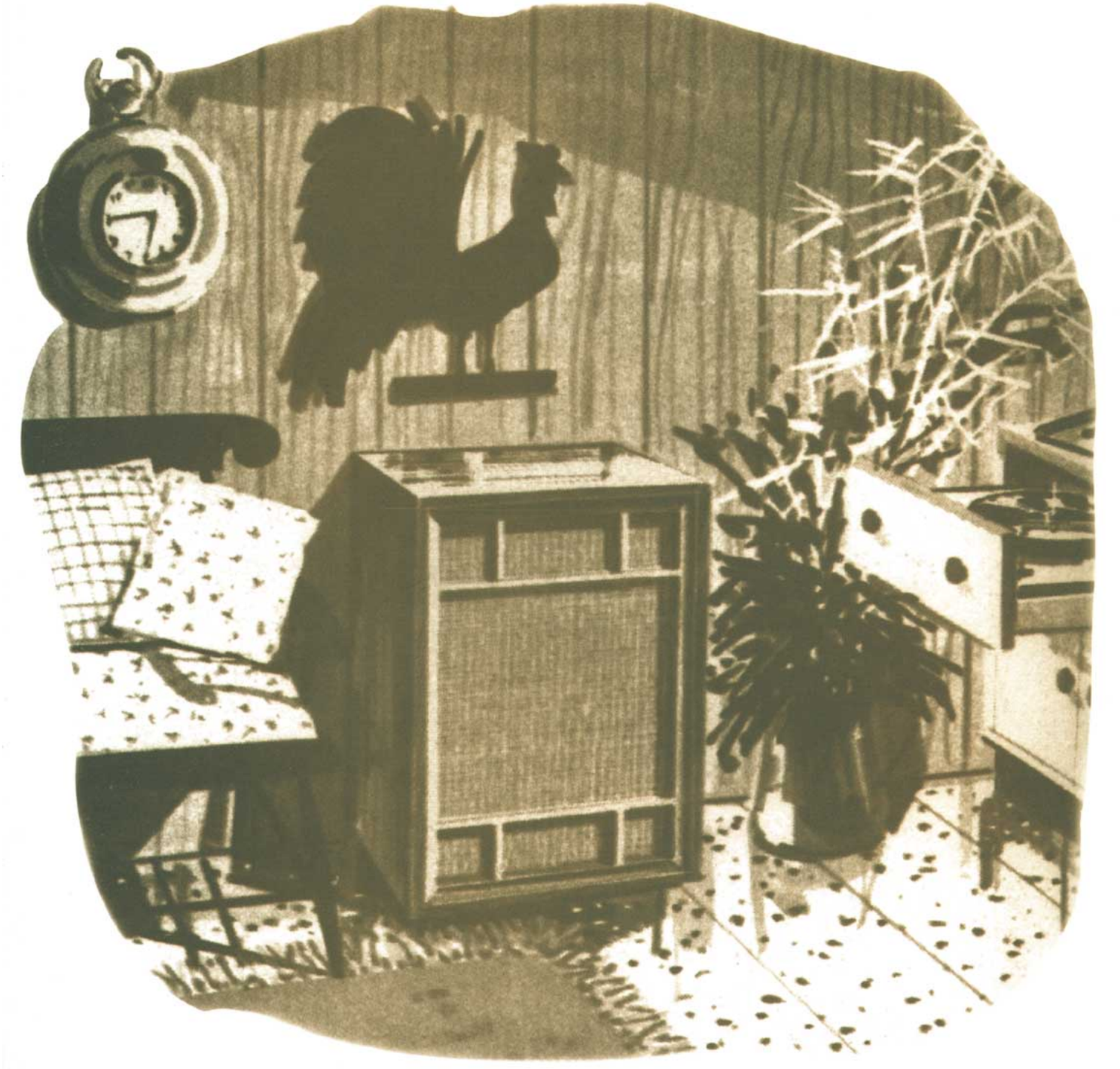
SOUND PRACTICES

A JOURNAL OF AUDIO TECHNOLOGY FIVE DOLLARS



Exotic Reference Systems Issue 11

Sound Practices

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...and MUCH MORE !!!

The Age of Hyperreality

In a nearly incomprehensible essay about our slow and steady drift away from reality as we knew it towards a fragmentary, unrooted, "virtual" existence, the post modernist Baudrillard observes that the deep problems of high-fidelity audio illuminate and embody the core principles of a universal crisis of being in the contemporary world.

Baudrillard outlines a "stereophonic" model of social practice and argues that we have moved beyond old-fashioned cause and effect related history into a non-linear quasi-reality grounded only in *simulation*, the powerful legacy of modern communication technology and the profound capacities for re-production that our wondrous machines provide.

He uses hi-fi as a metaphor to illustrate how we have gone beyond the "vanishing point" into the era of news over direct experience, digitally created collaborations over live ensemble playing, the triumph of represented experience, in all aspects of life.

> *"We are all obsessed with high fidelity, with the quality of musical 'reproduction'. At the consoles of our stereos, armed with our tuners, amplifiers and speakers, we mix, adjust settings, multiply tracks in pursuit of a flawless sound. Is this still music? Where is the high fidelity threshold beyond which music disappears as such? It does not disappear for lack of music but because it passed this limit point; it disappears into the perfection of its materiality, into its own special effect."* —from *The Illusion of the End*

Baudrillard argues that we now live in a "hyperreality" that is a by-product of exploding media sophistication and our increasing reliance on mediated input to construct what passes for *real*. Read audio magazines and note how we have developed parallel definitions of *real* sound that apply only to reproduced sound, without thinking it unnatural in the least to do so.

Under such circumstances, *reality* as we knew it in a more innocent age is a casualty of technology and our uses of it, erased along with the barriers that space and time *used to* present to sensory experience.

Now, that is a rather heady concept but I can relate to the general trends of the argument from the perspective of an audio hobbyist. We all recognize the distinction between music listening, even if it's "simulated" music, and just geeking out on audio for audio's sake. Both pursuits clearly have their attractions and rewards but they are different adventures. Audio maniacs often ignore the fact that they are not the same thing, let alone indications that hi-fi and music exist in a state of tension, such that one denies the other when you really get down to it. If a jazz master is playing solo piano in your living room, what do you need a stereo for? And if you have a perfect stereo, what use is live performance?

Although it is hardly worthwhile or productive to dwell obsessively on this metaphysical predicament, there is a threat that once we enter the domain of audiophilia, we can never listen to recorded music the same way again. Hi-fi music exists within its own system of reference, one where the answer to the question "Is it live or is it Memorex?" is always obvious yet we continue to ask it in hopes that someday we won't have a ready answer. We can fill in the gaps in reproduction partially with faith and desire, but live music only gets played that way once.

This discussion of the mental postures we adopt in listening reminds me of an interview with drum great Max Roach in the August *Stereophile*. Max related how jazz musicians can't help listening *for* certain things when listening to music. Max spoke as though musical civilians were blessed in their technical innocence while musicians are cursed with an involuntary analytical attitude that puts them into a working mode whenever the music plays. The thrill of music listening, acccording to Max, comes when you listen like a layman, an innocent, because then you can get truly involved in the "feeling of joy of music".

Sounds like the familiar "I, Reviewer" syndrome where obsession with sound overshadows the "feeling of music." The point is that it usually matters more how we're listening and why we're listening than what we're listening with. An obsessive focus on the musicological aspects of performance or the perceptual artifacts of reproduction technology virtually guarantees a non musical experience. In this day and age, we need all the joy of music we can get!

La Voice of the Theater Chez Nous

Taming the ALTEC A5 Classic for Domestic Use

by John Stronczer
Bel Canto Design

When I had the opportunity to hear Jean Hiraga's A5 system in the *Nouvelle Revue du Son* listening room with our *Orfeo 30*, 845 SE amp, I *instantly* knew that I had heard the system that could replace the Spendor SP-1s that have been doing the job in our living room for over 13 years.

Actually, the Spendors officially belong to my wife. She always had a suspicion, totally unjustified of course, that I would go out and sell the old reliable SP-1s in an audio frenzy.

I confess that it was love at first listen with the A5s. I mean I listened to a single bar and I *knew.* When I chose the Spendors it took me about 10 minutes of listening. It doesn't take me much listening to recognize a speaker I can really live with.

In any event, the decision to explore a large scale horn system has proven itself to be a positive step. Music has injected itself totally into our lives through these devices, they are, indeed, the other half of the wonderful music creating possibility of the SE triode amplifier.

No, they aren't perfect, although I am not yet certain if any weaknesses are a result of other system components or the recording or the speakers. These speakers make music completely engaging, without any 'High End' audiophile pretensions in the traditional sense.

Sure they aren't perfect (what is?), but they are so much better than any alternatives, and they play music so convincingly that I just don't really notice or care about weaknesses.

A properly set-up A5 system can make one forget about the little audiophile worries and just listen, becoming engaged with the music, whether Hendrix, Gould, Bizet (opera comes positively alive), Brel, Evans, Miles, Nina Simone, the Beatles, you get the idea, every artist communicates their musical potential through a system like this. The source can be CD, LP, radio or even an old cassette, you will still hear more of the music and the musician(s) than you ever have before.

I am not an audio reviewer, so I won't take apart the performance. Let's just say that they can do everything very well, some things better than any other system I have laid ears on. Overall, they are good enough to make other familiar systems seem Dead End. Instead they incite you to dance or laugh or sing or just shake your head in wonder at the musicianship of a performance.

Actually, after living with our customized version of the classic A5 Voice of the Theater system we have concluded that it would be just about impossible to go back to a more 'normal' type of loudspeaker.

Jean Hiraga's System

How do they do what they do? As an engineer this is the first question that comes to mind when I experience something unexpected. This was what led me to the 845 triode and SE amplifiers some 10 years ago and it is happening again with these loudspeakers. I will describe the system that I heard in Paris and continue by describing what I have managed to assemble, looking at the parts before trying to home in on the whole.

M. Hiraga uses the 828 style bass/midbass cabinet with a Westrex (Westrex was the export arm of Western Electric/ALTEC) sourced 515B type 16" bass/mid driver below 500 Hz, a Westrex 2080 1.4" compression driver (Altec 288 C) comes in at 500 Hz and drives a 1505B, 15 segment exponential horn, and for large spaces he brings a JBL ring type tweeter in above 15 kHz.

The crossover/EQ design generously shared by M. Hiraga was essential for getting a loudspeaker which was originally designed to fill a large theater to make music in a reasonably sized home.

The third octave sweep from the system in France and the crossover circuit from M. Hiraga are shown below. It looks somewhat complex but is really quite a simple and elegant solution to the challenge at hand.

The crossover marries these two drivers very well, yielding a response that is remarkably flat in room from about 40 Hz to around 16-17 kHz. I did not use a ring tweeter, agreeing with M. Hiraga that it is not necessary in smaller spaces.

The 828 cabinet is a hybrid design using a short horn loading the 515 above 150 Hz. Below this it behaves as a reflex cabinet, using both the front and back waves plus room augmentation to get enough efficiency to match the short horn midrange. The result is about 100 dB/W/m down to around 40 Hz. This is very high sensitivity for domestic use, enough to get tons of sound out of a 3 watt amp.

Despite the high sensitivity of the A5 system, Hiraga prefers high power SE amps such as the 30 or 60 watt *Orfeo 845* amps, meaning he gets lower overall distortion, better bass and still has plenty of headroom for dynamics in his large listening room. He brings in the HF horn at 500 Hz with some EQ in the crossover to extend the upper end response to around 16-17 kHz and bring the overall efficiency in line with the bass cabinet.

The 1505B is mounted above the bass cabinet, phase aligned and directed down towards a listener about 12-15 ft away from the speakers. The Altec horn has a fixture which allows the vertical angle of the horn to be changed, permitting you to aim the horn at the listening height and blend it with the bass driver. The horn is not rigidly mounted to the bass cabinet, you can move it to align for best phase response with the bass.

The JBL super tweeter is placed well back on the external rear top of the bass cabinet, also phase aligned and firing at a 45 degree angle into the listening area. This fills the room with the high harmonics and reduces the directionality of the system.

Thanks to the extensive EQ in the crossover, a passive unit designed for use with one amplifier, the sound is very balanced. M. Hiraga changed the port opening on the bass cabinet to better align the reflex cabinet and he uses side mounted bass 'wings' to restore the low bass efficiency for use away from room boundaries. There is some strategically placed damping putty on the mid horn and there is a large thick felt blanket in front of the JBL to prevent reflections off of the cabinet top.

I find the whole assembly attractive in a purposeful industrial design, no nonsense kind of way. My wife has been convinced to live with ours, especially after hearing what they do for music, and a promise from me to clean up the finish a bit. It does take up space, to be sure, but it makes more and better music than any other system I have heard.

Despite the size, it won't go down to 20 Hz, that will have to wait for some kind of serious subwoofer system in the future. The rest of the spectrum reveals how uninvolving and uncommunicative most 'High-End' systems are. Not even taking SE triodes into the equation, this kind of speaker will get the most out of whatever goes in front of it. This is the direction that we need to go.

The Logic of A5 Systems

So, what can we learn from Hiraga's A5 based system?

1) Use high performance, intrinsically linear (i.e. low distortion), high efficiency, drivers and cabinets.

2) Avoid overly extended or resonant cabinet alignments.

3) Use as wide a midrange bandwidth as possible, avoiding crossovers in the 1000 to 3000Hz region. The special qualities of this loudspeaker are in part due to the use of only two drivers for full range response.

4) Phase align and focus the driver alignment.

5) Pay attention to response smoothness over absolute maximum efficiency, 96-100 dB will be enough for virtually any domestic situation even with only a few watts.

6) Make sure the upper harmonic energy is there and can get around the room.

7) Don't worry too much about the lowest octave, especially at the expense of the upper and mid bass performance. The low bass is where the mud starts. And above all, keep it simple.

I will now detail the speaker by addressing each of the above points and discussing specifics of my implementation:

Driver Quality is where everything starts...

The 515 bass driver and 825/828 style cabinet are remarkable for their efficiency, bandwidth and low distortion. I used a 16 ohm 515E driver. This is the ceramic version of the 515B, the legendary Alnico driver.

The 515B and 515E apparently have less midrange output than the new 515G version. This is probably a good thing as there is about a 5 dB step from around 150 Hz up shown in the 515G documentation. This is great when projecting sound in a theater, through a screen, but it definitely needs taming for domestic use.

I personally have no problem with the ceramic version of this driver, the moving

1— According to Altec expert Gary Jones, the early versions of the A5/A7 bass cabinet were called 825, which was replaced by the 828 when the 515 switched from a 15" frame to a 16" frame in the mid-70s. The later woofers will fit in the 825 cabs because the mounting holes are slotted. The early woofers will not fit in the 828.

elements are the same as the 515B version and assuming the gap linearity and flux density is high enough I won't ever have to agonize about whether the Alnico needs to be remagnetized as they sometimes do after time or after a mechanical blow or overload. The 515s are great drivers in any version.

515s have enormous magnets and the 3 inch edge wound aluminum ribbon voice coils are underhung, which greatly increases the driver linearity. The 16 ohm version has a BL factor, which is a measure of the magnetic flux density times the number of turns of wire in the gap, of about 22 for the 515E. Contrast this with a good 8 inch High End woofer BL factor of around 5-8. This is remarkable for any driver and especially impressive in combination with the underhung design mentioned above. This gives an idea of the acceleration potential and the control that this motor system can provide.

The cone is a beautiful paper construction with a very stiff spider. You can push on the edge of the 15 inch cone and there is no rocking, just a linear movement of the whole cone.

The dust cap has a 1 inch hole in the center to avoid compression distortion and dust cap coloration and the damped, pleated suspension avoids the low level hysteresis loss typical of rubber surrounds.

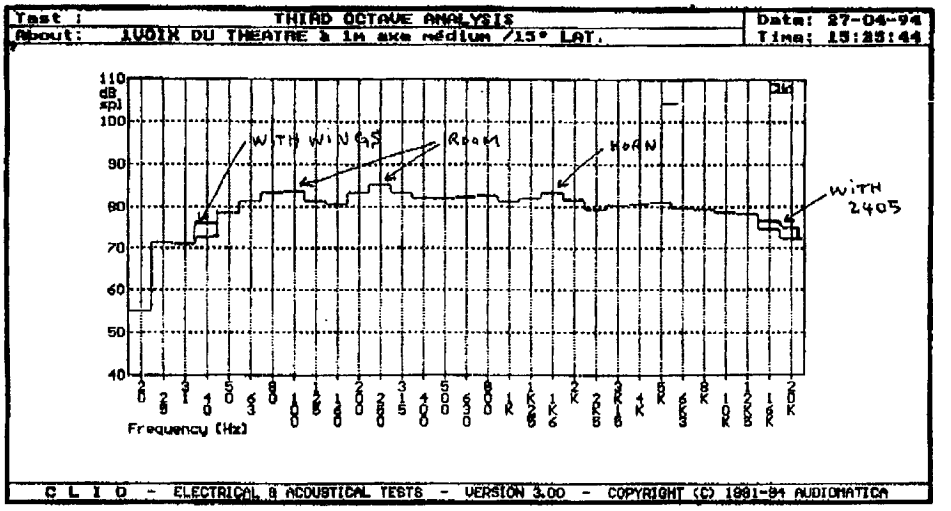
The frame is a masterpiece, with a 1 inch thick edge and massive support beam construction with little area to constrict the back wave flow. The 515E weighs in at a cool 30 pounds. There is really no other way to get the low distortion, high efficiency and impact that the 515 provides.

Altec 515s are not mongo PA speakers like many massive pro drivers. Rather, they are delicate instruments which can knock your socks off while they tantalize your subtler senses. They are true high fidelity devices and are rated to handle only about 75 watts of power, no power at all in today's pro speaker universe.

The upper half of the acoustic spectrum is handled by a wonderful driver and horn, the 288K-16 1.4" throat compression driver and the 1505B horn. The version of the 288 that I am using is a newer ceramic magnet 16 ohm unit with the Tangerine precision cast metal phase plug. It goes even higher and cleaner than the older Alnico drivers, making the JBL super tweeter even less necessary.

Above: the A5 system that changed my mind. Jean Hiraga's reference loudspeakers at *La Nouvelle Revue du Son* in Paris

Below: Third octave sweep of frequency response showing contribution of extension "wings" and JBL tweeter.



