VALVE

in this issue:

inspired moments in audio design -
"OK, now imagine my nose is the grid of the output tube, and my eyes are the plates of the drivers...."22

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VALVE

the monthly magazine
for tube audio eXperimenters

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editor's thing

Yo, bottleheads-

Sitting here on the Bainbridge Island ferry on a stunning March morning, chopping away at a "vintage" (read here, more than three years old) notebook computer.

Gods, Seattle is a beautiful place on a sunny spring day.

A near perfect place for folks to gather and do things audio.

Had an interesting conversation with John 'Exemplar' Tucker and Tony 'Lowther Medallion' Glynn a few weeks back, while John and I were visiting the Lowther Club of America HQ.

They simultaneously waxed enthusiastic about a first annual VALVE show, with manufacturers of fine tube friendly audio gear showing their wares. Then Reid Welch called me and mentioned that the Sakuma group would like to bring their mysterious Sakuma mono system to Seattle in late August or early September to perform one of their super esoteric concerts. Then several folks e-mailed me with requests for a class on designing and building your own equipment.

At last somebody besides me has gotten enthusiastic about the idea of doing an audio event in Seattle!

The main event

As to exhibitors, for starters, I think that we could bring the following local companies to such a show:

Triode Support Systems
Lowther Club of America
Wright Sound Company
Audioprism
Antique Audio Labs West
Northwestern Electric
Shamrock Audio
Electronic Tonalities (natch!)

Certainly manufacturers and distributors from more distant locales would be willing to participate as well if all these folks show up.

This would be a proper audio show, at a hotel, with the exhibitors in rooms with operating systems to audition, and lots of press types and potential buyers in attendance.

A special concert

Our esteemed Japanese fellow bottleheads have demonstrated the all tube, all transformer coupled, all mono Sakuma system in Japan and Europe, and would like an opportunity to perform a concert style demonstration here in the States. This system is really outrageous, antique tubes, bizarre phono equipment, and exotic horn speakers. For those with web access, check out the Directly Heated website for some insight into this cult-like approach to tube esoterica. The Sakuma folks are pretty confident they can fill a small hall with the proper publicity, so this might make for a really nice opening ceremony event for the show.

A little class
John Tucker and I have discussed the idea of a 'master tube builder's' class in the past. We feel that we could offer the S.E.X. kit in various iterations as a platform from which small groups of students could spend a few days mastering the techniques of designing, building and tweaking their own personal expression of valve ecstasy. By the time of the show (the class would start the day after the show's end) we should have 2A3 and 300B versions of the S.E.X. kit worked up and available, so one could start with the original recipe and take off in any number of creative directions, taking home skills which would enable one to continue the process on the rest of their system.
Tony Glynn has expressed interest in holding a class on building the Medallion kit cabinet as well, so we could hook all this creative output together at the end of the class and listen to the result.

What else?
Hey it's our party, we can do whatever we want - a swap meet, a vintage gear display, seminars, equipment shootouts, barbecues, wet T-shirt contests, mud wrestling.....

What we need now is expertise. I would appreciate hearing from anyone who has experience putting on an event of this nature, as well as anyone who wishes to enthusiastically volunteer (and get free admission!).

So call me folks, September is just six months away!

Doc B.

did you just tune in? here's what's happened so far...

Back Issues

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

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

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

pro sound at AES

By Paul Joppa

The January meeting of the local AES was at the Paramount theater, and featured some pro sound reinforcement speakers. Since these kinds of speakers are also high efficiency, there is some interest in them on the part of us SE-triode loonies. So I went to the meeting, and I thought others might like to hear what it was like.

The purpose was to listen to some speakers in a large room, at high levels, to hear not only how they sounded but how much output they could generate and what their directivity was like. There were four different systems, all mostly horn-loaded and with bass down to 80Hz or so (there are subwoofers for those who want more...). These puppies are big, typically 2 ft wide, 2.5 ft deep, and 3 ft tall, usually wedge-shaped so they can be arrayed. We listened to single units, placed on the lip of the stage (i.e. no room reinforcement at all) with us in the theater a minimum of 30 ft away - in other words, we were in the reverberant field even in this large and absorbent hall. We heard pink noise first, then some k. d. lang, and a string orchestra doing "Danny Boy" (!) and finally some anechoic voice recordings. We wandered around the room to listen to the directivity.

The session started out at 80dB level, which was pretty loud. After listening to all the sources on each speaker, the level was jacked up to 90 dB and everything was repeated. At this point I got out my earplugs except for a few moments of paying attention. Then they went to 100 dB; even with earplugs it was unpleasant and no more listening was possible at least for me. Finally they repeated everything at 105dB, which was downright painful even with the earplugs. At this level, I figure the speakers were running at least 130dB/meter, with hundreds of watts for each driver (multi-amped of course). When they started setting up for two of each in parallel, I left.

OK, so clearly these speakers were not intended for domestic use! But they were mostly horn-loaded and high efficiency, so I was curious to hear them and see what the pros are up to. Here are some of my notes, including design notes gleaned from the handout literature.

1) EAW KF-850 -- All-horn, with a 15" woofer 80-300Hz, then a 10" cone mid, horn-loaded, to 2500Hz, and a 4" voice coil beryllium diaphragm horn driver. Sensitivities claimed are 108/110/113dB respectively.

Too much bass (mid- and upper-bass only), highs a little rolled, splashy but not spitty treble. Beams at more than 5 deg. off-axis. Top end unnatural and unpleasant (but the best of the lot). Transients were good, with plenty of punch.

2) Apogee -- No handout, don't know what's in this thing. It roars! It hisses! It doesn't do much else! The mids were light on-axis and missing off-axis. Sounded chesty and sibilant, with a honk around 300Hz (though many had some of this, some at least must have been the room). The bass was oppressively over-loud, and the top end was hard and screechy. Overall, an intimidating and unpleasant unit.

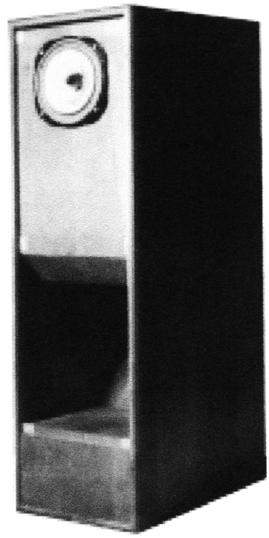
3) Electro-Voice DMS-1183/64 -- The only real woofer, this was an 18" unit in a secret enclosure (I think a bandpass box) covering 48-160Hz at 96dB. 12" horn-loaded mids to 1480Hz (107dB), with a concentric neodymium-magnet horn tweeter to 16kHz (110dB).

