to get a flat acoustic response, you can use a horn, such as the Klipsch K-400, employing a geometry which results in a decreasing coverage angle with frequency. This gives a sort of "acoustic equalization" for a lucky on-axis listener, but listeners off to the side of the horn don't get the highs. And the music can seem oddly "closed in" to me. Not my idea of cool! What to do?

The other way to get a flat response where you're listening is to use EQ. With a CD horn, obviously, it's the *only* way.

4— Use one of the latest tools of pro audio—a digital signal processor—to EQ for the Newman Criteria and artfully integrate the woofer and tweeter in a biamp configuration.

To make the system sound right to me, I hook it up the way I would at work. Ten years ago, we had 1/3 octave EQs and active crossovers. Today, it's digital processors with adjustable crossover, parametric EQ, shelving, and signal delay to get the drivers in step without having to have equal path lengths to the listener.

The way I see it, life is too short *not* to use the most effective tools at my disposal to tune up a horn system. Essential tools in my arsenal include a good flat lab mic and a spectrum analyzer, plus extensive EQ and active crossover facilities.

I know what you are all thinking: "How could he listen to that evil digital processor?" How could I cut up my nice analog signal and try to piece it back together before I send it to a neat little SE triode amp? What you really mean is how could I listen to it and get anything like musical ecstasy out of the deal?

Well, all ya gotta do is come over to my house some night for dinner and hear Dinah Shore and Andre Previn doing "It Had to be You" followed by Les Brown and his big band at concert level, and you might get hooked—Capitol's late-1950s recording style in the tower at Hollywood and Vine might have something to do with it. We do country, rock, and Carl Orff too.

Sure, it would be possible to do the compensation with analog electronics, resonant

Get back, Jack! The Bardmobile out prowling the woods for more lumber.

circuits using caps and coils, but there's a lot to be said for the ease of dialing it right in with the processor. Here's a brief rundown of the setup procedure I use:

1– Start by EQing the in room response of each speaker/amp combo operating alone for a flat response 6 dB down at the crossover point. A pink noise source and one-third octave spectrum analyser are what I use, although software is available to adapt your computer to this worthy purpose. I also like to roll off the lowest woofer below its bandpass to keep infrasonic junk the speaker can't reproduce from muddying up the sound.

2– EQ the HF horn for a flat response above 500 Hz measured on-axis with the mic about three feet away (to minimize room effects). The curve may vary a bit in a more distant listening position, but the direct field will be essentially flat and the ear/brain combo keys in on this.

3– EQ the bass horn and sub and adjust the LF/HF balance *at the listening position.* Efficient bass speakers "put a big handle on the room" and, thus, the room– walls, floor, and all– puts a big handle on them. Deal with that at the listening position.

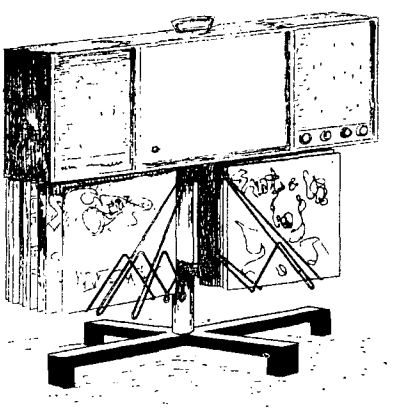
Of course, it is possible to go too far with compensation. If you try to EQ out every little bump in the response, you can squash the music out of it. Plus, if you can cancel out all the narrowband variations in one position, when you move the mic a bit you'll just have another set of small variations to contend with. In my system, a gradual broadband HF boost does the trick.

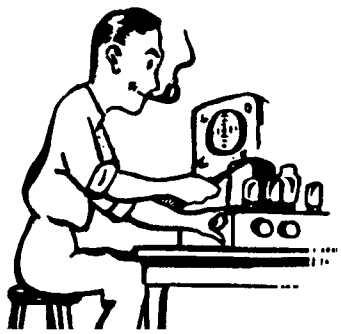
4– Adjust for path-length differences from the speakers to the listening position with the signal delay feature of the Dx34. Delay is adjustable in 20 microsecond increments, equivalent to a distance of about 0.3 of an inch. Close enough for me.

Looking at the system from the listening position, the subs are nearest, meaning their signal arrives first. The HF drivers are about 24 inches farther away, and the drivers in the folded LF horns are about another two feet away.

To adjust delay, I set the SPL of each speaker operating alone to be equal at the crossover frequency using a signal generator. Next, I turn them both on, inverting the polarity of one driver and advance the delay until the sound level at the listening position begins to drop then increase again. At the null, the signals are exactly 180° out of phase, causing a cancellation of the output. Restore the correct polarity of the inverted device and there you have it, perfect, instep summing at the crossover point.

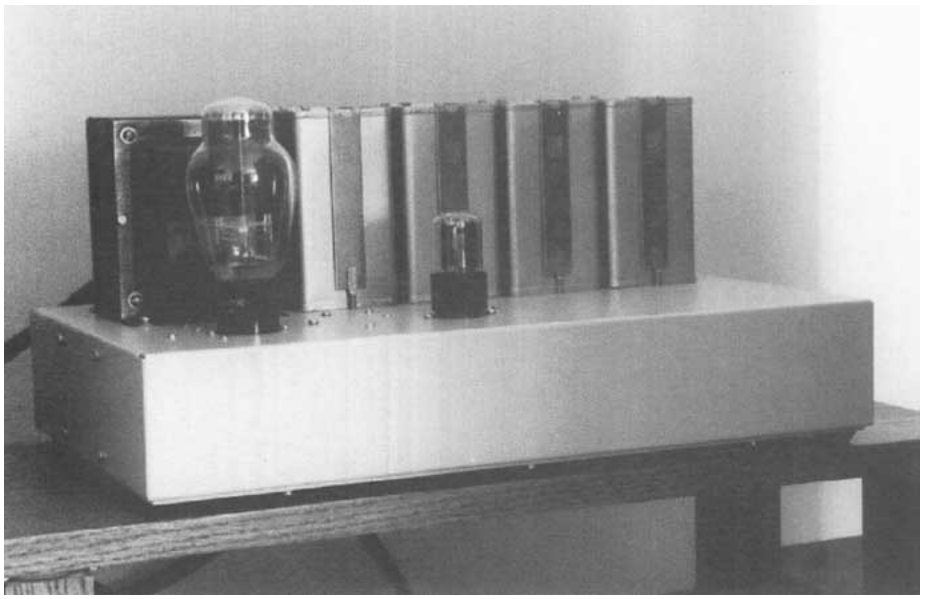
It took a few years to get everything lined up the way I have it now, but almost every night, we sit down to enter another world—MUSIC. We don't hear horns or crossovers, even with the big speaker rigs only eight feet away. And we've had enough friends over to know that our great happiness is transferable. Musical ecstasy? Go for it– I think we've got it!





Homebrewer of the month

Bruce Berman of Long Island, NY



Bruce's homebrew 300B SE mono amplifier audio chassis

One look at Bruce Berman's carefully hand crafted triode and horn music listening system is all the evidence we need to recognize Bruce as a Tube Man of the first order. Hey, good job!

What better evidence of dedication and commitment to the craft can there be than this monument to the gods of music, not to mention the gods of the homebrew art?

A system like this is one man's audio dream made real through hard work, so naturally Bruce has a great deal of pride in his audio setup—as well he should, because he turned a pile of old cast off junk and raw materials into a custom high-performance music system unlike anything you can buy anywhere. There's only one way to get a system like this—if you want one, you've got to build it for yourself.

As far as circuits go, Bruce swears by time-tested, carefully engineered, simple circuits with the best parts that he can buy, scavenge, or recycle, selected for sonics, not fashion. Although he does seem to have a certain fondness for old US-made industrial and broadcast parts, if the new stuff sounds better, the cool old parts don't make the final cut.

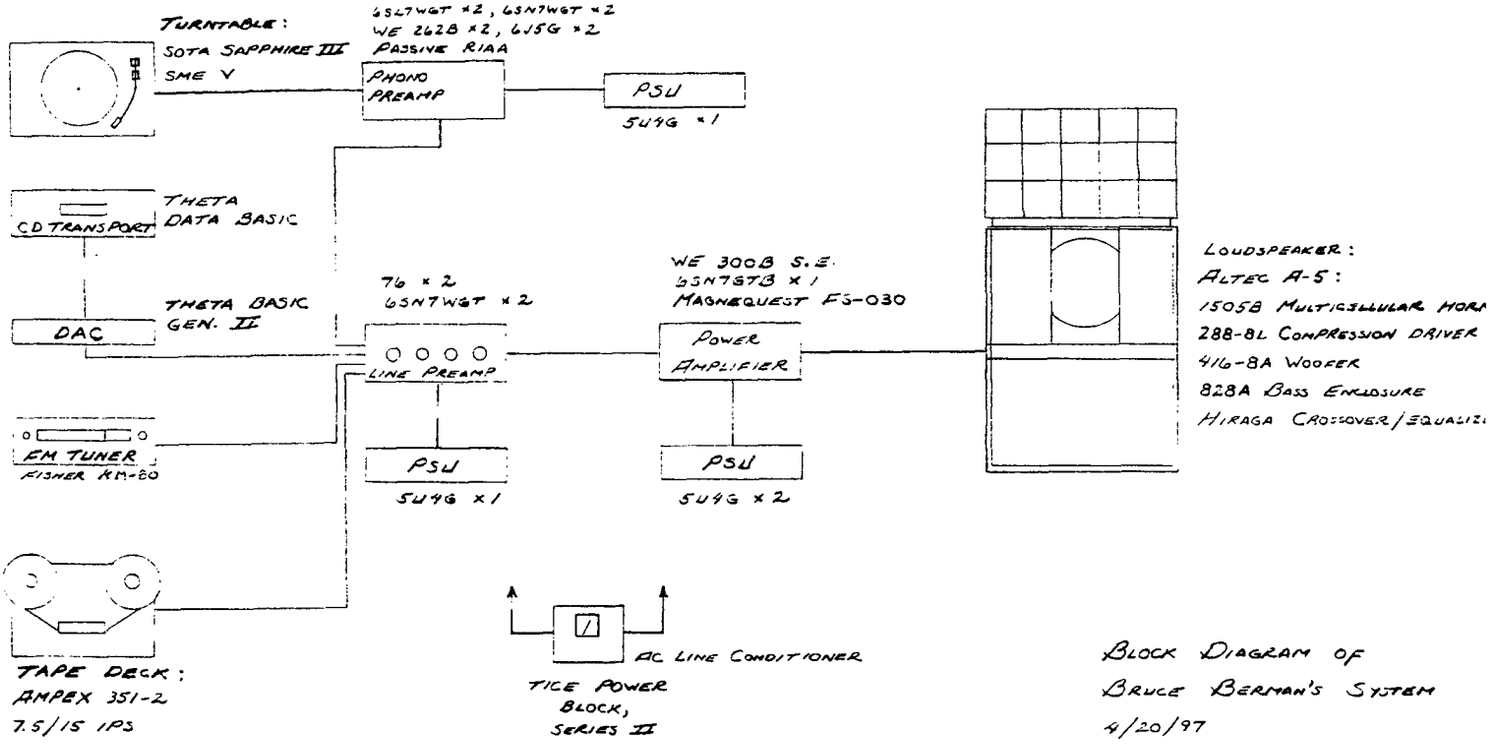
He experiments with circuits using breadboards to perfect the operating points and evaluate component sonics. After he knows exactly what is going in, then he does an exacting mechanical layout with calipers and graph paper. The clean look of Bruce's equipment owes a lot to his "measure twice and cut once" philosophy.

It's obvious that a lot of hours and hard work went into putting this system together. yet Bruce is super-content these days because he feels he's arrived at a lifetime system. Indeed, aside from tubes, most of this simple and solid equipment could easily last several lifetimes.

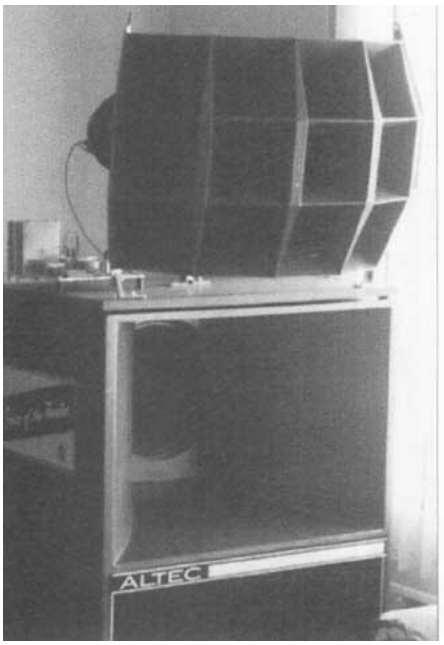
A system like this is an investment in the future but it draws heavily on the past for lessons and inspiration. It is obvious from the way this gear is put together that Bruce has a real appreciation for the classic American industrial electronics tradition.

