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A TUNE-UP FOR THE DUAL TURNTABLE

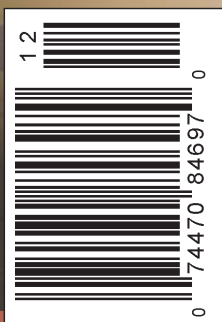
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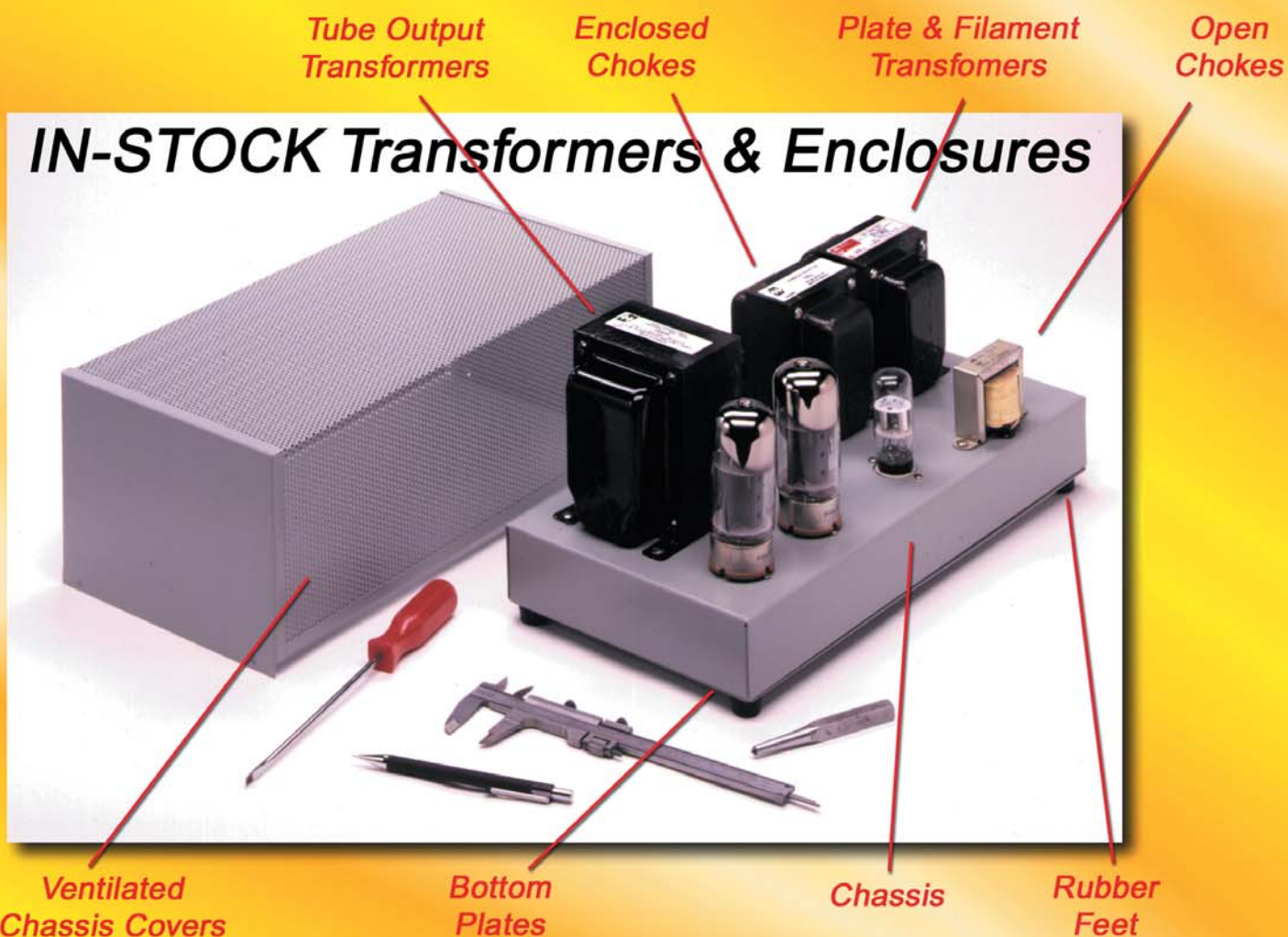
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CONTENTS

VOLUME 41 NUMBER 12 DECEMBER 2010

FEATURES

A DUAL 701 TURNTABLE TUNE-UP

Bring your turntable in for a tune-up to extend its usefulness.

By Tom Perazella.....8

ALL ABOUT STROBOSCOPES

Stroboscope solutions to determine correct turntable speed.

By Ron Tipton.....18

TURNTABLE SPEED CONTROL

Building a variable frequency AC supply to control turntable speed.

By Joel Hatch.....22

THE WRETCHED EXCESS AR TURNTABLE RENOVATION, Pt. 1

Try this hands-on approach to reviving a classic turntable.

By Tom Yeago.....28

VERTICAL BLENDING

Is a blend control useful for vertical-cut recordings?

By Don Walizer and Ron Tipton.....36

RELIABLE REVIEWS

OATLEY ELECTRONICS K272A HEADPHONE AMP

Reviewed by Aren van Waarde.....39

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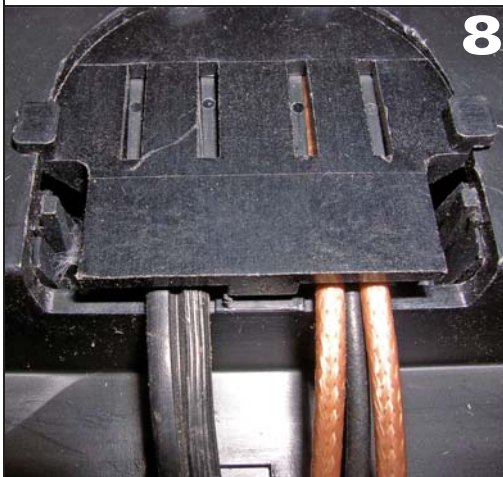
DEPARTMENTS

EDITORIAL.....6

XPRESS MAIL.....43

CLASSIFIEDS.....35

AD INDEX.....35



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audioXpress (US ISSN 1548-6028) is published monthly, at \$50.00 per year. Canada, add \$12 per year; overseas rates \$85.00 per year; by Audio Amateur Inc., Edward T. Dell, Jr., President, at 305 Union St., PO Box 876, Peterborough, NH 03458-0876. Periodicals postage paid at Peterborough, NH, and additional mailing offices.

POSTMASTER: Send address changes to: **audioXpress**, PO Box 876, Peterborough, NH 03458-0876.



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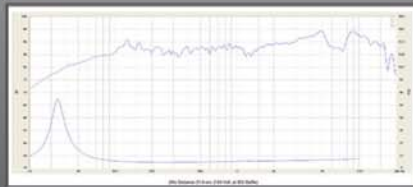
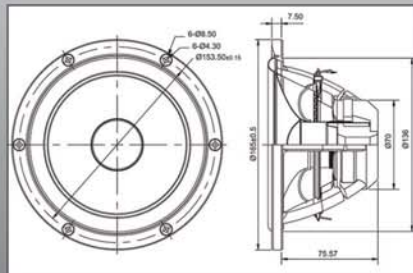
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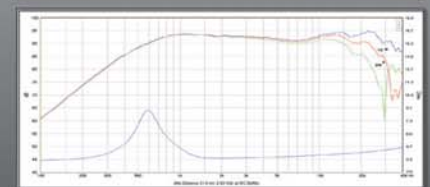
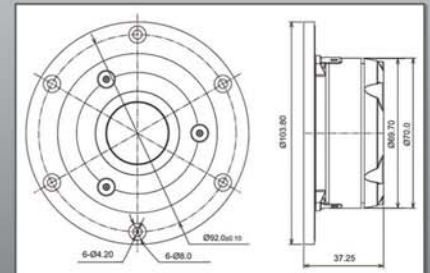
Preliminary Data

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TW29R

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- Cast housings
- Customizable for OEM use
- Patented



Preliminary Data

Specs :

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DC resistance, Re	6.2 Ω	Sensitivity (2.83 V/1m)	87.5 dB
Voice coil inductance, Le	0.16 mH	Mechanical Q-factor, Qms	4.9
Effective piston area, Sd	119 cm ²	Electrical Q-factor, Qes	0.36
Voice coil diameter	35.5 mm	Total Q-factor, Qts	0.34
Voice coil height	17 mm	Moving mass incl. air, md	13.4 g
Air gap height	5 mm	Force factor, Bl	6.5 Tm
Linear coil travel (p-p)	12 mm	Equivalent volume, Vas	44.8 ltr
Magnetic flux density	1.17 T	Compliance, Cms	2.23 mm/N
Magnet weight (NEO)	0.13 kg	Mechanical loss, Rm	0.5 kg/s
Net weight	1.01 kg	Rated power handling	60 watt

The parameter are measured on drive units that are broken in

Specs :

Nominal Impedance	4 Ω	Free air resonance, Fs	590 Hz
DC resistance, Re	3.0 Ω	Sensitivity (2.83 V/1m)	93 dB
Voice coil inductance, Le	0.02 mH	Mechanical Q-factor, Qms	2.5
Effective piston area, Sd	9.6 m ²	Electrical Q-factor, Qes	1.5
Voice coil diameter	29.0 mm	Total Q-factor, Qts	0.9
Voice coil height	2.0 mm	Force factor, Bl	1.8 Tm
Air gap height	2.5 mm	Rated power handling*	100 Watt
Linear coil travel (p-p)	0.5 mm	Magnetic flux density	1.0 T
Moving mass incl. air, Mms	0.45 g	Magnet weight	0.22 kg
		Net weight	0.5 kg

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HOW ARE WE DOING?

All of us are dealing with some effects of the “downturn.” We are not an exception. We see these forces every day in those who decide about advertising in our pages, and those of you who are sending your renewals. We are all asking each other “How are you doing?” or “Hope all is well with you.”

It is a hard time, and one which often appears endless. I think we are all tempted, in our frustration, to look for scapegoats, or people to be mad at for causing all this. We would do well to step back and give some calm thought, unaffected by our feelings, about where we are and why.

My answer to people who inquire about the situation at Audio Amateur is to reply that we are responding in positive actions. Some of our people are work-

ing off site, and in a case or two, fewer hours. We have been cutting costs in a number of ways. We are using less paper, we use heating oil more sparingly. We work four days a week. We have been using interns occasionally. We are encouraging readers to seriously consider digital versions and delivery of all our periodicals. This is working and we are seeing lower printing bills every month. *AudioXpress* is now being distributed on newsstands in Europe and Britain. Our office has been helped enormously by a local IT company and the addition of Google's wonderful apps Docs, g-mail, and calendar. This links all of us together as editors, customer servants, marketing, and advertising. We are, insofar as possible, using open source software, believing that such widely used capabilities should not be monetized indefinitely.