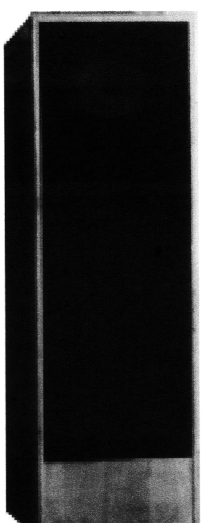
This was the only one with decent bass, not overblown and thumpy but deep when it was needed. The directivity was wider and better balanced off-axis than the others also. I liked the midrange here the best, it was smooth even off-axis and in good balance with the rest of the spectrum.

There's a honk around 800 Hz that was a little off-putting. And in common with all of them, but worst than most, the high treble was sibilant, spitty, and painful to listen to. Only the Apogee was worse in this respect. It's interesting to note that the only one to have decent bass uses the same sub format as Dan's Whammo's...

4) Meyer MSL-4 -- Two-way, with a horn-loaded 12" woofer 65-800Hz and a 4" diaphragm large-format tweeter horn to 18kHz. This was weak on the bass and weak at the top, but at least it had some midrange, especially on-axis, that was not unpleasant to listen to. Bass was sort of chesty and thin at the same time, there was a "cupped hands" resonance around 1-1.5kHz, and a presence peak around 3kHz, which gave the mids a breathy quality. The top end was a little sharp and spitty but sibilant only at the highest levels. Because of the weak bass, this one sounded best with the earplugs in (which reduced the highs enough to restore some balance). More colored than most, but the colorations were relatively pleasant; only the thin bass kept this one from matching the EV overall.

-Paul Joppa





winding your own single ended output transformer part three

By Jim Flowers

Insulation

The wire table in Figure 7 (*see Feb '97*) suggests layer insulation thickness. This is the insulation used when winding in the layer method (not random wiring). This is the insulation between layers of an individual winding (layers of the primary), not between windings (where primary meets secondary). The thickness of insulation separating adjacent windings depends on the voltage potential between those windings - the higher the voltage, the thicker the insulation. The minimum thickness also depends on the dielectric strength of the insulation. Materials that can withstand higher voltage gradients don't need to be as thick.

Kraft paper is often used as insulation. A good quality paper can also be used. The paper needs to be uniform and free of acid. Over time the acid in the paper can corrode the wire's insulation. Electrically, multiple layers of thin paper are better than a single thick layer. I have used wax paper (right out of the kitchen drawer) as insulation.

I'm not a materials expert, but I'm sure there are better, more modern materials available. The insulating material should have a low dielectric constant to minimize the parasitic capacitance. The material must maintain its thickness over time and not cold flow. Preferably, the material is non-hygroscopic, i.e., it won't absorb moisture. Paper fails this test, but others such as mylar, polypropylene, and kapton, do not. "Transformers For Electronic Circuits" (reference 4) has a particularly good chapter on insulation. This is an area still under investigation for me, so anyone knowledgeable on the subject please speak up.

Choose A Winding Arrangement

In order to decide which winding arrangement from Figure 6 to use (*see Feb '97*), the maximum tolerable amount of leakage inductance and parasitic capacitance has to be determined. Figure 9 shows a simplified equivalent circuit for a step-down transformer at high frequencies. Rp is the plate resistance of the output tube, C1 is mainly the self-capacitance of the primary, Llk is the leakage inductance, N is the turns ratio, and R is the load resistance.

Ignoring C1, the transformer equivalent circuit simplifies to a series low-pass LR circuit. R is the

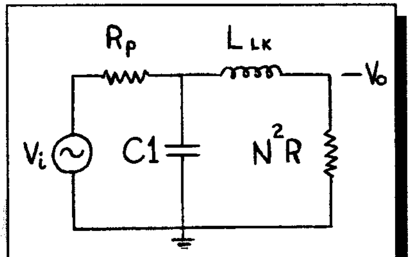


figure 9 - equivalent circuit

series combination of the output tube plate resistance and the load resistance reflected into the primary. The -1db point occurs where the reactance of the leakage inductance is equal to one half of the series resistance.

L =
0.5R/[2 x pi x (Frequency at -1dB)] = (1700 + 5100)/(4 x pi x 20,000) =
27 mH

This time ignoring Lp, the transformer equivalent circuit simplifies to a series low-pass RC circuit. R is the parallel combination of the output tube plate resistance and the load resistance reflected into the primary. The -1db point occurs where the reactance of the parasitic capacitance is equal to twice the series resistance.

C = 1/[2 x R x 2 x pi x (Frequency at -1dB)] =
1/[4 x (1700 // 5100) x pi x 20,000]
= 3.1 nF

As mentioned before, the interlayer capacitance is a function of the layer's surface area and separation, and the dielectric constant of the insulation. For a single pair of wire layers, the parasitic capacitance Co is:

Co = 0.225 DC AMT Wb / d (in pF)

where:

DC = the dielectric constant of the insulation

AMT = the length of winding turn in inches
Wb = the width of the bobbin in inches

d = the thickness of the insulation in inches

Using a dielectric constant of 3, an average turn length of 9.63 inches, a bobbin width of 2.125 inches, and an interlayer insulation thickness of 1.5 mils:

$Co = 0.225 \times 3 \times 9.63 \times 2.125 / .0015$
$= 9.2$ nF

The primary winding is built up from many layers. The self-capacitance of the primary winding Cp is calculated as follows:

$$Cp = 4/3 \; Co \; (NLp - 1) / NLp^2$$

where:

NLp = the number of layers in the primary

Assuming the primary winding is made up of 20 layers, the primary self-capacitance is:

$Cp = (4/3) \times 9.2nF \times (20 - 1) / (20)^2$
$= 580$ pF

In the simple, second-order transformer model above, C1 equals Cp. Because C1 is much less than the tolerable maximum (580 pF < 3.1 nF), the model predicts that the self-capacitance of the primary will not cause a frequency response rolloff in the audio band.