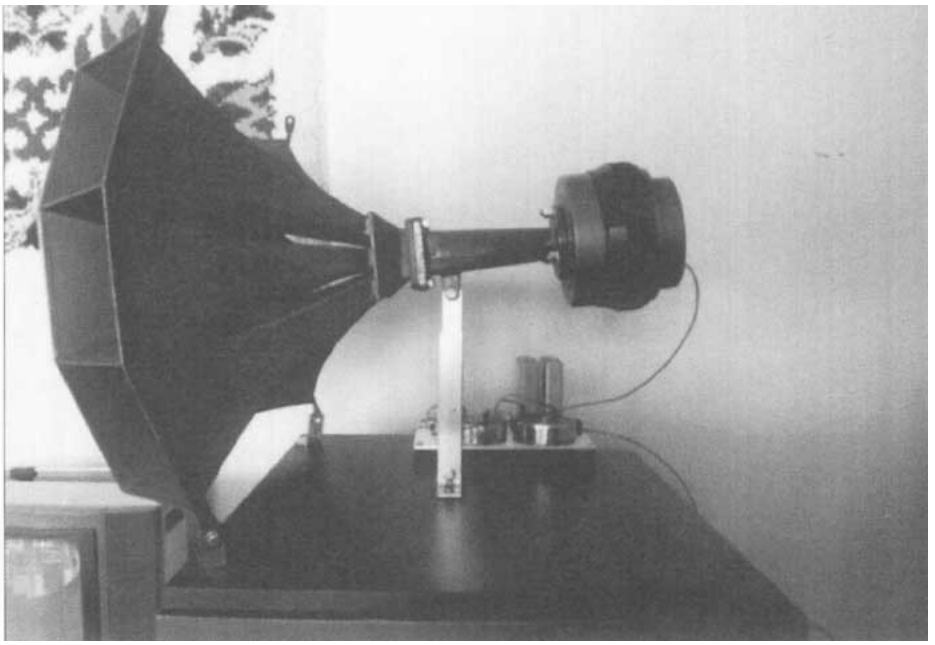
They don't build them like that anymore, and perhaps they haven't since World War II, but Bruce is still doing it. Keep the faith, brother!

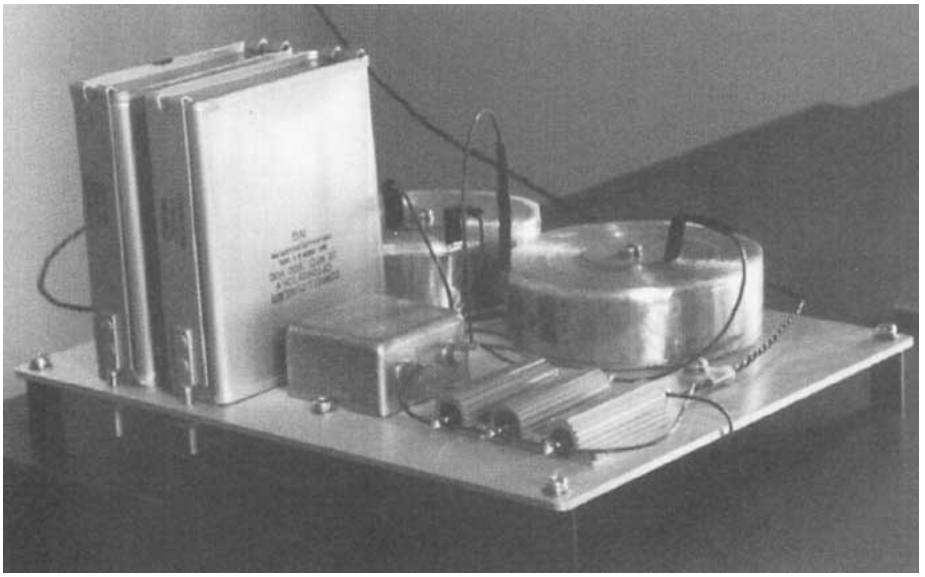
Tube rectified , choke input power supply for one 300B mono amplifier. Bruce believes that the power supply should always be much heavier than the audio chassis—in this case, the PS for each channel weighs a chunky 75 pounds!



BLOCK DIAGRAM OF BRUCE BERMAN'S SYSTEM 4/20/97





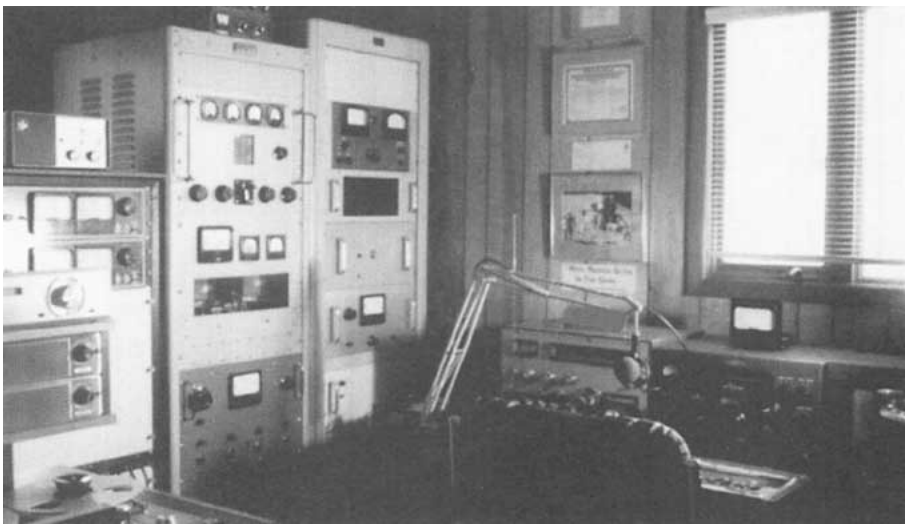


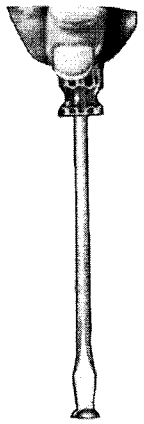
Fine attention to detail in layout, construction and parts selection is evident in Bruce's Hiraga-style EQ crossovers (see Stronczer, SP #11) for his Altec A5 "Voice of the Theater" loudspeaker systems.

Vintage Cornell Dubilier oil caps, Solo CFAC foil inductors, and Dale non-inductive, aluminum-cased, power resistors definitely looks like it ought to sound good. Bruce highly recommends the EQ crossover to VOT users, saying that the speakers really "clicked in" for home music listening with the new x-overs.

Being the consumate tube man that he is, Bruce is not content to limit himself to the 20 Hz-20 kHz frequency range. Pictured at right is his all "hollow state" amateur radio station, featuring a homebrew AM transmitter using a 4-400A modulated by a pair of 833A (behind the glass window in the center rack), capable of 1 kilowatt of broadcast-quality Class B audio. The speech amplifer driving the modulator is a Dyna ST-70.

Bruce definitely knows how to keep warm during those long New York winters! If this guy turned on all of his tube gear at once, the line voltage would sag all over the neighborhood!





My Homebrew Type 76 Preamplifier

by Bruce M. Berman

Very few things compare with the thrill of designing, building, modifying, and most importantly, listening to audio equipment that sounds utterly entrancing and that you built with your own hands. You will never experience this deep sense of accomplishment by buying an Audible Illusions preamp from your local audio salon. I am a strong proponent and practitioner of the almost lost art of homebrewing your own electronics gear.

J.C. Morrison wrote some time ago that, "if you change as a result of listening to your hi-fi, then the hardware is doing it's job." I completely subscribe to this philosophy of combining art with creative engineering, in that it makes for a more well-rounded, purposeful, and interesting lifestyle, and this is only further enhanced when you build your rig yourself.

The design of this line stage preamplifier began with the realization that the overwhelming majority of recorded music, be it LP or digital, is very mediocre in terms of technical quality, and while this is certainly no revelation to most of us, I needed a system which would play most of my records all of the way through. Having a harsh, unnatural-sounding system that will only play Cheskys, Audioquests, Living Stereos, and other audiophile-grade recordings to our satisfaction, is foolish and deprives us of the emotions to be realized from the tremendous quantity of recorded music that exists. This has been discussed most eloquently by Herb Reichert and others in these pages before, so I will not elaborate any further, only to say that I too am in full agreement with this attitude.

In my household, digital and analog (LP and reel-to-reel tape) playback generally peacefully coexist, although I spend considerably more time listening to LPs. I prefer the modular approach to preamplifier design, in that my phono and line stages are built on completely separate chassis, and this modularity provides the serious enthusiast with considerable flexibility in the design and configuration of his system.

For example, I am currently building a new phono section, and my system doesn't have to be completely out of commission because my preamplifier is being torn apart. Most importantly, separate components provide considerable electrical isolation and freedom from interaction between stages, and the sonic benefits to be derived from this design approach are significant and well known. Then too, line preamps are a relatively new phenomenon within high-end audio, brought on because a lot of listeners enjoy only CDs, and have no need for phono playback electronics.

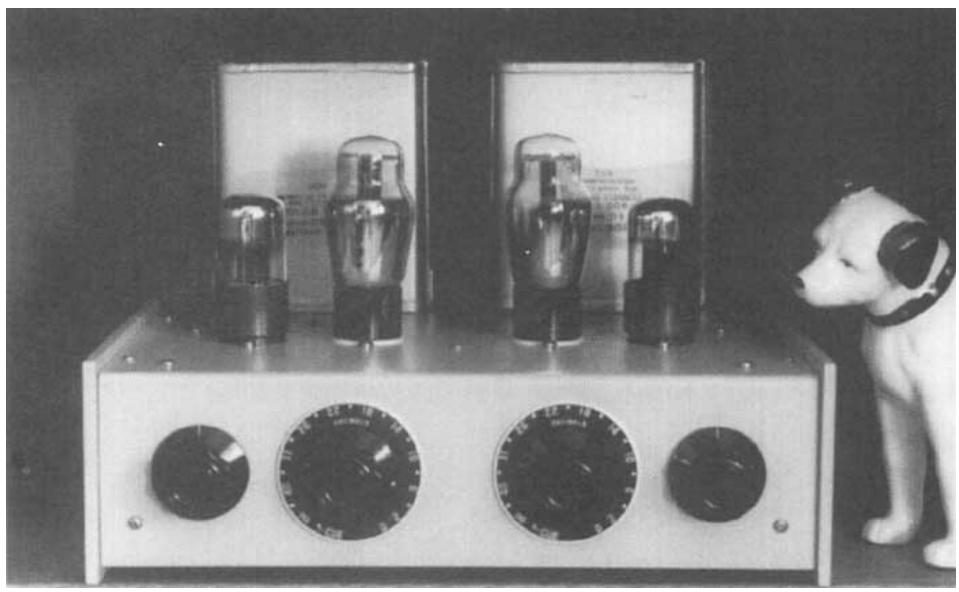
Built the way I describe it below, this unit sets very high standards for purity, naturalness, ease, speed, and all of the other criteria currently used to evaluate high-end audio reproduction equipment. When mated with a phono stage of comparable quality, you can fully expect superb results.

Finally, let me say this: When using directly heated triode single-ended amplifiers, horn-loaded loudspeaker systems, and no negative feedback anywhere within your system, all of the rules change. Before you begin the full-scale construction of this unit, you may wish to breadboard it first to ensure that the sonic results are to your liking with your system. Even if you decide not to build this preamp, I hope that some of the construction techniques and component parts recommendations that are described here will be of value in building your own audio creations.

Preamplifier Topology

This line stage unit is really nothing more than my own personalized version of a simple, mature, well known and certainly tried and true circuit which has been used by a number of experimenters for many years. It consists of a single 76 indirectly heated triode in an anode follower configuration, direct-coupled to one-half of a 6SN7WGT connected as a cathode follower to the amplifier load.

The choice of the 76 was largely motivated by the positive comments regarding this tube by J.C. Morrison and my good friend and ultimate audio experimenter, Tom Weiss, among others, who have utilized the 76 in various preamp and power amplifier input/driver stage topologies. For those who have never heard the 76, it brings an incredibly open, clean, clear, natural, and fast sound to the listening room. I believe



the cylindrical plate structure has much to do with the beautiful sound that 56s and 76s can create.