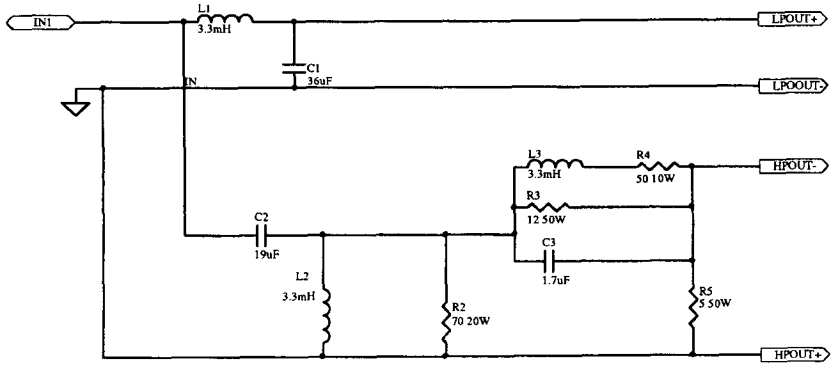
The 288K uses a 2.8 inch diameter concave aluminum alloy dome with integral tangential suspension and edge wound aluminum ribbon voice coil. This "tweeter" weighs 30 pounds giving an idea of the construction quality and magnet size! It has 20,500 gauss flux density in the gap (as much as a Lowther).

The 288K's maximum excursion capability of only 0.035 inches indicates that it is designed to operate without any diaphragm breakup throughout the frequency band and up to very high levels.

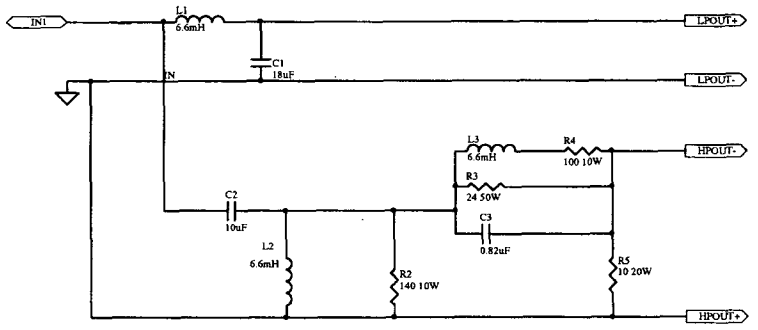
When coupled with a horn like the 1505B it has 112 dB/W/m sensitivity in the 1-5 kHz band! The response drops above this to about 103 dB at 16-17 kHz.

Be sure to pry out the bug screen that these drivers have to protect them in pro use. On the other hand, if you are buying some used you may want to be sure the screens are there if they have been used professionally.

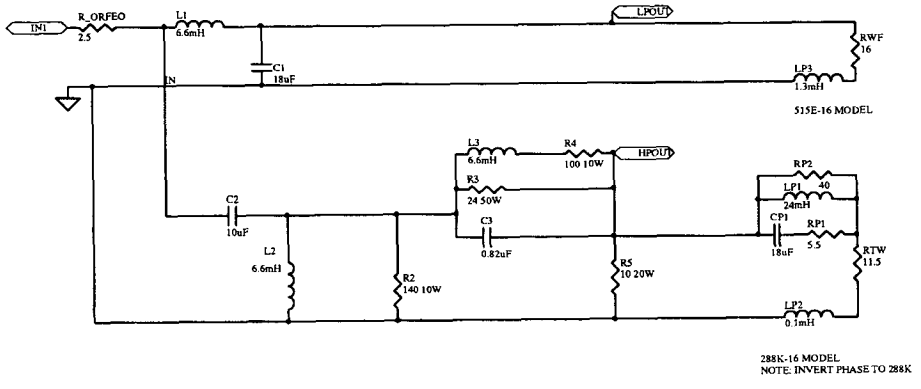
Altec still supplies diaphragms for most of these compression drivers and they can repair, recone and remagnetize most old



Jean Hiraga's crossover for 8 ohm drivers



Crossover component values scaled for 16 ohm drivers from Hiraga's original design



SPICE simulation schematic, including models of 288HF driver, 515 woofer, and simulated output impedance of Orfeo SE 845 amp

cone drivers. The record shows that these puppies can last for over 40 years in auditorium and theater use with virtually no service.

The 288 driver and horn is designed to play at peak levels up to 128-130 dB although its continuous power handling is only around 15 watts. Like the 515 it inhabits a different world from typical "hi-fi" drivers.

Both the low and high frequency horns have controlled directivity with 120 degree horizontal for the high frequency and 90 degree for the low. Both horns have 40 degree vertical dispersion. These dispersion figures mean that they can nicely fill a room but they won't tend to interact as a direct radiator but more like a panel speaker for ceiling and floor reflections.

The very wide dispersion of the 15 cell exponential high frequency horn removes any tendency to beam high frequency energy and cut off your head as many horns can.

The 1505B deserves more description. It is a very large and impressive looking device made from 15 individual exponential horns which come together in a complex assembly having over 3 square feet of radiating area. They are specified for use in theaters with over 400 seats! In my 450 square foot listening room they are barely breathing.

These exponential horns are designed assuming a planar wave launch from the compression driver. It is the job of the phase plug to align the acoustic phase off of the concave diaphragm to approximate a planar wave launch into the driver throat.

The horn really begins with the phase plug. The "Tangerine" plug used in the 288K is a beautifully formed metal piece and allows much of the diaphragm to remain visible through the center of the horn. It appears that the 288 uses about a 2:1 compression ratio through the phase plug. This helps to keep distortion low at high levels and the clear acoustic path helps high frequency extension and clarity.

The 1505B uses long cells to get good low frequency extension with 15 cells in three rows of 5 and a small mouth opening on each cell to get good high frequency extension and dispersion.

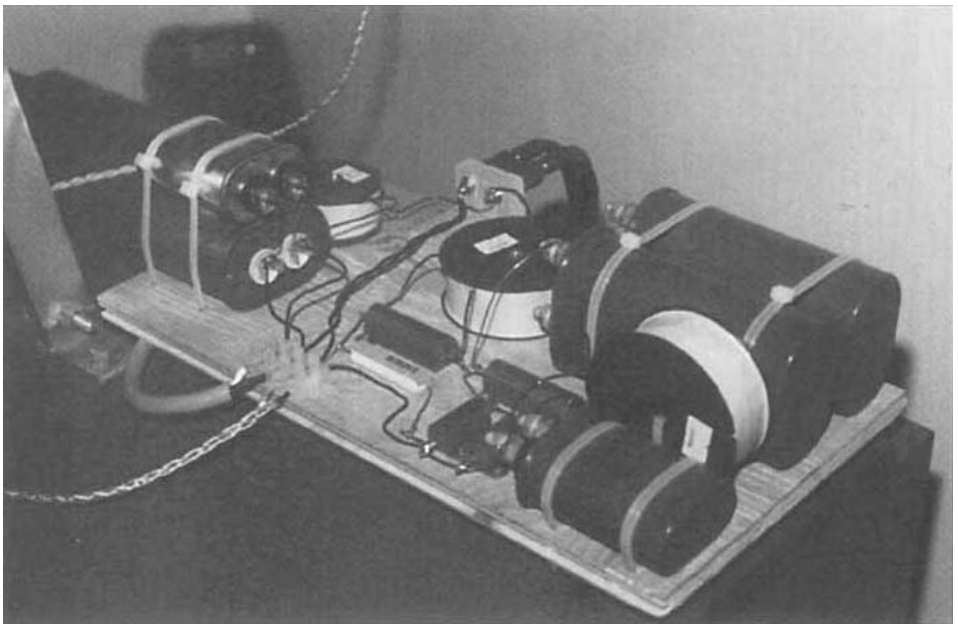
Each individual cell is a hand made aluminum construction with some sort of material like car undercoating used to

dampen any high Q resonances. This is a very effective method and I have had no desire to further dampen this horn.

I hate to think of how much these horns would cost to produce today. They are the only part of this system which cannot be bought off the shelf. If you find some extras, let me know...

I suspect that the enormous mass difference between the moving elements of the 288K and the stationary parts of the 30 pound driver and 30+ pound horn make it doubtful that much energy from the diaphragm goes into resonating these structures. The ability of this combination to reveal natural detailing of harmonic structures and dynamic inflection argues in that direction.

This pair also has the sweetest high frequencies, much like a Maggie ribbon but with much greater impact and dynamic potential.



Constructional Details of Crossover

Make the right tradeoffs in the bass...

The 515 is designed expressly to work in a horn enclosure like the 825/828 cabinet. M. Hiraga has mentioned the golden number ratio when talking about the proportions of this cabinet. These proportions may be why it sounds good even unmodified, with little of the 'boxy' sound that many bass cabinets have. It loads the 515 perfectly, newer ones have the correct volume and port area to allow optimum bass extension and efficiency.

Older ones will need to have the area behind the short horns closed off and the port area reduced by up to 50%. The cabinets that I bought allow some adjustment of the port area and I have set these to the minimum of 25 1/2 by 8 1/4 inches. This port arrangement is near ideal in that the depth of the port is only 5/8", the thickness of the panel. The usual port turbulence and airflow noise is eliminated.

Taken together with the mid-bass short horn and the 1505B HF horn there is about 8.5 square feet of radiating area in each A5. They image and energize a room much like a panel speaker but they have lower distortion, much better efficiency and dynamic capability. There is no troublesome back wave to contend with.

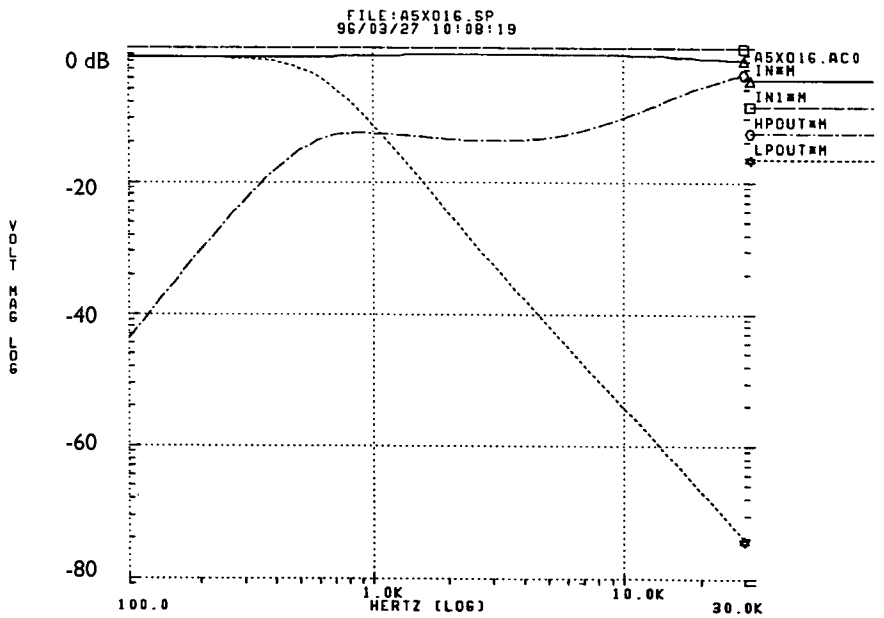
My recent vintage 828 cabinet is well constructed, although it is made of 5/8 inch compressed board. I will be augmenting this with 1/2 or 5/8 inch thick Apple ply, a high quality plywood with thick hardwood ply material. I am going to do this for cosmetic and acoustic reasons.

It has been suggested to inject the area behind the short horn flares with polyurethane insulation material. This sounds like a good idea and should stiffen and dampen the short horn. Although I haven't tried this yet, I don't find much to complain about in the performance that I am getting with the stock boxes.

Make sure that you have a thick bat of fiberglass or other acoustic material on the inside back wall of the enclosure to absorb the back wave at midrange frequencies, the driver is quite close to the back of the enclosure. Don't go overboard here as the low frequencies need to get out of the cabinet or the low frequency extension will be compromised.

If you are looking at older plywood cabinets beware of delamination of the plys as this can be impossible to rectify. Like ceramic magnets, compressed board may not be as sexy but it may be a better overall solution!

I have measured average levels at the listening seat of 100-103 dB when listening



Response of LF, equalized HF driver, and summed response

STANDARD "VOICE OF THE THEATRE" COMPONENT CHART

Model	Amplifier Power (Watts)	Distribution V° H°	L.F. Drivers	H.F. Drivers	H.F. Horn	Throat	Network	L.F. Cabinet	Overall Size – Inches H W D	Approx. Shipping Wt. Lbs.
A1X	200	60 x 125 60 x 105 40 x 100	(6) 515B	(4) 288C	1804B or 1504B or 1004B	(2) 30170 (2) 30170 (2) 30170	N500C	610	113 x 152 x 39½ 113 x 152 x 39½ 105 x 152 x 39½	1530 1500 1475
A1	100	60 x 105 40 x 100	(6) 515B	(2) 288C	1505B or 1005B	(1) 30172 (1) 30170	N500C	610	108½ x 152 x 39½ 102½ x 152 x 39½	1410 1390
A2X	150	60 x 105 40 x 100	(4) 515B	(4) 288C	1504B or 1004B	(2) 30170 (2) 30170	N500C	410	113 x 113 x 39½ 105 x 113 x 39½	1400 1334
A2	80	60 x 105 40 x 100	(4) 515B	(2) 288C	1505B or 1005B	(1) 30172 (1) 30170	N500C	410	108½ x 113 x 39½ 102½ x 113 x 39½	1263 1250
A4X	60	60 x 105 40 x 100	(2) 515B	(2) 288C	1505B or 1005B	(1) 30172 (1) 30170	N500C	210	108½ x 80½ x 39½ 102½ x 80½ x 39½	788 775
A4	40	60 x 105 40 x 100 40 x 80	(2) 515B	(1) 288C	1505B or 1005B or 805B	(1) 30166 (1) 30210 (1) 30162	N500C	210	108½ x 80½ x 39½ 102½ x 80½ x 39½ 102½ x 80½ x 39½	763 750 745
A5X	35	60 x 105 40 x 100 40 x 80	(1) 515B	(1) 288C	1505B or 1005B or 805B	(1) 30166 (1) 30210 (1) 30162	N500C	825B	64 x 30½ x 30 59 x 30 x 27 59 x 30 x 27	393 280 275
A7-8	50	40 x 90	(1) 416-8A	(1) 807-8A	811B	None	N801-8A	825B	52½ x 30 x 24	154
A7-500-8	50	40 x 90	(1) 416-8A	(1) 808-8A	511B	None	N501-8A	825B	54½ x 30 x 24	160
A8	30	60 x 90	(1) 416A	(1) 806A	30623	None	N800D	39624	42 x 30 x 12	112

to some recent Clapton (he sounds like he's fronting a great bar band...). At this level, with plenty of drum and bass energy and peaks of 110 to 115 dB, the 515 drivers are barely moving! This is a direct indication of the low distortion level that this system has under even extreme conditions. Most woofers would be moving up to 1/2 inch at these kinds of levels. This system is not even moving 1/8 inch peak to peak – well within the linear range of the driver.

Like the 1505B, the short horn in the 825/828 enclosure is inherently pleasing to look at and I would recommend leaving it open to the world. I suspect that a clear finish on light birch ply would complement the neutral gray of later 828 cabinets. I am going to make a simple hardwood foot assembly to support the 1505B and the 288 driver assembly. Typically they are mounted with 4 inch long L brackets and the adjustable rear support leg to a piece of 'vulgar' painted plywood, as my wife calls it. A more elegant T shaped construction with three cones for support would bring the 1505 somewhat lower and also provide some worthwhile mechanical isolation from bass cabinet energy.

The crossover brings the system together...

If I did not have M. Hiraga's valuable input into the crossover design I would have been much more concerned about the outcome of this experiment. As it happens, his 10-20 years of experience with this type of system and his insight into how to knit the system together nearly guaranteed some level of success.

His original network shown above is for 8 ohm drivers. I scaled the values for the 16 ohm versions and added R5 to match levels. The complete crossover schematic is shown on p. 8.

I simulated the schematic using SPICE, a program that I use for Integrated Circuit (IC) design. It uses complex matrix equations to solve the nodal values for the circuit and is quite accurate if your model is accurate. The complete simulation schematic is provided on p. 8, including models I developed to simulate the non-linear impedances of the loaded drivers and I have added a 2.5 ohm resistor to simulate the output impedance of a typical SE triode amp driving this network.

L1 and C1 make up a 2nd order butterworth low pass network at 500 Hz for the 515 driver. It is quite simple and classic. For now I have a 500 watt rated ferrite core inductor with less than 0.5 ohm DCR and I used high power 660VAC rated oil filled polypropylene and paper capacitors for the low pass section (GE type 97F41XX). The idea is to be sure that the crossover components are stressed as little as the drivers in typical use.

The high frequency section is more complex with a basic high pass 2nd order section consisting of L2 and C2. I used an air core coil and 10 kHz rated low inductance, high power, oil filled caps for this section (GE type 97F85XX). R2 controls the maximum Q of the inductor and dampens transient overshoot energy, having little effect on the steady state frequency response. L3, and C3 along with R3, R4 and R5 make up a resonant trap with controlled Q and attenuation to equalize the 112 dB midband response of the 288 driver down to 100 dB and to allow it to go to 16 kHz with little attenuation.

The resulting response of this network into the simulated driver impedances is shown on page 9 above. Note that there is about 12 dB (over 4X voltage or 10X power) attenuation from 1-5 kHz with the response above and below this region allowed to rise as the natural rolloffs of the driver/horn take over. Again, L3 is an air core coil and C3 is a 19 kHz rated oil filled cap which are totally unstressed in this application.

The off the shelf cost of these components is more than a manufacturer would put in an entire $1500 pair of speakers, let alone a crossover network. I probably will replace L1 in the woofer circuit with a copper ribbon or some other exotic inductor as it is likely the limiting element in the implementation. All resistors are 50 watt rated wire wound aluminum cased units. You could give some range to R5 for a treble level control. I would suggest a 5 to 20 ohm range, this would give you several dB of adjustment without affecting the crossover frequencies. Use a good quality 20 watt single turn wire wound rheostat with a fixed resistor in series for an adjustable R5.

It is very instructive to listen to each driver alone through the crossover. Each frequency section sounds so very different that you wonder how the mushy low end and tinny high end can come together to make music. I believe that the 500 Hz crossover point is an ideal place for a crossover, as the Fletcher Munson curves show that the ear's operation changes at this point, acting differently above and below this frequency band. It seems a natural point to divide the spectrum. Listening tests bear this out.

Phase align the Bass and Mid drivers...

The separate 1505B horn allows you to move the upper frequency driver to align it with the bass and focus the energy toward your listening area. This is similar to what Wilson does with his larger systems and gives great flexibility in system setup and optimization.

I am using the speakers only about 8 inches from the back wall with the cabinets toed in so that the center is around 10-11 inches from the back and about 55 inches from the side walls. They image fine in this position and the Bestplace software available off the net from RDL Acoustics shows about 6-8 dB of room gain at 40 Hz. If used in a larger room, farther from room boundaries, you will need to add the wings to extend the last octave or so to get 40 Hz response. Putting them nearer to the back wall is great because it reduces the physical impact relative to smaller free standing speakers and the controlled directivity above 150 Hz means that imaging does not suffer at all. If they are too close to the back wall there will be too much mid bass energy.