Leakage inductance is also based on coil geometry. It is approximated by the following formula:

$$Llk = k \; IF \; NT^2 \; ALT \; [d + dCu/3] / Wb$$

where:
$k = 3.19 \times 10^{-8}$ (when all dimensions are in inches)

IF = the interleave factor = 1 / "N-squared"

NT = the number of turns

ALT = the average length of a turn

d = the sum of all insulation spacing between sections

dCu = the total copper thickness

The simplest winding arrangement of one primary section covered by one secondary section has no interleaving and therefore "N-squared" = 1. (See upper left corner of Figure 6.) The transformer model is referred to the primary, so NT = 3000. There is only one interwinding insulation space. The interwinding insulation thickness is 10 mils, so d = .01 inches.
Estimate the copper thickness at 75% of the window height making
$dCu = 0.75 \times 0.7 = 0.5$ inches.

$Llk = 3.19 \times 10^{-8} \times 1 \times (3000)^2 \times 9.63 \times [0.01 + 0.5/3] / 2.125$
$= 229$ mH

This is more than the allowed 27 mH. Interleaving will be needed to lower the leakage inductance. The leakage inductance is too high by a factor of 8.5. Try winding arrangement #7 having an "N-squared" value of 16. (Arrangement #6 with "N-squared" equal to 12 would probably be sufficient, but #7 has a better interleave factor with the same coil complexity.)

$Llk = 3.19 \times 10^{-8} \times (1/16) \times (3000)^2 \times 9.63 \times [(4 \times 0.01) + 0.5/3] / 2.125$
$= 17$ mH

Using this winding arrangement, the calculated leakage inductance is less than the maximum tolerable limit determined above. It is best to have some headroom because leakage inductance doesn't act alone as assumed in the first-order analysis of the model. When doing the coil layout design, the distances used for insulation and copper thickness will be determined more accurately. Smarter analysis and implementation of the transformer model will give better results.

Coil Layout Design

Designing the coil layout is a trial and error procedure. Choose a winding arrangement, select the wire gauges, the insulation thickness, add it all up, allow for some margin, and check to see if it all fits in the allowed space. Compromises have to be made. Yours will be different from mine. Here's what I did.

I started with the secondary layout. I felt that 120 turns resulted in too much resistance. The available space wouldn't allow thicker wire, so I chose to use fewer turns in the secondary. Figure 10 shows one of the four sections. As shown in the figure, each section is made up of 2 layers. The first layer is 54 turns of 19 gauge wire. The second layer consists of 27 bifilar turns of 19 gauge wire.
The layout shown has six terminals to allow flexibility to experiment with many different load connections and combinations. It is interesting to see the differences in the frequency response of the same partial winding in each of the four sections. For example, the 54 turn layer in section #1 rolls off in the high frequencies differently from the 54 turn layer in section #4. The astute coil parasitics experts in the audience will knowingly attribute the dif-

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ferences to the physical location of the winding within the coil.

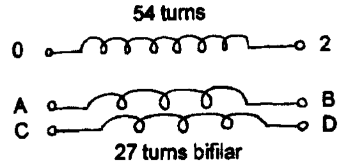

fig. 10a - 2-layer secondary section

Dispense with the flexibility and consider the entire secondary winding as shown in Figure 10a. In each of the four sections, the terminal pairs 2-to-A and B-to-C have been permanently wired together.
The 8 ohm connection is a 108 turn secondary (54 + 27 + 27). This requires two jumpers; one connecting Black0 to Brown0, and another connecting Blue8 to Green8. The 8 ohm load is connected across Black0 and Blue8.

The 4 ohm connection (actually 4.5 ohms) is 81 turns (54 + 27). This requires two jumpers; one connecting Black0 to Brown0, and a second one connecting Red4 to Orange4. The 4 ohm load is connected across Black0 and Red4.

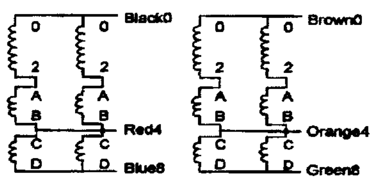

fig. 10b - complete secondary

The 16 ohm connection is 162 turns [(54 + 27) + (54 + 27)]. This requires one jumper; connect Red4 to Brown0. The 16 ohm load is connected across Black0 and Orange4.

Changing the number of turns in the secondary forces a change in the number of turns in the primary to maintain the transformer ratio. To keep the "transformer impedance" at 5.1 kohm, the primary must have:

NTp = N NT = 25.3 x 108 = 2732 turns

This is somewhat less than the 3000 turns originally specified. The inductance equation discussed earlier shows inductance to be a function of the turns ratio squared, so dropping to 2732 turns from 3000 would seem to result in a large drop in inductance. In practice, the permeability u also changes; and the inductance in an SE OT behaves more like a linear relationship with respect to the number of turns rather than a square law. The Hanna curve can be used to estimate the new inductance:

$X = NT\ I / MPL = 2732 \times 90 / 9 = 27320$

According to the curve, for X = 27,000 the Y value is 9,300.
Solving for L:

$L = Y\ Volume / I^2 = 9300 \times 24.3 / (90)^2$
$= 27.9\ H$

Going back to the wire table, 140 turns of 28 gauge wire will fit in one layer across a 2.125 inch wide bobbin. I actually fit 144 turns per layer, perhaps the wire table is conservative. Using 144 turns per layer, 19 layers are needed to reach 2700 turns.

Figure 11 shows the coil layout. Note that this winding arrangement does not strictly follow the interleave pattern. The outer-most primary sections are not precisely equal to one half of the inner sections. To follow the pattern exactly requires the outer-most primary sections to have 2.5 layers instead of only 2. There wasn't enough room for the half-layers; they were omitted and consequently, an unknown (probably small) increase in leakage inductance resulted.

The wiring shown is only representative; it is not the exact connections. The intent is to show that the primary sections are connected in series, and the secondary sections are connected in parallel. The secondary requires additional jumpers that depend on what load will be attached.

It might seem reasonable (or is it heresy) to provide a center tap on the primary so that the transformer can be used with a push-pull connection. The center tap lead would be attached at the 72 turn of the third layer of the central "5 layers of primary" splitting the primary into two equal parts. Perhaps you recognize that the parasitics of the outer half of the primary are not equal to those of the inner half due to the physical coil geometry. This results in an imbalance that only gets worse as the output stage begins to operate in class B. Be

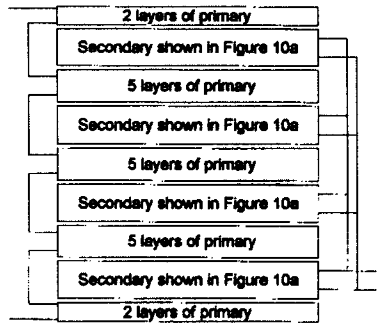

figure 11 - coil layout

aware that the best coil layout for push-pull is different than shown here. All of the textbook references have examples for distributing the primary winding for push-pull operation.