This tube is certainly one of the most linear indirectly heated small signal triodes ever made and traces its lineage back to the 1930s. The 76 and its 2.5 volt filament older cousin, the 56, enjoyed wide popularity as an inexpensive yet high quality voltage amplifying device in many consumer as well as commercial and military applications.

Many radio sets manufactured for the home from the 1930s thru the early 1940s used these rugged little ST-shaped triodes in their audio stages. Fortunately, 56s and 76s are still fairly common, having been made in significant quantities for many years, both as the standard commercial as well as JAN/military versions.

The 6SN7 probably needs no introduction, as the highly linear amplification characteristics of this tube are well known. The real advantage of the 6SN7 in this circuit lies in this tube's relatively low plate resistance and moderate transconductance, which results in a low source impedance, making this device ideal to drive a difficult capacitive load such as an interconnect cable when terminated in a typical 100K ohm load impedance.

I have gone the full route of playing around with the so-called "designer" or "boutique" tubes, such as the ubiquitous 12AX7, 12AT7, and 12AU7s manufactured by such well-known and revered companies as Telefunken, Mullard, and Amperex. These companies manufactured some of the best sounding low microphonic tubes within this classic family, and they have now become very scarce and expensive. I say let the Jadis and Audio Research enthusiasts enjoy using them.

There are many tubes out there that are readily available, reasonably priced, and yet leave these famous and now highly sought after tubes totally in the dust from a sonic standpoint. The 56, 76, 6SL7, and the 6SN7 are but a few of these examples.

The 6SN7, 76, and 12AU7 are generally somewhat similar in electrical characteristics, but that is where the similarity ends. After auditioning these tubes in my system when utilized as resistance-loaded anode follower voltage amplifiers, the 12AU7 would be the first one to go. Its lack of clarity, control, and that essential characteristic, tempo or pace, becomes immediately apparent when compared to the 76 or 6SN7. The 12AU7, and I don't care if they were made by Telefunken or anyone else, always seem to impart a tired, sleepy sound to the musical presentation.

As mentioned earlier, the 76 has a certain sense of refinement, pace, and excitement, that makes it almost mandatory to employ this tube as the voltage amplifying element in our line stage section. These attributes will really shine in terms of the overall sonic character of the preamp. The 76 is biased at an operating point which results in a quiescent idling current of 6.0 milliamperes at a plate voltage of 200 VDC, and this puts the operating point of the tube way into the linear region.

Forgive my lack of enthusiasm for the currently much in vogue SRPP and mu-follower circuits, but I have never found the sound of these designs to be much to my liking, my experience being that the sound tends to stray from the natural and relaxed. To my sense of logic, nothing is more linear than a good quality resistor acting as a plate load, compared to another tube sitting on top, making every effort to behave as a constant current source.

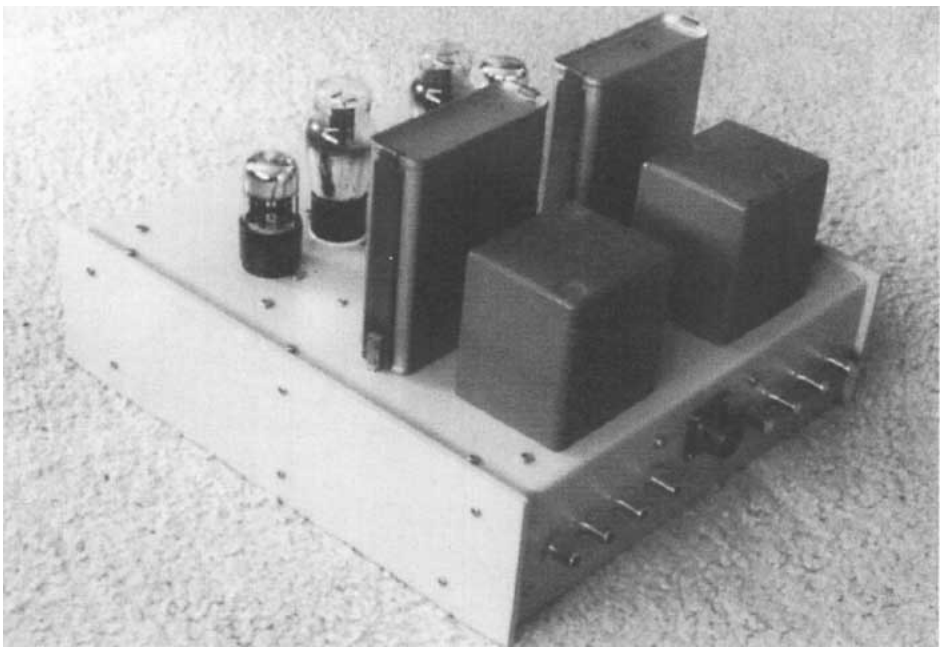
The 76 would be a less than ideal choice without the cathode follower output stage. I like to keep my signal paths as simple as possible, but sometimes too much simplicity can stray from the best possible sound. Tom Weiss did try the 76 as an anode follower driving his amplifier without a cathode follower buffer, and although this tube does boast a reasonably low plate resistance (Rp), he found the sound to be somewhat wooly and lacking in refinement.

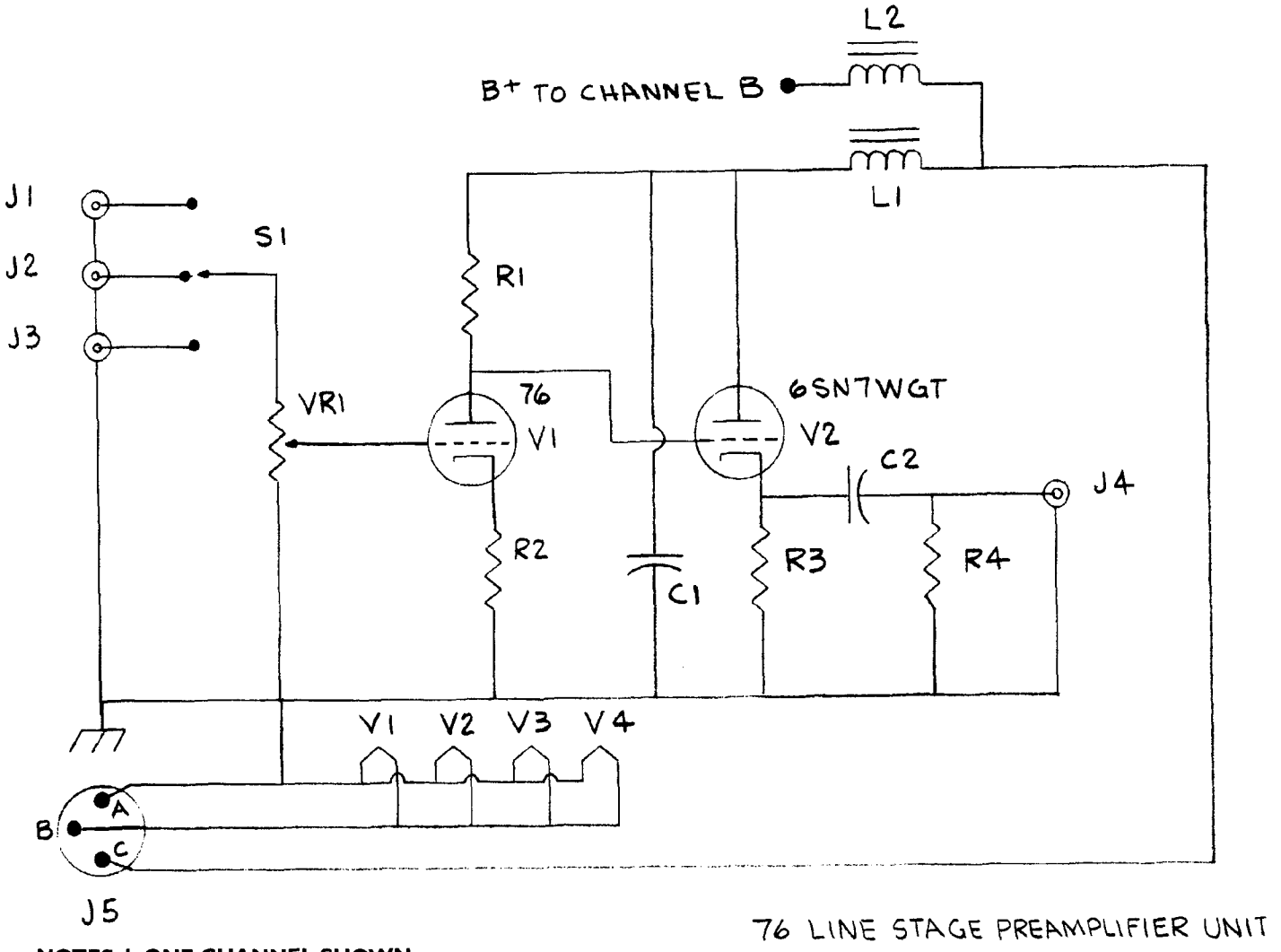
The 6SN7 effectively isolates the 76 from the capacitive interconnect load, and leaves the sound fast and tight. It is biased for 10.5 milliamperes idling current at a plate supply voltage of 400 VDC, which also puts the operating point for this tube well into the linear region of operation.

Note that I only use half of the 6SN7 as a cathode follower in this circuit. Some experimenters will point to their *Radiotron Designers Handbook* and recommend that both halves of this tube should be paralleled to halve the plate resistance, increase the transconductance, and reduce the output impedance.

In theory, I would agree. In practice, when two tubes or tube sections are connected in parallel, the slight fine-grain variations in the transfer function between the tubes will tend to interact, with the effect that the tubes are constantly fighting each other.

The result is a lack of focus and a loss of clarity, definition, and naturalness. Although the use of isolating resistors will tend to minimize this effect to some degree, you will never have the naturalness or refinement achievable with a single amplifying element. Some designers think that it borders on the sacrilegious to have an unused tube section flapping in the breeze, but 6SN7s are readily available and dirt cheap, so I say the heck with it. I want good sound.





NOTES: 1. ONE CHANNEL SHOWN
2. J5 – PIN A: GND; PIN B: 6.3VDC; PIN C:+400 VDC

The Parts Make The System

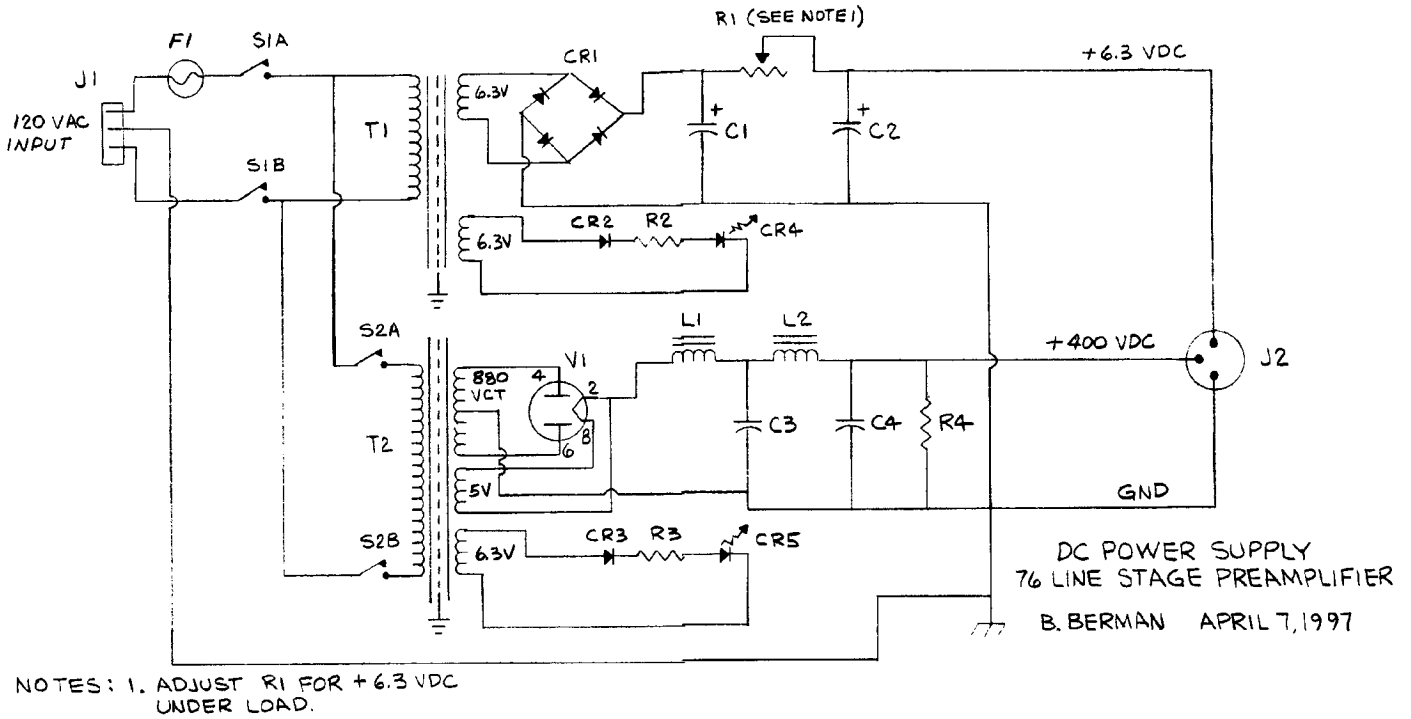
I am a strong proponent of oil and paper capacitors for use as interstage coupling and decoupling purposes. I use these capacitors for interstage coupling in my homebrew single-ended 300B amplifiers, (Audio Note copper foil), and for the capacitive elements in the high and low-pass networks within my speaker crossovers. I also use them for power supply filtering, and decoupling in my phono section, preamplifier line section, and power amplifiers.