I found that moving them only a few inches can make a real difference in how they load the room. My room is probably about as small as you would want to go with these and it is about 19 x 23 x 8 1/2 feet. This lets me put them 11 feet apart with a listening position 13-15 feet away. In this setup they have a remarkable ability to disappear acoustically and images can occur between, behind, and beyond them, as the recorded material allows.

When I align the HF horn I use a flashlight to make sure that I can see the diaphragm through the center horn from the listening chair. Then I move the horn forward and back relative to the bass driver while listening to a good female vocal to get the smoothest response through the crossover region. Movements as small as 1/8 inch can be audible.

Why doesn't the stock crossover work in this type of speaker?

That is really quite simple. For theater use the crossover is designed to be as lossless as possible, efficiency is everything when trying to fill a large space with intelligible speech and music.

	515	515B	515C	515E	515-8LF	515-8LFE	515-8G	515-16G	515-8GH
Power	35W	75W	75W	75W	125W	125W	75W	75W	200W
Response*	55-1000Hz	55-1000	55-1000	45-1000	45-1500	45-1000	50-4000	55-4000	60-4000
X-over	500	500	500	500	500	500	2,500	2,500	2,500
Sens.**		105 dB	105 dB	105 dB	105 dB	105 dB	105 dB	106 dB	106.5 dB
Z	16 Ohms	16 Ohms	16 Ohms	16 Ohms	8 Ohms	8 Ohms	8 Ohms	16 Ohms	8 Ohms
Fs	25Hz	25Hz	25Hz	25Hz	25Hz	25Hz	37Hz	37Hz	37Hz
Magnet	Alnico	Alnico	Alnico	Ferrite	Alnico	Ferrite	Ferrite	Ferrite	Ferrite
Flux		1.4750 T	1.4750 T	1.3T	1.4750 T	1.3T	1.5T	1.5T	1.5T
Frame	15"	15"***	16"	16"	16"	16"	16"	16"	16"

Notes: *Frequency response corrected to indicate 3dB down points for all models
**Sensitivity measurements corrected to 1W/1M rating
***515B manufactured after July 1977 had 16" frames

Altec 515 LF Driver Revision History

In a small room for music listening you need at least 12 dB of HF attenuation and you can let the higher harmonics come in better. These horns sound remarkably sweet in the upper frequencies and can even seem overly soft until some real HF energy comes in and startles you with its presence and detail. When EQed correctly, they have a very natural bloom and energy with very low distortion giving a sweet yet detailed sound.

Distortion of this speaker above 100 Hz at 100 dB out will be typically less than 0.05%! This level of distortion is even less than that provided by the 30 watt *Orfeo* amp which is around 0.07% at 1 watt out. I would guess that most people have never heard a loudspeaker with as low distortion as these. This contributes greatly to the naturally detailed sound and dynamics that approach those of live music.

Upper frequency energy is very important to living, breathing music.

Most (virtually all) dome tweeters are totally anemic in presenting upper frequency energy. They lack the bloom and subjective power that is needed to fill out the harmonic structures in music. They also tend to pinch the sound and lack dynamic headroom. The 288/1505B combination allows these frequencies to fill the room with ambiance and harmonic detail that otherwise I have only heard live.

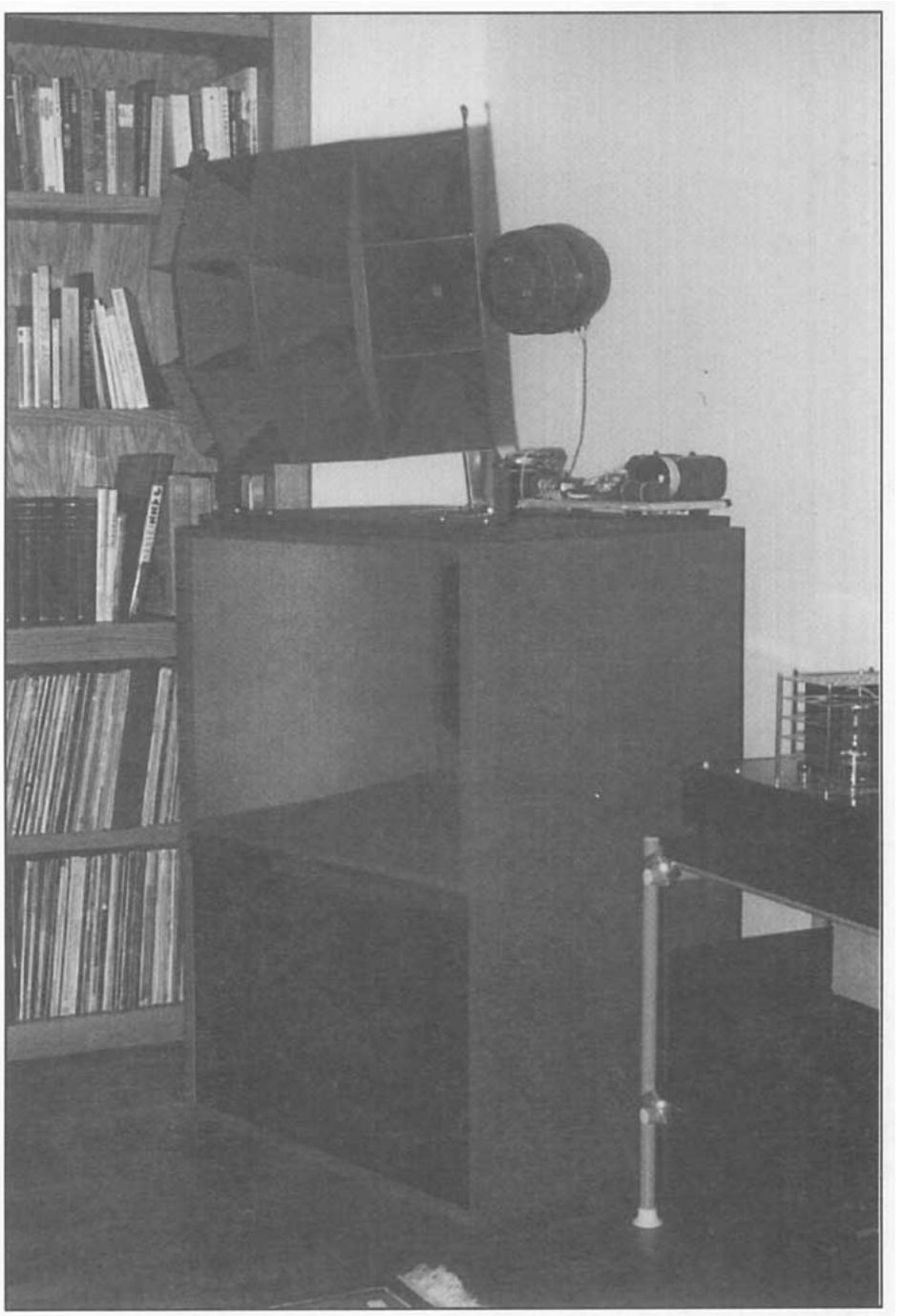
These speakers will not impress your friends with ultra low frequency energy and sensaround experiences.

They will play a cello, timpani and string bass better than you have heard them before with tremendous midbass presence from the short horn and excellent, resonance free bass. If this can't impress your friends, get new ones! I hope that you can hear what a system like this can do. It's worth it.

Addendum

I have just read a recent article in the *Journal of the Audio Engineering Society* (Vol. 44, No. 1/2, 1996 January/February) which throws some light on why the 1505B sounds so much better than other mid horns in my experience. This article titled 'The Sound of Midrange Horns for Studio Monitors' should be required reading. It describes a very well constructed test to compare the sound of midrange horns from 1kHz to 4kHz with several references. These references are the old QUAD electrostatic which is a long time reference for subjective midrange quality, an Audax (Polydax) 6 1/2 inch pro quality cone driver and two horn coupled mids including a large sectoral Fostex and a Tannoy. These references are compared to 14 different horn mids and a couple of cone control drivers. This article could be a model for scientifically valid subjective testing. Care was taken to choose test material and test methodology to avoid listener fatigue and stress and to insure valid results which correlate to listening to music. The authors' approach is much more sophisticated than the ABX method which some have tried to force on the industry.

Anyway, the results showed that there is a horn 'sound' with most mid horns. There were, however, two horns which were never identified as being horns in the blind testing. One is a prototype short horn with a medium mouth opening and a length of only 230mm. The other horn is an old ALTEC 806C 8 cell multicell which is a smaller version of the 1505B with the same basic construction and fewer individual cells.



There are two keys to these horns' performance. The short horn length on the one means that any mouth reflections occur in a short time span and are subjectively innocuous. On the long ALTEC horn the mouth area is large enough, compared to the cutoff frequency, that the mouth reflections are a small fraction of a dB.

The second key to the subjective sound quality is that these horns are designed to have no abrupt flare rate changes along their lengths from the phase plug to the mouth opening. Any flare rate discontinuity causes high frequency reflections which cause spectral colorations and problems in the upper mids and high frequencies. Neither of these horns have flare rate discontinuities when used with the right compression drivers.

Indeed, the ALTEC multicell horn was thought to sound most like the QUAD electrostat. It was not identified as a horn speaker by any of the listeners, including a 'Golden Eared' pro who was among the test subjects. It seems that this old design was very well thought out when it was done originally for cinema use in the 30s and 40s.

I also suggest that you seek out Harry F. Olson's 1947 book *Elements of Acoustical Engineering*. Page 106, section 5.24 has an excellent discussion of the mouth reflection effects of a horn and shows clearly why a large mouthed long horn will sound better, avoiding the 'horn' sound problem that shows up with many small midrange horns. The solution to mid horn sound problems was clearly known back then, they knew more than we have forgotten.

Special thanks to Jean Hiraga for sharing his research with the audio community.

Thanks also to Jim Long and Gary Jones of the Mark IV Audio North America pro sound team.

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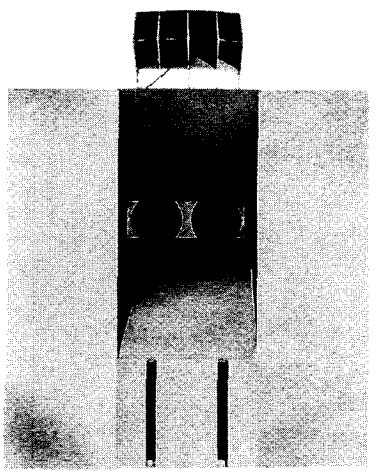
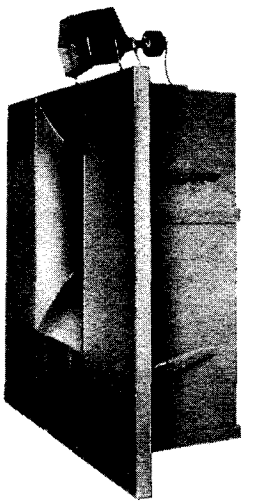
Low Frequency Horns





210 Horn with speakers installed

Features

Direct Radiating

Rugged Construction

Authentic Bass Reproduction

Exponential Expansion

Wide Distribution

Exceptional Air Coupling

Uniform Response

Variety of Sizes

Efficient Bass Projection

For High Quality, Two-Way Sound Systems In . . .
Theatres • Auditoriums • Arenas • Churches
Concert Halls • Audition Rooms

Altec "Voice Of The Theatre" speaker systems are used in more than 12,000 motion picture theatres, auditoriums, arenas and other sound reinforcement installations throughout the world. An important component of each such system is an Altec Low Frequency Horn.

These large low frequency horns ensure proper loading which effects excellent air coupling and enhances the performance of the low frequency loudspeakers. Exponential expansion, properly spatial phased with the high frequency horn, assists the projection of the important mid-range frequencies.

Front loaded in design, Altec Low Frequency Horns have no folds or bends to introduce 'holes' or 'hot spots' in the sound coverage. The elimination of any irregularities assures a uniform response across the dispersion angle of the horn, a factor essential in the calculation of sound systems. The combination bass reflex/front loaded design prevents the boom and false accentuation often associated with public address systems which use other types of enclosures, reduces the amplitude of cone movement at resonant frequencies, and allows higher power input without distortion. The efficient use of the lower end of the sound spectrum contributes to the illusion of loudness and presence required to distinguish the outstanding Altec "Voice Of The Theatre" system from ordinary loudspeaker systems. For installations where the 210 and 410 horns are used on the floor, the use of wings will further improve the bass projection.

Altec Low Frequency Horns are carefully constructed with heavy materials and braced where acoustically required to exclude unwanted vibrations. The sturdiness of these horns permit them to be mounted in walls and ceilings of auditoriums, or to be suspended overhead in large areas. All horns are finished with a flat finish, dark grey, instrument lacquer. Where the horns are to be used in outdoor installations, a weatherproof coating of resin may be applied without impairment of their performance.

These horns are designed for use with either the Altec 416A or 515B Low Frequency loudspeakers. They should be used in conjunction with high frequency horns (multicellular or sectoral) and high frequency drivers for a full range, two-way system (see Table II).

ALTEC LANSING

A Division of LTV Ling Altec, Inc.

1515 S. Manchester Ave., Anaheim, Calif.
New York

1966 ALTEC Engineering Specifications

ALTEC L-F HORNS

TABLE I: SPECIFICATIONS

Horn Model Number (A)	Number of Low Frequency Speakers Per Horn (B)	DIMENSIONS (C)				Weight (Without Wings) (D)
		Height	Width		Depth	
			With Wings	Without Wings		
210	2	84"	80½"	32½"	39½"	560 lbs.
211*	2	32½"	(Not Used)	84"	39½"	560 lbs.
410	4	84"	103"	65"	39½"	890 lbs.
825	1	42"	(Not Used)	30"	24"	100 lbs.

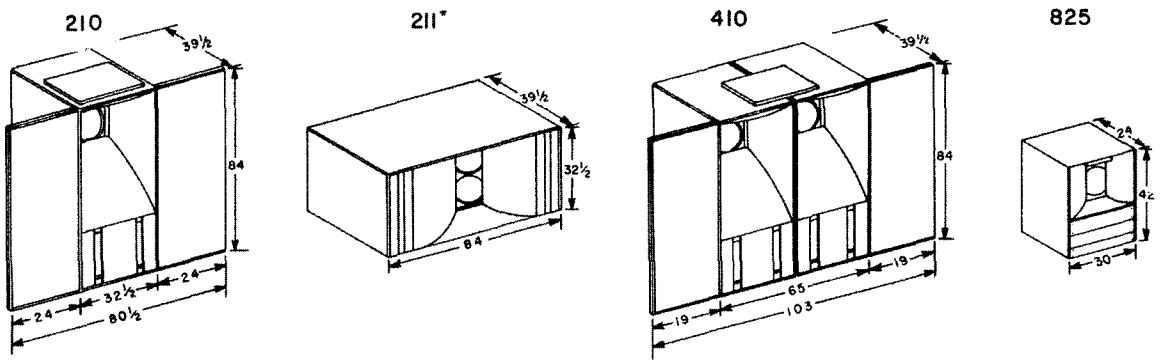


FIGURE 1: Dimensional Drawings of Altec Low Frequency Horns
*Available on special order only

TABLE II: Recommended Components for Complete Systems

LF Horn	Power (Watts)	HF Drivers	LF Drivers	HF Horn No.	Distribution	Throat	Network (16 ohm)	Overall Size H W D	Approx. Shipping Weight
410	150	4 — 288C	4 — 515B	1804B, 1504B, 1004B	60° x 125° 60° x 105° 40° x 100°	2-30170 2-30170 2-30170	N500C	113" x 120" x 39½" 113" x 120" x 39½" 105" x 120" x 39½"	1400
410	80	2 — 288C	4 — 515B	1505B, 1005B	60° x 105° 40° x 100°	1-30172 1-30170	N500C	108½" x 120" x 39½" 102½" x 120" x 39½"	1250
210	60	2 — 288C	2 — 515B	1505B, 1005B	60° x 105° 40° x 100°	1-30172 1-30170	N500C	108½" x 80½" x 39½" 102½" x 80½" x 39½"	775
210	40	1 — 288C	2 — 515B	1505B, 1005B, 805B	60° x 105° 40° x 100° 40° x 80°	1-30166 1-30210 1-30162	N500C	108½" x 80½" x 39½" 102½" x 80½" x 39½" 102½" x 80½" x 39½"	750
825	35	1 — 288C	1 — 515B	1505B, 1005B, 805B	60° x 105° 40° x 100° 40° x 80°	1-30166 1-30210 1-30162	N500C	64" x 30½" x 30" 59" x 30" x 27" 59" x 30" x 27"	275
825	30	1 — 806A	1 — 416A	811B	40° x 90°	None	N800D	54" x 30" x 24"	200
825	30	1 — 806A	1 — 416A	511B	40° x 90°	None	N500E	54" x 30" x 24"	200

NOTICE

We recommend that you obtain your Altec products from factory trained authorized Altec Sound Contractors and Distributors. This will assure you of proper installation, a continuing source of knowledgeable advice, service, and quick warranty protection.

ARCHITECTS AND ENGINEERS SPECIFICATIONS

The low frequency horn shall be of the direct radiating type with an enclosure of combined bass reflex/front loaded type. It shall consist of a short exponential horn designed to match the phasing of the high frequency horn specified elsewhere. Horns which employ folds or bends will not be acceptable under this specification because of their tendency toward frequency concellation.

The horn shall measure (C) and weigh approximately (D). It shall be of heavy plywood and shall be fully braced with 2" x 3", and 2" x 4" frames. It shall be designed to mount and properly load (B) low frequency speakers of the type specified elsewhere.

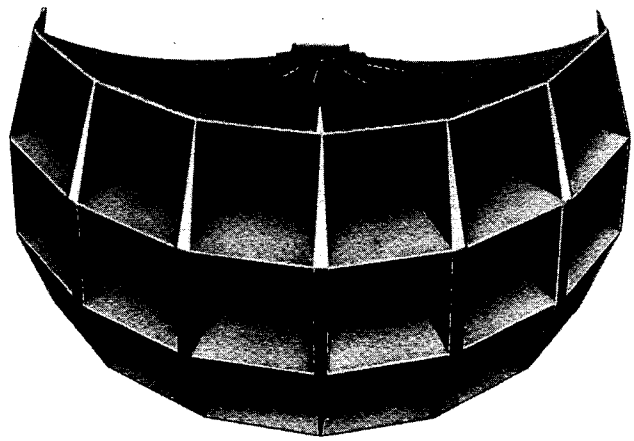
Any low frequency horn not meeting these requirements shall not be acceptable under this specification.

The low frequency horn shall be Altec Lansing Model (A).

Litho in USA C/P 3/66

AL-1435-3

Multicellular Horns



AUDITORIUMS • STADIUMS • ARENAS • THEATRES • AIRPORT TERMINALS
OUTDOOR VOICE WARNING SYSTEMS • INDUSTRIAL AND COMMERCIAL INSTALLATIONS

The exponential multicellular horn is the most efficient of all projectors for delivering top quality sound uniformly over a defined listening area. The unique excellence of the multicellular horn results from its distinctive design:

(a) The multicellular horn consists of a number of individual horns assembled in various configurations to provide controlled angles of vertical and horizontal distribution for best sound coverage of any listening area.