AudioBytz is our new newsletter, free to anyone interested in excellent sound. David Ranada is one of the most informed and experienced commentators on the audio scene anywhere. Go to our website (www.audioXpress.com) and join the thousands who are reading David every other Thursday. Watch for a new blog from the publisher on life here at Audio Amateur. We have a lot going on in this 40-year-old enterprise dedicated to hands-on audio craftsmanship. Blogs require snappy titles, so we decided on **Ed Dell's deciBels**. Watch for an announcement on our website.

A lot more than I have detailed here is going on in our corner of Peterborough. I'll be sharing a lot of that in my impending blog.—E.T.D.

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A Dual 701 Turntable Tune-up

New life for an audio classic.

Can you remember what you were doing in 1975? Lately, I feel lucky if I can remember what I was doing last week. Recently, I decided to do a tune-up on an old friend, my Dual 701 turntable. It had been a reliable companion. However, it started giving me a few problems, noticeably a failure of the neon lamp that enables operation of the stroboscopic speed indicator and a reluctance of the automatic start function to move the tonearm over the lead-in groove.

I decided to check my records and found that in 1975 I was in the process of drooling over the reviews of this spectacular new turntable. That eventually led to my purchasing one that summer. I still had the original product sheet, a review from the spring 1974 *HI-FI Stereo Buyers' Guide*, and the owners' manual, plus the unpacking and setup instruction sheets. I really am a pack rat. Certainly, this turntable had provided a whole lot of excellent listening in the ensuing 30+ years of use and proved to be an amazing value. I did not hesitate to begin the tune-up process.

DISASSEMBLY

Before starting the project, I searched

the web for other problems that may have been common with the turntable but I had not yet encountered. A great resource is www.vinylengine.com. I found that there were a reasonable number of failures of a suppression capacitor that was wired across the incoming power line. I added replacing that capacitor to my to-do list. I was also able to download the service manual for the turntable from this site, which proved to be very helpful.

Most of these upgrades required removing the bottom of the case on which the turntable rested and working on it from below. To prevent damage to the tonearm or switches, I built a support stand from some scrap $\frac{3}{4}$ " thick by 2" high wood pieces to safely hold the turntable in an inverted position while working. The inside dimensions of that stand were $13\frac{1}{4}$ " $\times$ 15 $\frac{13}{16}$ ".

In preparation for the tune-up, I removed the clear plastic dust cover by moving it to the open position and then lifting it out of the two spring-loaded hinge clips located at the rear that hold it in place. One of the hinges is shown in **Photo 1**.

Next I secured the turntable to the

base using the built-in shipping screws and also secured the tonearm to its rest by using the built-in spring-loaded clip. For additional safety, I removed the carrier holding the cartridge from the tonearm and put it aside in a safe place to prevent damage to my irreplaceable Shure Ultra 500 cartridge. It was now safe to invert the turntable and place it on the special stand I made.

There are essentially two steps to removing the bottom plastic cover. The first is to remove the strain relief holding the power, signal, and ground leads in place so that they can pass through the base. Next, you must remove the staples and screws holding the plastic cover to the composite wood base.

Photo 2 shows the strain relief in place on the bottom plate. In order to remove it, I moved the two plastic locking tabs toward the center of the relief. I then lifted the relief out of the base.

Photo 3 shows the retaining clip that keeps the power cable separated from the audio and ground cables. I slid this clip off the track in the relief and then lifted it off, releasing the cables.

The bottom is held in place around its periphery by a combination of staples, screws, and adhesive. I used a small flat-

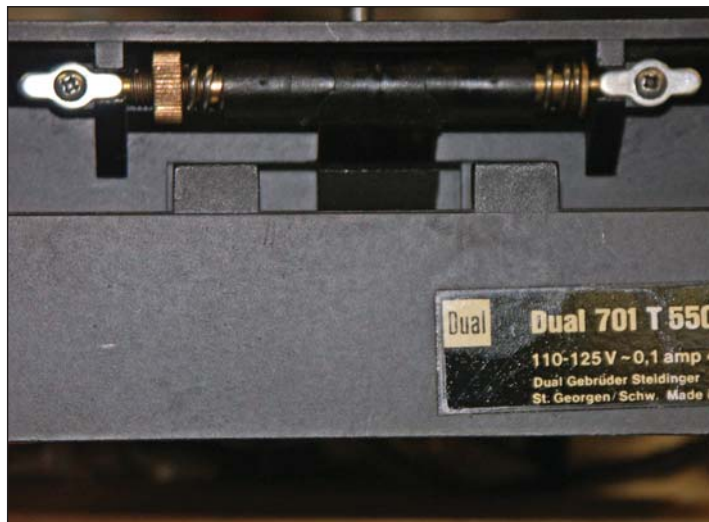


PHOTO 1: Hinges on back of case.

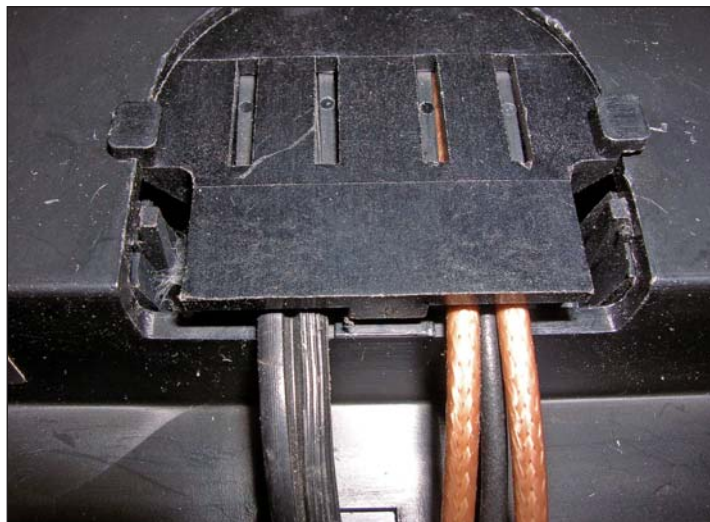


PHOTO 2: Strain relief on bottom.

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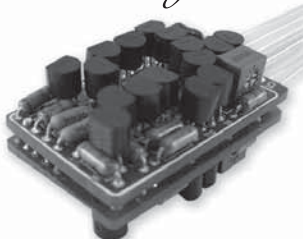
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Ed Simon - AudioXpress, October 2009



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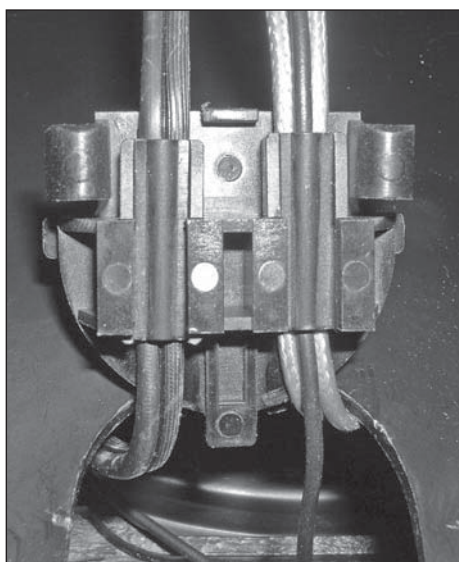


PHOTO 3: Clip holding cables.

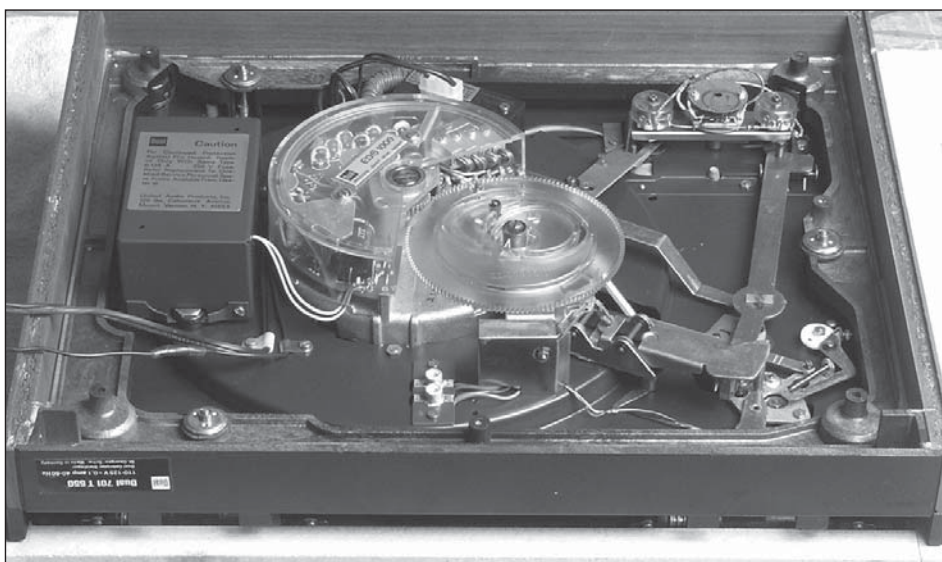


PHOTO 4: Bottom view of inside components.

bladed screwdriver to start lifting each staple and then finished with a pair of needle-nose pliers. After removing all the staples and screws, I carefully pried the cover from the base taking care not to damage the underlying particleboard. Because the signal leads are attached to the turntable with RCA jacks, I removed them so they would not be in the way during the process. **Photo 4** shows the open inverted turntable resting on the stand.

Whenever I disassemble a component for which I don't have assembly draw-

ings, I always photograph each stage of the process as a reference for use with the subsequent reassembly. This has saved me no end of grief over the years and is a much easier process since the advent of digital cameras. I then proceeded to photograph all stages of the disassembly.

CAPACITOR FIXES

The first upgrade involved replacing the potentially troublesome capacitor that was across the mains line. In **Fig. 1** it is identified as C52 and has a value of

47nF. This type of capacitor has specific properties that make it suitable for direct connection across the mains line. You should always use capacitors that are certified for X2 "across the line" applications and bear UL, CSA, VDE, and so on approval marks. If not, you may compromise safety with a possible fire if the capacitor should fail catastrophically.

Figure 1 shows another capacitor in that section of the power supply that I used to drive the neon lamp in the strobe section. Because I would already be working on the board, I decided to also replace that one. It is identified as C51 and has a value of 68nF. Both capacitors are available from Digi-Key (www.DigiKey.com) as part numbers BC1616 and BC1879. They have working voltages of 275V and 630V, respectively, and although both have nearly doubled in price since I purchased them, they are currently still relatively inexpensive at \$0.82 and \$1.17.

This section of the power supply is located in a small metal box on the underside of the chassis (**Photo 5**). To access the components inside, I removed the two small retaining screws that are located at each end of the case and lifted up the cover. The two capacitors were now clearly visible (**Photo 8**). Because there are no component labels on the board, I took note of the values marked on the capacitors to determine their identities.