For those of you who have never listened to an old stock oil and paper capacitor, they have a smooth, liquid, glare-free sound, completely non-fatiguing, which is in marked contrast to the coarse, unrefined sound exhibited by conventional electrolytics. If you are looking for a natural sound, one that is utterly non-fatiguing, full, weighty, and rich, you must consider the use of old stock oil and paper capacitors in this circuit. I think that if you get lazy and skimp here and use something other than oil and paper for decoupling, you won't know what you're missing. Remember, in any single-ended preamp or power amplifier circuit, the output or decoupling capacitor is directly in the signal return path to ground, so the quality of this part is just as important as the interstage coupling capacitors.

Do not get overzealous and go with large amounts of capacitance for the decoupling capacitors. A small value (i.e. 10 uF. or so), will charge and discharge much faster than a large value capacitor, resulting in fast rise and fall times of the audio signal. Too much energy storage here will slow the sound down, and will result in poor transient response. In addition, 10uF. at this node in this circuit provides a very low impedance return path to ground at the lowest audio frequencies, and a further increase in capacitance will not provide any material improvement in bass slam or weight.

For the output coupling capacitor, I was a bit more open-minded. I am currently using an old, out of production, REL-Cap polystyrene and tin foil capacitor, which in conjunction with the oil and paper capacitors used elsewhere in my system, provides a really nice blend of transparency, speed, and clarity.

The 15 henry chokes in series with the B+ on the preamplifier chassis provide a high order of electrical isolation between channels to minimize crosstalk and maintain high channel-to-channel separation. They also isolate the preamplifier electronics from the power supply and provide an additional section of power supply filtering.

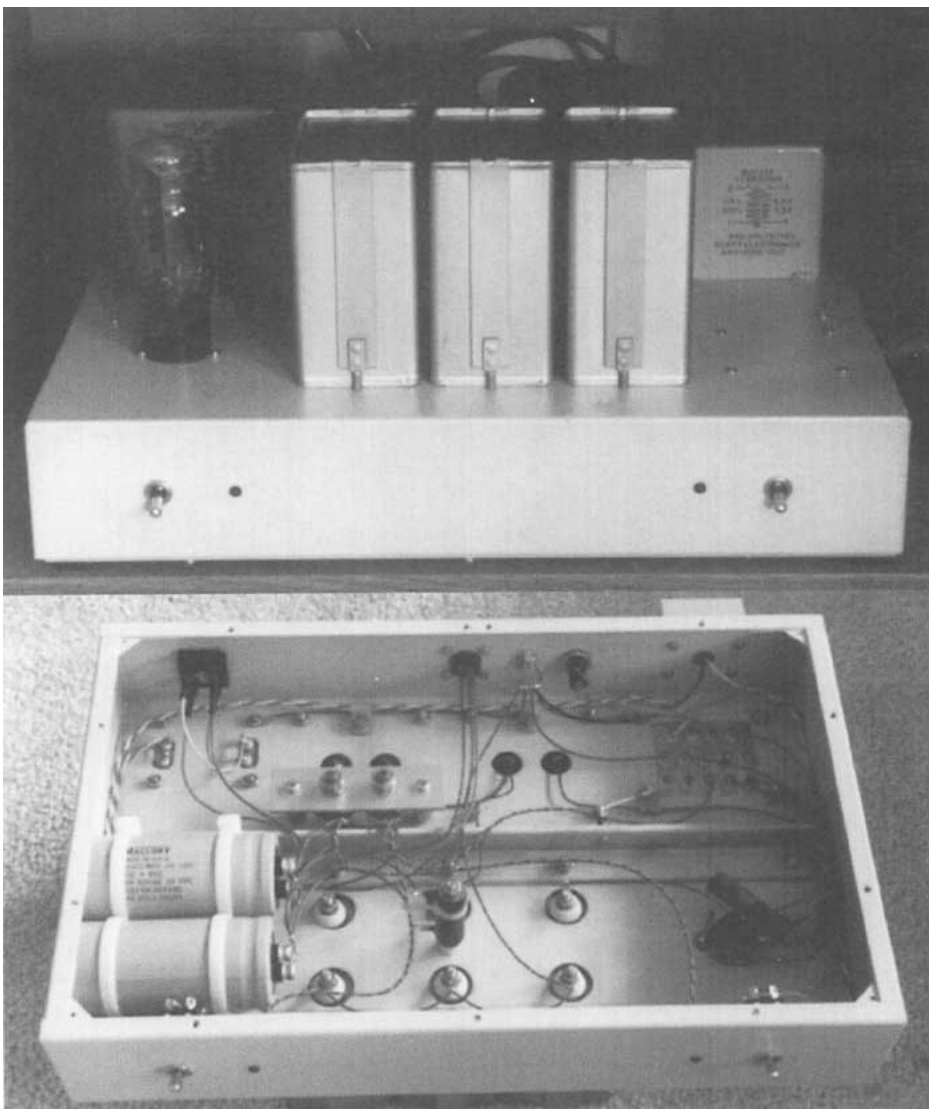


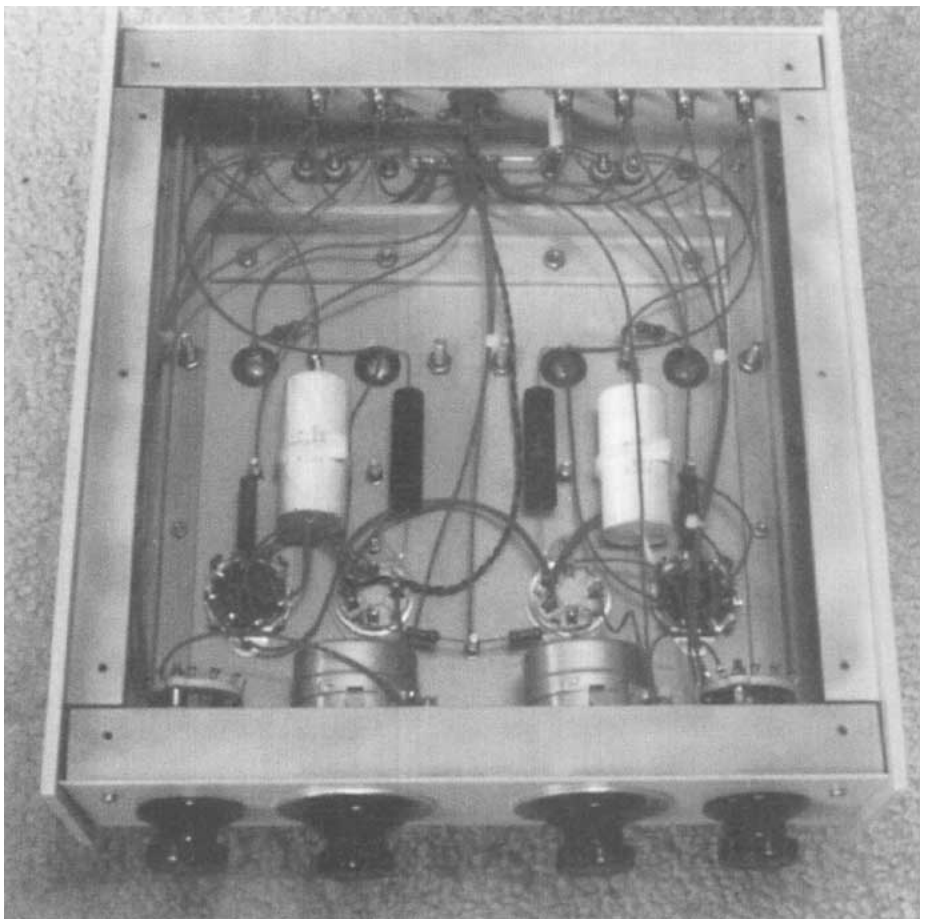
PARTS LIST

C1: 10uF, 600 VDC, oil & paper
C2: 1.0uF, 400 VDC, polystyrene & tin foil
L1, L2: 15hy, 100mA
R1: 33k ohm, 2W, non-inductive wirewound
R2: 1.5 k ohm, 1/2W, tantalum (Shinkoh or equivalent)
R3: 20k ohm, 5W, non-inductive wirewound
R4: 1 meg ohm, 1/2W, tantalum
S1: Ceramic rotary selector switch, silver contacts
VR1: Stepped attenuator, 100k, log. taper Daven Company or equiv. (see text)
J5: MS-style connector (see text)

DC POWER SUPPLY

C1,C2: 30,000 uf., 16VDC
C3,C4: 15 uf., 600 VDC, oil & paper
CR1: Bridge rectifier assy., 100 PIV, 10A
CR2, CR3: IN4003 or equivalent
CR4, CR5: LED, 2Ma.
F1: 1 Amp, Slow-blow
J1: IEC-style power connector, male
J2: MS-style connector (see text)
L1, L2: 12 Hy., 150 Ma.
R1: 3.0 ohm, 25W, wirewound, adjustable
R2, R3: 5.0k ohm, 1/2W
R4: 20k ohm, 50W, wirewound, chassis-mount
T1: 6.3 VAC @ 3A transformer, electrostatically shielded
T2: 880 VCT @ 120 Ma., 5 VAC @ 3A, 6.3 VAC @1A transformer, electrostatically shielded
V1: 5U4G or 5R4GY (see text)





I consider 15 henry chokes mandatory in this circuit because the power supply is unregulated, and therefore it presents a relatively high source impedance to the electronics. The chokes provide a high impedance to the audio on the preamp chassis and in conjunction with the oil and paper decoupling capacitors located within the preamp electronics, keep the audio from finding its way back to the power supply. Any 15 hy., 50 ma. choke with a DCR (DC resistance) of 250 ohms or less will work just fine here.

I have experimented endlessly with both vacuum tube as well as solid state voltage regulators in preamps and I've never liked the electronic sound that these regulators can impart. Series regulators depend on 100% voltage feedback to establish the servo control loop and the deleterious sonic effects of voltage feedback apply here.

Yes, I did try this preamp with a really tricked and optimized 5U4G/6AS7G vacuum tube regulator circuit and the sound became hyper-dynamic, and right in your face, with the usual graininess and coarseness commonly associated with feedback. This "hyper-dynamic" sound may be desirable when driving lifeless amplifiers with lots of negative feedback and speakers of 88 dB sensitivity, but for horn loudspeakers and zero feedback electronics, a natural and relaxed presentation is what we need.

Another element which has a major impact on the sonics of a preamplifier and which is frequently overlooked is the volume control. Avoid the usual ALPS and Noble units seen in most modern high-end gear. My experience has been that they lack definition and impart a certain coarseness and loss of transparency to the sound. I use stepped series potentiometer or L-pad attenuators for the gain controls, to avoid the pitfalls and sonic degradation common to the generic volume controls.

Used rotary attenuators occasionally turn up at electronic flea markets and surplus stores. Probably the most common and well known of these units were manufactured by the Daven Corporation. These controls were the de facto standard for many years for broadcast, recording, film sound and high quality test equipment. They feature silver-to-silver contacts, and precision wirewound resistive elements.They track very accurately and last forever.

I have used the Daven stepped 100K pots for quite some time, and I find them to be really excellent sounding units, so it may well be worth the effort to try to source these devices through the usual surplus channels.