Coil Build

The wax paper interlayer insulation measures 1.25 mils thick. Insulation between windings is 10 mils thick. There are 19 layers of 28 gauge wire plus 8 layers of 19 gauge wire plus 19 pieces of interlayer insulation plus 8 pieces of interwinding insulation.

Coil Build $= 19 \times 0.0136 + 8 \times 0.0373 + 19 \times 0.00125 + 8 \times 0.010 = 0.661$ inches

The height of the available window measures 0.706 inches. Therefore, the left over space is:

$0.706 - 0.661 = 0.045$ inches

This is not much room left over. Some space must be allowed for the inevitable bulge in the wire. According to Lowden (reference 2), allowing for 15% is common practice. That much extra puts the coil build over the limit. Previous experience with this size coil winding led me to try anyway, and I was able to make it fit, but just barely. A lot of care was taken to ensure that the windings were wrapped snugly and that no slop built up. I was tempted to reduce the interwinding insulation thickness below 10 mils to make some extra room. As I am not confident about the insulation requirements at this time, I retained the full 10 mils thickness.

At this point, the easy part is done. Theory,

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(Continued from page 9)

design, and the math to back it all up is easy once you get used to it. Winding on the other hand...well...I'm still not used to it.

The Winding Machine

It is necessary to fashion some sort of a winding machine (see Figure 12). I used half-inch threaded rod as a spindle, plywood for a base and two pillow blocks, poplar wood for a mandrel and the crank handle, and lots of nuts and washers to hold it all together. I also constructed a separate wooden base to hold the wire spool in place (horizontally) during the winding.
I didn't have a turns counter. Only the secondary turns count is critical (during parallel connections) and the 54 turns of 19 gauge wire was easy to count. I counted a single layer of 28 gauge wire just once to verify the turns count per layer in the primary.

It is important for the mandrel to securely hold the bobbin. The mandrel was formed from two pieces of 0.75 inch thick poplar cut to size on a table saw and then screwed together (see Figure 13). It required a half-inch hole along its central axis to fit on the threaded rod spindle. It was easy to center a square pilot hole using the rip fence on the table saw. A half-inch drill bit enlarged the hole to proper size and shape.

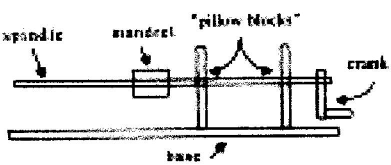


figure 12 - coil winder

The spindle extends out far enough to carry along the 28 gauge wire spool while winding the 19 gauge secondary. The spool is tightly clamped to the spindle so that it rotates with the bobbin assembly. I did this so that I wouldn't have to splice the primary wire across each secondary section. This really isn't worth the hassle and not particularly recommended.

As you can tell, this winder is very crude. It did work adequately though. I'm sure you can do much better.

Winding

The bobbin I used is a rectangular tube with flanges, also called end plates or cheeks. The flanges provide the margin (insulating distance) at the sides of the coil and would support the coil if random wiring was used. If the bobbin didn't already have flanges, I would add them because I'm not certain that my winding technique is good enough yet. I'm

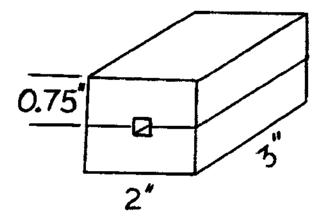


figure 13 - mandrel

concerned that the first and/or last turn of an upper layer might slip off the edge and fall down to a lower layer. Even with the help of the flanges, I had to be careful to avoid this mishap.

The squarish bobbin has two exposed faces and two interior faces. The interior faces fit into the core window between the tongue and the limbs of the E lamination. Take extra care to keep the winding layers flat and as compact as possible on the interior faces. Confine all coil maintenance to the exposed faces. This includes leads, splices, crossovers, taps, tape anchors to secure the start and finish points of each layer, and insulation overlap.

For thin wire, like 28 gauge, use a flexible wire as a lead at the start and finish of the winding. Splice and tape anchor the lead at an exposed face. Figure 14 shows one method of anchoring the first turn of wire.

Lay each turn down neatly side by side until the other side of the bobbin is reached. Tape anchor the last turn. Wrap a layer of insulation and begin the next layer. The style of layer winding is defined in two ways depending on the polarity of adjacent windings. In a conventional winding traverse, also called a U winding, the polarity switches at each layer. In a flyback winding traverse, also known as a Z winding, the polarity of each layer is the same because the rotation and direction of the winding traverse are the same from layer to layer.

The Z winding requires that the first turn of each layer starts on the same side (at the same flange) of the bobbin. See Figure 15 for a pictorial representation of the U and Z winding methods.

Using a flyback winding traverse minimizes the peak voltage difference between adjacent layers in a coil. This reduces the stress on the insulation and also lowers the effect of the interlayer parasitic capacitance. Less capacitance extends the upper bandwidth pushing the rolloff to a higher frequency. Refer to Grossner (reference 4) for a detailed explanation.

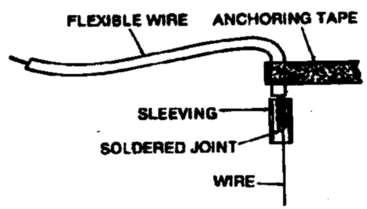


figure 14 - lead attachment

For me, the entire coil winding process was spread out over a period of five evenings. Keep a written record of the build progress. It's not encouraging to resume the next day uncertain if this newest layer is number 4 or number 5.

Cutting the paper insulation to the exact width of the bobbin can be tricky. Stiff paper can be accurately cut on a paper cutting table - those curved one armed slicing things. Thinner materials require a straight edge and a razor blade. The best cutting surface I've found for the thinnest insulation is the Rotary Mat made by Olfa that my wife uses for cutting patterns in clothing material. The 2 ft by 3 ft mat has a grid on it marked in inches and the cutting tool resembles a rolling-wheel pizza cutter. Rolling the cutter along a steel ruler gives straight, accurate cuts.