Access to the bottom side of the board requires that you remove it from the box. To do this, I first needed to remove seven leads—two mains leads, two

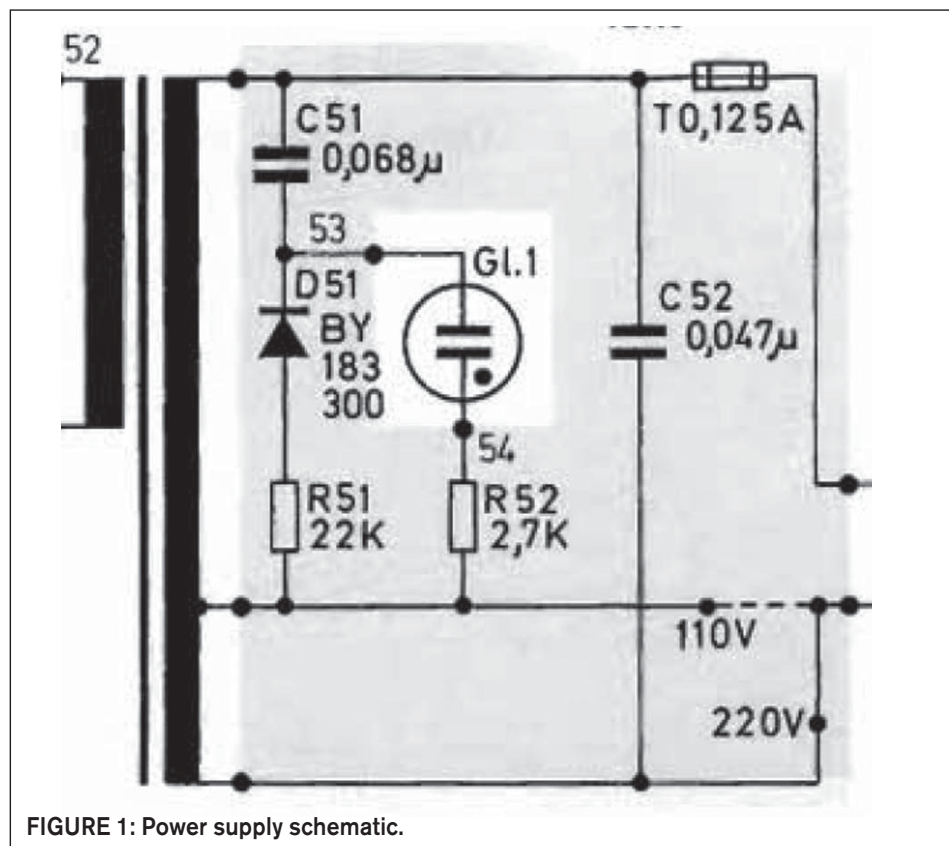


FIGURE 1: Power supply schematic.

neon lamp leads, and three transformer leads. You can unsolder the mains and neon leads from the lugs on the board and unsolder the transformer leads from the lugs directly on the transformer. As always, I made sure to record the connection sequence of the leads before removing them. One end of the board is held in place by metal tabs punched through the box, and the other end fits through a slot in the box. Once the cover was off, I moved one side of the box away from the side of the board that is in the slot and lifted the board out.

Next I turned the board over and removed the two capacitors. The 68nF capacitor is the same size as the original and you can simply solder it into place. The 47nF capacitor has a lead spacing that is less than the original. Instead of bending the leads at a sharp angle to fit

the existing spacing, I decided to drill two new holes centered between the old ones. I inserted the capacitor into the new holes and used hook-up wire to connect the leads to the old pads as shown in **Photo 7**. The board with the new capacitors is shown in **Photo 8**. I then reinstalled the board, reconnected the leads, and replaced the cover.

LUBRICATION

It always amazed me that the Dual turntables seemed to be able to do the same functions as their British counterparts using about half the number of components. However, even the fewer parts in this design occasionally need lubrication. I was actually quite surprised that the turntable worked for as long as it had with my neglect of lubrication. The service manual was quite helpful

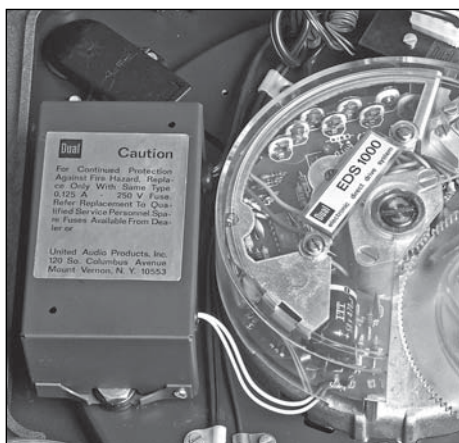


PHOTO 5: Power supply enclosure.

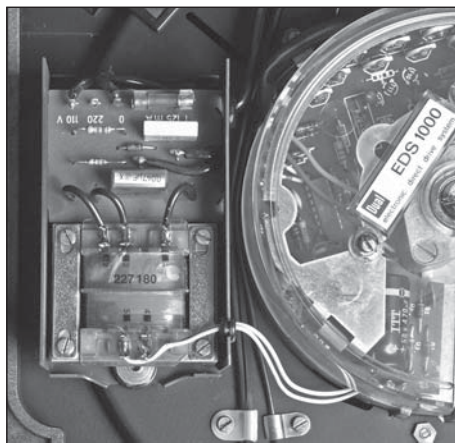


PHOTO 6: Power supply.

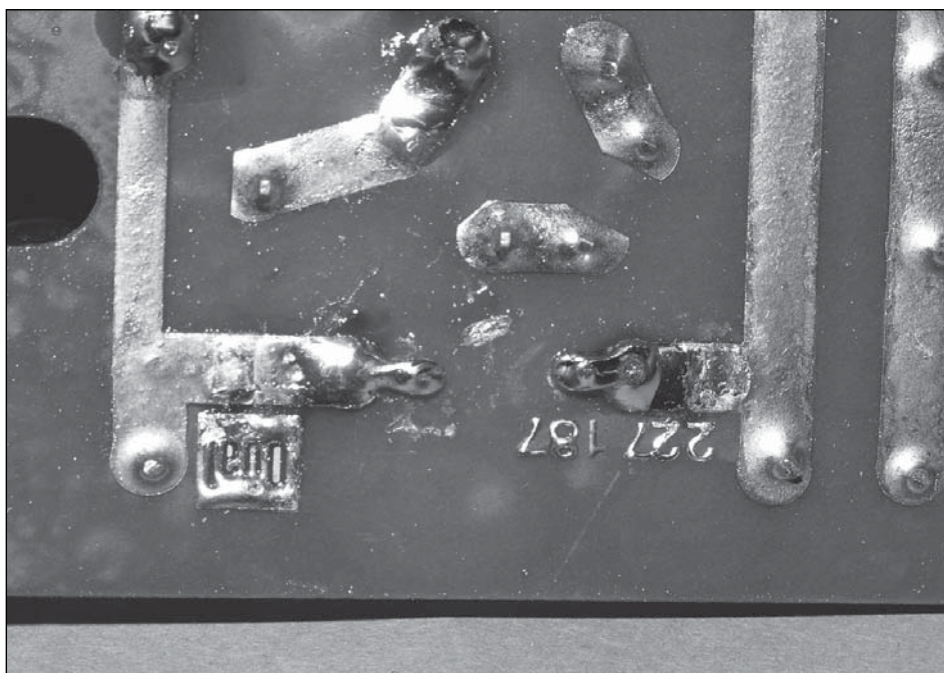


PHOTO 7: Connections on circuit board.



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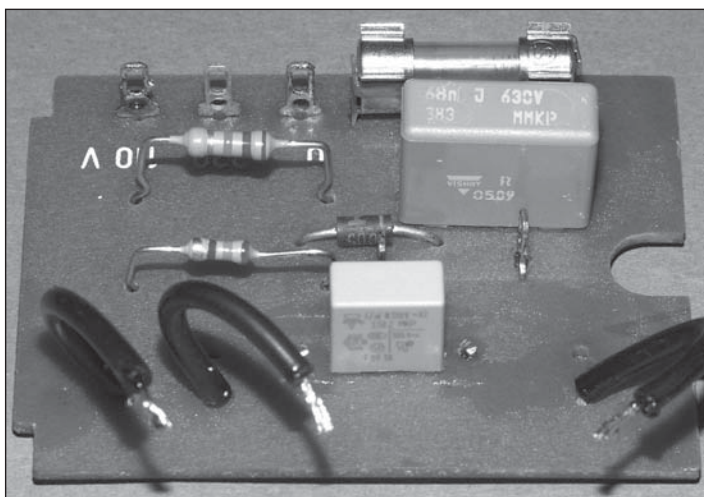


PHOTO 8: Board with new capacitors.

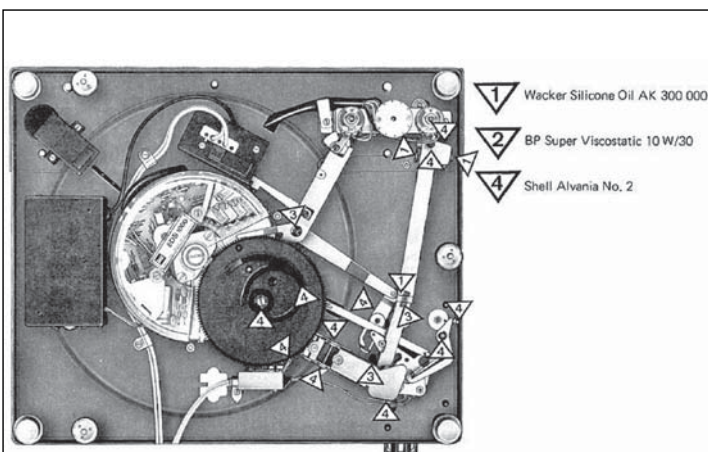


PHOTO 9: Lubrication points.

in doing this job, showing two exploded parts views, with a photo of the bottom mechanism and callouts for each point of lubrication indicating the type of lubricant to use (**Photo 9**).

The service manual called for three brands of lubricants that are no longer generally available: a high-performance oil, a silicon lubricant, and a high-performance lithium-based grease. I had on hand modern replacements for all three. For the oil I used Mobil 1, for the silicon lubricant I used CRC heavy-duty silicone, and for the grease I used Panef white lithium grease. I am sure there are many other modern lubricants that will work as well.

Before beginning the disassembly of the turntable, I manually ran it through its cycles while watching the action of the components. I had to release the tonearm to do this. All of the mechanism is driven through a large plastic cam wheel connected to a gear at the bottom of the

motor assembly (**Photo 10**). At rest, the cam wheel sits with an open space in the teeth opposite the motor gear.

To begin operation while the motor is running, a pivoted arm on the cam wheel moves against the motor gear which rotates the cam wheel to a point where its teeth engage the motor gear. It will continue to rotate until it again reaches the rest position where there are no teeth. During that rotation, depending on the function selected, levers move through various slots in the cam wheel. I will not try to describe all the movements for the different conditions because you can see them in action better than I can describe them.

When I was familiar with the operation of the various parts, I removed the cam wheel to access the parts that lie beneath. The wheel is held in place on its shaft by a "C" clip as shown in **Photo 11**. After removing the wheel, I cleaned the old grease

from the wheel and applied a new lubricant. The bottom of that wheel showing the actuating levers is shown in **Photo 12**.