Ladder attenuator kits are available from both Michael Percy Audio and the Sonic Frontiers Parts Connection. Although technically this may offer the ultimate gain control solution due to the limited number of resistive elements in the signal path, these kits use metal film resistors which may not be to everyone's sonic palate.

A bit of audio attenuator trivia; the Daven controls feature a removable rear cover for accessing the contact and wiper assembly. The contacts should have a film of light gray grease or oil on them. This trademark grease or lubricant was called "Davenoil," and was an electrically conductive material which was applied at the factory to ensure smooth mechanical operation, and should never be wiped off.

For resistors, I recommend the use of Mills non-inductive wirewounds in the plate circuit of the 76 voltage amplifier stage and in the 6SN7 cathode follower stage. I like the sound of Allen-Bradley carbon composition resistors in the plate circuit of my power amplifier input and driver stages, but not in a preamp.

The clear, open sound of the Mills' resistors complements the slight softness and sweetness of the carbons later in my system. For the 76 cathode resistor, and 6SN7 1 megohm output terminating resistor, I prefer the sweet sound of the Shinkoh tantalum resistors distributed by Audio Note. I would not condone the use of metal films here, as they can sound a little on the hard side, but many mainstream high-end audio systems may benefit from a little boost.

Grounding in any audio circuit is extremely important, and is a topic which is usually given minimal attention. I always employ the so-called "star-grounding" configuration, in that all components which must return to ground do so only to a single point on the chassis. When fairly complex point-to-point wired circuits are built, this can become somewhat difficult to manage, so I use a solid copper (12 ga.) ground bus, terminated to the chassis at one end only, with all components to be grounded ultimately returning to the bus.

RCA

76

MEDIUM-MU TRIODE

GENERAL DATA

Electrical:

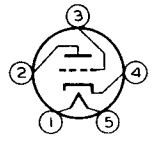
Heater, for Unipotential Cathode:		
Voltage	6.3	ac or dc volts
Current	0.3	amp
Direct Interelectrode Capacitances:[o]		
Grid to Plate	2.8	μμf
Grid to Cathode	3.5	μμf
Plate to Cathode	2.5	μμf

[o] With no external shield.

Mechanical:

Mounting Position	Any
Maximum Overall Length	4-3/16"
Seated Length	3-3/8" ± 3/16"
Maximum Diameter	1-9/16"
Bulb	ST-12
Base	Small-Shell Small 5-Pin
Basing Designation for BOTTOM VIEW	5A

Pin 1 – Heater
Pin 2 – Plate
Pin 3 – Grid
Pin 4 – Cathode
Pin 5 – Heater



AMPLIFIER – Class A_1

Maximum Ratings, ***Design-Center Values:***

PLATE VOLTAGE	250 max.	volts
PLATE DISSIPATION	1.4 max.	watts ←
PEAK HEATER-CATHODE VOLTAGE:		←
Heater negative with respect to cathode.	90 max.	volts
Heater positive with respect to cathode.	90 max.	volts

Typical Operation and Characteristics:

Plate Voltage	100	250	volts
Grid Voltage	-5	-13.5	volts
Amplification Factor	13.8	13.8	
Plate Resistance	12000	9500	ohms
Transconductance	1150	1450	μmhos
Plate Current	2.5	5	ma

Maximum Circuit Values:

Grid-Circuit Resistance	1 max. megohm

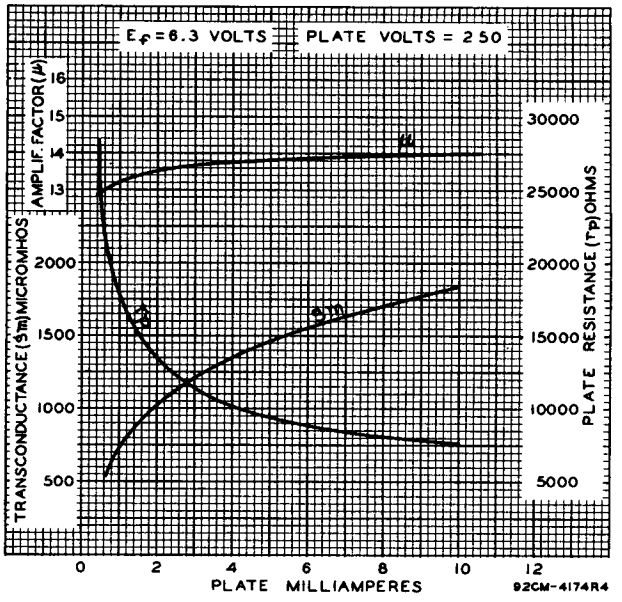
← Indicates a change.

JUNE 15, 1948 TUBE DEPARTMENT DATA
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

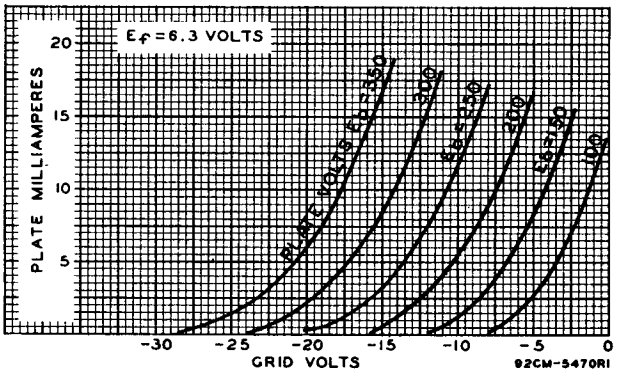
RCA

76

AVERAGE CHARACTERISTICS



AVERAGE CHARACTERISTICS



MAY 19, 1948 TUBE DEPARTMENT 92CM-6983
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

The grounded end of the bus should always be located at a point midway between the audio input jacks on the chassis. The other end can be supported by a ceramic standoff or terminal post to provide mechanical rigidity.

I used aluminum for my chassis; the thoroughly obsessed might wish to use copper or silver sheet for their preamp chassis groundplane. Whatever you use, don't use steel; go with non-magnetic materials.

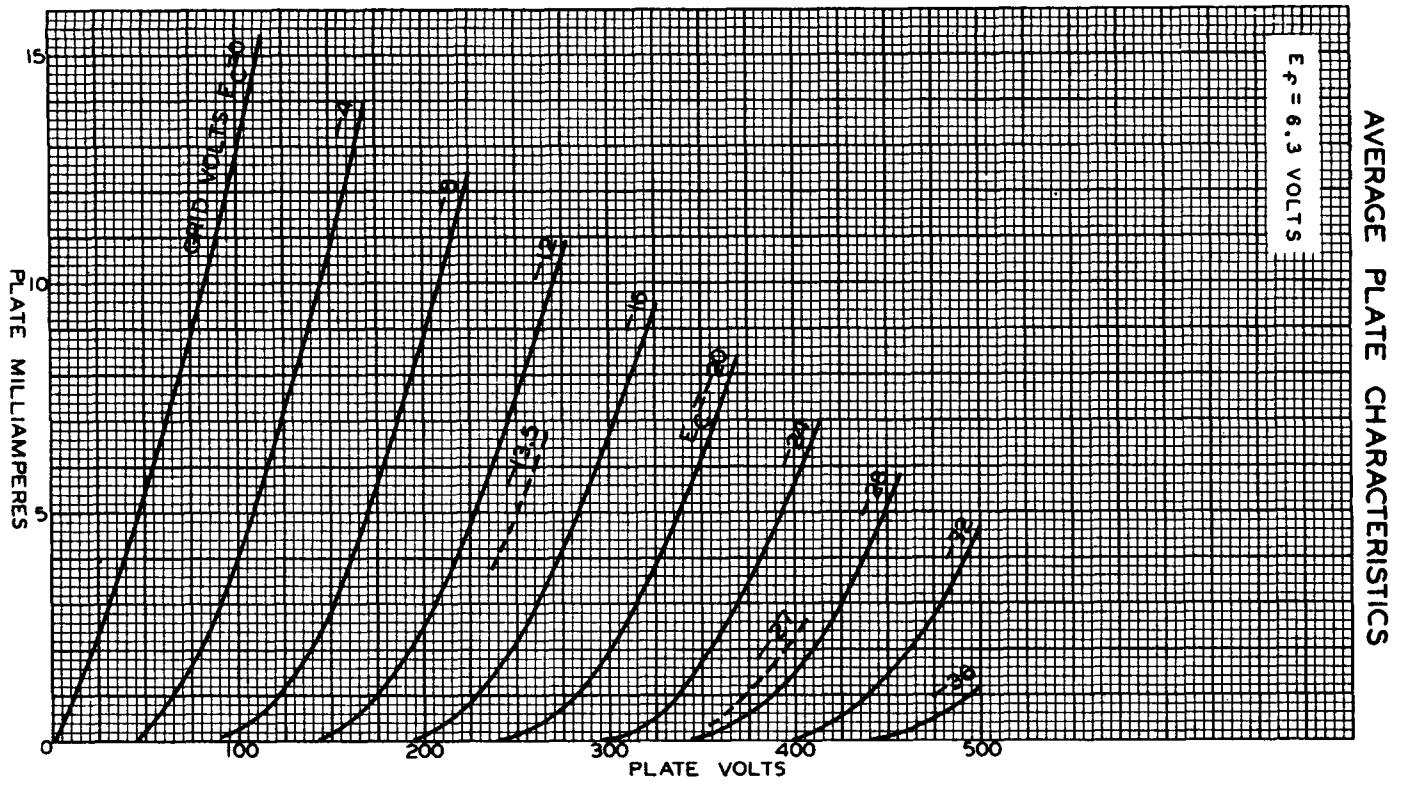
It's The Power Supply, Stupid!

The fact is, any audio amplifier is only as good as it's power supply, as the amplifier's basic function is to linearly modulate the DC provided by the supply. Any noise, ripple, or other artifacts not suppressed by the power supply will find their way into the electronics, with impure, unnatural sound being the end result.

My design philosophy stresses that all power supplies should be mounted separately from the active electronics which they support. This significantly reduces the possibility of any stray 60 Hz. electromagnetic fields, etc., from finding their way into the preamp or power amplifier assemblies. This is an extremist design approach, and although it adds significantly to the size, weight, cost, and complexity of the system, the results are well worth the effort. Another advantage to a separate outboard power supply unit is the ease in making minor or major modifications to the system. How many times have we all been forced to scrap out a piece of equipment because we ran out of real estate to implement a much-desired modification?

Electrically, my unregulated power supply is completely straightforward and quite a traditional design. Using full wave vacuum tube rectification, a two-section choke input filter, and a separate DC supply for the preamplifier tube filaments, it is really just a high-quality implementation of the typical industrial-grade commercial or military-grade power supplies of 40 years ago.

At a nominal line voltage of 120 VAC, the B+ is about 400 VDC. This supply is really overdesigned for this application, since it can support a steady-state load of 120 mA.



Type 76 Plate Characteristics

continuously, and would be ideal for powering up a single 300B in self-bias.

I always use electrostatically shielded power and filament transformers in my equipment. These transformers employ a copper shield, known as an electrostatic or Faraday shield, between the primary and secondary windings to reduce the interwinding capacitance. If you have never used these transformers before in a high resolution audio system, the results can be quite startling, in that the music comes from essentially a black background with none of the veiling or fuzz which we normally take for granted as being an inevitable part of sound reproduction.

The shielding isolates most of the noise on the AC line from reaching the secondary of the transformer, since the shield is connected to ground and this noise is effectively bypassed. Electrostatically shielded transformers can be identified by the schematic diagram screened on the transformer case as a series of lines between the primary and secondary windings, terminating in a "ground" symbol.

I am continually amazed at the number of high-end audio products which do not use these shielded transformers, although most professional audio gear from the 40s, 50s, and 60s consistently utilized them.

In my judgement, vacuum tube rectifiers always provide the purest, most natural sound, free from the buzz, hash, and broadband noise of conventional silicon rectifiers. Diode noise suppression techniques and ultra-fast recovery silicon rectifiers have been described in these pages before, but I can't admit to having much success with them from a sonic standpoint.

My favorite rectifier tube is the 5U4G family for power amplifiers, and the 5R4GY for the preamp line stage, although I use the 5U4G for my phono section as well. 5U4Gs are very rich sounding, with considerable weight and authority in their presentation. The 5R4GY tends to be a little thinner and perhaps more open sounding, a nice blend in conjunction with the 5U4Gs found elsewhere in my system.

I find that these directly heated rectifiers always sound better than the indirectly heated variety, such as the 5AR4, 5V4G, 6X4, etc.; to my ears, these always sound muffled and somewhat rough sounding, and lacking in absolute clarity and naturalness.