After all winding is finished, wrap the coil in a protective layer of insulation. If solder tag terminals are to be attached to the coil, heavily spot insulate the coil at this location. Solder the winding section leads to the terminals per the layout paying careful attention to polarity. If you are not completely sure which wire is which, this can be determined with a signal generator and an ac voltmeter later. The secondary I used required 24 connections to 6 different terminals. Hopefully, the insulation coating the magnet wire is the soft solderable type - it will melt away during the soldering process exposing the copper beneath (*this type is polyurethane insulation, not the "high temp" stuff - Doc B.*). Other types of coatings must be scraped off. Of the soft solderable types, I was told that the red colored coating is easiest to work with, followed by gold, and then green, and lastly blue.

Transformer Assembly

Now its time to gather up the laminations and form the core. Before starting, be sure that the screw holes punched in the laminations are clean. If the salvaged core was impregnated, the residual potting compound on the laminations can be used to reduce transformer "singing" due to magnetostriction. Stack the E laminations together forming the E-core. Sandwich the E-core between two flat steel plates and clamp the assembly together with C-clamps. Carefully square all sides of the core and keep the edges of the laminations flush particularly where the gap will be formed. When all is square, tighten the clamps. I used my table saw as a jig to help square the core and clamp assembly. Follow the same procedure for the I laminations.

Let the core soak in a hot oven until the potting compound has softened throughout. Use the temperature and time learned from disassembling the core (probably around 300 degrees for about 30 minutes). Remove the core pieces from the oven and set on a flat surface to cool. Ensure that everything is still square; the softened compound may allow the stack to shift.

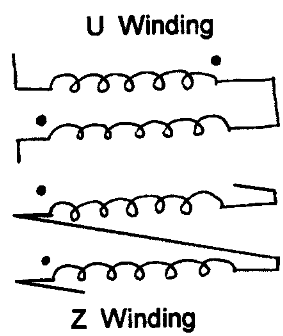


figure 15 - winding styles

Remove the clamps after the core has cooled down. The steel plates come free from the core because the lamination surfaces in contact with the plates had been cleaned with solvent before clamping.

Fit the bobbin onto the E-core; this should be a tight fit. I don't recommend using the keepers (assuming they survived core disassembly). If the keepers are absolutely required to fit the core snugly into the bobbin, they must first be modified. Trim the legs so that they are slightly shorter than the legs on the E laminations. It is vitally important that no ferromagnetic material crosses the air gap.

Add the spacer and the I-core and bolt it all together with the appropriate hardware. Make sure all screws, brackets, and even the end bells are of non-ferromagnetic construction; use brass for example. It would be irresponsible to build such a nice transformer with hardware that magnetically saturates with every beat of the music.

OK bottlebuds, we're done building. Next month Jim wraps it up with testing and adjusting our creation - Doc B.

letters

see, we don't just talk about SE

Hi Dan,

Got the three years back issues. Will try to catch up with you guys.
Built the 4 watt PP 6DN7 according to VALVE October '96, with full wave bridge rectifier and cap regulator. With two 330 mfd caps and a 0.1 mfd coupling cap, the sound is too bassy (no feedback) with my dad's old ITT speakers (+25 yrs.). Changing the B+ caps to two 150 mfd sounds great.
The 120 mA stereo rating for B+ is underrated. With a measured 305VDC, the bias for each 6DN7 is found to be about 40 mA, so the custom order power transformer (250V, 150mA, 6.3V, 5A) is running hot.
Yes, here in City of Angel, you can order (custom made) one 70W power transformer for $16 and two 10K ohm CT 10W output transformers for $10 each. Since the 6DN7 is now running at about 12 watts above the rated 10 watts, what would be the best solution, reduce the B+ or increase the cathode resistor value?
Waiting for EF86 and 6A3 delivery from AES. The custom order output transformer for this project - 25W, airgapped iron with 3-4 mm separation, with paper or plastic - price? $20 each.

T. Song
Bangkok, Thailand

PS - If you don't let the blue smoke out some time, you will get blue all over...

T. - My inclination would be to increase the cathode resistor value on the PP 6DN7 so you run your power transformer cooler, along with your tubes. Doc B.

S.E.X.tasy with Janis Joplin

Doc B.,

Hi, I finally managed to finish building the S.E.X. amp this past weekend. What took me longest was finding the 14 ga, solid copper wire for the ground buss. The nearest place that sold it, when I allowed my fingers to do the walking for me, was a good 50 minute drive away.
Then one day I happened upon a moving sale from a local hardware store and there I got a half spool for half a buck. I even got some 12

ga. spools for the mod to the power cord.
Anyway, to make a long story short, I finished the first amp at around 11:00 on Saturday evening — checked all the readings and found that terminal 6 and 14 of both showed 153K rather than 110K ohms I desoldered (I think I am misusing a term here, hell, I don't know the difference between soldering and desoldering) all the resistors and caps and tried again, still the same result. What the heck, I plugged it in and the voltage reading was a mess (I think I didn't realize that after the first two readings I was supposed to switch to DC on my DMM).
Anyway, I was too eager to have S.E.X.. I pulled the interconnect off of my Golden Tube Audio SE40 and plugged it into the S.E.X. RCA jack, then hooked the Kimber 8TC (double stranded) to my KEF 103.2 (I wired the amps for 8ohm speakers), slowly turned up the volume on my QUAD 44 pre, then Shirley Horn sang in my living room like she never sang before. I put the preamp into mono mode and it sounded even better.
The KEF was rated, if I remember correctly, at 86dB. Boy, I could play it just as loud as the GT SE40, only this was sweeter, more details, but not the etched kind. "Thank you, Doc" was all I was saying as I headed back to the kitchen to finish the other amp. And all the time playing CD after CD.
Well, this one was finished at 3:00 in the morning. And all the readings were right on the money. Plugged it in, and at that point I didn't care if I woke my neighbors up. They should have been there anyway, enjoying S.E.X. with me and Janis Joplin. I mean, like she was right there.
Went to bed finally at around five. Woke up at around seven to play some more CD's, then records. When I put on Turandot with Inge Borke and Mario del Monaco, which on my other amps have an incredible amount of deep bass from the huge drums, I could hear why two watts aren't enough to drive speakers like my KEF's. Actually, another record, Cassandra Wilson's New Moon Daughter, which uses double bass on almost every track, sounded downright strange with the S.E.X. and KEF combo.

Thanks for creating the S.E.X. kit,

Stephen Shew
Chicago, IL

Wahrmayun returns

What's left? Speakers wires!