Next, I cleaned and lubricated the assembly that controls the levers on the bottom of the cam wheel as shown in **Photo 13**. Note that one of the levers is connected to the tonearm and trips the cycle at the end of record play. That lever *must* move very freely or there will be drag on the tonearm. It originally was "dry"—that is, it had no lubrication. I did not apply any lubricant to that lever to eliminate the possibility of drag that could result from its use.

The assembly shown in **Photo 14** is central to the operation of the arm in automatic mode and proved to be the solution to my arm movement problem. The photo shows a central horizontally pivoting plate to which are attached two vertically pivoting arms. The arm on the left is actuated by the cam wheel and

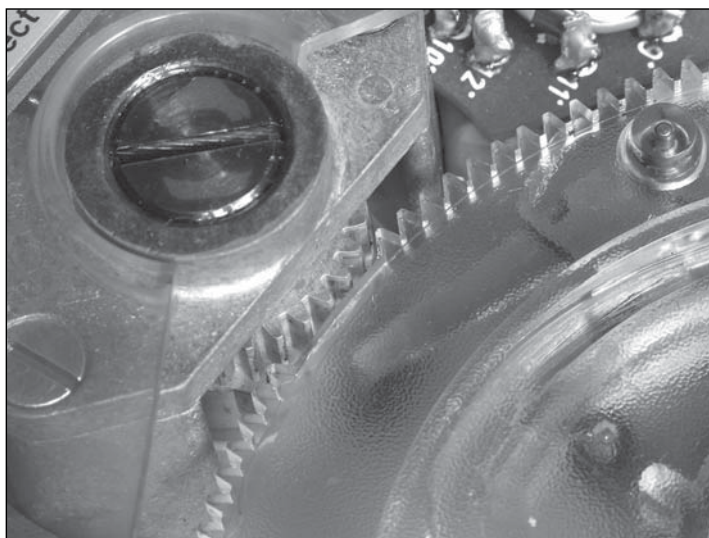


PHOTO 10: Cam wheel rest position.



PHOTO 11: "C" clip retainer.



PHOTO 12: Bottom of cam wheel.



PHOTO 13: Cam level actuator.

moves both horizontally and vertically.

Because that arm is not pivoted in the horizontal direction, its horizontal movement is transmitted to the center plate and from there to the right arm, which provides the actuating movement for the tonearm. In addition, its vertical movement is transmitted to the right arm. As a result, as the cam goes through its cycle, the actuating arm is moved both vertically and horizontally. The other end of the actuating arm rests just above the bottom of the tonearm when viewed in the inverted position as shown in **Photo 15**.

The tonearm has a coupling pin that provides intermittent contact with the actuating arm. When the actuating arm moves vertically, it presses against the coupling pin, raising the arm. When it then moves horizontally, it swings the arm over the record to the lead-in grooves if it is in a start cycle or to the rest position if it is in a stop cycle.

The movement of the tonearm in the horizontal direction is the sole result of friction coupling of the pin with the flat surface of the actuating arm. The broad flat surface of the actuating arm allows the horizontal coupling to the arm pin regardless of the arm position, but depends on the proper friction coupling. In the case of my turntable, over 30 years of activity were enough to wear the surface of the pin sufficiently to prevent that friction coupling from occurring properly.

To fix the problem, I first cleaned and then lubricated the actuating arm and tonearm coupling pin. Then I adjusted the vertical movement of the actuating arm using the screw shown in the center

of **Photo 14**. It took less than a quarter turn of the screw to achieve proper operation. Using more than that resulted in excessive force on the arm which caused the cam to stall partway through the cycle. Use care when making this adjustment. Once done properly, the arm operation was flawless.

The levers that control the manual lifting of the arm are shown in **Photos 16**

and **17**. They needed to be cleaned and lubricated. **Photo 17** also shows the linkages for the anti-skating section. The lever that links the automatic start and stop lever on the top of the platform to the actuating mechanism is shown in **Photo 18**. As with the others, I cleaned, then lubricated, them. I then reassembled the actuating cam and tested the operation of the mechanism. At this point, the opera-

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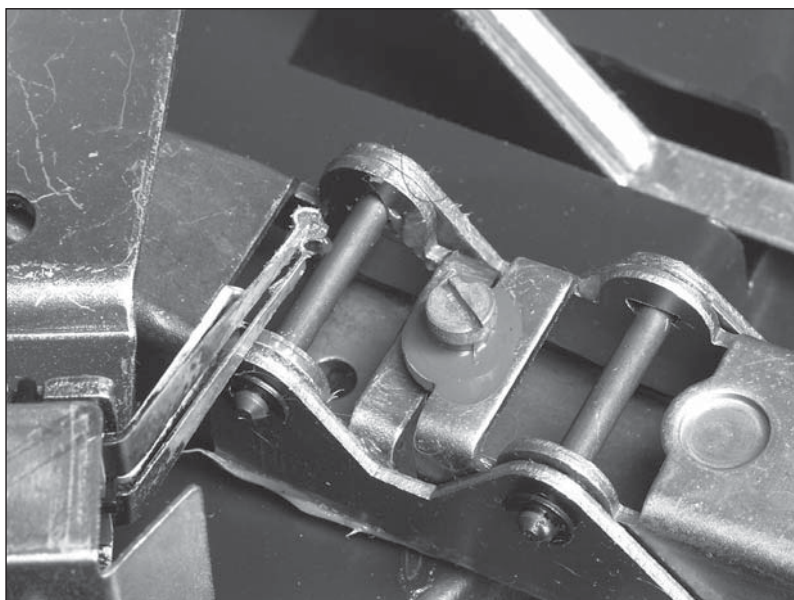


PHOTO 14: Tonearm actuator assembly.

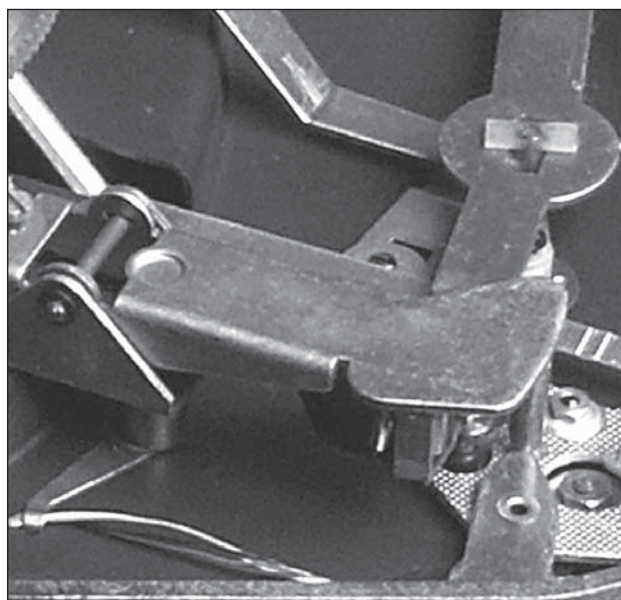


PHOTO 15: Tonearm contact plate.

tions under the deck were complete.

The remaining parts to be lubricated were the hinge assemblies that operate the dust cover. To remove them from the base, first release the spring tension by using the knurled wheel shown on the left side of **Photo 1**. Removing the two Phillips screws and the retaining plates will allow the hinge assembly to be removed. Repeat for the other side as well.

Once the hinges are out of the base, remove the knurled wheels and pull the hinge pins out of the assembly. Then you can disassemble the hinges as shown in **Photo 19**. Clean all the parts and lubricate the hinge pins and cam surfaces with the lithium grease. Reassemble the hinges and install them in the base. You will need to readjust the hinge tension by trial and error after attaching the dust cover.

THE STROBOSCOPE

The final repair was to replace the bad neon lamp in the stroboscope section. The original lamp was a special design as shown in **Photo 20**. At the time I searched the web for a replacement, there were very few left and they were expensive. At first I thought about designing a circuit that would drive an LED synced to the line as a replacement for the neon. It would probably outlast whatever life was left in the turntable. However, that would require a power supply and additional circuitry that would not only add complexity, but might also add noise in the low-level environment of the signal circuit.

Instead, I decided to see whether the ubiquitous NE-2 lamp would work as a substitute. I had quite a few in my

parts bins but would need to deal with the fact that the wire leads were quite different from the flat contacts of the standard lamp.

Access to the stroboscope lamp is from the top section under the platter. A small black housing holds the lamp. The cover of the housing has the prismatic lenses that direct the light to the strobe pattern printed on the bottom of the platter and return the image to the viewing window.

The assembly is fastened to the turntable by two screws that also provide for mounting in two positions, one for operation at 60Hz and the other for 50Hz. Removing the cover gives access to the lamp. Once the cover was off, I lifted the lamp from the clips that held it in place.

Mounting the NE-2 replacement in the housing turned out to be easier than

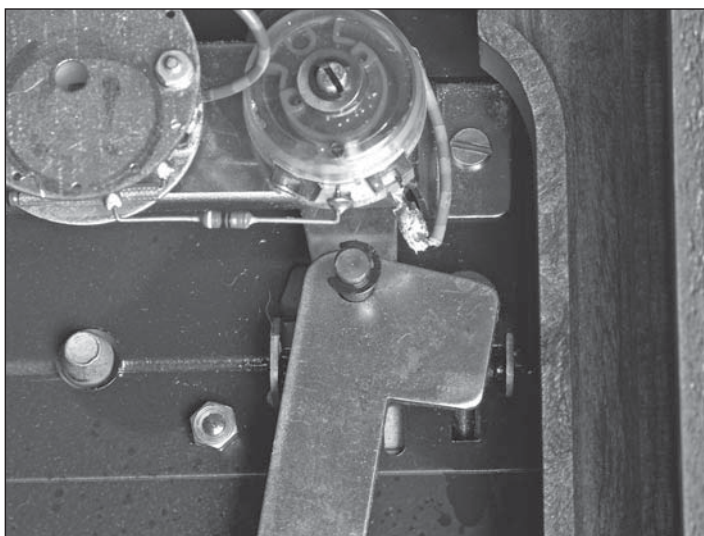


PHOTO 16: Manual arm lift lever.

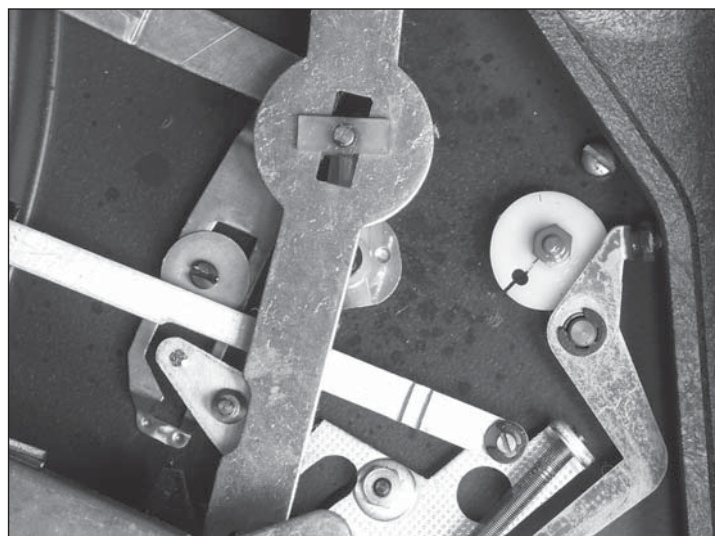


PHOTO 17: Manual arm lift lever.