I believe that the most overrated and overpriced tube rectifier of them all is the WE 274B, which tends to sound thin and uninvolving in my system. I have yet to try the mercury vapor types such the 83, and these offer the lowest internal impedance of any tube rectifier, which clearly is an intrinsic advantage. Note that they must be used only with choke input filters to ensure maximum reliability and operating life, and they can generate broadband noise if not utilized properly.

The double-section LC filter is mandatory. Do not go with a single section as considerable ripple will be present at the power supply output, and you will plainly hear it. In my system, with 100 dB sensitivity horns and zero feedback electronics, I never have any hum, even with my ear right up to the woofer.

Use chokes with a DCR of no more than 150 ohms each or so, a power transformer of at least 120 ma. continuous current capability, and the total power supply source impedance will not be of any concern. Obviously, chassis real estate permitting, if you have access to magnetics which have even lower DCR, use them, because it is always advantageous to have the lowest possible internal impedance within the supply. Be aware, however, that a point of diminishing returns will be reached quickly, and I'll let you find out where that is.

The separate filament supply allows the filaments to be powered up first, and permits them to come up to operating temperature before throwing on the high voltage, so as

to maximize the operating lifetime of the tubes. All of the power supplies in my system have been configured this way. I could have used a simple timer chip and relay circuit to achieve the same thing, but let's keep any digital noise out of our electronics. Be sure to use an electrostatically shielded transformer for the filament supply as well, as we really want to keep all stray noise present on the AC line from reaching the preamplifier assembly.

Although probably not necessary, I also used a star ground for the power supply. The interconnect harness between the power supply and preamplifier units utilizes Amphenol MS (Military Standard) style connectors at each end for a positive, yet easy to remove physical interface. These connectors feature silver-plated contacts, unbeatable strain reliefs, ease of assembly, superb mil-spec quality, and an incredibly wide variety of possible configurations. These connectors can usually be found at flea markets or surplus shops, but the dumpster diving-challenged can buy these connectors directly from Newark Electronics. Shield the interconnect harness with copper braid, and ground the braid at the preamp assembly-side only.

Since the chokes on the preamplifier chassis effectively isolate the preamplifier from the power supply, little audio is really returned to ground through the power supply capacitors, so there might seem to be little theoretical basis to use premium audio-grade caps here. However, when I breadboarded the power supply with electrolytics, the sound was noticeably worse than with the oil in paper. The SCR film capacitors were much better than the electrolytics I tried, but the best sound to my ears was with the oil caps.

Built Like A Battleship

Much has been written in the mainstream audio press of late about the sonic wonders to be derived from electronics which feature mechanical damping, improved rigidity, and so on. In reality, the equipment should have been designed in this fashion in the first place, without depending upon Shun Mook Pods, Shakti Stones, and other dubious, snake oil gimmicks which offer no valid engineering rationale for their claimed effectiveness. Flimsily constructed electronics sound just that way, and for the best possible sound, we should spare no effort in terms of ensuring that the chassis used for the preamplifier and power supply units are as rigid and robust as we can make them.

I fabricated the preamplifier chassis myself, bending 0.062 inch thick aluminum stock during my lunch hours in the machine shop of the company where I work. I'll never do this ever again, but the resulting metalwork is definitely much better than anything you can buy at the store.

For off-the-shelf chassis, consider those made by Premier Metal Products, of Bronx, N.Y. They offer a line of reasonably well-made standard products which are stamped from 0.062 inch thick aluminum, but be prepared to extensively brace them. I machined some side panels from 0.250 inch thick aluminum, and bolted the entire assembly together using stainless steel machine screws and 3/16 inch thick by 1.0 inch wide 6061-T6 structural aluminum angle stock.

This angle stock is also used to stiffen and brace the top panel of the chassis, and completely eliminates any flexion of this surface as well.

All blind holes, such as those used to attach the bottom cover, utilize interference-fit no. 6/32 PEM-style nuts; I don't use a single sheet metal screw in my entire system. PEM nuts can be installed by any machine shop specializing in sheet metal work. To have 20 or so of these fasteners installed in the power supply and preamplifier chassis for securing the bottom covers should not cost more than $25.00, and is well worth the cost. Drill out the through holes in the bottom cover panels first, bring everything to your favorite machine shop, and they will transfer-drill the correct sized holes and press the PEMs into your chassis.

I don't recommend the standard-issue chassis bottom covers offered by Premier, Bud, etc., as these are usually fairly flimsy; have the machine shop shear you a 0.125 inch thick piece of aluminum for this.

Before the chassis are painted, they are given a gold irridite chemical film treatment. Irriditing is a simple and inexpensive process which renders aluminum impervious to oxididation while at the same time maintaining an electrically conductive surface which is low in resistivity. It also provides an ideal bonding interface between paint and aluminum. It should not cost more than $25.00 to have two chassis and two bottom panels irridited. Irriditing can generally be sourced through the telephone directory, under "Metal Finishing".

In contrast to most commercially manufactured high-end audio equipment, I strongly believe that all individual mating metallic chassis components should be assembled so that they are free of paint, etc. We are looking for a chassis that will not only serve as a robust structural framework for our electronic creations, but one which will provide effective electrical shielding as well.

Since there is no accounting for taste, I'll leave the industrial design aspects up to you. Some homebrewers prefer a more modern grained black or champagne-gold anodized finish, whereas I prefer the 1950's gray hardcore industrial look.

The Sound of The Tubes

I have listened to 76s made by RCA, Sylvania, Tung-Sol, and Philco. In my system and to my ears, they all sound very similar. Considering the incestuous nature of the vacuum tube manufacturing business, perhaps all of these different brands were really built by only one company and private labeled for everyone else. You can safely use any of the aforementioned brands in this circuit.

Note that some 76s can be microphonic, so beware. I am using 1943 production RCA JAN 76s in my preamp, and I have never had any problems with microphonics, but you may have to screen a few tubes to get quiet ones.

The 6SN7 is an entirely different story. First off, the 6SN7 cathode follower in this circuit uses 100% current feedback to improve the linearity of this stage, and my belief set led me to think that cathode followers have no real sound of their own, but was I seriously mistaken on this assumption. The choice of 6SN7 will have a significant effect on the voicing of this preamp.

I tried RCAs, Sylvania JAN and commercial-grade versions, GEs, Raytheons, CBS Hytrons, and red base RCA 5692s. In my system, the obvious winner was the Sylvania brown-based JAN 6SN7WGT with either the green or gold lettering. Fast and clear, with an open, detailed and natural sound, it is the obvious choice to drive the side-getter GE 6SN7GTB input/driver stage I like in my power amplifiers. The Sylvanias sound very different from the warmer, somewhat slower sounding GEs, and the two tubes really complement each other in my system.

The other 6SN7s auditioned were strictly second-rate, and unworthy of serious consideration. Most disappointing is the highly touted and expensive RCA 5692. Classy looking, to be sure, but no real contest with the Sylvania 6SN7WGT and GE GTB.

Interestingly, the commercial version (6SN7GTA/B) of the Sylvania JAN tube is distinctly inferior in sound, and I have no

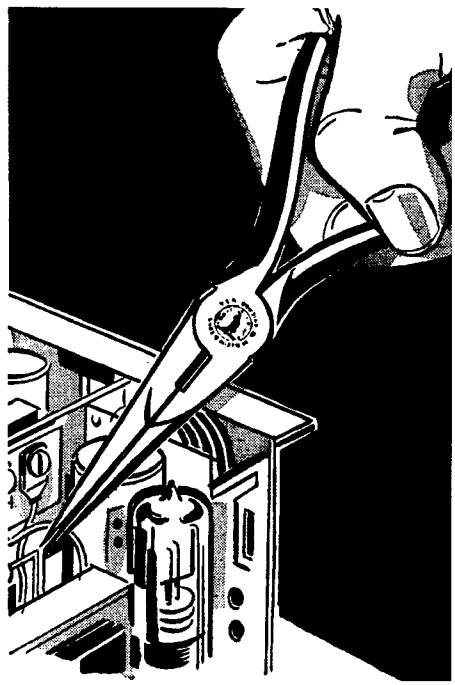
plausible explanation for this. Tung-Sol made a round-plate JAN 6SN7 with a VT nomenclature, probably using 6SL7 tooling, which is fabled to be really great sounding, but I have never heard these. Forget about the Russian and Chinese versions which are currently available since the great NOS tubes are still so easy to get.

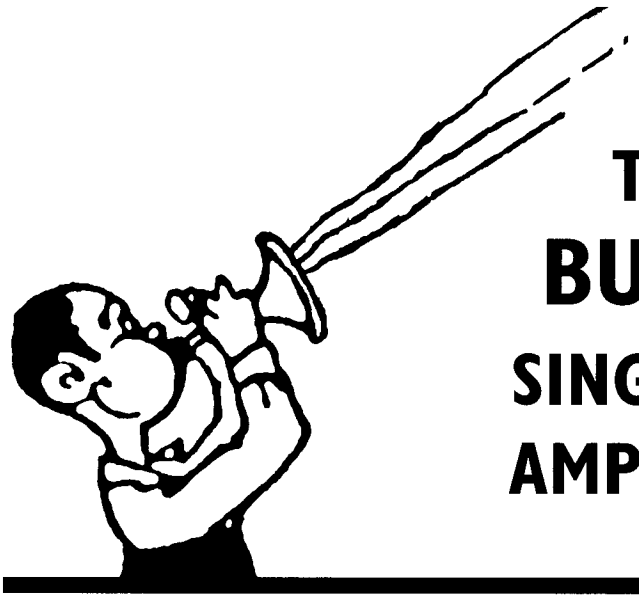
For the power supply, use any U.S.-made 5U4G, GA, or GB; or for an airier, more open sound, try the 5R4GY, GYA, or GYB versions. Whatever you do, experiment with different tubes until you arrive at the combination which most suits your listening tastes.

As discussed earlier, this line stage preamplifier will not be to everyone's liking. Perhaps listeners of conventional off-the-shelf high-end systems with inefficient direct radiating speakers and so forth using this unit may possibly find the sound to be somewhat slow and uninvolving, due to the sound of the oil and paper capacitors and other reasons elaborated on earlier.

I tried to design and construct a unit that aspires to my sonic ideals, aesthetics, and system-building style. I believe that this line amplifier would fit most comfortably in systems utilizing directly-heated single-ended or push-pull triode amplifiers with no global feedback, driving horn-loaded loudspeakers.

But, then again, I could be mistaken about this. Many of the strongly-held assumptions and beliefs I had about system matching and audio engineering in general have been seriously challenged of late, and this could well be another example!





THE BUGLE SINGLE 45 AMPLIFIER

by Gordon Rankin, Wavelength Audio

The chief scientist at Wavelength throws the DIYers another bone...

For some time now I have been building obscure amplifiers under the names of some of the better brass instruments. The *Trumpet* was my original name for the *Baby Ongaku* from *SP #9*, the *Flugelhorn* is an interstage coupled parallel 45 amplifier and the *Trombone* is a cool 300B circuit. All of these designs are less than apt for today's market because of one attribute or another—unavailable tubes, "weird" idea, not enough power for the US (bull-headed) market.

Today we are going to analyze my favorite from this collection, the *Bugle*. The *Bugle* is a stereo 45 amplifier yielding a generous 2.5W of power. I don't even try to sell this amp anymore because of time and sketchy availability of the 45 tube, but sound-wise this amp would be a good investment for the DIY hobbyist. It is designed to be a simple, high performance circuit that also would be simple to build.

One nice thing is that a 45 is always a single plate tube and a lot easier and cheaper to find than the single plate 2A3. Also, there are rumblings that the Chinese are remaking the 45 tube, but I haven't seen any yet myself!

When designing an amplifier, I always start by characterizing the speakers and work my way back. I would estimate a good speaker of 95dB sensitivity or better at 8 ohms or higher to be right for this project.

So, let's pick the super-sounding 45 tube, which has a dissipation of 10W on the plate. In my experience the 45 is best with no more than 35mA plate current. We can take the plate voltage up to 275V at that point. I believe that when using the 45 (as well as other directly heated triodes) that self bias is best. The required bias at 275V for 35 mA plate current is -55V (actually, based on the dozens of 45s I have tested, you can expect between 52-54V in real life), which when added to the 275V plate voltage makes for a total B+requirement of 330V.