Referring to my January article on interconnects, first thing you can do with speaker wires is reduce the spacing from 5" to 3". And still using uninsulated solid copper wire - and don't forget the wire orientation thing!
All speaker wire has a "frequency range", so, depending whether your speaker system has one , two or three drivers, you vary the size of the wire from your amp to each driver accordingly.
For a three way system a good combo is 18 ga. for the woofer, 20 ga. for the midrange, and 24 ga. for the tweeter.
For a two way system, 20 ga. on the woofer gets the voicing right. A heavier wire sounds too "heavy" and a smaller wire won't carry the bass. And of course, 24 ga. for the tweeter.
And for those who use only one driver - boy! Well, I've never heard one of those things - but you might try a pair of 20's and a pair of 24's from amp to driver - good luck!
I would like to hear from anybody who has one of those one way systems using this wire combo. It just might work!
For my next Wireman stuff, how about a balanced capless tweeter crossover - and other thoughts on crossovers - plus parts orientation?

Good listening,
Wireman

tweaks

- Tom Tutay says use a 6087 next time you spec a 5Y3 for a design, It's the same spec rectifier, but has a slow warm up, like a 5AR4.
- Several folks have suggested taking apart your favorite tonearm and filling it with spray insulation foam. This stiffens and dampens the tube. Rebalance it!
- Bruce Nilson and others are touting anti static spray as a new cheap tweak. Some suggest its use on cables, Bruce suggests using it on everything, even tubes. Supposed to reduce noise and hash.
- Several folks have also told me they got much improved bass on their turntable when they replaced the existing mat with a glass mat. Get a 12" circle cut at a glass shop. The center hole should be approximately .284 in. Make sure that it is very well centered. Cost, maybe $15.

DAC attack - part two

By L. Dean Moore, Audiogenics

Last month, an attempted was made to lay some general ground rules and give some idea as to the direction of this series of articles. Measures for keeping radiated noise out of DACs were also examined. In addition, some idea as to what one might expect this month was given. Looking back at the last article, although it is important to lay a good foundation, the article was shall we say, "a bit dry". This month, hopefully, things will be different. So, roll up your sleeves, pop-the-hood on your DAC, and start your soldering irons because we're about put in a few turns of wedge and make an air pressure adjustment in an effort to win the race with the best DAC on the market. Needless to say, NASCAR season is in full swing now and I'm a fan.

> *this guy could solder your nose hairs together in the dark after chugging a 16oz. Mt. Dew. All I can say is, its a good thing this guy doesn't drink beer or we'd all be in trouble.*

Basically, most DACs can be broken down into the following sections from digital input to analog output. The input interface, the oversampling digital filter, the DAC(s), the I/V conversion, and the output buffer.(1) Having said that and provided an excellent reference for basic DAC topology, let's examine what changes were made to the power supply for each of these sections. The main filter capacitors were increased to approximately 3,000uF/35V. The digital section, or input interface and oversampling filter, +5V supply is realized by a 7805 regulator. For this regulator, the input bypass was increased from 10uF to approximately 100uF/35V and the output bypass from 10uF to 10,000-15,000uF/6.3V. The 7815 and 7915 regulators, which supply +/- 15V for the I/V conversion and output buffer stages, output bypasses were changed from 10uF to 5,000-10,000uF/16V. The +/-5V supplies for the DACs are realized by 7805 and 7905 regulators which are cascaded off the 7815 and 7915 regulators, respectively. The output bypass capacitors for these were changed from 0.1uF to 10,000-15,000uF/6.3V. Panasonic HFQs were selected for these changes because they have a significantly lower impedance per unit volume. The exact value was selected based on what fit physically with respect to lead spacing and circuit board layout. Digi-Key, 1-800-344-4539, retails Panasonic HFQs and their catalog provides tables for the physical dimensions. If you don't know the pin out of these regulators, make a trip down to Radio Shack and drop five bucks for a copy of their semiconductor reference guide. It should get you there.

This is the point in most articles where, irrespective of the reasons given, I just want to choke the author because they didn't put in the specific values which were used. However, don't get your undies in a bind about the values. It's not that critical here. What's important is to know and understand what is trying to be accomplish. Think of the changes as a brute force approach to power supply regulation in conjunction with an attempt to further reduce the Z (impedance) of the power supply. In other words, you're shootin' for ripple reduction and low Z. The high frequency bypassing is coming and will be accomplished locally; besides, it's pointless to think that an effective job of that can be performed here. The original values were included to show that what was used in the original design was probably somewhat of a "cookbook" approach for each regulator attempting to strike a compromise between regulation, low power supply impedance and high frequency bypassing. The range of values for the changes were included to give a sense of magnitude of the changes and give an idea of what value might be appropriate. I won't bore you with the calculations. Just pay attention to the orientation of the capacitors and the voltage ratings, use the Panasonic HFQs, and pick something that fits in the space available on the circuit board. Don't forget that at some point you're gonna have to put the hood down on this baby and go back out racing; so, you want the capacitors to fit under it. Otherwise, you'll be using color coordinating duct tape to hold your hood on like them boys that get tangled up in the crashes.

Speaking of puttin' the hood back down, this is probably a good point to do just that. This way you'll know if everything is working or if you made some mistakes. It should also help narrow things down if you make a mistake in the following modifications. The other benefit is you will learn what effect each modification has. I found that the changes made to the power supply really helped the bass reproduction and for the first time I started to believe that I had the right gear in the rear-end, if you know what I mean.

Having checked things out, you're now ready to try your hand at changing the local bypass capacitors. What you're trying to accomplish is what I like to term a noise free wide bandwidth purely resistive driving point impedance with respect to each power supply node directly at each component in the signal path.

Uh, yeah, right.

Experts probably have an idea what I'm talking about; DIY virgins, are heading for the bathroom for a long read and know exactly what they are going to do with this article when they're done. Hold on, this modification makes the single greatest improvement of anything I have ever done to a DAC.

Let's examine where things are. First, some measures have been taken to eliminate radiated noise from entering the DAC. Second, the power supply ripple and impedance has been reduced. Now, if you've been following along with your spectrum analyzer, and it's a perfect world, the only types of signals you should find at the power supply pins of the various chips is induced noise, diode noise, clock noise, harmonics of all sorts and etc. depending on the design layout, circuit board and other various things. Pretty depressing; but, no problem. The local bypasses are the means for attempting to make up for all these shortcomings. Were things laid out differently and designed appropriately, you wouldn't be doing this; but then again, you probably would have paid much more for the DAC. I've already told you my "cookbook" story. Here's what you do. Using a network analyzer, characterize the Z of these nodes. Now synthesize a network which, in conjunction which the characteristic Z, produces the lowest possible purely resistive path to ground for those frequencies where the noise was found with the spectrum analyzer.