(b) Each horn or cell of the multicellular horn is a straight exponential trumpet through which sound can pass unimpeded. This is a distinct advantage over horns of the re-entrant or reflex type which severely attenuate the high frequencies and cause distortion due to sharp folds or bends in the sound passage.

(c) The column speaker exercises control of sound only in the vertical plane, whereas the multicellular horn controls sound in both the vertical and horizontal planes thus providing the added advantage of restricting sound projection into reverberant side walls.

(d) The re-entrant or reflex horn and the column speaker are handicapped by the fact that the beam width becomes steadily narrower as frequency increases, to a point where sound coverage in the critical high frequency range between 2,000 and 10,000 cycles shrinks to a narrow pencil of sound, in some cases only 15° to 30° wide.
In contrast, the beam width of the multicellular horn above the cross-over region and in the important mid- and high-frequency regions to 12,000 cycles and beyond, is independent of frequency. This entire portion of the frequency spectrum is uniformly distributed throughout the full angle of the horn.

(e) The multicellular horn with its great undistorted power handling capacity (up to 400 watts) is unequaled by any other commercially available sound projector for distribution of highest quality sound over large outdoor areas.

Altec multicellular horns will accommodate as many as four drivers of the 288C type for indoor use, or 730B and 290D type for outdoor use. The latter drivers and the 30546 angle adaptor in combination with a multicell horn constitutes a complete All-Weather system.

The multicellular horn was developed by the Bell Telephone Laboratories of a necessity to insure the success of early talking pictures. Ordinary horns proved incapable of providing good quality coverage to every seat in large theatres, most of which were far from ideal acoustically. The folded horn was discarded in theatre work in 1934 and since that time the multicellular horn has remained the standard of excellence.

The 300 cycle cutoff multicellular horn is often used as a "one-way" speaker where voice only is to be reproduced, or where maximum intelligibility is required to penetrate high ambient noise levels, or for projection over long outdoor distances. The 500 cycle multicellular horn with a 500 cycle crossover network and low frequency speakers, Altec 416A or 515B, are generally used for full range "two-way" loudspeaker systems such as Altec "Voice of the Theatre" systems for the reproduction of high quality voice and music.

PERFORMANCE AND SPECIFICATION DATA ON BACK PAGE

ALTEC LANSING

A Division of LTV Ling Altec, Inc.

1515 S. Manchester Ave., Anaheim, Calif.
New York

MULTICELLULAR HORN PERFORMANCE CHART

Horn Model Number* (a)	Quantity of Drivers Used per Horn (b)	Driver Model Number (c)	Sound Pressure Level Full Power Each Driver** Measured at 30 feet (d)	Sound Pressure Level Full Power Each Driver** Measured at 100 feet (d)	Distribution Pattern (e)	Cutoff Frequency (f)	Cell Configuration	Throat Code Number ***
203B	1	288C	118 db	108 db	20° x 40°	300 cps	1 x 2	(not required)
		290D	121 db	111 db				
		730B	114 db	104 db				
803B	1	288C	115 db	105 db	35° x 70°	300 cps	2 x 4	30162
		290D	118 db	108 db				
		730B	111 db	101 db				
804B	2	288C	118 db	108 db	35° x 70°	400 cps	2 x 4	30172
		290D	121 db	111 db				
		730B	114 db	104 db				
805B	1	288C	113 db	103 db	40° x 80°	500 cps	2 x 4	30162
		290D	116 db	106 db				
		730B	109 db	99 db				
1003B	1	288C	113 db	103 db	35° x 90°	300 cps	2 x 5	30210
		290D	116 db	106 db				
		730B	109 db	99 db				
1003B	2	288C	116 db	106 db	35° x 90°	300 cps	2 x 5	30170
		290D	119 db	109 db				
		730B	112 db	102 db				
1004B	4	288C	119 db	109 db	40° x 100°	400 cps	2 x 5	(2) 30170****
		290D	122 db	112 db				
		730B	115 db	105 db				
1005B	1	288C	112 db	102 db	40° x 100°	500 cps	2 x 5	30210
		290D	115 db	105 db				
		730B	108 db	98 db				
1005B	2	288C	115 db	105 db	40° x 100°	500 cps	2 x 5	30170
		290D	118 db	108 db				
		730B	111 db	101 db				
1504B	4	288C	118 db	108 db	60° x 105°	400 cps	3 x 5	(2) 30170****
		290D	121 db	111 db				
		730B	114 db	104 db				
1505B	1	288C	110 db	100 db	60° x 105°	500 cps	3 x 5	30166
		290D	113 db	103 db				
		730B	106 db	96 db				
1505B	2	288C	113 db	103 db	60° x 105°	500 cps	3 x 5	30172
		290D	116 db	106 db				
		730B	109 db	99 db				
1803B	1	288C	110 db	100 db	53° x 105°	300 cps	3 x 6	30166
		290D	113 db	103 db				
		703B	106 db	96 db				
1803B	2	288C	113 db	103 db	53° x 105°	300 cps	3 x 6	30172
		290D	116 db	106 db				
		730B	109 db	99 db				
1804B	4	288C	116 db	106 db	60° x 125°	400 cps	3 x 6	(2) 30170****
		290D	119 db	109 db				
		730B	112 db	102 db				

* Model code denotes number of cells and horn cutoff frequency. Example: 1504B = a 15 cell horn (3 rows of 5 cells per row) with cutoff frequency of 400 cps.

** Sound Pressure Level (SPL) as shown in column (d) above is based or measured at 30 and 100 feet with full rated power applied to each driver as shown in column (b) and averaged uniformly over 600 to 2,400 cps. (see note 1.)

*** One 30474 Adapter required in addition to indicated throat for each 730B Driver used.

**** If only two drivers are desired on the 400-cycle horn, use two 30210 single throats in place of two 30170 double throats.

NOTE 1. Full power rating on
288C is 40 watts
290D is 100 watts
730B is 60 watts

NOTE 2. Driver units should be protected against low frequency by use of N500C Altec Network, or the 15045A Line Transformer.

NOTE 3. It is recommended that 30546 45-degree angle adapters be added to each driver for added weather protection in all outdoor installations.

NOTE 4. Sound Pressure Level Conversion Table

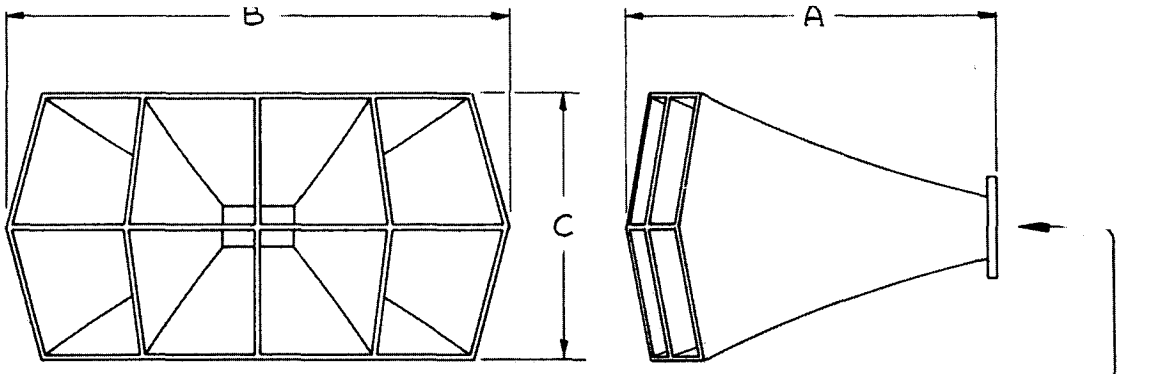
I) To increase SPL 3 db double the input power; to increase 6 db, quadruple the input power.

II) Each time distance of horn projection is doubled substract 6 db SPL.

ARCHITECTS AND ENGINEERS SPECIFICATIONS

The high-frequency horn shall be of the multicellular type, equipped with proper throat and adapters and (b) (c) compression driver or transducer. As specified elsewhere, it shall produce a uniform sound pressure field of (d) db at a distance of (select from d) feet with (Note 1) watts input power applied to each driver over a field of distribution of (e) uniformly averaged over the band of 600 to 2,400 cps. Single frequency measurements will not be acceptable under this specification. The low-frequency cutoff shall be (f) cps.

The horn shall be constructed of individual weatherproofed metal cells with a special damping material coating the external surfaces of each cell. The cells shall all be straight with an exponential expansion. Folded or re-entrant horns or horns fabricated of wood or other fiberous materials will not be acceptable. The horn shall be equipped with mounting brackets or facilities both on the front or mouth and on the appropriate cast throat. Multicellular horn shall be Altec Lansing Model (a).
(Note: Fill in proper values and numbers from Horn Performance Chart.)



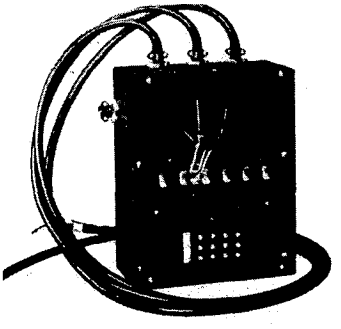
Multicellular Horns

HOW TO SELECT THE CORRECT MULTICELLULAR HORN FOR SPECIFIC AREA COVERAGE

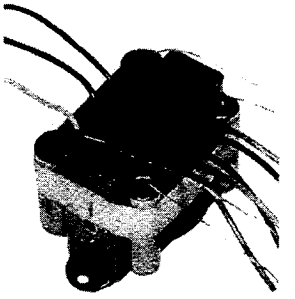
Multicellular projectors are available in several configurations. The sound distribution pattern (angle) is determined by the cell arrangement. Each cell of a 500 cycle horn projects sound over an area of 20° square, or 400 square degrees per cell; a 400 cycle horn distributes sound over an area of 19° square per cell and a 300 cycle horn over an area of 17-1/2° square per cell (2038 horn - 20° square per cell). The sound distribution pattern, both horizontal and vertical, of a horn, is established by the total number of cells assembled in each plane.

Determine the area to be covered and, by reference to the chart on page 4 of this bulletin, select the horn having a distribution pattern which will most closely cover this area. To obtain full advantage of controlled distribution, no greater area of sound coverage should be provided than can be effectively used. Multicellular horns are composed of a group or stack of individual horns so that each small horn becomes a component part of the large horn assembly. All cells are fed from a common throat. The partial spherical front achieved by grouping the cells allows each cell to contribute to the whole without overlap or confusion. In installations where speech only is to be projected, the projection ability of a 300 cycle horn can be increased by sharply cutting off the low frequency energy fed the horn an octave above the rated cutoff of the horn by use of an Altec N-500C network or the 15045A 70-volt line transformer. In this manner, the horn has an effective length considerably greater than its physical length. By selection of the proper cell configuration, the projected sound is fully controlled in both the vertical and horizontal plane and this feature proves useful in combating high reverberation and in minimizing or eliminating acoustic feedback. A 300 cycle horn in combination with a 500 cycle crossover network, will greatly aid in overcoming objectionable reverberation by giving the horn greater projection ability by restricting the radiation of the low frequencies, which are often undesirable in the masking of sound and contribute little or nothing to speech intelligibility.

Accessories



N-500C Dividing Network Set



15045A 70-Volt Line Transformer

30546 45° weatherproof throat adapter

30162 horn throat (single unit)

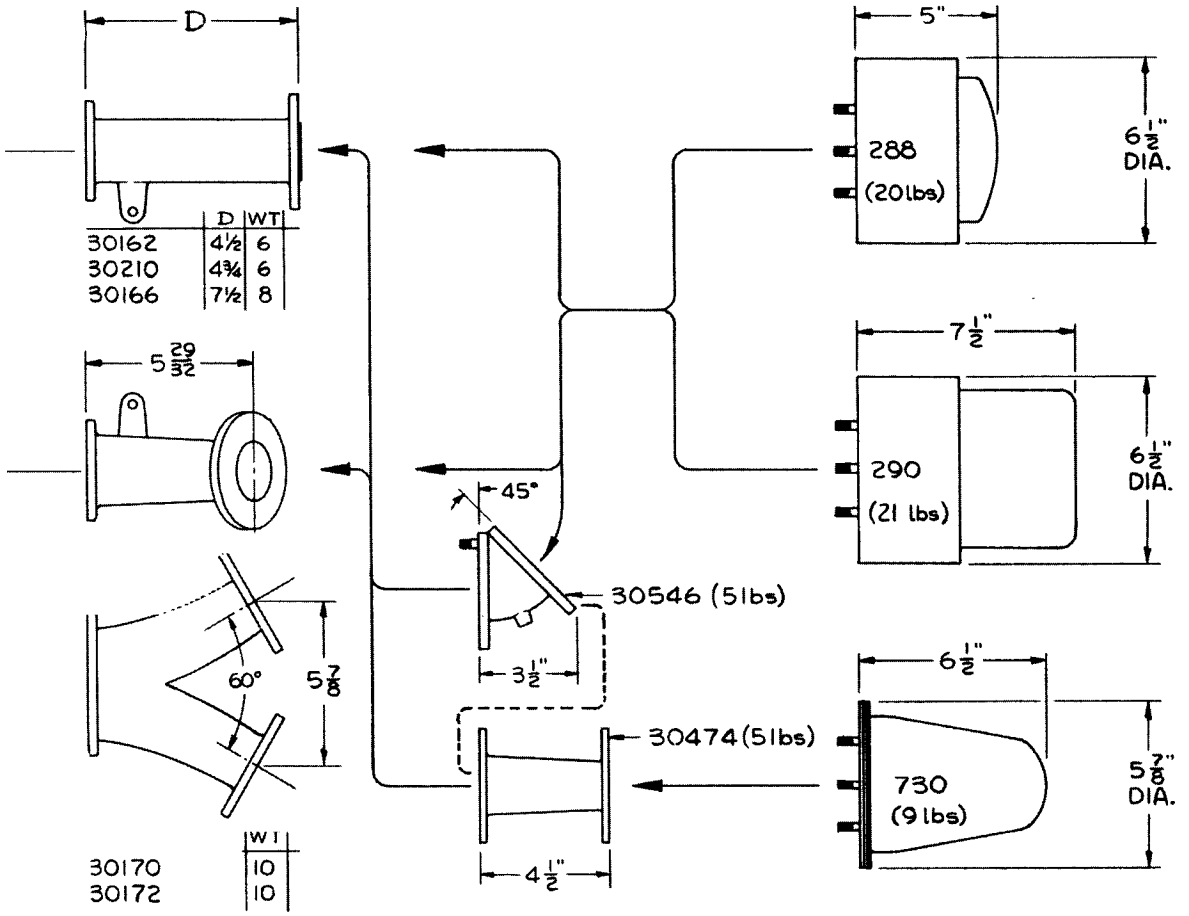
30210 horn throat (single unit)

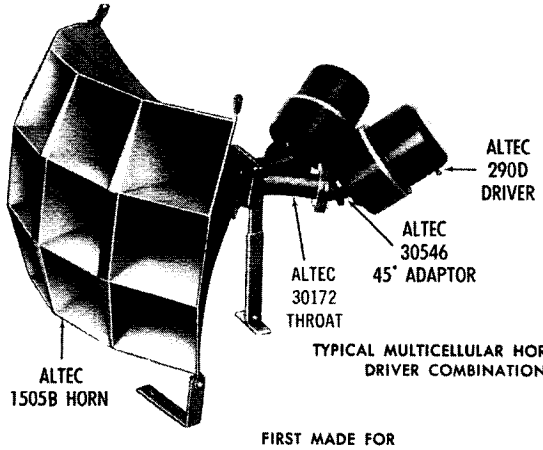
30166 horn throat (single unit)

30170 horn throat (double unit)

30172 horn throat (double unit)

30474 adapter





TYPICAL MULTICELLULAR HORN AND DRIVER COMBINATION

HORN	A	B	C	WT.
203B	31	32	17	22
803B	26 1/2	32	16 1/4	27
804B	23 1/2	32	16 1/4	25
805B	17 1/2	24 1/2	13	17
1003B	25 1/2	38	16 1/8	32
1004B	*20 1/2	38 1/2	16 1/4	30
1005B	17 1/4	30	13	20
1504B	*21	38 3/4	24	48
1505B	16 3/4	30 1/2	18 1/2	22
1803B	27 1/2	44	24	60
1804B	*23 1/2	44	24	58

*(Add 4" for throat adapter)
(Furnished)

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TOLERANCES EXCEPT AS NOTED: FRACT. ± 1/64" DEC. ± .005" HOLE SIZES 0 TO 1/2" ± .001 OVER 1/2" ± .005 ANGULAR ± 1/2°

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A Hardwire Technique for Tube Circuits

by Ron Sawyer

Order out of chaos

Hardwire circuit assembly techniques offer several advantages for the Do-It-Yourselfer who is constructing a one or two of a kind vacuum tube audio project. In addition to eliminating the need to design and fabricate an etched circuit board, hardwire assembly can result in superior ventilation of components and also excellent serviceability, including the ability to make radical modifications.

Photo number 1 is hardwire hell, an excellent example of how not to construct a circuit. Not only poor in appearance, this type of assembly is difficult to service and/or modify. In contrast, Tektronix tube-type instruments are superb examples of a well evolved hardwire technique.

A detail from a Tektronix power supply is shown in photo number 2. The Tektronix factory utilized ceramic terminal strips to support passive components near the associated tubes. We can use readily available edgeboard connectors as terminal strips to emulate the Tektronix style of construction.

Photo 3 shows a selection of edgeboard connectors compared to old style fiber terminal strips. The longest of the edgeboard connectors is shown with threaded aluminum spacers installed as a means of mounting the connector to the chassis. The solder eyelets will be used as the tie-points of the circuit as illustrated in the subsequent photo-demonstration.

The edgeboard connectors are most commonly available with two electrically isolated rows of contacts of which the constructor may utilize one or both depending on circuit complexity. The connectors are available with as few as 6 positions/12 contacts per unit to as many as 43 positions/86 contacts; the larger connectors are more economical on a per terminal basis.

I found that connectors with .156" spacing between terminals are most appropriate for accommodating the larger resistors and capacitors often used in tube circuits as the solder eyelets are bigger and sturdier than those found on the edgeboard connectors with .100" or .125" spacing. For the remainder of this article I will refer to the edgeboard connectors as terminal strips.

The first step is to plan out the wiring scheme of the circuit you wish to construct. Figure 1 is a schematic for a simple line-level voltage amplifier with a direct-coupled cathode follower and Figure 2 is a drawing of the wiring plan. Although layout is not generally critical in this type of audio circuitry, you should try to orient the tube socket to allow for direct and tidy wiring. Low level/high gain amplifiers do require more care in layout and you should try to isolate, as much as practical, the input circuits from the output. You should make a life-size drawing for your plan, and try to have on hand the actual components you will be using.