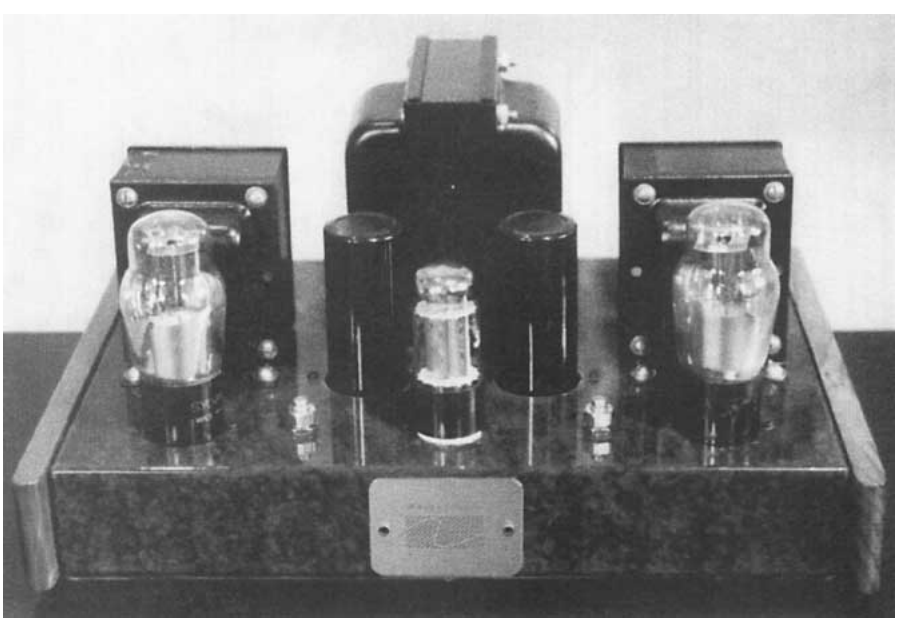
From here, we can calculate the rest of the output stage by selecting the output transformer and the biasing resistor. The plate impedance for a 45 running at 35mA is 1700 ohms. For the best results when using triodes, the transformer primary impedance should at be at least three times the plate impedance of the tube. Since there are no 5.1K primaries in stock, we can easily make do with a 5K primary transformer with a rating of about 35 mA or more.

The bias voltage is between 52-54V volts so, by Ohm's Law, we divide the mean voltage by 35mA and get a bias resistor of 1514 ohms or better yet use a readily available 1.5K unit.

We can determine the wattage dissipated of this resistor by I squared x R = 1.8375W. I try to de-rate all my wattages by a factor of 5 for long life and stability. In this application, I would use at least a 10W rated part. In my version, I used the 12W Mills MRB-12 resistor because they are really nice units at that wattage.

We can see from Sidebar A that the bypass capacitor we need is at least 22uF. A SCR AEON 24uF/250V would work fine.

For the drive stage, we see from Sidebar B that we need a slew rate drive current of 1.1ma or better. Actually we reach the maximum output well before the bias



The Wavelength Audio Bugle Stereo 45 SE – great amp but not a big seller among the power-crazy mainstream market at 2.5 Watts per side!

voltage of -55V, but it is better to have a higher slew rate current for better transient performance.

To get the most out of an input stage I try to set it up so that with a 1V input to the amplifier, I get the maximum output. I then bias the gain stage so that the bias voltage is a factor of 1.5 to 2 times the 1V input (i.e., -1.5V to -2V of biasing). This is done so that the input stage does not clip before the output does.

In the *Bugle,* I originally set everything up for the 6072A, one of my favorite tubes. Then I also found that with the same biasing resistors, the 5751 also worked and provided a higher overall gain. I biased the 6072A at 2V @ 2mA at about 140V per plate in SRPP mode. The bias resistors for each section work out to be 1K.

You can use Sidebar A again to determine the bypass of the lower R in the SRPP. I use the Black Gate BGN 33uF/16V for the job.

I find the SRPP drive stage to be good sounding, and easy to implement,offering a lot better output capacity than plate loading the same tubes. Because there is enough local feedback in an SRPP so that it is not beating the tube for maximum gain, I find it vastly superior in sound to all the types of the mu follower designs. Following this logic, a simple plate loaded tube should sound best, and maybe it does, but then you have to use two stages and that introduces another set of problems. In my experience, the SRPP is the best sounding simple way to go.

At 2mA, the 6072A has plenty of slew rate current. This design has an output impedance of about 15K. The 45 has a maximum grid resistance of 1M in self bias mode. If we use a resistance of 470K (I found some of the globe 45s draw grid current when a higher value is used) we can determine the necessary coupling capacitor.

I found that the best plan for bypassing is to use 5Hz as the limiting low end for calculations. Most designers go way overboard with the bypass capacitance, slowing things down. So we have 1/(2*PI*F*R) = 1/(2*PI*5*470K) = 0.0677uF. I use a 0.047uF for a low end response of 7.2Hz, plenty for this type of amplifier.

Also, the smaller the capacitor the better the sound. Lately the largest coupling capacitor that I can stand is a 0.25uF in an amplifier. I would try the Audio Note copper or silver foil or the Hovland *MusiCaps.* Since there is a potential of 140V across the capacitor, a 400V or higher voltage rating is required.

Okay, so we have the gain, output stage, now we need the power supply. The 45 requires a 2.5V filament at 1.5A, 6072A needs 6.3V/0.3A each, and we need a supply B+ voltage of 330V.

I prefer a choke loaded power supply over a Pi filter because the bass is so much faster and punchier with choke input. For this design I would use the 5AR4/GZ34 rectifier because of the low B+. If you are building an amplifier with a higher B+ voltage, then you may have to use its bigger brother the GZ37. To determine the transformer necessary for the desired B+ output using the curves supplied by Amperex we see that we need a plate to plate voltage of 700-720 for the full dissipation of some 80mA (stereo circuit).

What I do to trim the voltage is to add the input capacitor Cx to get the B+ up to where I want it. The reason the circuit does not come in at the exact voltage shown in the curves is because of the resistance in the choke and losses in the power transformer. A small input cap can be used with a choke input to raise the output voltage to make up for these losses.

With the transformers and chokes I used, the correct value of Cx is 0.68uF. This cap should have a DC voltage rating of 630V or better. Some would say this is a Pi filter but because of the small amount of capacitance after the rectifier this is not really the case. It actually acts very much like a choke input. Refer to Chapter 30 in *Radiotron Designers Handbook,* 4th ed. for details on power supply calculations.[Or look up the power supply chapter in "The Radio Amateur's Handbook," published annually by *The American Radio Relay League* since the dark ages—*ed.*]

SIDEBAR A—
Determining bypass capacitor values

We know that the gain when the bypass is fully functional is mu*R1/(R1*Rp). We also know that with a unbypassed resistor R2, the gain is mu*(1/((Rp +mu*R2)/R1)).

Capacitance has a reactance at any frequency which is given by 1/(2πf).

From these three equations we can determine the bypass capacitance in the following steps:

1) Find the total gain of the circuit.

2) To find the bypass C at a desired -3-dB point, use algebra from gain equ #2:

R2=((mu/gain -1)*R1 -Rp)/mu

R2 is actually the resultant R at frequency f of the C in parallel with Rbias.

3) Then we find the phasor resistance of C from 1/R2 = 1/Zc + 1/Rbias

4) Knowing Zc we calculate C = 1/(2πf*Zc)

Example for the output stage of the Bugle

1) 5000*3.8/(5000+1700) = 2.836

2) -3dB at 5Hz makes the gain at 5 Hz equal to 0.707*2.836 = 2

3) ((3.8/2 - 1)*5000 -1700)/3.8 = 730.7 ohms

4) 1500 ohms in parallel with 730.7 yields a Zc = 1424.739

5) At 5Hz then C= 1/(2*PI*5*1424.739) = 22.34uF close enough to 22uF.

SIDEBAR B—Slew Rate Calculation

Knowing the bandwidth, input voltage and the two input capacitances of the tube, we can determine the necessary slew rate drive current to overcome the input capacitance of the stage.

1) Slew Rate = 2*PI*BANDWIDTH*Vin

2) Per Borbley and others, to fully overcome the input capacitances, multiply #1 by a factor of 5 in slew rate current calculation #4 below.

3) Determine the combined input capacitance as

Ct = (Gain +1)*Cgrid-plate (Cgp) + Cinput (Cinput is sometimes referred to as Grid to Cathode or Cgk).

Plug in the actual gain achieved in the circuit, not the mu of the tube.

4) I (slew rate current) = Ct*5*Slew Rate.

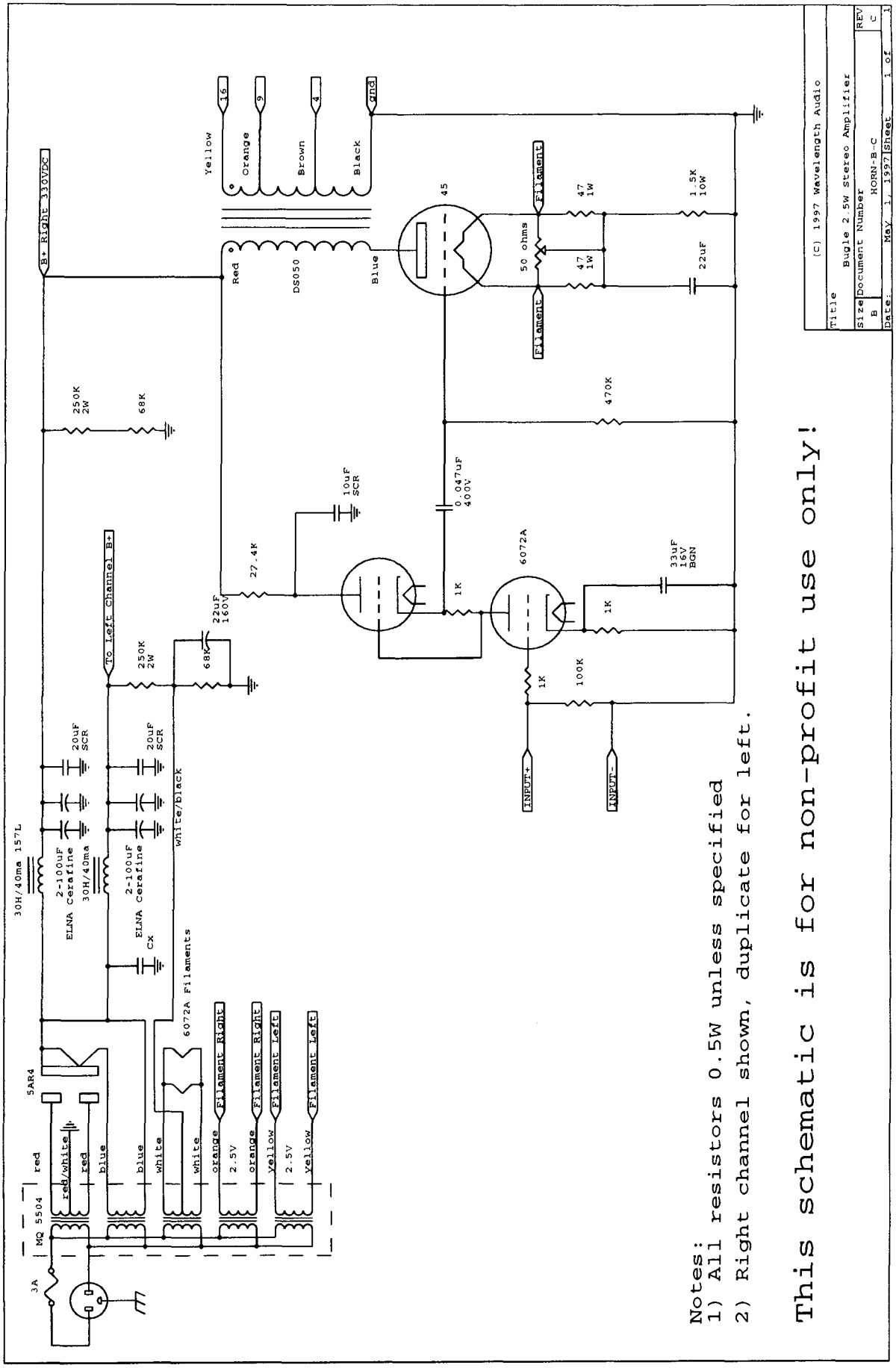
Example for the Type 45 power triode:

1) 2*PI*20Khz*55V = 6,911,503 referred to V/uS works out to be 6.9V/uS

2) 5*6.9V/uS = 34.55V/uS

3) Ct = 7pF*(2.836 +1) + 4pF = 30.8pF

4) I = 30.8pF*34.55V/uS = 1.066ma


This schematic is for non-profit use only!
Notes:
1) All resistors 0.5W unless specified
2) Right channel shown, duplicate for left.
(C) 1997 Wavelength Audio
Title
Bugle 2.5W Stereo Amplifier
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B
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C
Date:
May 1, 1997
Sheet
1 of
1
B+ Right 330VDC
To Left Channel B+
Yellow
Orange
Brown
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16
9
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gnd
Red
Blue
DS050
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Filament
Filament
50 ohms
47 1W
47 1W
1.5K 10W
22uF
470K
250K 2W
68K
10uF SCR
0.047uF 400V
27.4K
22uF 160V
68K
250K 2W
6072A
1K
1K
1K
100K
33uF 16V BGN
INPUT+
INPUT-
20uF SCR
20uF SCR
2-100uF ELNA Cerafine
2-100uF ELNA Cerafine
Cx
30H/40ma
30H/40ma 157L
white/black
6072A Filaments
5AR4
MQ 5504
3A
red
red/white
red
blue
blue
white
white
orange
2.5V
orange
2.5V
yellow
yellow
Filament Right
Filament Right
Filament Left
Filament Left

I have found large chokes and smaller capacitors to be the best case for choke loaded supplies, but high capacitance or multiple stage supplies are necessary for low ripple on the supply. Here we will use 2-100uF in parallel with a 20uF SCR film for a high-C, single-section supply. That will drop the ripple down to less than 30 mV p-p with a 30H Hammond 157G choke for each channel.