All this, kind of, reminds me of how they run "Tech Talk" when there's a crash and they're just trying to kill some time with some filler material. But, the powers that be, namely Doc, said y'all kinda like this stuff, so I put it in. Pragmatically, here's what it boils down to. If you could afford the kind of test equipment I used to do this, you would have bought a Mark Levinson No. 31 and would be listening to tunes right about now instead of sitting in the can reading this article. So, get off the can and swap all the local bypasses with something like what follows. In my particular DAC, the local bypasses consists of a Panasonic HFQ in the 100-250uF/25V range and two ultra low ESL (<200pH) AVX ceramic chip SMT (surface mount) capacitors in parallel mounted as close to the power pins as possible. Again, your chances of getting the AVX capacitors that I used are slim to none and the values that I used are only good for my DAC, not yours. You'll need to try the Panasonic HFQ, and perhaps, four 50-100pF 1206 SMT in parallel in your DAC. Just stack them on top of each other between the power pins or the capacitors leads on the back side of the circuit board. This parallel combination should reduce the ESL to an appropriate level and allow you to purchase parts which are readily available form Digi-Key.

I'd like to take this opportunity to publicly thank our sponsors and my buddy, David Bickel, for driving a great soldering iron through this whole process. These modifications do take a bit of a "touch" and this guy could solder your nose hairs together in the dark after chugging a 16oz. Mt. Dew. All I can say is, its a good thing this guy doesn't drink beer or we'd all be in trouble. I'm glad he's on my side.

At this point, the DAC was total transformed. Real bass, even from Altec A7s, in my opinion. I didn't think the amps I'm using now were capable of this kind low frequency performance. Blacker background. Much better note definition, larger presentation, and greater sense of ease. If you don't hear the kind of changes that occur with this modification, I would seriously question the resolution of the rest of the system. These modification are clearly evident with the S.E.X. amps in stock form.

Tune in next month when we'll see if we can close the gap on that 31 car, a little bit. Whoops, I mean Mark Levinson No. 31 DAC.

(1) Norman Tracey, A Tube DAC, Glass Audio, Volume 6, Number 1, 1994.