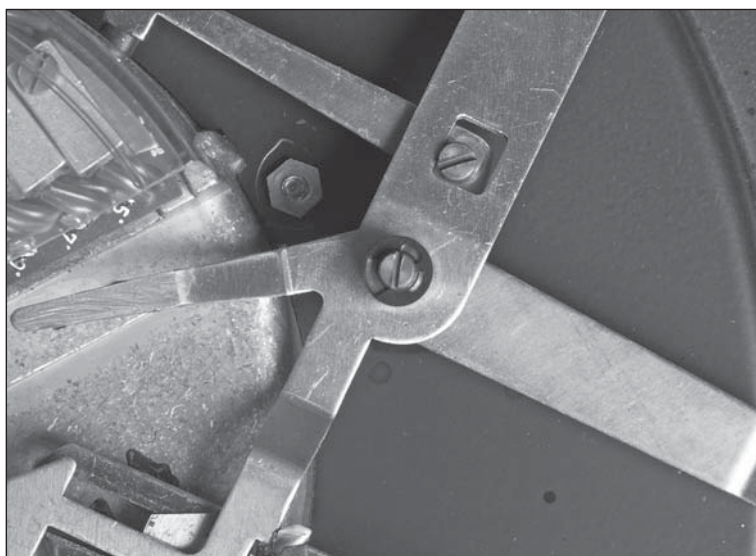


PHOTO 18: Automatic start actuator.

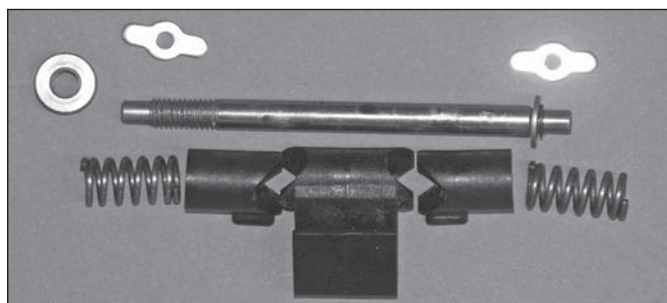


PHOTO 19: Disassembled hinge.

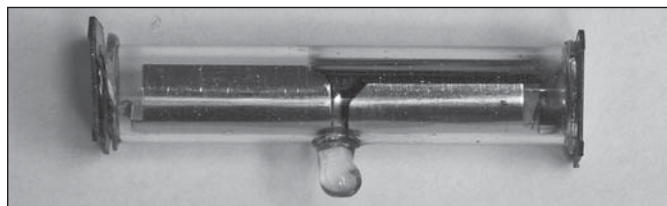


PHOTO 20: Factory neon lamp.

I expected. I first positioned the lamp in the housing at the appropriate location and measured the required lead length. The leads were trimmed, tinned, and covered with shrink tubing, leaving only the ends to be connected exposed. I then inserted the lamp in the housing, being sure to properly route the wires.

Once the lamp was in place, I soldered the wires to the existing lead wires that fed the lamp contacts. The result is shown in **Photo 21**. You can see that it all fits rather nicely. I reinstalled the cover, making sure that the proper alignment for 60Hz was maintained. You can see the lamp through the window in **Photo 22**.

REASSEMBLY

It was then time to replace the cover on the base. I did not like the idea of using staples as was originally done at the factory. If future access to the inside of the turntable ever became necessary, I did not want to repeat the hassle of removing the staples. Instead, I decided to use small #2 wood screws.

At each point on the plastic cover where a staple had been, I drilled a clearance hole for the screws between the existing staple holes. I then laid the cover on the base and marked the position of each clearance hole on the base. I removed the cover and drilled pilot holes for the screws at each of the marked locations. I reconnected the signal cables to the RCA jacks and passed all the leads through the base. I reattached the strain relief to the leads and positioned it on the cover. I then screwed the cover in place with the small wood screws and

the original Phillips screws.

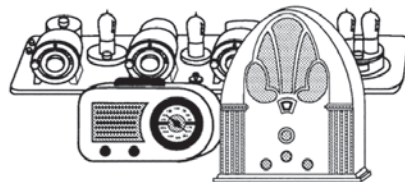
I removed the turntable from the support and placed it right side up on the base. I replaced the platter and the cartridge housing with the cartridge reattached. After releasing the lockdown screws and tonearm lock, I rechecked the cartridge tracking force and anti-skate setting, plugged in the power cord, and placed an LP on the platter. The

moment of truth was at hand.

I activated the automatic cycle. The platter began to spin. The tonearm raised and positioned itself over the lead-in groove and the arm gently descended to the record. Yes! Success! I then looked at the stroboscope window and saw a bright clear pattern (**Photo 23**). All was well for the repair phase of the project.

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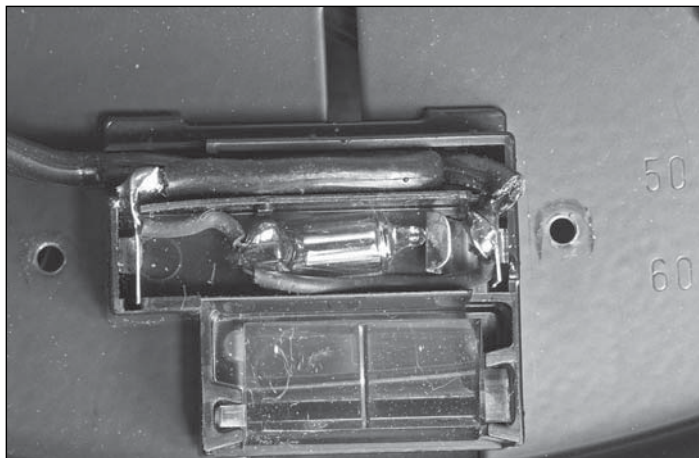


PHOTO 21: New neon position.



PHOTO 22: New neon in housing.

ADJUSTMENTS

To get the maximum benefit of a tune-up, you need a good test record, a protractor disk, instructions, and an oscilloscope. I already had the oscilloscope and obtained the rest of the items from the Old Colony Catalog at www.audioXpress.com. Their test LP from *Hi-Fi News* (part number LP2) produced by Len Gregory also includes the required protractor and instructions. In addition, as a comparison for the anti-skating test, I used the blank band #4 of the Shure Audio Obstacle Course (TTR 101) LP.

The first step was to level the turntable and connect the audio leads to a standalone phono preamp that I built. I then fed the output of the preamp to the oscilloscope.

Next I checked the cartridge alignment in the head shell with the protractor. The cartridge had originally been mounted using the gauge supplied by Dual. You mount the cartridge so that the stylus tip is centered in a "V" shaped cutout in that gauge. When I checked it with the protractor, it was right on. No adjustment was needed, but it was good to have confirmation of a correct setup.

With a pivoted tonearm, distortion

will occur due to a vector force that tries to move the stylus in toward the center of the record. This is commonly called skating. The Dual 701, like most turntables, has the ability to apply a force to help offset this skating force. On the 701, it operates in a nonlinear manner as the arm moves across the record because the skating force is also not linear.

There are two scales, one for conical styli and one for elliptical. The owner's manual states that one scale is white and one is red. However, on my unit one scale is black and the other is red. I used the red scale that had a symbol for an elliptical stylus. According to the manual, you should set the anti-skating level to the same number that you have for tracking force. In my case, my tracking force was 1.5 grams, so that was the setting I used in the anti-skating dial.

The first anti-skating test I did was to use the recommended force and then set the tonearm down on to the blank section of the Shure Audio Obstacle Course record. That level proved to be too low and caused the arm to skate toward the center of the record. To get the arm to remain stationary on the blank section required an indicated anti-skating force of 2.5 on the dial.

In the second anti-skating test, I used the bias bands of the *Hi-Fi News* test LP. Bands 6–9 on the front side each contain a 300Hz tone but recorded at four different levels of +12dB, +14dB, +16dB, and +18dB, respectively. A simple test requires that you listen to the tones from each channel and identify any distortion. You can then adjust the anti-skating force to minimize the distortion. For a more critical test, you can direct the left and right cartridge outputs to two differ-

ent traces of an oscilloscope and look for waveform distortion on either channel at the different levels of modulation.

I proceeded with the oscilloscope test. During the test, it was interesting to note that at the setting suggested by the blank band test, there was no visible distortion until the +18dB level was reached. At that level, the distortion was only in one channel, and increasing the anti-skating force further to a scale setting of 2.75 eliminated it.

It appears that manufacturer recommendations may be considerably off from what is truly needed. Using the blank band test is a better method of setting the force, but actually looking at the reproduced waveforms is the best way to set this parameter. The large discrepancy in the setting recommended by the manufacturer could be the result of decreasing spring tension of the mechanism with old age yielding a force that is actually less than that indicated on the dial.

Band five of side 2 of the *Hi-Fi* LP contains a cartridge alignment test. If the stylus is not perpendicular to the record surface, the outputs of the right and left channel will be unequal. The test band contains identical 300Hz tones in both the left and right channels that are out of phase. You can test this without instrumentation if you have a mono switch on your preamplifier. I do not, but I do have a sum function on my oscilloscope that effectively adds the signals from both traces and displays the sum of those two. When I used that function, the resulting signal was a null indicating both channels were in balance and the azimuth was correct, which is good because there is no easy way to change that parameter in this tonearm.

After all the adjustments were com-



PHOTO 23: Operating view of strobe.

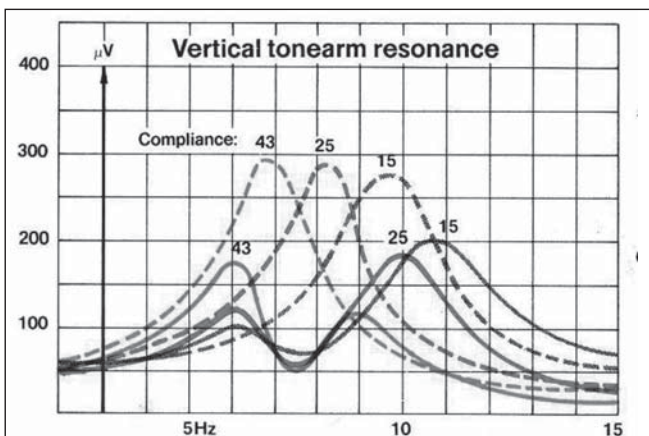


FIGURE 2: Vertical tonearm resonance.