In Figure 2, I chose a 1.6" spacing between the two rows of terminal strips; this distance may be altered depending on the size of the components you are using.

I like to generously derate (by a minimum of 400%) the resistors I use; if one is going

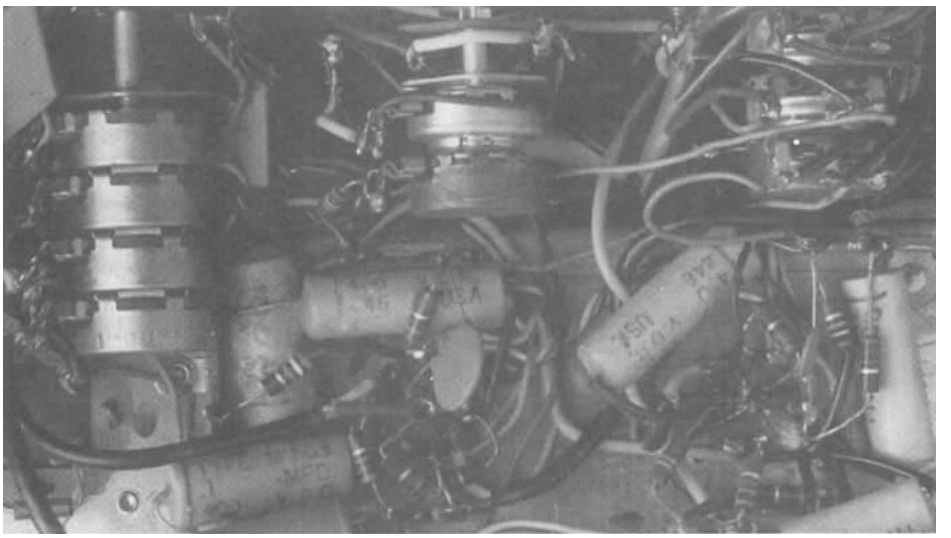


Photo 1—Typical old-fashioned consumer grade hardwire hell

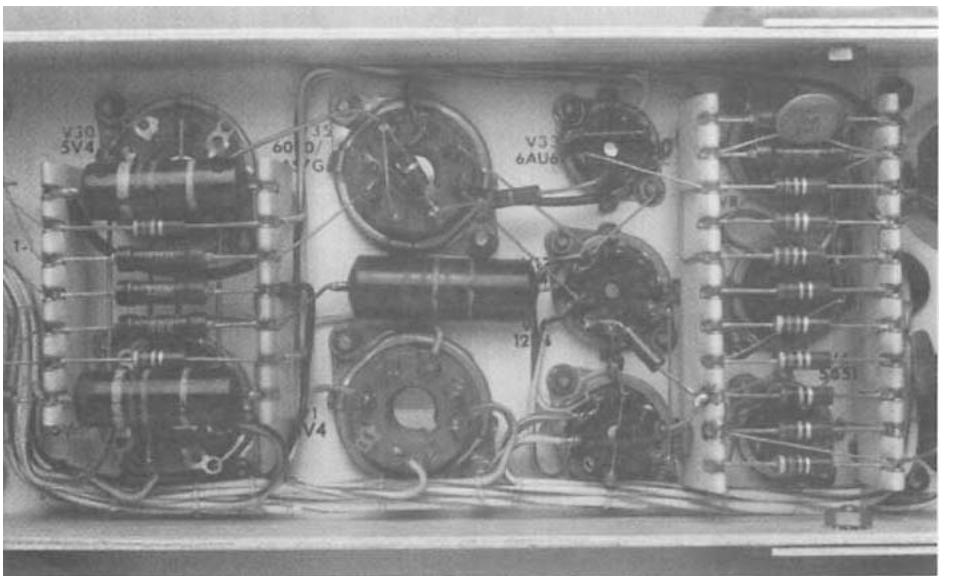


Photo 2—A well-evolved hardwire construction technique

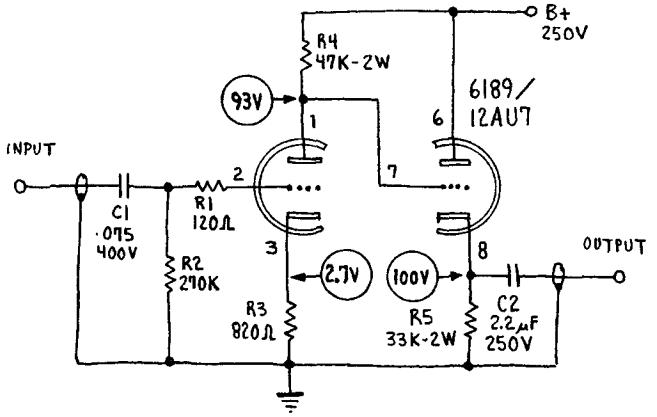


Figure 1 — A simple line amp circuit

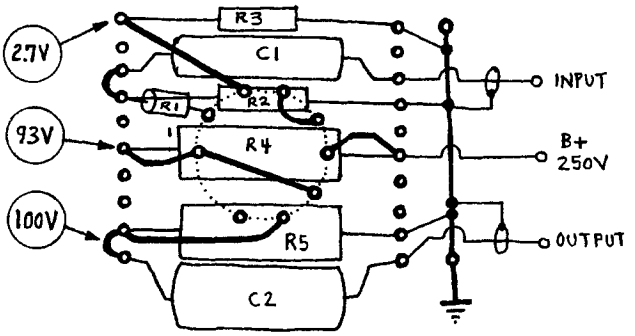


Figure 2—Wiring plan for the circuit of Figure 1

to dissipate 1/2 watt, I use a 2-watter. This aids in achieving stable circuit operation and long service life.

The final drawing plan, when it is verified by actual construction, should be saved for future reference. You may note appropriate electrode voltages as I have shown for the cathodes and plates of the two sections of the 6189/12AU7.

The first assembly step is to mount the tube sockets and terminal strips to the chassis. If you will be using both rows of terminals on the edgeboard connector, you should press-fit a length of artists' mat-board between the two rows of connectors as shown in Photo 4. This precaution avoids the possibility of electrical arcing between the opposing contacts. Artists' mat-board is a compressed cardboard used in picture framing; it is about the same thickness as printed circuit board material that would normally plug into the edgeboard connector. Cut the strip of mat board about 3/8" wide; its length will be determined by the length of the edgeboard connector. Use standoffs to mount the terminal strips; a standoff length of 5/8" is about right.

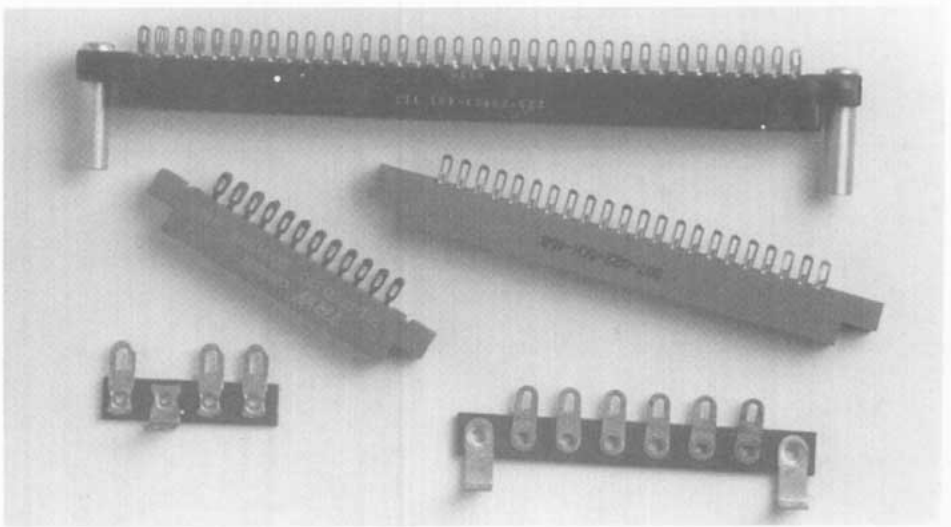


Photo 3— Modern edgeboard connectors and old style fiber terminal strips

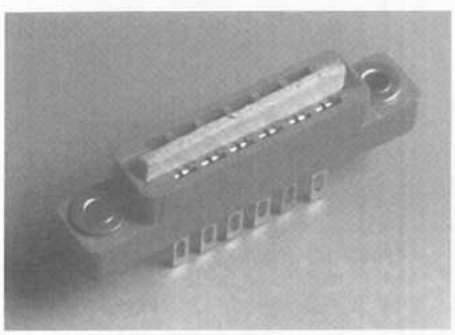


Photo 4— Plug in a strip of mat board to prevent arcing between the two rows of connectors

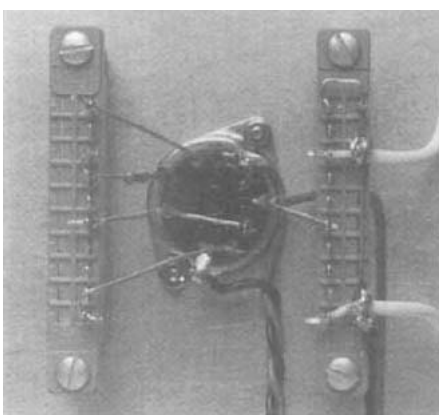


Photo 5— Circuit after initial wiring

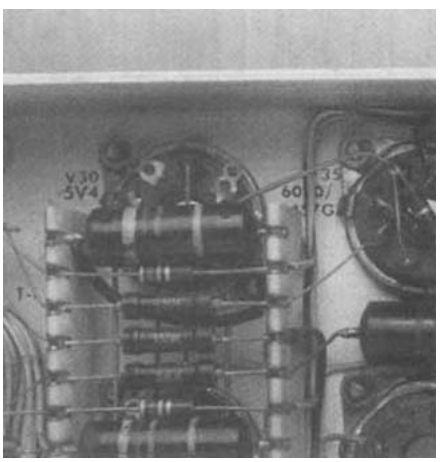


Photo 6 — The circuit with resistors and capacitors mounted

Photo 5 shows the circuit after the initial wiring step. I made connections between the tube socket and terminal strip with tinned copper buss-wire. The "grid-stopper" resistor (R1) has been soldered in place between the terminal strip and the

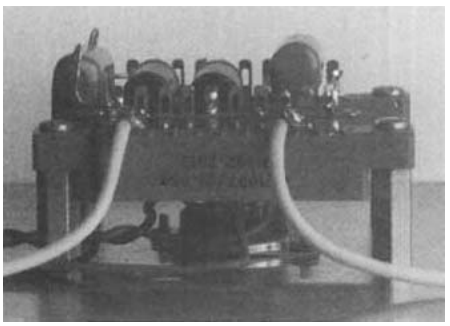


Photo 7—A side view of the circuit

tube socket. Wiring for the tube heaters, the "B+" and ground, and the input and output are also done at this time. If you are using shielded signal wires as I have shown, you may prefer to use teflon insulated types because of their superior heat resistance during soldering.

The final stage of construction involves the installation of the remaining resistors and capacitors, and Photo 6 shows the completed circuit. Photo 7 is a side view. When installing the resistors and capacitors into the terminal strips prior to soldering, do not bend or crimp the component leads as shown in Figure 3a. It is not necessary, and it makes subsequent removal of the part difficult. The terminal eyelet acts as a cradle support for the component leads as in Figure 3b. In Photo 8 you can see how this style of assembly can result in good cooling air circulation around the circuit components which should result in improved long-term reliability.

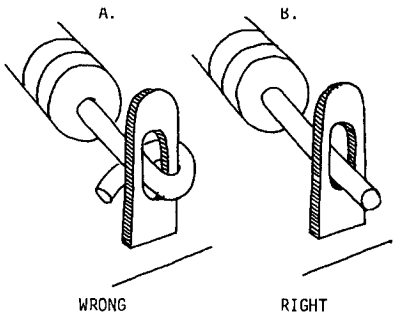


Figure 3 —The proper way to install conductors into the connectors before soldering

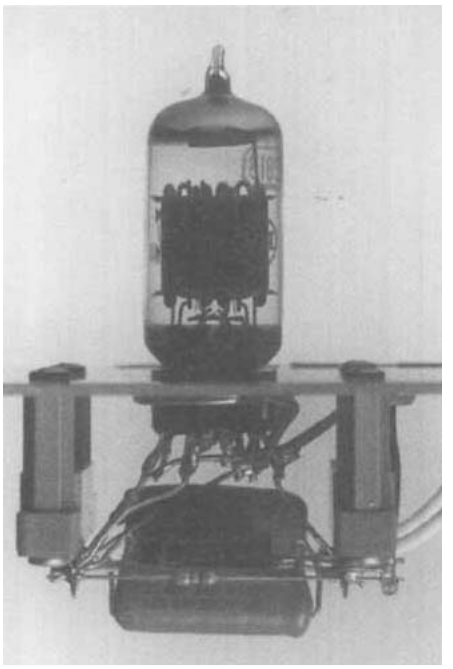


Photo 8 —The hardwire technique presented above allows for good air circulation around components

Vacuum Tube Curve Tracing

by Alan Douglas

One annoying thing about working with tubes is the lack of information. Good tube manuals are hard to come by, and even the best are incomplete. RCA's five-volume manual only includes information on the tubes they made (the "not invented here" syndrome) and at most only includes the basic data and two graphs. Western Electric's is far better, but of course only covers W.E. tubes. Commercial manuals (other than Western Electric's) contain only plate-family curves, but non-linearity shows up much better on "transfer" or "mutual" characteristics, plate current plotted versus grid voltage, where it appears as curvature of a line. On plate-family curves, non-linearity appears as unequal spacing between successive lines, a difficult thing to see.

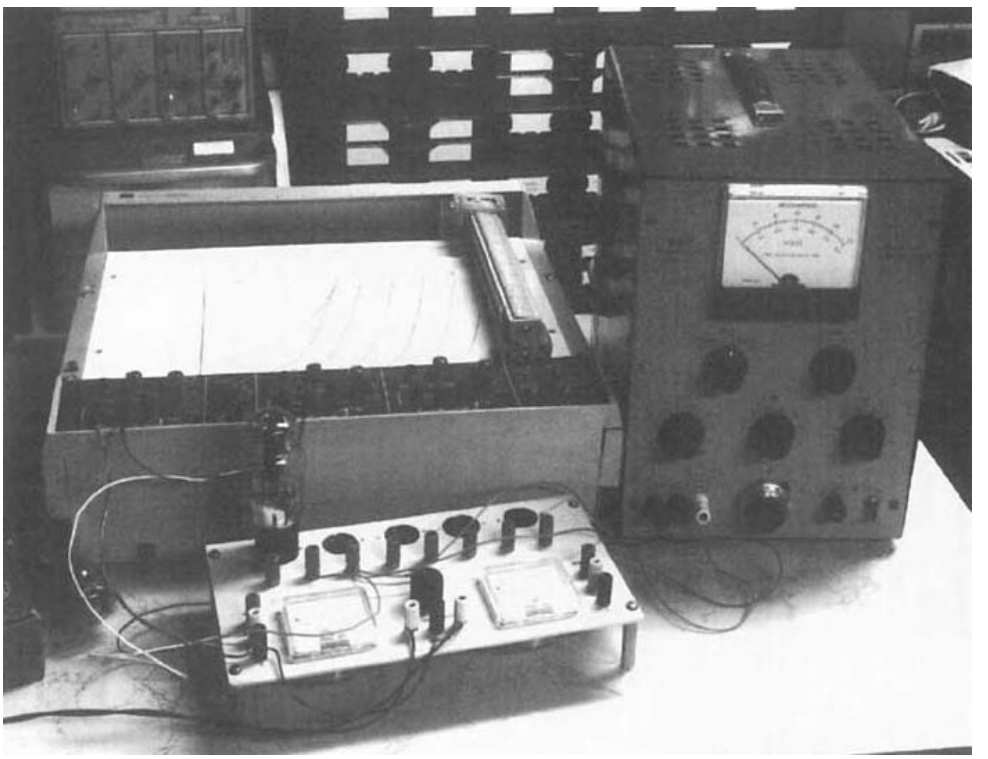
Finally, even if you had the full manufacturer's data, it wouldn't cover audio applications of tubes not originally intended for such use, such as RF transmitting or TV sweep tubes, nor all possible triode connections. And tube-manual curves only apply to average tubes made thirty to fifty years ago, not necessarily to ones we have now.

The answer is to plot them yourself. Years ago, tracing curves was a laborious business, reading values from meters and plotting them point by point on graph paper. Only tube manufacturers would ever have attempted it. With the advent of cathode-ray oscilloscopes, rapid curve-tracing became practical, and several designs for such tracers were published in the1940s, but they were quite elaborate and difficult to calibrate.

Tektronix made a commercial curve tracer in the 1950s, a scarce and desirable instrument now. But it is limited in ranges and modes, and in any event will read out only on a 5" CRT screen,with no permanent record other than a Polaroid print from a scope camera.

A two-axis chart recorder, or X-Y plotter, could replace the oscilloscope, and give a larger, permanent record on graph paper. Back in the 1950s, when tube-characteristic plotting was still important, a servo-controlled X-Y plotter was a very complex instrument.