Since we have a B+ of 330V we need to drop this voltage for the 6072A by around 55V @ 2ma, requiring a resistor equal to 27.5K ohms. A 27.4K with a wattage of 0.5W or better should do the trick.

Also since the upper cathode of the 6072A (or 5751) will be at 140V+ volts, we want to put a positive voltage on the heaters relative to ground so that the cathodes do not exceed the rating for cathode to heater voltage (90V for both types). If we use around 70V, both cathodes will be in good shape. A voltage divider consisting of 250K & 68.1K resistors across the B+ provides the needed 70V bias.

That's it for design, now some parts notes:

I use Shinko tantalums for all my 0.5W and 1W needs these are available from *Angela Instruments* (301)725-0451. The Mills and most of the capacitors are available from *Michael Percy* (415)669-7181. The chokes are available from *Handmade* (610) 432-5732. The chassis are available from *Experiences Sonores* (418)652-8788 FAX—see ad in *SP #12* page 50, right picture is the *Bugle* chassis. The output and power transformers are from my faves *MagneQuest* (what's that number...) (215) 288-4816.

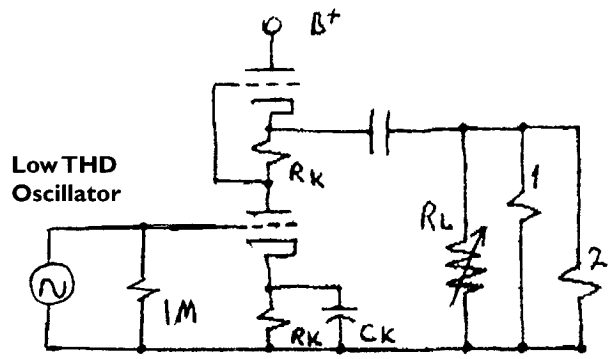
I present this work in the spirit of DIY for the personal, non-commercial, hobby use of SP readers *only*. I must restrict copying of this schematic, without written permission from *Sound Practices* and *Wavelength Audio*. Also, please do not call me and ask me what color to paint the amplifier. I can respond to *e-mail questions only* at: waudio@cinti.net. No calls please! Somebody's got to work around here!

Thanks and have a good time!

Gordon

DISTORTION MINIMA LOADING of the SRPP

by
Mike Vans Evers,
The Vans Evers Co.



1- 5 Megohm VTVM

2- 100k Input Impedance of distortion analyser

Rk = 787R
Ck = 47mF
B+=300 V
Oscillator at 2kHz

SRPP DML Test Set-Up

The series-regulated push-pull (SRPP) circuit has an interesting quirk that bears illumination. Decreasing the value of the load resistor on a normal active stage, tube or otherwise, usually causes distortion to go up, and maximum Vout for a given distortion level to go down. Not so with the SRPP. There is a dip in the distortion/load curve (see graph) that cuts distortion at least in half. Of the more than three dozen tubes that I tested, only a few failed to exhibit this characteristic dip. The value of load resistor is different for each type and brand of tube. At this point in time, there is no cookbook formula, so a THD analyser is necessary for determining this value.

It seemed apropos to call this technique Distortion-Minima Loading (DML). Looking at the DML benefit another way, an SRPP loaded properly will have a higher output swing for any given level of %THD (see table 1).

This quirk has side benefits that can be exploited in minimalist line-level preamps. Voltage gain circuits amplify more than just the signal. They also amplify internal and externally generated noise. High gain circuits generally have more noise at the output of the preamp than do low gain circuits. Because these circuits are commonly connected after the volume control and thus directly to the output of the preamp, all the self-noise becomes part of the signal. This amplified noise can become a significant portion of low-level signals, causing low-level detail and three-dimensionality to suffer.

The benefit of a low-gain line stage is that for a given output level, there is less noise mixed in with the signal. The DML technique reduces distortion AND gain, without the need for loop negative feedback. For example, a 12AU7 SRPP using the DML technique has a gain of about 10 dB, which is more than plenty for most line amplifier applications.

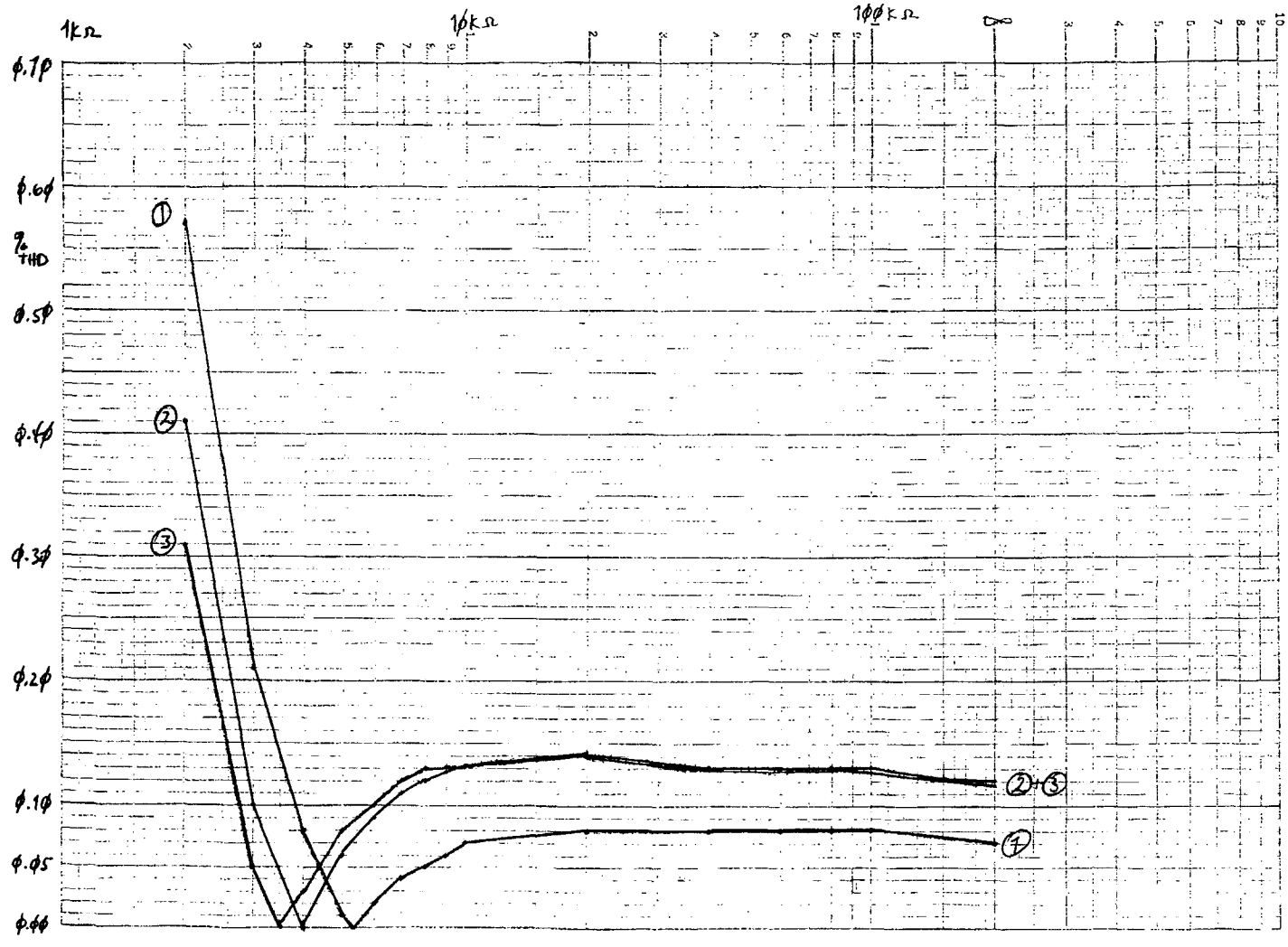
Table 1

R_L (Ω)	DML=Actual Load RL/5MΩ/100kΩ	Ck (μF)	V_{RMS} Output for 1% THD 7119 #1	5687 #1
20k	16.6k	0	24.1	22.5
20k	16.6k	47	12.1	12.3
10k	9.98k	0	35.6	26.7
10k	9.98k	47	11.5	11.3
7k	6.99k	0	44.8(0.45%)*	
5k	6.99k	0		34.3(0.7%)*

* Insufficient Osc. Vout for 1% THD

Table 2

Tube	Max.Vout @ 1%THD (unless other % given)	DML Ω	Frequency Response @ 20 kHz @ DML	R_L=98k
7119 #4	44.2 (0.37%THD)	6.18k	-0.04	-0.06
RCA 5965	50.2	22.2k	-0.36	-0.54
Brand X 12AX7A	28.4 (Rk=1.24k)	16.4k	-0.59	-1.36
Brand Z 12AX7A	20.3	28.9k	-1.66	-2.44
National 12AT7	27.2 (Rk=1.24k)	11.2k	-0.30	-0.87
Sylvania 6DJ8	34.3 (B+=240V)	6.71k	-0.06	-0.11
Syl-ECG 6CG7	19.5	3.66	-0.01	-0.23
GE 6BL7	14.2 (Rk=255R)	794R	0.00	-0.07
Tung-Sol 6BX7	12.4 (Rk=255R) (0.53% THD)	576R	-0.02	-0.04



Vout= 2.0 VRMS
100K analyser Rin not included in graph figures

1— Gold Dragon 6DJ8
2— Amperex BB 6DJ8
3— Telefunken E88CC

Rk=787R
B+=240V

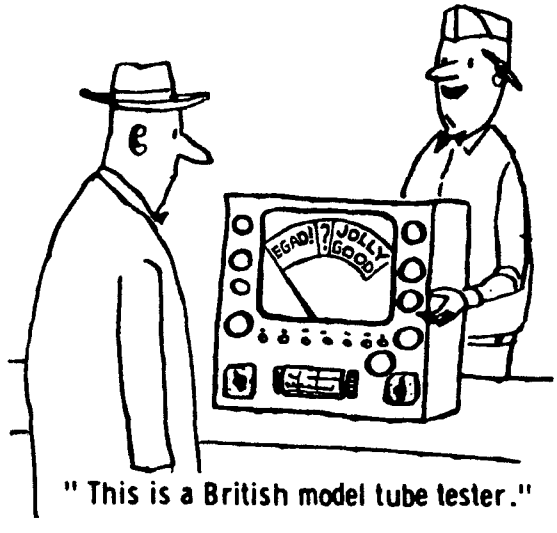
Typical behavior of triode SRPP voltage amplifier illustrating effects of Distortion Minima Loading

Other applications include drivers for EQ circuits, long interconnects, and power amp output tubes. A 7119 DML-SRPP with only 300V B+ can swing 125 volts peak-to-peak with less than 0.5% THD (Tubesox and Pearl iso-sockets recommended to combat microphonics).

There are a couple of questions that would make life easier if they could be answered:

1. How does tube aging affect the DML value?

2. How can the DML value be determined mathematically? (Hint: the DML value usually changes in proportion to the value of the cathode resistor; if Rk goes down, so does the DML value).



" This is a British model tube tester."