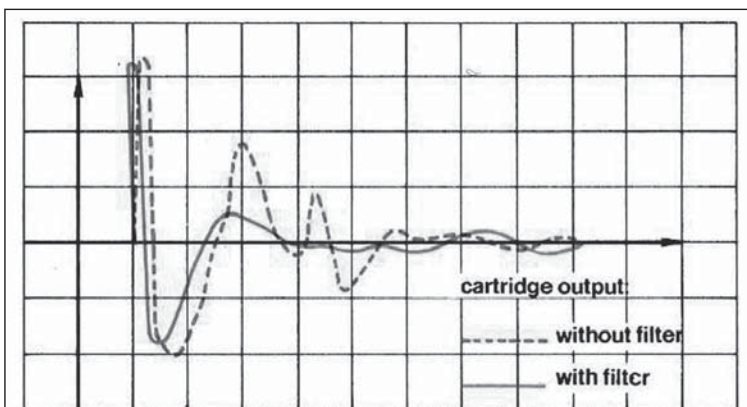


FIGURE 3: Anti-resonance filter damping.

plete, I ran tests for tracking ability. The *Hi-Fi* LP has three bands, numbers 1, 4, and 8, on the second side to test tracking. All three contain a 300Hz signal recorded at +15dB. Their positions across the face of the disk allow you to test cartridge performance as the geometry changes with distance from the outside of the disk to the inside.

The Ultra500 cartridge had exceptionally high stated tracking ability. Quoted figures were 42cm/sec at 400Hz, 65cm/sec at 1kHz, 100cm/sec at 5kHz, and 75cm/sec at 10kHz, all at a tracking force of 1.2 grams. Therefore, given those specifications, I was not surprised that the test yielded no mistracking on any of the bands.

The last test was for cartridge/tonearm resonance. The test LP has two bands, numbers 2 and 3 on the second side that test for the resonant frequency in the horizontal and vertical modes, respectively. Each contains a low-frequency sweep and a 1kHz pilot tone for audible confirmation of the resonant frequency.

Tonearm/cartridge combinations have a resonant frequency that depends on the mass of the assembly and the compliance of the cartridge. This is similar to resonant frequencies in other mechanical devices such as dynamic drivers or even automobile suspensions. If the mass or the compliance of the system is increased, the resonant frequency will decrease. If either or both are decreased, the resonant frequency will increase.

With most tonearms that are rigid from the cartridge through the counterweight, a resonance in the 8–16Hz range is a good compromise that provides acceptable bass performance without making the arm too susceptible to record warp. If the resonance is higher, bass performance will be

lost. If it is lower, warps will cause excessive movement of the stylus with respect to the cartridge body leading to the generation of large low-frequency signals, distortion, and potential mistracking.

The tonearm on the 701 is an interesting design. The counterweight is isolated from the arm with a two-stage flexible coupling. As a result, for steady-state conditions such as playing a flat and perfectly centered record, the full mass of the counterbalance is reflected back to the stylus compliance.

However, unlike conventional fixed counterweight arms, when the 701 arm encounters a record warp the flexible coupling effectively reduces the effect of the counterbalance mass. It is as though the mass of the counterbalance is not reflected back to the stylus for a fraction of a second while the warp is occurring. This makes the arm act as though it had a higher resonant frequency that does not respond to the low-frequency warp. During the large transitions caused by the warp, the flexible coupling slows the rate at which the force of the warp is transmitted to the counterbalance, much as the springs on your car limit the rate at which a road bump can transmit energy to the car body.

This is, of course, a tuned system with the mass of the system and the compliance of the coupler determining the resonant frequency. That tuning must be such that it effectively decouples the counterbalance at the expected frequencies of record warps and off-center holes with cartridges of various compliances. The 701 arm was designed to accommodate compliances of from 15 to 50×10^6 cm/dyne.

The benefit of the 701 arm design is its ability to work at lower resonant frequencies for the arm/cartridge combination while at the same time reducing sensitiv-

ity to record warp and off-center holes. As a result, when you work at the low end of the resonance range with this arm, you will have better bass performance while retaining high immunity to warps as though the resonance were much higher.

Figure 2 shows the effect of the tonearm with and without the anti-resonance filter. Cartridges with three different values of compliance are charted. You can see that there is a reduction of the peak output at resonance when the filter is used and that the total energy is displaced into two smaller outputs at two frequencies. You can't get rid of the energy, but you can disperse it so that the effect is less intrusive on the signal.

Figure 3 shows how the system damps resonances by showing outputs for the both filtered and unfiltered arms being dropped on a grooveless record. The filter has a profound effect on the amplitude of the signal generated.

The measured resonance of the arm with my Ultra 500 mounted was 8Hz. I have always had excellent bass response with this combination and no problems even with severely warped records. The Ultra 500 also has a built-in damper in the form of a small pivoting brush attached to the cartridge body that will damp vertical and horizontal movements, but I did not use it for this test. The resulting resonant frequency is strictly the result of the interaction of the tonearm and cartridge.

The turntable is now happily back in my system and I expect many more years of superb performance. If you have an old turntable that is getting a little rickety, consider taking the time to give it a tune-up. Patience and attention to detail may very well return an old friend to former glory. *aX*

All About Stroboscopes

Use a stroboscope disc to determine whether your turntable is set to the correct speed.

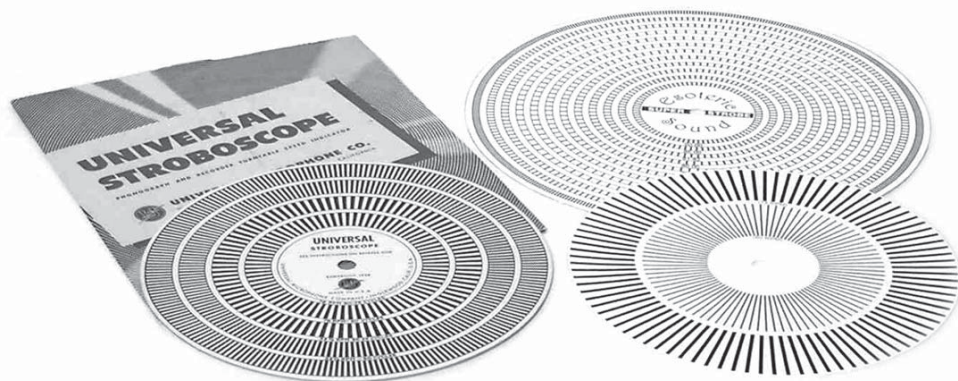


PHOTO 1: Commercial stroboscope discs. The Esoteric Sound disc is shown right rear.

To a phonograph turntable user, a stroboscope is a paper or cardboard disc with a spindle hole in the center that you can put on the turntable to measure its rotational speed. This works with alternating current (AC) lighting because the light flashes depending on the

power mains frequency (50 or 60Hz), and the pattern of bars on the stroboscope disc appears to be stationary when the turntable speed matches the speed printed on the stroboscope. A stroboscope does not work with direct current (DC) lighting or with sunlight.



PHOTO 2: The KAB SpeedStrobe™. Instead of bars, this disc has the rotational speed numbers printed on it. The 60Hz light source limits its use to 60Hz powered turntables.

Stroboscopes have probably been around since the first turntables were produced; that is, over 100 years. However, the earliest one I have has a copyright date of 1934. It was printed and given away by the Universal Microphone Company, Inglewood, Calif. It contains four bands: 78 RPM (25 or 50Hz), 78 RPM (60Hz), 33 1/3 RPM (25 or 50Hz), and 33 1/3 RPM (60Hz). The disc came in a cardboard folder and is shown on the left side of **Photo 1**.

OTHER COMMERCIAL STROBOSCOPES

Esoteric Sound¹ sells a 12-band stroboscope covering 16.67 to 90 RPM (for 60Hz). This disc is also shown in **Photo 1**. I'm not sure where the other disc in the photo came from because it has no company name. It is for 78 and 80 RPM (at 60Hz).

KAB ElectroAcoustics² offers a turntable speed tester, the KAB SpeedStrobe™. It consists of a stroboscope printed on a 10" diameter, 20 mil thick PVC disc with a quartz-crystal-controlled illuminator (60Hz) that is said to be 99.99% accurate. The illuminator is battery powered, so you can use it anywhere. The strobe disc is unique because instead of bars it has the rotational speed printed as numbers that you can read directly from the disc. It covers the following speeds: 16.66, 33.33, 45, and 70.59 to 90 RPM in 15 bands. The published specifications note that the speed accuracy can be measured to 0.03% by timing the drift of the display for one minute. **Photo 2** shows the disc and illuminator.

Clearaudio³ has a speed strobe test



PHOTO 3: The Clearaudio LP and 300Hz light source, which are available separately. Because it's 300Hz, you can use the light source for both 50Hz and 60Hz turntables.

LP and light bundle. You can play the two-sided strobe disc like a regular LP so that stylus drag can be taken into account when setting the turntable speed. One side of the disc is for 33 1/3 RPM, and the other side is for 45 RPM. It does not work for 78 RPM records. The illuminator is quartz-crystal controlled (300Hz), battery operated, and sold separately, so

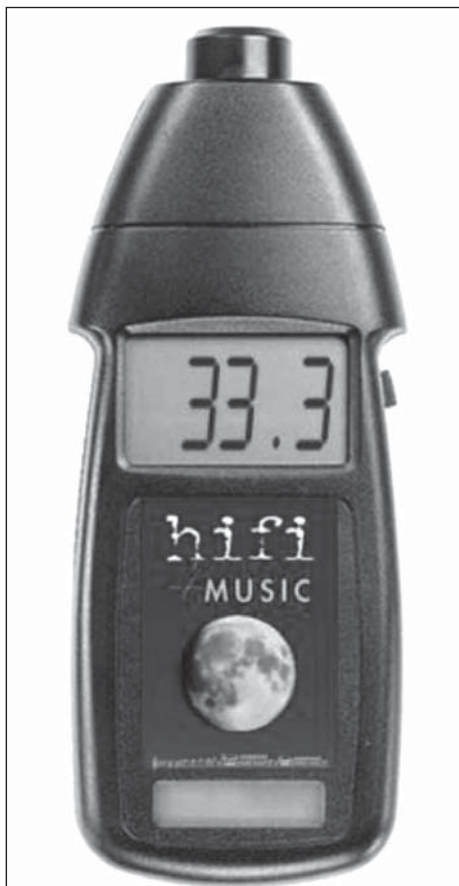


PHOTO 4: The battery-powered DIGIstrobo directly reads the rotational speed of the turntable.

you could easily use it with any stroboscope disc for improved measurement accuracy. The bundle is pictured in **Photo 3**. Because the light flashes at 300Hz, you can use it with any stroboscope disc on turntables operating on 50Hz or 60Hz power.

Hifi4music⁴ markets the DIGIstrobo, which is a rotational speed measuring device adapted to audio use; that is, it directly reads and displays the turntable speed so it can be used for all records from 33 1/3 to 90 or higher RPM. The published accuracy is $\pm 0.05\%$ (or 0.1 RPM). You can check the speed while playing a record if you provide something for the DIGIstrobo to "see." A small piece of reflective tape on the turntable edge will work, and a supply of tape is furnished with the unit.

You can also use the device to measure speed stability. After a ten-minute or so turntable warmup, press the DIGIstrobo's memory store button. It automatically captures the last speed, the maximum speed, and the minimum speed. It is pictured in **Photo 4**.