Nowdays, though certainly not cheap, X-Y plotters are available, and seem to me to be the obvious answer to the problem. With minimal additional equipment, you can make plots for the very tubes you



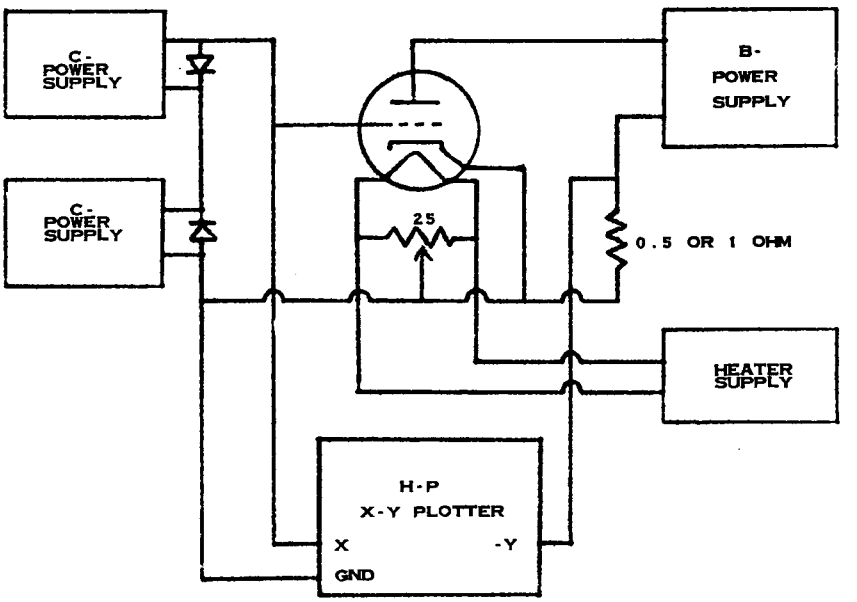


Diagram of curve tracing system

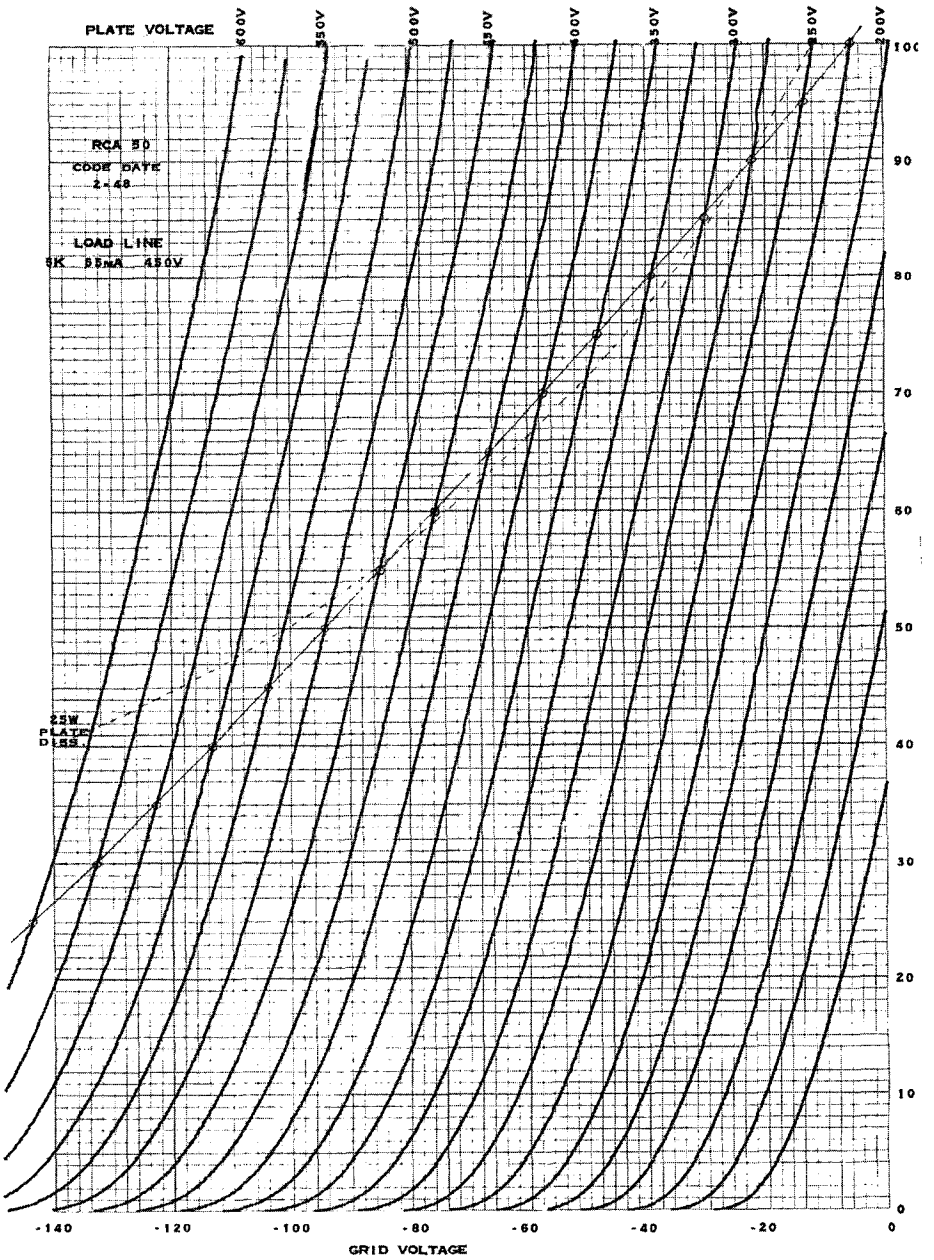
own, under any operating conditions you like. Furthermore, the resulting plots are easily large enough to determine tube parameters and distortion by graphical methods, no higher mathematics or computer simulations being necessary.

Other than the X-Y plotter, the equipment required is simplicity itself: regulated power supplies and a current-sensing resistor. Actually only the plate supply needs to be regulated, since in taking transfer characteristics, the plate is set to a particular voltage which must remain constant as the current varies from zero to maximum. A beam tube or pentode would of course require two regulated supplies. The grid bias is varied manually anyway, and its current demands are negligible, while heater supply is trivial.

As the old recipe for rabbit stew goes, "first catch your rabbit." Suitable X-Y plotters, while they are available, are perhaps not easy to catch. I was able to borrow a Hewlett-Packard 7046A which, after some overdue cleaning and maintenance, works very nicely. It has selectable input sensitivity and will even plot two Y channels, in different colors, up to 11 by 17 inches.

The one-ohm precision resistors came from my junk box (10 mV per inch on the plotter corresponds to 10 mA full scale; with 0.5 ohm, full scale is 200 mA). Chokes or ferrite beads on at least the plate lead are absolutely necessary to keep some tubes (6L6 or 6550) from becoming RF transmitters. The Y plotter input is reversed in polarity, to allow both channel grounds to be tied together. A 25-ohm pot across the heater leads provides the cathode return for directly-heated tubes. I sometimes use two bench supplies for grid bias, one being set at 20 volts positive, to be able to run the grid slightly into conduction without discontinuities in the plotted curves.

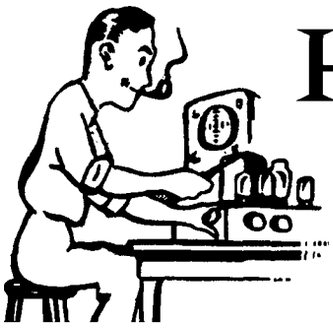
The photo shows some of the equipment I use. The PRL Electronics (who? what was an electronics maker doing in Rahway, New Jersey?) power supply provides 0 to 600 volts as set by switches; the 50-volt steps are very convenient for doing families of plate curves. It is rated at 100 mA but 200 mA is possible for a few seconds since the pass tubes are three rugged 6146s in parallel. It also supplies variable grid bias. This thing sat in my shed for more than ten years before I realized what it was good for. I have a couple of Hewlett-Packard 6209 transistorized power supplies, 0 to 320V at 100 mA, for plate or bias use, and a Lambda LH118, 0-10V @ 4A for heaters.



Set of curves for Type 50 generated with setup discussed in text

The panel in the foreground contains tube sockets and current-sensing resistors, but it has been replaced by a larger instrument with plate and screen milliammeters and provision for direct Gm measurement at any point (AC signal on the grid, and 10-ohm resistor in the plate with transformer coupling to an external AC millivoltmeter. All of this stuff came from flea markets or (the PRL) was free.

Tube curves are explained in Langford-Smith's Radiotron Designer's Handbook, fourth edition, pp. 26-27, while graphical methods of determining distortion are found on pp. 550-551 (pp.272-273 and 281-282 for the poor unfortunates stuck with the third edition).



Homebrewer of the Month

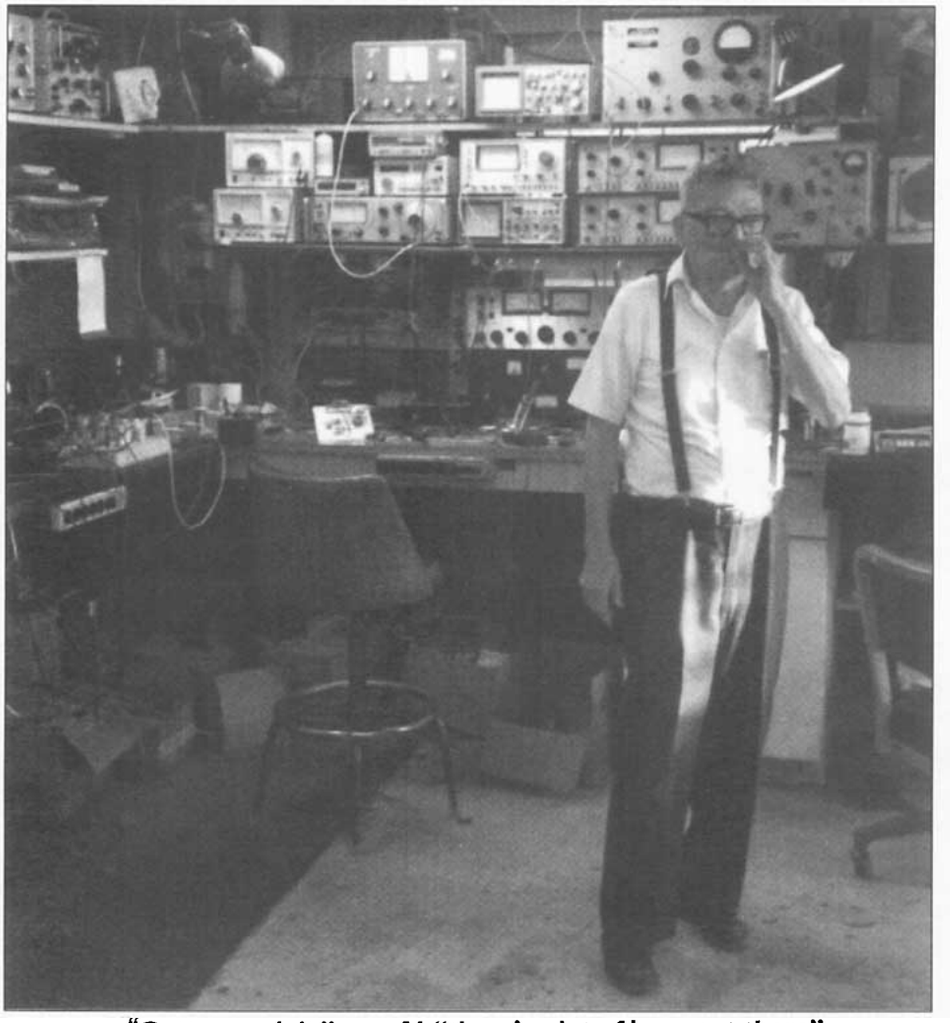
Al Bryant of Tomball, TX

When you meet a hardcore do-it-yourselfer like Alvin Bryant, you're meeting a person who really loves audio. Al has been at it for more than 40 years and he still gets as excited as a little kid over the stuff.

Back when he was working at Lawrence Livermore Labs in the early 50s, Al ran around with a group of hard-bitten Bay area hi-fi nuts who believed that triodes were the last word. Al stuck with the old three-element tube ever since, even though most of his buddies must have thought he was crazy back in the 60s and 70s when the 6550 was king.

Actually, the filamentary triode was already out of the mainstream power tube picture by the 50s. Even back in the early years of hobbyist hi-fi, triode aficionados had a bit of a retro twist, even though the word retro had yet to be coined.

Al built his first 300B amp around 1955 as a construction job for a musician friend who wanted the best amp obtainable to drive a bank of 16 speakers. This was back in the mono days when some sound buffs tried to get the width perspective of the orchestra by using a lot of speakers. The musician was serious enough and sufficiently well-heeled to pop for $900 for a single amp so Al built him a killer, no holds barred 300B PP job.



"Gotta watch it," says Al, "there's a lot of hype out there"

Everybody liked that amp, especially Joan, Al's better half and perhaps even a bigger audio nut than Al, if that can be imagined. Joan is the "ears" of the operation and she controls at least least half of the technical knowhow, so she wields considerable decision-making power. 300Bs it was.

Although they are longtime supporters of the 300B, Al has built innumerable push-pull pentode combos over the years. However, he remains fully convinced that PP triodes are the way to go. "6550s aren't bad and the extra power is a plus, but if you really want to hear the music, you got to use the 300B."

Al and Joan are definitely set up for serious audio experimenting. Years ago, looking forward to a audio-centered retirement lifestyle, they built a huge workshop outfitted for electronic construction, metal work, and wood working. Stacked on huge wall shelves big enough to use as bunk beds, sagging crates of mil surplus power transformers, chokes, and other parts were piled high. They have a small factory set up in there, I swear.

Back in the 70s, Al decided which parts he would need then bought 100 matching 50 mA filter chokes, 100 matching 150 mA chokes, 50 similar gray mil surplus power transformers, and so on. Gives a certain visual uniformity to his projects. All Bryant creations also share his "trademark" style of using aluminum baking pans for chassis. He lucked into a big sale down at the local discount store a while back and bought all they had. Some of the pans even come with slide on covers, perfect for shielding low-level circuits.

Once built and checked out in the lab, the latest experiment gets a spin in the big system in the house and *Big* is the right word. Al's mammoth reference speakers are about 8 or 9 feet high and 4 feet wide, no mini monitors here. These monsters have four 15" woofers, four 8" midranges, and a couple dome tweeters per side, and they put out enough sound to listen from anywhere in the house.

When we stopped in, Al and Joan were running the system on four mono PP 300B amplifiers with an active crossover. Like all speaker builders, they were deeply interested in crossover technology and I saw evidence of a lot of crossover projects out in the workshop, including LC line level passive crossovers, and speaker level crossovers where the coils were made out of whole spools of heavy gauge wire.

When Al needed some low DCR coils for his woofers, he just took a big roll of 12 ga. wire and measured the inductance on a

"Hey Al, you love 300Bs. Interested in trying out single-ended?" we asked

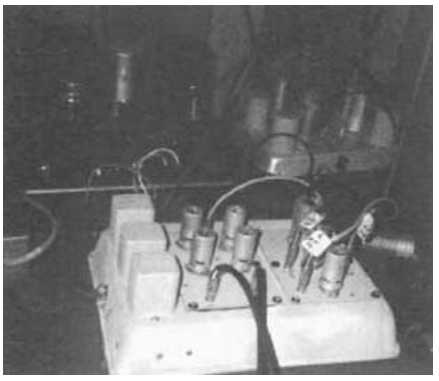
"Nah, not really," says Al

bridge while removing turns to get the desired value. Voila. Air core coils. Big honkers at that.

Given his reasoned, scientific approach to audio electronics, Al takes particular pride in his well-outfitted test lab. He loves to build various circuits and see how they perform on the bench. The circuits have to do an admirable job on the scope before they'll go into one of Al's amps. He builds a lot of stuff but he's not in a hurry.

Strictly a push-pull kind of guy, Al is unimpressed by recent claims for the superiority of single-ended. In fact he's a bit suspicious of the whole concept on technical grounds. He wants amps that measure good and sound good, with some reserve power. PP 300Bs give him exactly what he wants. Check out Al's simple 2A3/300B at http://www.soundpractices.com or send the mag an SASE and we'll cut you a copy.

Yeah, Al sure knows what he likes. We asked him if he was at all interested in trying out SE. "Nah, not really," he replied.



2-way active crossover in front, regulated power supplies in back

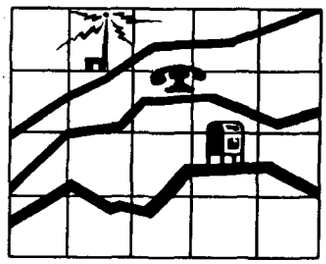
Al Bryant's one of a kind totally homebrew reference system featuring one dozen drivers per side driven by four mono PP 300B amps

Al was interested in learning *about* single-ended amps but not so interested in doing it himself. He said he had at least five years worth of projects in the cue and he's happy enough with the trusty old push-pulls. We broke the news that Magnequest kindly donated a nice pair of single-ended transformers as sort of an honorarium for the recently-invented Homebrewer of the Month concept but he was not lured in by the offer.

"I have plenty of transformers here. Why don't you just give them to some young kid who is out mowing lawns trying to save up for a pair of output transformers," Al suggested. That's just the way Al is. What a nice guy! We'll have to write him up for him a free *SP* subscription or something.

Al said he's not into the hobby for money or fame, a good thing because there's not much of either to go around. Al said he's just real happy to to see that he has some company these days, as a homebrewer and as a lover of the 300B. Way to go, Al—keep that homebrew spirit alive!

The workshop : One 300B amp and power supply in foreground featuring Al's trademark cake pan chassis style. Wood shop in the back.



THE MANUFACTURERS' CORNER

welcomes J.C. Verdier

Laboratoire J.C. Verdier

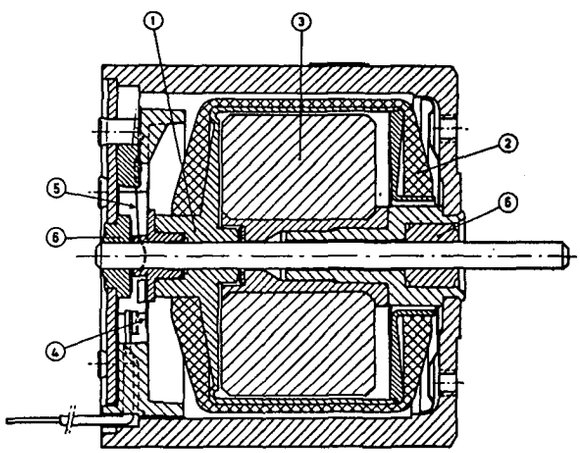
What a surprise! When I read the last issue of *Sound Practices*, I didn't expect to find an article on analog turntables, especially one speaking widely of the turntable I produce—the *Platine Verdier*. I am really surprised, because I know the author well. We met each other during some hi-fi shows and also another time in Germany in the shop of my distributor "Auditorium 23" in Frankfurt. I remember that we discussed some technical information.

Since I am no stranger to Dr. G.W., I don't know why he didn't contact me to discuss my perspective on the turntable. I would have gladly given him some useful information for his article.

First of all, let's approach the question of the motor. Certainly, I use a motor marked Philips, a name that could make one think of an ordinary motor, because that big European trademark is very prominent in the mass market for consumer goods.

That is misleading, because Philips is also very involved in very advanced technology. The motor used in the Platine Verdier is produced by a special branch named "Philips Technology." The motor is certainly not an ordinary part—given that the price is 2500 FF for one unit in the shop of the French distributor! That is not exactly a gift for a motor of diameter 40mm and 50mm high. It must have something very special inside. Let us see:

First of all, it is a "low inertia" motor. In the case of the Philips unit, that term refers to a very special technology. In a "low inertia" motor, the turning part—the rotor—consists of a copper coil, the turns almost parallel to the rotation axle cutting the field lines of the magnetic circuit, excited by a permanent magnet which is totally fixed. The weight of the rotor is reduced as much as possible, so the inertial tendency is small relative to the work provided by the motor.



1 Rotor
2 Rotor winding
3 Stator magnet
4 Commutator
5 Brushes
6 Bearings

Cross Section of Philips Technology Low Inertia Motor

I must say that I don't think that low inertia in itself is that interesting of a quality for a turntable's motor. It can even be a deficiency for players with relatively light platters, as indicated in my discussion of the value of mechanical braking below.

Another quality of the low inertia motor is much more interesting and relevant to the issue at hand: its rotation speed depends directly on the DC voltage. A simple integrated circuit regulator such as an LM 338 is enough to obtain perfect stability of the speed.