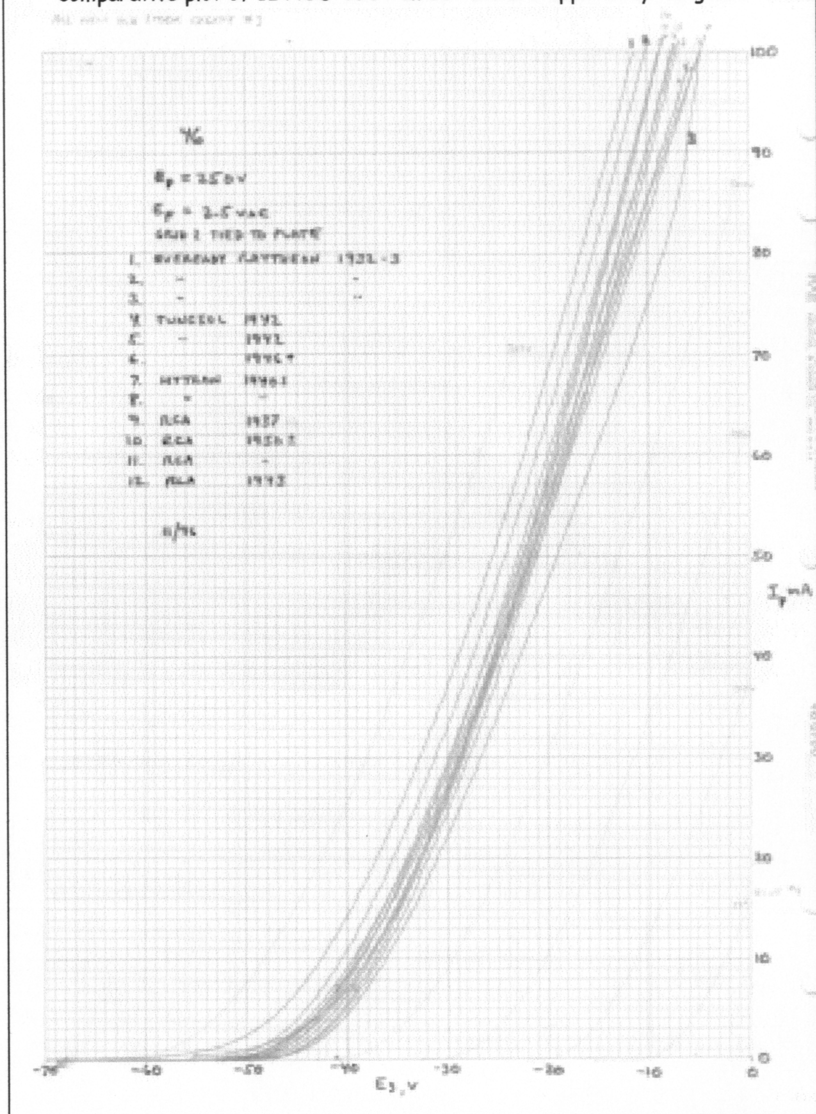
tracing the 46

by Alan Douglas

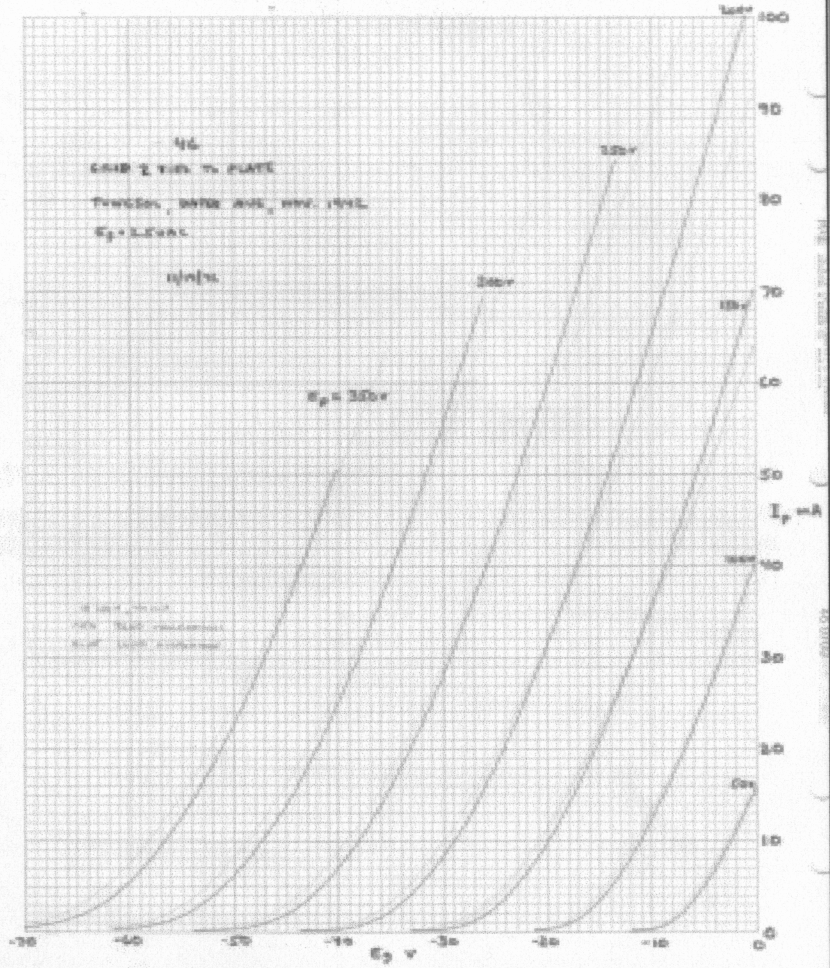
I used to wonder if I would ever use all the obsolete tubes I collected when they were practically free for the taking. I mean, I have a 1932 Atwater Kent console that uses 46's, but since I never play it, do I really need two dozen spare tubes? Answer: no, but they do make it possible to run tests like this one.

I took a dozen new boxed 46's of several brands and ages, and plotted them all on one graph. Omitting the three antique examples, the remainder were surprisingly close in char-

comparative plot of 12 NOS 46's - all but one are apparently Tung-Sol



curve for 46 tetrode wired as triode



acteristics: biased at 25V, their plate currents were within a 5mA spread, and the Gm varied from 2600 to 3200 micromhos, roughly (taken from the plots graphically). Incidentally, all but one of these tubes seems to have been made by Tung-Sol, whatever the brand stamped on the base. All the makers bought tubes from each other, if it was more expedient than making their own.

Historically, the 46 had a very short vogue, in the 1933 model year only. It was intended to do double duty as a class B tetrode and a class A driver triode, to reduce the number of different tube types in a radio. Nice try, but class B didn't sound very good and was too expensive. Current fluctuations from the class B stage got back into the RF B+ unless elaborate filtering was used: this Atwater Kent actually has two power trannies and two mercury rectifiers to avoid such interaction.

By the way, there was a similar tube, the 59, designed for the same A/B service and used by companies like Zenith that would not be caught dead with an RCA designed 46, but still wanted to keep up with the class B fad.

cravings

For sale:

- McIntosh MC60 - $200
- Conrad Johnson PV-3K preamp - $150
- Dynaco ST-70 - $250

407-729-6005, Rich Barrett.

Wanted:
HF60 pair in good original condition. Willing to pay good price for excellent condition. Send offers via e-mail: Ed_Fausto@colpal.com, or fax: 632-671-7530, Ed Fausto.

For Sale:

- Filament transformers, 6.3V CT 1A, new, Mouser PN 81FD010, unused 70's stock, 20 available - $5 each.
- 6SJ7WGT, NOS, glass envelope, metal base, nice black plates, replaces WE 310A in SET designs such as the Angela Model 91 - $5 each.
- GE five star 6080, NOS - $5 each.
- KLH model 5 speaker, single - $20
- Wharfdale model W-4 corner speaker, 3-way, single - $75
- Eico HF-87 stereo power amp, needs caps and tubes - $250
- Radio Craftsman mono tuners: 2 model RC-10, 2ea model 10, 1 model 800 2 of them have broken glass, a few missing knobs $100 takes all.
- Harmon Kardon Citation IV preamp $200.

Call 6-9 pm weekdays, 9am-9pm weekends, 360-871-5921, Crazy Eric.

Wanted:
Older GE or RCA 5751 tubes, also RC-14, RC-29, RC-30 tube manuals.
541-345-7631, Michael Cameron.

For sale:

- Newform ribbon tweeters, 8" model - $175/pr.
- Audioquest AQ 404 high output MC cartridge, low hours- $125
- Grado MC+ high output MC cartridge - $35

360-697-1936, M-F 9-6, Doc B.

april

To pull this VALVE show off, we really need to get some coordinated effort going.
So I would like to suggest the following for our April meeting Sunday April 6, 12 noon, daylight savings time, at Electronic Tonalities:
First half, let's play. I've done some pretty extensive mods to my tonearm/cartridge combo, now a Koetsu Black cartridge/Linn Basik LV X arm (which shall be heavily breathed upon by the meeting), so bring your favorite album to play, and help me sort it out.
As usual, bring your latest project too.
We didn't get to audition the new Foreplay line preamp kit prototype at the last meeting, so we'll hear that too.
Second half of the meeting, I'd like to ask everyone in attendance to give ideas of what they would like to see at the VALVE show, and to see what folks can offer in terms of organizational help. We need to find a venue, advertise, coordinate with potential exhibitors, and schedule the various activities.
We need to develop promotional material and programs, find out about insurance, figure out security, contact manufacturers and distributors, establish a time line, etc, etc.
We need to coordinate with the local dealers and the PAS, PSARA, and other audio clubs across the country.
We need to contact and invite as many members of the audio press as possible.
Does anyone in the local club area speak Japanese? We could use an interpreter to aid our relationship with the Sakuma group.
A little live music might be nice to incorporate into the event, just to keep us honest. Could someone set up a gig?
And, as uncomfortable as it is to ask, we need some one with some capital to float us through the "putting it together" phase. If you could help with finance please call me.
HEY-
Don't think that you couldn't possibly do any of this stuff. If we put our heads together we should be able to solve all the problems through sheer desire, given enough manpower. If everybody pitches in on one selected part of the puzzle, we can pull this off and learn one heluva lot in the process.
So come to the meeting with an idea of what YOU want to see and hear at the first annual VALVE show.
And you bottleheads across the country and around the world - mark your calendars! September is coming!

Doc B.