DO IT YOURSELF

These days it's not necessary to buy a stroboscope disc if you have a computer, because you can easily print your own for any speed and for either 50 or 60Hz power. There are two public domain programs: one is named strobe.exe and it's an MS-DOS program which will run under Windows 98SE, 2000, and XP. It will print up to five strobe bands on a single sheet but the bars are a bit "jagged." I really recommend the other

program: strobo.exe, which was originally written for Windows98 but also runs on 2000 and XP.

Both programs are available for free from several websites, including the TDL[®] site⁵. The zip file, strobe.zip, contains both executable programs with documentation. **Figure 1** shows an example printout from strobo.exe: the outside diameter of the bars is over 7", which makes it easier to see whether the bar edges appear stationary. It's a good idea to print on at least 67 pound stock (or heavier), because you want the disc to lie flat on your turntable.

You can easily trim your printed stroboscope to a round disc with a pair of scissors, but one problem remains: cutting the spindle hole in the center. I solved this by building a "spindle holecutter" shown in **Photo 5**. Except for the inside diameter of the tubing, the dimensions aren't critical. I measured the spindle diameters of all my turntables and found they were all nearly 0.28". So I chose brass tubing with an inside diameter of 0.316"⁶.

I sharpened the lower end of the tubing with a file, and it can be re-sharpened as needed. I added the brass top cap (soldered on) to make it easier to hit with a mallet. To cut the hole, place your printed disc on a piece of smooth hardboard or wood, center the cutter over the printed hole, and hit the cutter cap with your mallet.

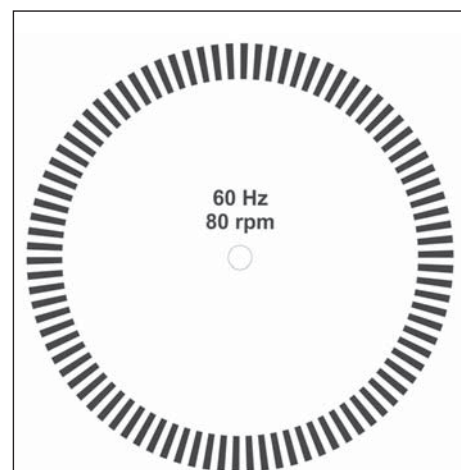


FIGURE 1: Sample printout from the free strobo.exe program. The large diameter makes it easier to see whether the bar edges appear stationary.

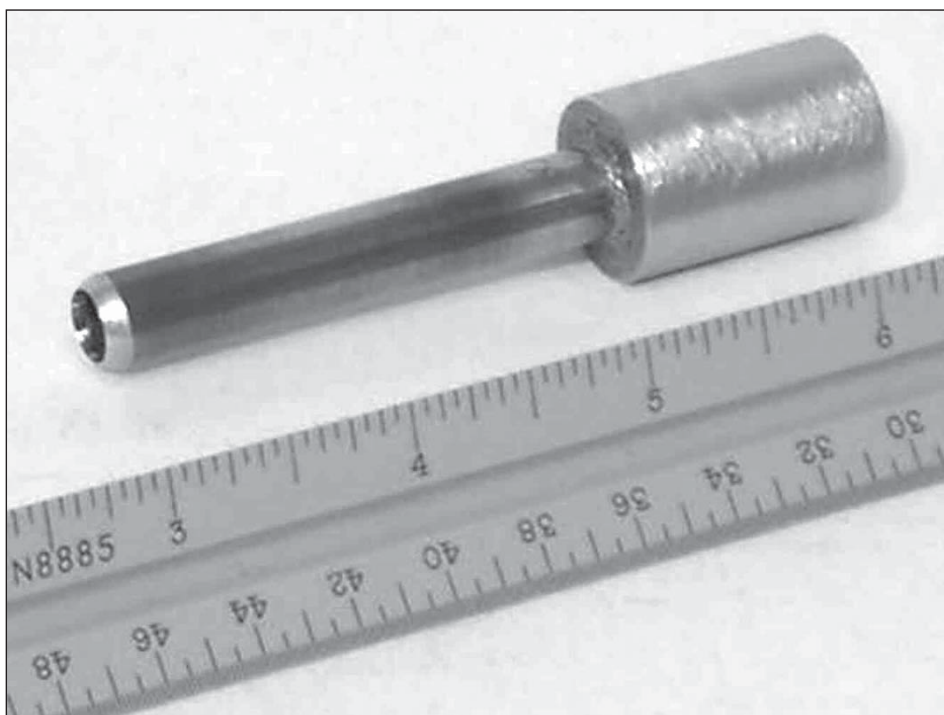


PHOTO 5: The center hole cutter, which I built from a piece of brass tubing with a piece of $\frac{3}{4}$ " diameter brass rod for the mallet cap.

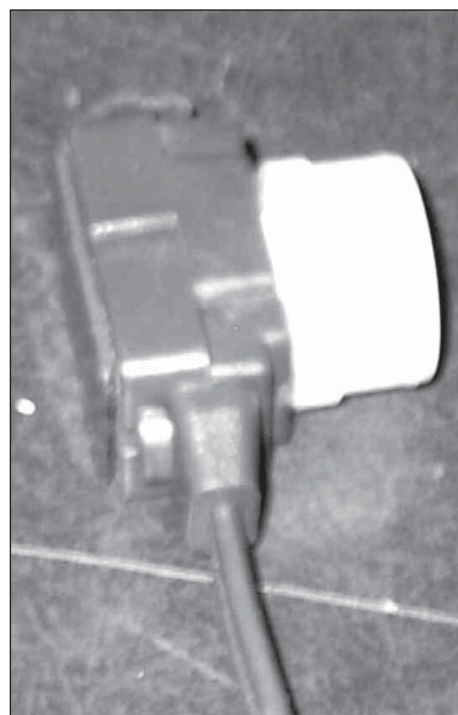


PHOTO 6: An ordinary neon "night light" makes a usable but dim strobescope lamp.

STROBOSCOPE LAMPS

Incandescent lamps (ordinary light bulbs with a filament) work, but not too well. The filament does not cool very much between cycles of the AC power so the light output is rather constant. Fluorescent lamps are about the same. The phosphor coating on the inside of the tube continues to radiate light between the AC power cycles. You can see the stationary-

appearing bars, but their edges look fuzzy, so it's difficult to set the speed "right on."

Neon lamps and white LEDs operating on AC power work well because both produce pulses of light even though your eyes can't really see the pulses, at least not with 60Hz power. You can use a neon "nightlight" (Photo 6), but it's rather dim so it's not too useful unless the room is dark! Better lamps

are available.

For my use I built a multiple-LED lamp (Photos 7A and 7B). A circuit diagram with parts lists follows in Fig. 2. As you can see, the circuit is simple and the wiring is not at all critical. This lamp operates from a 12V AC wall transformer and the "bars" are much clearer than with an incandescent light. The cost of the parts was under \$20.

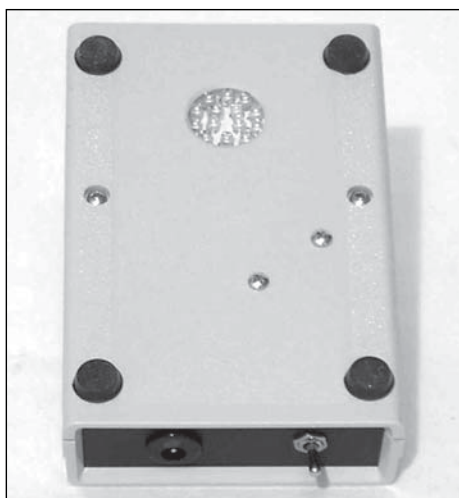


PHOTO 7A: The DIY multiple-LED strobescope lamp. The 14-LED array is epoxied to the inside of the PacTec enclosure. The four rubber feet (included with the enclosure) ensure the LEDs do not touch the tabletop.

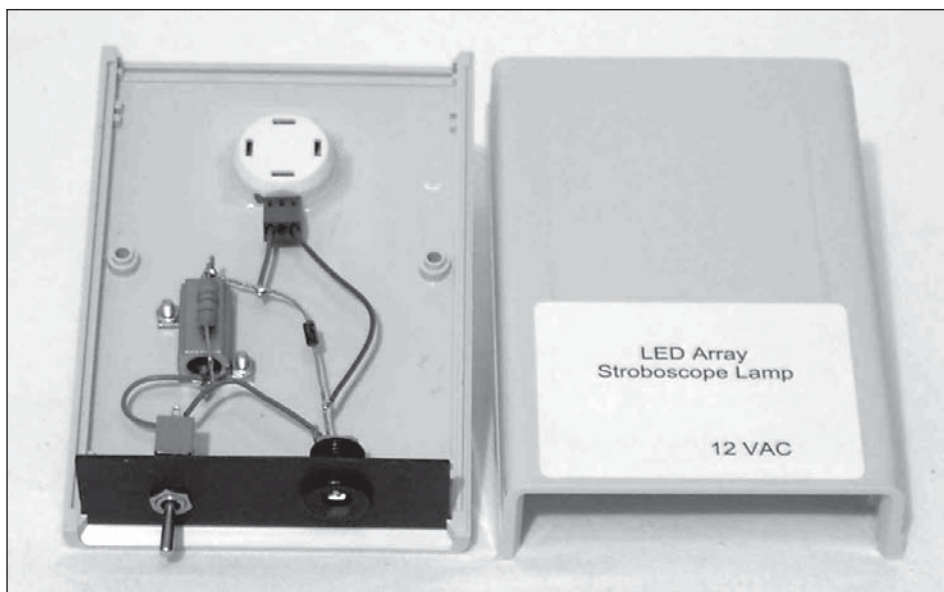


PHOTO 7B: Inside view of the multiple-LED lamp. The male power connector mates with the connector from the 12V AC wall transformer. The power on/off switch is optional because you can unplug the lamp from the transformer.

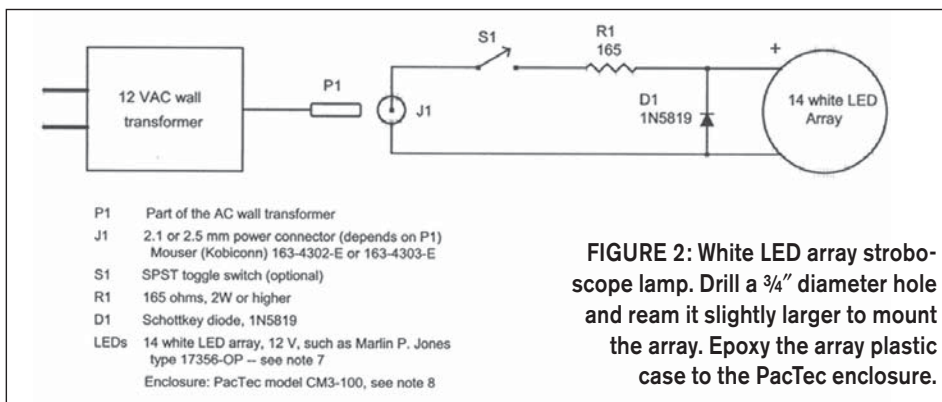


FIGURE 2: White LED array strobo-scope lamp. Drill a $\frac{3}{4}$ " diameter hole and ream it slightly larger to mount the array. Epoxy the array plastic case to the PacTec enclosure.