Let us come back to the motor description: The magnets are very powerful units in a small package. They are metallic alloy (nothing like cheap ceramic magnets). The collector and the brushes are gold plated to minimize the resistance of the contacts.

The axle of the motor turns in fitted and self lubricated bronze bearings, its diameter is 3mm. When the motor is powered at its nominal voltage of 12V, we hear the rubbing of the brushes on the collector. It requires a very silent environment to be able to hear this small noise.

In the *Platine Verdier*, the actual voltage applied to the motor is 3V for 33 RPM and 4V for 45 RPM. At those low voltages, it is necessary to press your ear directly on the motor to hear the commutation sound.

In the *Platine Verdier* system, the motor is located far away from the platter and any vibrations are effectively isolated from the turntable by a piece of thread used as a drive belt. In essence, the inconvenience of that tiny vibration is completely removed in practice.

Now, let us approach another point: Dr. G.W. explains that playing a record with a stylus consumes energy and that this energy is variable on account of the changes of musical modulation, resulting in drive speed variations of the platter.

That is absolutely correct and it is one of the basic problems facing the turntable designer. The author then explains how to remedy this: the motor must renew the energy as swiftly as possible to keep constant speed, that is the reason for using a low inertia motor. I think that if this were true, no turntable could work well, because no motor is good enough. Fortunately, we can make use of more powerful tools to settle that problem.

The first tool is well known, it is the platter's inertia. The heavier the platter, the more it works to counter momentary variations in speed, but the challenge is to make a very thick and massive platter which doesn't ring like a bell.

The second tool is less well-recognized than the first: the constant-coupled brake system. Since the player stylus consumes variable amounts of energy, we have to mask that consumption by permanently consuming much more energy by the use of a brake. The larger the ratio between the energy consumed by the brake and the energy consumed by the stylus, the better the turntable works.

To be clear: only a few models of turntables have this device. To understand the concept better, have a look at a Thorens TD 124 which uses a brake with Foucault's current excited by a permanent magnet, or EMT 927 which has a completely mechanical brake consisting in washers placed around the axle with the capability of adjusting the pressure and therefore the braking action.

On my turntable, the brake is present but invisible to the casual eye—it is furnished by the axle and the bearing. The two parts are unusual in their very large dimensions. The two facing surfaces of about 60 cm^2 separated by lubricating viscous oil form the brake.

Numerous times, I had to explain to customers that it could be a big mistake to replace my viscous oil with a more fluid oil to "allow the platter to turn for a longer time." This total misunderstanding of the problem is unfortunately very widespread. Some time ago I heard that there exists a turntable which is lubricated by pressurized air, without any braking action whatsoever, and it enjoyed good commercial success despite this obvious deficiency!

Let me wrap up this discussion by describing the general design features present in my turntable.

Examing my turntable, the first thing you will notice is that the platter is very heavy and massive, weighing about 16 kg. Such heavy weight forbids the use of a ball bearing support for the spindle. It would quickly produce intolerable rumble due to wear.

To avoid that inconvenience, I use a magnetic suspension. The drawing shows clearly how two opposite magnets placed in treated cast iron magnetic circuits are configured to bear all the weight of the platter by their repulsive force.

The bearing interdependent of the platter is Zamac fitting: it is an alloy of zinc and aluminum which is easy to work, self lubricating and silent. The axle is of course of tempered and rectified steel, its important diameter is 20mm.

The base is a paving stone of granito (sort of cement conglomerated with marble splinters). A special molding procedure permits us to realize that part very easily. The cavities forming the air suspension are molded in and don't require any additional working.

The three suspension springs are fitted in the middle of the cavities isolated by a foam rubber washer. That is the fitting of the air suspension, completely effective against feedback effects.

The drawing shows the adjustment screw of each spring which permits adjustment of the horizontality of the turntable. The arm rest is produced in massive aluminium block to give a good rigidity.

"Platine Verdier" is produced like that since more than 20 years. To bring the discussion up to date, I have to add that I recently designed a new base machined out of high density fiberboard weighted down by steel plates. In this base, the finish is more luxurious and the black lacquer shines like a beautiful concert piano. The motor is fitted in a box totally separated from the platter assembly. The whole setup weighs about 45 kg (not counting the motor unit) for dependable stability.

The drive chain still relies on a linen thread, an arrangement satisfactory to all users of the Platine Verdier, except for a few!!!

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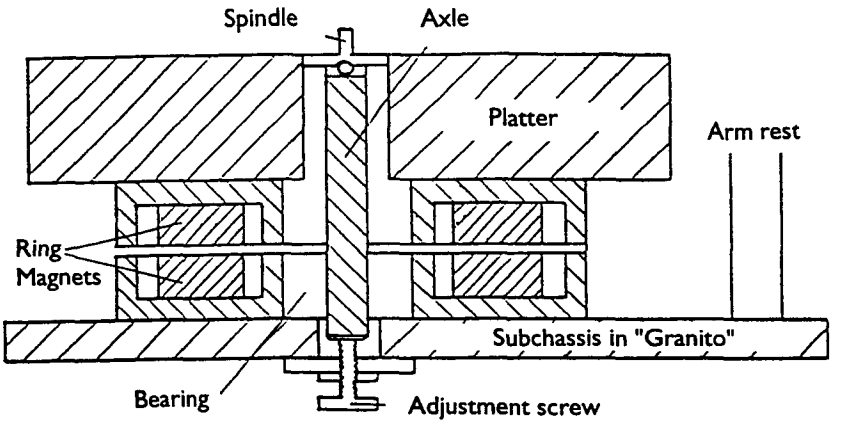
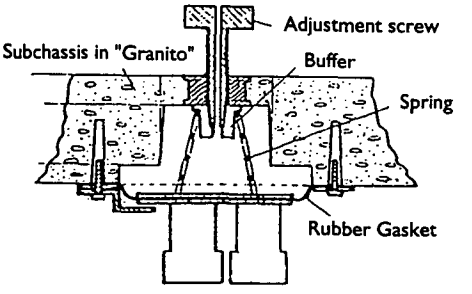


Cross Section of Turntable



Cross Section of Pneumatic Foot

Ennemoser

The bone doctor of musical sound

by Joe Roberts

Over the last ten or so years, the audio world recognized the vital role of materials in musical reproduction. There's a lot of concern with resonance control and tuning. Audio metallurgists and jewelers tout the advantages of .9999 OFC copper and soft annealed silver. There's plenty of discussion about Teflon™, Delrin™, and other lab-born brand name materials but how often do you read about human bone and tissue, the business end of every audio system, in the pages of the glossy audio magazines? Music as we experience it is, after all, a sensation of shaking bone and flesh at the most basic level.

Ennemoser is the first person I met who truly appreciates the fundamental notion that our hearing apparatus is made of bone and the whole thing is mounted in a skull that is also made of bone. Ennemoser said it took a long time to recognize this powerful truth because laziness of thought and language makes us stupid about some very important things.

Even after 20 years of working with these concepts, Ennemoser complains that he often feels silly talking about bones given all the scary monster movie connotations we attach to this most natural substance. Everybody who hears about Ennemoser's works feels obliged to throw in a few Frankenstein jokes to lighten up the conversation. Ennemoser himself jokes about it.

Because he constantly struggles against old habits of language, Ennemoser is concerned about being cast as one of those audio guys who invent colorful theories and then elaborate on them using verbal logic and poetry. Real science builds theory from experience, not the other way around, he rightfully insists.

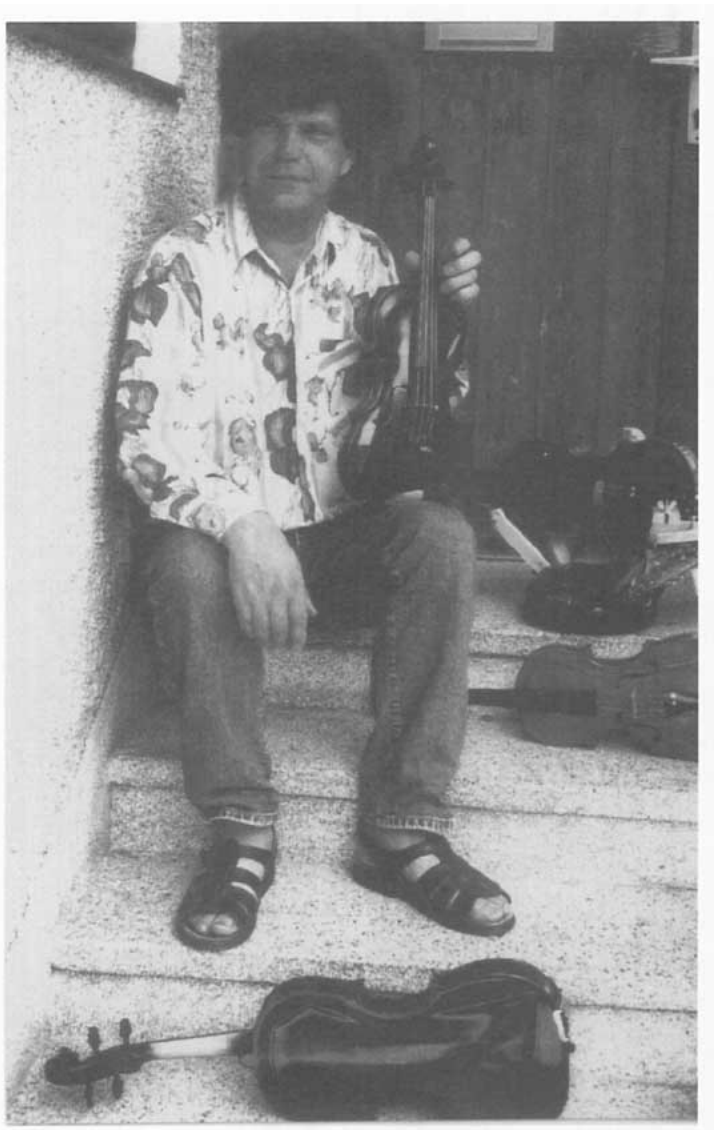
That kind of thinking is what got me interested in Ennemoser's ideas when I am usually inclined to let wacky tweaks and overly creative reinterpretations of audio physics pass me by. When I first heard about Dieter Ennemoser, I thought he was just another flaky smokescreen artist.

After I talked to him and read his stuff, he impressed me as being down to earth, almost too down to earth for the average Joe to get a handle on. Ennemoser definitely seems more interested in digging deeper into what is right in front of his nose rather than inventing wild new stuff. The irony is that people like that often come up with the most radical inventions and freshest insights.

The other thing that impressed me about Dieter Ennemoser is that the man builds violins. Can't do that with theory and thought experiments. Even Stateside resonance gurus Michael Green and Shun Mook can't build violins. Demonstrated success in this craft is a strong credential in the practical black arts of vibration, resonance, and musical sound. The nature of materials and their behavior is all that matters. Musical capabilities are paramount.Violin makers get paid for sonic results. Call me a hick, but I'm impressed – Ennemoser is not just another unemployed TV repairman trying to break into the luctrative tweak accessory market.

Ennemoser started out as a student of mechanical engineering but he doesn't like to talk about it much. He claims it took 20 years to unlearn the mindset imposed on him by the books. He found that much of what he needed to know to produce instruments was completely outside the usual domain of mathematical physics and the usual measurements had little to do with the art of the violin and the life of music.

As Ennemoser developed his talents as an apprentice, the learning curve he had to follow to perfect his craft steered him off the trail of routine scientific engineering and usual violin making practice. The ear is the ultimate lab instrument for the violin maker and nothing else could tell Ennemoser what he knew in his bones.



Ennemoser followed his ears to a point that got him into trouble with the authorities. Based on his acoustic research, he developed some innovative violin designs outside the tradition of the official instrument makers' guild. They tried to force him to stop making unauthorized instruments. He tried to claim an official "artist" legal status as a creative violin smith, but the Austrian authorities didn't buy it and they threw his butt in jail for his guerrilla violin making activities. This was back in 1989.

I can understand why the conservative violin makers' mafia didn't appreciate Ennemoser's instruments. They feature inset angular depressions designed to enhance radiation of "C37" frequencies, lending a very non-traditional almost "punk" look to instruments from the atelier of Ennemoser.

Even worse in terms of traditional requirements, Ennemoser's instruments are tinted in unexpected colors. He prefers the sound of blue violins, but says that pink and wine red are also good sounding colors. In short, body colors, "meat" colors, are what sound good.

In order for violins to enter competition, they must be tinted orange using a specific aniline synthetic dye, Ennemoser complains. "Orange is the worst possible color for a musical instrument because it is the opposite of blue." This is insanity, according to Ennemoser.

On the question of the sound of colors, Ennemoser claims psychic kinship with the great von Karajan. The maestro customarily required his players to wear sky blue shirts or wine red jackets, although he also liked bright vibrant red. Maybe most people are moving too fast to pick up on subtle energies like the sound of color. I'm willing to concede that sensitive individuals can tune into dimensions of perception that I miss entirely.

However, it is difficult to discuss even the slightest possibility of color sounds because we are conditioned to think that such a relationship is a totally crazy concept. With that kind of an attitude, how can we ever learn?

While in the slammer, Ennemoser wrote the essay which was later published in Switzerland and excerpted below. He says that until he went to prison, he was unable to gain much sympathy for his cause because he was fighting a well-entrenched lobby with no fame or money behind his cause. As a political prisoner, a status that attracted attention, Ennemoser's voice was heard.

Ennemoser stuck with the case and, after his story was told, he ultimately won out. It was a long five year battle but the government is now one of his great supporters and also one of his customers. For examle, the *Tiroler Landesmuseum* recently purchased a blue string quartet for its permanent collection of local arts.

Looking back on his tangle with the system, Ennemoser has no hard feelings. It was a learning experience for everyone involved.

Ennemoser's Practical C37 System

On the surface, Ennemoser's C37 theories might come across as just another abstract and flaky explanation thrown together to account for an ethereal sonic phenomenon. Actually, the C37 scheme is grounded in the earthiest, least ethereal substances there is. C37—Carbon at 37 degrees C. Carbon at body temperature. Warm bone.

Fearing the worst, the first thing I asked Ennemoser is whether his stuff has bone in it. I flashed on the romantic image of Dieter in his workshop drilling cartridge mounting holes in a tonearm made from the shinbone of an antediluvian ox chipped out of the glacial Alpine icepack up in the mountains.

Dieter said "no bone in my stuff" but I'm pretty sure he liked the idea. He joked about how many of his friends are now using pieces of actual bone in their projects, inspired by his ideas on the special resonance character of bone.

Right Blue violin from Ennemoser's Tirolian workshop exhibiting special angles designed to enhance C37 patterns.

Left 18 C 37 technology 3000 Hz LF driver with angled diaphragm and laquered cone

Below Detail drawing from Ennemoser's patent for transducer with "discontinuous variation of the aperture angle" designed to produce decay behavior similiar to the human auditory organ. Specific angles of 163, 157, 140, 114, 98, 82, or 66 degrees are employed. (European Patent # EP 0 491 139 B1)

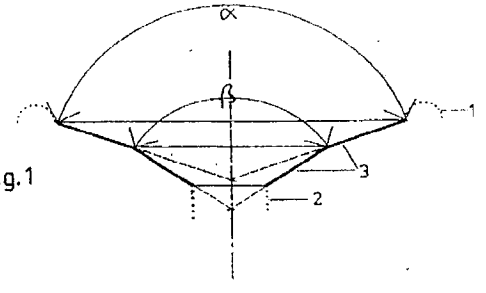


Fig.1

Basically, what Ennemoser is excited about is the *sound of bone* at body temperature when struck. He believes that the "dry" sound of bones is a very special illusion that occurs because our auditory apparatus is itself made out of bone. Our hearing bones filter frequencies in a particular way and then feed them to a brain which evolved over millions of years of processing sound stimuli transmitted through warm bone. Bone is a privileged material because we are made of it.

The interplay of music and the mind is a dance of the bone vibrations inside our bodies and instruments which vibrate in a manner relevant to our carbon-based perception setup.

What Ennemoser is working to identify and manipulate is the C37 sound pattern that bone produces. For a quick sample of C37 pattern, you can tap your skull right behind your ear using your fingertip. You will hear a satisfying thunk that is controlled yet rich, not a bad material for speaker cabinets, huh? The point is that you're always doing this C37 test while listening, whether you realize it or not. All of the interconnects in our ears are bone.

So, that's how Ennemoser does most of his research. He taps on stuff, *plays it* as it were, and listens for the sound. Like I said he's super down to earth. He is a tuner, not a storyteller. Indeed, Ennemoser claims that his biggest challenge was trying to learn to think without using language. The logic of violins and music is not linguistic.

Ennemoser's C37 system builds on a set of practical tools and techniques. He found that certain angles enhance production of C37 frequencies and he uses these angles in his violins and in his speaker cones. The speakers use a patented multi-angle cone optimized for C37 signal processing.

Another novel idea of Ennemoser's is the notion that physical dimensions of electronic circuits are important determinants of sound. Changing the size of a printed circuit board, for example, can impact sonics and this can be tuned in accordance with C37 principles.

On the level of materials, Ennemoser uses a special C37 lacquer that you can paint on your favorite musical objects to benefit C37 patterns. Since the resonances are temperature related, the lacquer is formulated for use within a particular temperature range, e.g. there is 20°C lacquer for room temperature applications and a different formula to use inside heat generating electronics.

(continued on p. 37)

According to Stein Hi-Fi, the C37 *Speziallack* (lacquer) does wonderous things for CD players–two coats on the component side and mechanical parts of transport (watch the lens!). C37 *Lack* is also good on interconnects, they say. Recently, a German mag painted a Rickie Lee Jones CD with C37 and in a blind panel test, all 20 of the auditors preferred the smoother, more liquid sound of the C37ed version. It is also alleged to be great for painting circuit boards, parts and all. 1001 uses in the listening room.

Ennemoser sent me a sample 10 ml bottle of C37 *Speziallack 20*°C and a bottle of C37 *Spezialverdünnung* (thinner). Once I had these blue vials of bug juice, I had to try them out and I started looking around the room for stuff to lacquer up. A 10 ml vial is enough to do one 15" paper cone, two 8 inchers, one CD player, or other small scale job. Coverage depends on the surface.

The first thing I did was unscrew the cap and take a good deep whiff ...aaah, smells just like an old world workshop. My eye rested on the white cones of my Lowther PM-6As. I resisted the thought. No, I like them just the way they are. My mind raced on. I couldn't help it. Huffing lacquer will do that to you.

C37 *Speziallack* is a new concept in resonance tuning but its far less strange than some of the things people are doing out there. I drew faith from Ennemoser's comment about how C37 tuning produces "a more lively, open, and warmer sound and turns sharpness into brilliance." I really like that image and that was what I was hoping that the C37 would do for me. Even though I know Ennemoser is anti-linguistic, language is a difficult habit to shake.

So, the deed is done. The verdict won't be in in time for this issue however. C37 *Speziallack* takes *months* to dry completely on absorbent paper cones (much faster on non-porous surfaces). So forget quick A-B comparisons — fine by me since I'm not into 5 minute clinical psych lab experiments anyway. I like to take the time to make evaluations in the real context of my normal musical listening activity.

Nor am I into the tweak neurosis that I saw coming if I sat here for a couple months listening to the C37 *Lack* dry, so I decided to put the Lowthers away for a time and get on with my life while it cures. Started to sound interesting before I wheeled them out to storage, two weeks after the C37 aplication.

I wasn't out looking for Lowther mods since I think they're very good as is but I figured that in order to give the C37 lacquer its best shot, I should put it on something fine to start with instead of wasting it on a $50 CD player in hopes that it would magically transform into a Wadia. Nobody said it was magic, especially not Mr. Ennemoser.

Bone Doctor (continued from p.35)

Ennemoser is the first person I know to argue the point that temperature is a critical element in resonance tuning. For example, he says that glass sounds like C37 in the 70°-72°C range and at another point in the 180° range. Most preamp tubes run cooler than this and power tubes run too hot. You can experiment with concentrating the heat around your preamp tubes with a cardboard hat to get up to the 70°C range and try it for yourself.

Casual Reactions

by Herb Reichert, Audio Note NYC

Uchida: The Japan Homeboy

Thirty years after the Second War the fruits of Japanese manufacturing established a firm beachhead on American soil. The words Made in Japan appeared on tools, cars, toys, and on the majority of consumer electronics products. Americans purchased these items, not because of cachet and exoticism, but rather because the price/performance ratio was good.

Nearly all Americans believed that U.S. and European products were of better quality, but for the millions of consumers who bought these new imports, "The price was right!" At the same time, Japanamation youths were flying to America in search of cachet—and maybe some 'new-wave' excitement.

During the Sid and Nancy days of the late 70's, a most unusual trio of Japanese friends arrived in New York City. All the way from a rock n' roll band on Hokkaido Island off of Northern Japan (near the USSR) came Noriyasu Komuro, Tadataka Uchida, and his wife Sung Hee Lee. Expatriating an ancient culture, they arrived for the Second Centennial celebration looking for work in the music business. Sung Hee did vocals, Uchida played lead, and Komuro played bass.

Komuro got a job as an electrician while Uchida washed dishes and Sung Hee waited tables. The Japanese restaurant where Uchida and his wife worked was run by a successful man who was good at what he did, but secretly hated the restaurant business. One rainy, cold winter day the man who owned the restaurant arrived looking super glum and carrying a briefcase. He lined up his employees and told them, "It's over...I quit!"

Dumbfounded, the employees all stood silently, looking at each other. "Who wants the restaurant?" was his next line. Still, nobody said a word. Sung Lee kicked her husband in the foot and automatically his hand went up. A couple of years later, Uchida and his wife are partners in one of the most successful and fashionable restaurants in SOHO.

Today, Sung Lee is the proprietor of another fashionable macrobiotic Japanese eatery and Uchida is free to pursue his musical dreams. I forgot to tell you, Komuro and Uchida were avid single-ended amp designers back on the island near the USSR. They started in the late 1960s! Komuro brought one of his 211SE amps with him when he came from Japan and now, Sung Lee uses Western Electric 212E tubes for lights in the restaurant. Horns and 300Bs play music to eat macro by.

In the 'go-go' 80s, while this trio was doing food and electricity, I met a serious Japanese youth named Ryoichi Kimura. We became instant friends and partners in a triode-audio import business (Eddy Electric). He introduced me to Shindo, "sree-hundred-bees", single-ended amps, Western horns, and original (indigo dyed) Levis.

By 1990, Ryo was gone and I missed my Japanese friend. Ryo took about a million WE300Bs and went back to Japan to study Buddhist sculpture. So I forced my best friend J.C. Morrison to get 'high fever' and join the 'Dark Lantern' school of audio engineering. He and I walked, talked and slept single-ended triodes and horns. Eventually, J.C. and a carpenter turned Dark Lantern named Garber opened a store called fi in SOHO. It was there that J.C. and I met Uchida, Komuro and his girlfriend, the "Fire-cracker". They saw the triodes in the store window and couldn't stop themselves from wandering in.

Two weeks later...we were all down in the basement (even the "Fire-cracker") with our irons in a constantly heated state. Amps and speakers of all descriptions began literally pouring out of the basement door. We were all fanning each other's flame.

Five years later, Fire-Cracker's a hacker, Komuro and J.C. are famous amp designers, I am a partner in Audio Note and Uchida is the proprietor of April Audio, a company specializing in the import and sale of choice Japanese audio components and books about single-ended audio.

Where is it?

I seem to have this love thing about foreign audio. Maybe it's the Krells? I don't know why, but I keep getting caught up in overseas audio circles, Italy, Japan, Pakistan, Germany, France, Malaysia, Australia, the Philippines. I know little groups of triode/horn fanatics all over the globe. One day, just for fun I arranged for two of my Filipino friends, Ding and Jun, to visit Uchida for a taste of the Japanese audio experience.

At lunch the next day I said,"Well, how did you like Uchida's feral system?" Ding and Jun laughed, "We couldn't find his place" they both said in harmony. Turns out, they were looking for someplace normal. Uchida's 'den' is hidden in the East Village, behind locked steel gates, and looks totally abandoned. The front is completely covered in graffiti and there is just a big lock and no sign. Without a guide you could never find it.

What is it?

Ding and Jun finally got their Uchida experience, but please, take your shoes off and let me tell you what is behind those graffiti covered gates. It is just like *MJ* magazine come to life! It's like the hornspeaker home page. I go there to learn. Uchida collects everything musical: electric guitars, gramophones, radios, posters, records, tapes, amplifiers, recording equipment, books, speakers and tubes. Most of this stuff he has stashed away in the mountains and in warehouses, but there is still enough in this completely Japan-style living environment to be completely inspiring.

In Uchida's den you are transported to a back alley of the Akihabara. It is so narrow you can barely walk, you must take your shoes off. There's a big tree-slice for a table and a small low wooden bench to sit on. The rest is tube amps, records, and exotic STUFF. You really can't move around at all! A trip to the bathroom is a project; you get lost looking at the floor-to-ceiling tubes and speakers and musical exotica.

He will serve you something like 29 kinds of dried plums and a Japanese mountain soup filled with vegetables that, I guarantee, you have never seen before. In fact, it's likely you have never, ever tasted any of the food he serves. I bet you have never listened to music on a system like his either.

He has five or six types of speakers set up. Altec *Valencias*, Western Electric 755As, Lowther PM6As in Brociner TP-1 cabinets, PM7As in custom cabinets, and a couple of other Altec speakers I don't recognize. All of these speakers can be played on a moment's notice. This is nothing! Just a few speakers.

For a full-function preamp the legendary Japan Homeboy uses a circuit straight out of the RCA Tube Manual, with red base RCA 5691s in the phono stage and GE 6SN7GTBs for the line, permalloy choke filtered power supply and paper in oil caps. It's the amplification that gets really wild: WE27As, 212Es, and 300As, GEC DA30s, DA60s, and DET25s, PX25s, Mazda AT20s, Globe screen plate 50s, and my favorites, the Cunningham CX210s/310s.

Tell me the last time you heard a transformer-coupled, Western Electric 205D tubed, single-ended amp with Tango (#10429) super-permalloy transformers playing Miles Davis? This is a one-watt amp with a $1600 pair of the world's best quality output transformers. Can you beat this for triode exotica? These are the kind of amps and speakers that inspired the whole triode movement.

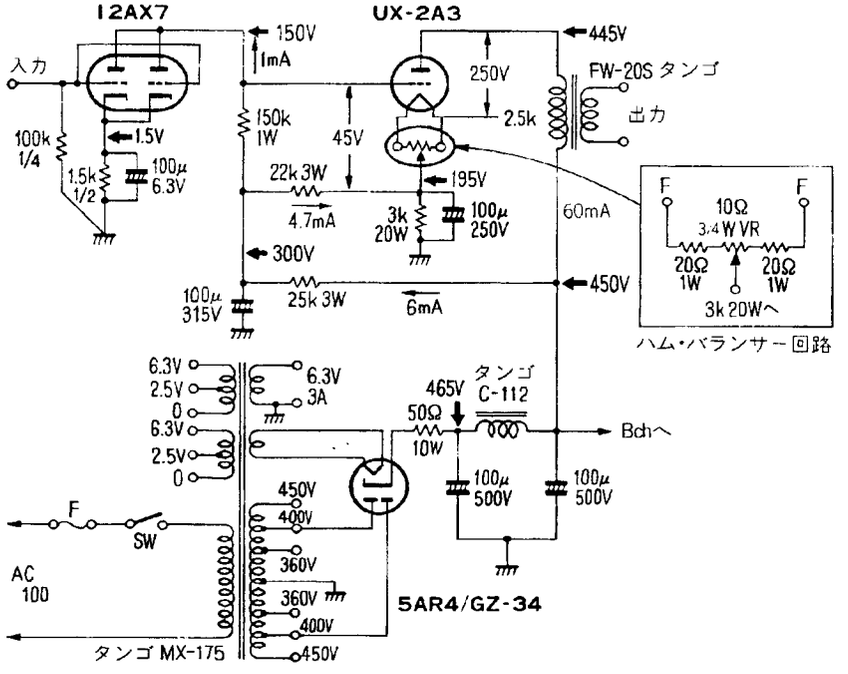
Trust me, the future of high-quality music reproduction is in the 1/2 watt to 5 watt amplifier! I am totally serious. To go very far beyond the WE300A/B amps you must go to the more exotic very low power tubes like the 10Y, the 45 and the 71A. Forget the 205D. Most of us will never even see one of these tubes, let alone listen to music through a pair. This is hyper-triode, ultra-fi Japanese style. So is Uchida.

I spend my days smoking my pipe and playing records through Kondo amps and giant German horns yet the kind of audio I hear at Uchida's is still totally exotic; very low power triodes driving permalloy core transformers from Tango and Nature Sound, these little beauties driving super high efficiency speakers and sounding like Mel Torme in a smoky room. This is the shadow of twenty-first century audio. Get Dark Lantern now!

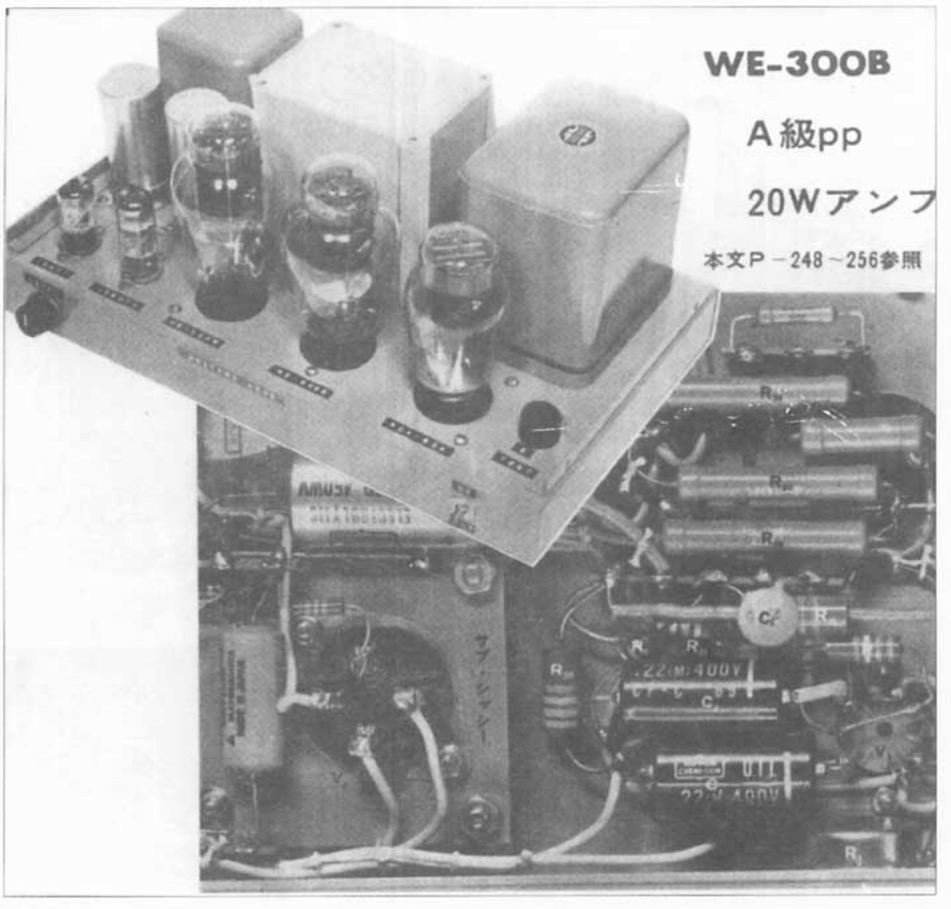
When I closed my Tango/Black Gate business there was a void. For a few years there was no place to get this level of audio parts outside of Japan or Italy. That changed when Sung Hee took over the restaurant business. Uchida became free and willing and now he sells ultra-fi stuff imported from Japan. He can bring the Akihabara to your doorstep.

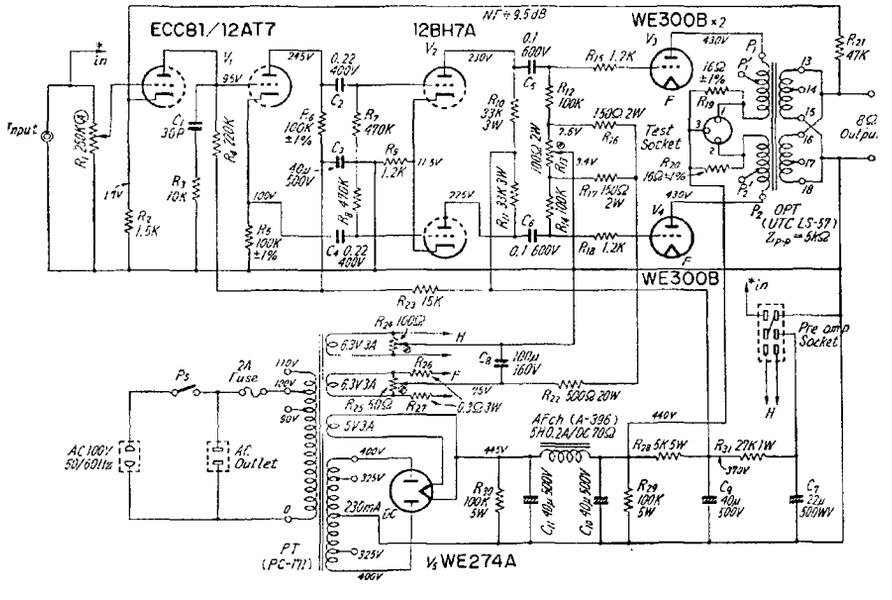
From here on, this article is shameless advertising and promotion. I can't help myself. I have a deep attachment to all of these products. I am not going to recommend you buy these items, I am going to demand it! Here are a few of the Japanese language books that every English reading tube lover will cherish.

First you have to buy both volumes of Isamu Asano's book, *Miwaku No Shinkukan*



Shishido's famous direct coupled Loftin White 2A3 design





PP 300B using old UTC iron from Asano's book

Amp ($100/two volumes). I would be selling women's shoes today if it weren't for these two books.

Asano was the most famous triode amp designer in Japan. He started building and writing about single-ended amps over thirty years ago! These books offer complete designs for dozens of different directly-heated triode amps. There are chassis layouts, circuit diagrams, tube curves, operating points and color photos of the internal wiring. The photos are so good, you can read the values on the resistors. Asano uses ALL kinds of iron, UTC, Tango, Western Electric, Tamura, Lux, etc.

These books make you feel like you built the amplifiers. You can really zoom in and absorb the details of these designs. The color pictures of home made amps from the 60s, 70s and 80s are the perfect inspirational tools. You can build your new life around these designs.

The big man, the top dog in the world of home-built triode audio is Koiuchi (Nobu) Shishido. Nobu was the first guy to champion SE amps in public and one of the earliest rediscoverers of the 300B. His adaptation of the Loftin White 2A3 reprinted above was the design that started it all in Japan. Today he designs amps professionally for WAVAC and is a steady contributor for *MJ* and other experimenter magazines.

Shishido's book, *Single-Ended Amplifiers with Transmitting Tubes* ($60.00) is an absolute must-own for all wannabe designers. The main theme in the book is how to use Class B and C transmitting triodes in Class A as single-ended audio amplifiers. Why bother? Because if you really love tubes, these types of triodes are super exotic, sound great, and they can be found for a fraction of the cost of WE300Bs or DT-25s.

Nobu can show you ways to use interstage transformers, and ways to load the cathodes of triodes that you will not find anywhere else. Buy it and study it!

The Classic Valves ($70.00) is the history of the vacuum tube with 860 tube photos. Reading Japanese would help a lot with this book, but if pictures of exotic, perfectly formed tubes gets you wet...

On the other hand, we all need the *World Tube Manual* ($120) by Masamitsu Yamakawa. Tell me where else to find complete curves and data on 7200 tubes?

Now that I have gotten you hot, knowledgeable and ready, it's time to heat up the irons. But wait! Before you begin your "big and final" amp project, please take this advice: Buy transformers that you know for sure are good. As we speak, there are tens of thousands of triode amps using Tango or Tamura transformers. Hirata, the man who founded Tango transformers, started building transformers during the second world war. No one has more knowledge or has greater proof of his design ability than this man. Tango trans specs are very conservative and the craftsmanship is on the highest possible level. People who have tried them all prefer Tango. These are trans you can use proudly for the rest of your life.

Hirata's NY-10S (45% permalloy) and 10429 (78% permalloy) 10 watt trans are simply the best outputs I have ever used. I have tried every kind of transformer that can be bolted to a chassis and nothing comes close to these monster Tangos. Only Kondo's all silver/ceramic/steel creations are clearly better.

Permalloy is used to create transformers that are very sensitive and responsive to low level current stimulation. Delicate, small signal information that conveys color, texture, and breathy little details of tempo and space are recovered, that are completely lost in ALL 'low nickel alloy' cored transformers. If you are not interested in hearing the other 50% of the musical information, that you never knew was on the disc, don't buy permalloy. Remember, what you don't know can't hurt you. However, if you are curious and can afford the hefty price tag ($430-$800 each) don't hesitate.

Don't listen to the wankers, who have never experienced permalloy, who say it saturates too easily, don't read the books they are reading either. Just run your output tubes at the right operating point and use sensible speakers and go straight to heaven.

I know this is complete advertising but I love this man and I love these products. Hey, I am not talking about Audio Note am I? [Wow, that's a switch!— ed] Tell me, when's the last time you heard a manufacturer shamelessly plugging his competitor's product? If you want more of this kind of stuff to become available, don't just write for literature, buy something! It is an investment in the future for all of us.