PHOTO 8: Stroboscope "bumps" cast on the platter rim are useful at 33 $\frac{1}{3}$ and 45 RPM only. If the turntable plays 78s, you will need a way to measure the speed.

You could also build a multiple-neon lamp, but the lamp firing voltages are different enough that individual current limiting resistors must be selected for each lamp. This makes construction a chore, so I decided to settle for the multiple-LED lamp, which works very well.

SOME FINAL THOUGHTS

A stroboscope is useful, if for no other reason than periodically checking your turntable speed. Many modern turntables have "strobe bumps" cast or molded into the platter rim (**Photo 8**) which are useful for 33 $\frac{1}{3}$ and 45 RPM records. These may suffice if you never play 78s, but 78s were recorded at so many different speeds that multi-speed strobe discs or a DIGIstrobe is essential.

How important is it to set the speed while actually playing a record? That is, how much does stylus drag slow the speed? With today's high-torque motors and low tracking force cartridges the answer is: probably not much. Perhaps if you have "golden ears," you can hear the difference, but for most of us all we need is to get the speed as initially close as we can. *ax*

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3. Contact Music Direct for Clearaudio products, 318 N. Laffin St., Chicago, IL 60607, www.musicdirect.com.
4. Contact Music Direct (see above) or Ultra Systems, Inc., for the DIGIstrobe, 127 Union Square, New Hope, PA 18938, 800-724-8333, www.ultrasystems.com.
5. www.tdl-tech.com/strobe.zip.
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Turntable Speed Control

Build this variable frequency synchronous motor controller to control turntable speed.

Recently I acquired a VPI HW-19 motor, platter, bearings, and other parts to build my own DIY turntable. Subsequent to assembly, I connected it to a strobe disc and noted that the turntable did not rotate at 33 1/3 RPM. I looked into adjusting the turntable motor's rotational speed; however, the VPI motor does not come with a speed or pitch adjustment to set the running speed for 33 1/3 RPM.

Although VPI (www.vpiindustries.com) offers an accessory power controller to provide this function, the price was a bit steep. I decided to design and build a variable frequency AC supply to control the turntable's speed rather than use a Triac or similar type of solid-state control circuit. Although these circuits are readily available at the hardware store, they are prone to generating noise that may be picked up by the cartridge.

I consulted my notes from several years ago when I rebuilt a General Radio Model 1311-A Audio Oscilla-

tor. This circuit, with minor modifications, formed the basis for designing and building a Variable Frequency Synchronous Motor Controller (VFSMC) suitable for driving the VPI motor.

I went to my parts bin and pulled out a few components that were used to develop the 1311-A rebuild and assembled them on a prototype/experimenter's board. My calculations showed I needed to design a circuit that would meet the motor's power requirements (11W) and allow for overhead. The LM386 power amplifier I used in the 1311-A was satisfactory to prove the concept; however, in deference to supplying the motor's rated output power and driving a step-up transformer, I would need a more powerful amplifier.

Substituting a resistor to simulate a load, and an old transformer I had laying around, I went through a few iterations of the circuit design to prove the concept and ensure the output was a pure sine wave and free from noise, with minimum harmonics. After prototyping

I found an AC inverter, manufactured by Radio Shack (www.RadioShack.com), which provided a suitable enclosure containing: aluminum heatsinking case, electrical outlets, fused inputs, on-off switch, and so on. This formed a basis for the VFSMC. I could build a circuit board, substitute a new transformer, and wire it back up to the existing 120V AC outlets. I only needed to modify the enclosure for my application (**Photo 1**).

CIRCUIT DESCRIPTION AND OPERATION

I used the same circuit I previously developed for the 1311-A oscillator. This circuit, which has proven to be very robust and reliable over the years for generating a sine-wave output, is based on an article by Maxim-IC, for their single chip 8th-order, low-power Bessel and Butterworth switched capacitor filters. The article is contained in Application Note 1999, "Sine Wave Generator is Crystal Accurate." Maxim has published a few other application notes using the same method/scheme for generating sine waves from square waves¹⁻³.

The application note states that sine waves are generated by filtering a square wave. A square waveform is composed of odd harmonics. Filtering out the odd harmonics leaves a sine wave composed of the fundamental wave. The IC filter selected requires a clock frequency at least 100 times the desired frequency.

Rather than use a separate crystal oscillator and divider network, I chose to use a single resistor setpoint type of oscillator, part number LTC1799⁴, manufactured by Linear Technology (www.linear.com). You may consider other options such as using a programmable microcontroller or similar logic-based device.

I chose a dual binary counter based on the design in Maxim's application note. The dual binary counter⁵ divides

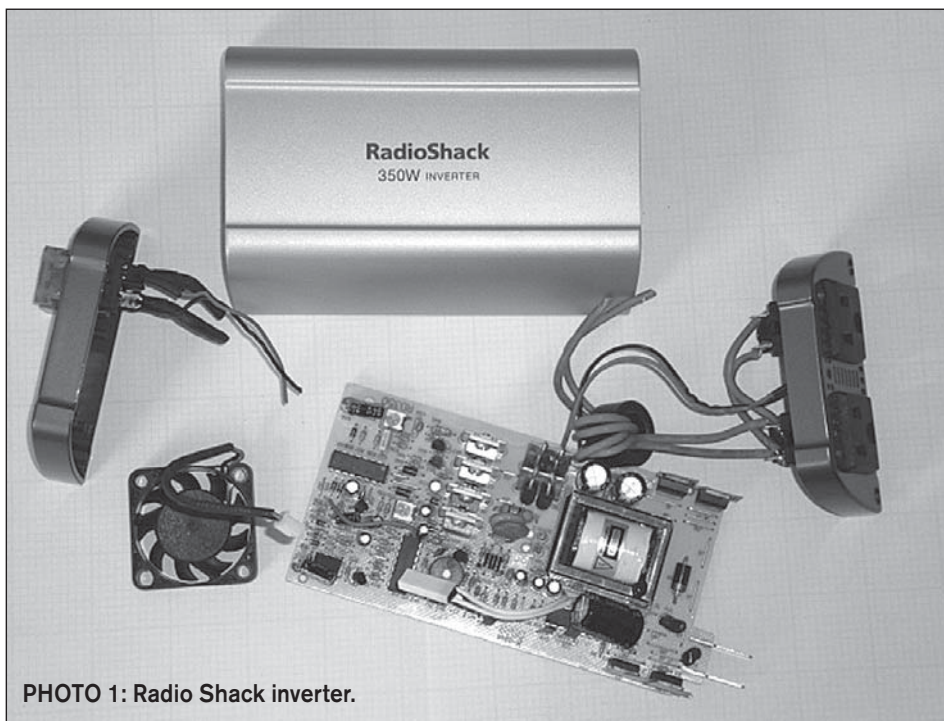


PHOTO 1: Radio Shack inverter.

the input square wave by 256. This provides a filter corner frequency meeting the 100× requirement of the filter. Because the desired output frequency is 60Hz, the equation for calculating the desired oscillator frequency is:

$$FOSC = 60\text{Hz} \times 256 = 15,360\text{Hz} \quad [1]$$

Next, I used the equation for selecting the resistor to set the oscillator frequency as follows:

$$R_{SET} = 1 \times 10^{11}/N/FOSC \quad [2]$$

In reviewing the application note's Fig. 2 R_{SET} versus Desired Output Frequency, "N" was selected for a factor of 100. From the graph, I then substituted the values for these variables to give a desired oscillator setpoint resistor of:

$$R_{SET} = 1 \times 10^{11} \text{ Hz}/100/ 15,360\text{Hz} = 65.104\text{k}\Omega \quad [3]$$

I consulted my Mouser catalog (www.mouser.com) and found a few fairly close resistor values. From my prototype experiments, I wanted to have a minimum of 2Hz adjustment in either direction from 60Hz. For this reason, I selected a standard resistor value slightly less than this: 61.9kΩ with 1% tolerance.

I then selected a standard 5kΩ value, ±5% 10-turn potentiometer to provide fine frequency adjustments of ±2Hz. Calculations indicate a frequency span

of approximately 58Hz to 63Hz. You can achieve a tighter frequency adjustment span and tolerance by using a 64.9kΩ resistor and 1kΩ potentiometer.

Note: Measure the setpoint resistor prior to inserting/soldering into the circuit. If you use a 1% tolerance resistor, the value of the setpoint resistor should be okay, but if you design for the tighter frequency adjustment span, the value may be too large, and you may not be able to achieve 60Hz.

The two logic outputs (**Fig. 1**) are taken from the counter, "HIGH CLOCK" and "LOW CLOCK." The "HIGH CLOCK" sets the corner frequency of the MAX7480 "8th-order, low-pass, Butterworth, Switched-Capacitor Filter," and the second-stage binary counter "D" output sets the "LOW CLOCK" output frequency of the MAX7480 filter and is the frequency the VFSCMC's AC output is set to.

The Dual Binary Counter, MM74HC393, datasheet is found at reference 5, while the MAX7480 datasheet is at reference 6.

The MAX7480 datasheet shows the "LOW CLOCK" output amplitude is too high. A resistor divider network, composed of R2 and R3, divides the 74HC393's output voltage by two, or about 2.5V peak-to-peak. This keeps the input signal to the MAX7480 within its lower THD operating curve—see Fig. 11 and Table A of MAX7480 datasheet. The MAX7480 output is a sine wave

with very low harmonic distortion and does not have the noise content that the truncated or modified sine-wave type DC-AC inverters have.

Finally, the sine-wave output of the MAX7480 filter is run through a 50kΩ potentiometer with the wiper AC coupled to the output power amplifier's inverting input via capacitor C5.

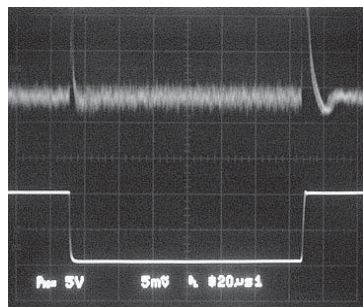
I looked at several output amplifiers before finally settling on a bridge type audio amplifier, TDA7396. The attractive feature about this amplifier is that it is a self-contained "bridge" type of amplifier, operating off a single voltage supply, capable of driving low impedance loads like a transformer. This keeps the parts count down and makes the circuit easier to troubleshoot.

You can drive the TDA7396's pair of outputs to a level of 45W, which is more than adequate for the motor's required 11W. Additionally, the TDA7396 device has several built-in protection features. The LED fault indicating logic output circuit was not used in this design.

The DIY VPI HW-19 turntable I have uses a Hurst Model PB, 600 RPM, 115V, 60Hz, 11W, AC Synchronous Motor, with part number "SP-2871." The datasheet for this family of AC synchronous motors is found at reference 7.

Complementary outputs, + and -, from the TDA7396 power amplifier are connected to the secondary windings of an Acme Electric/Amveco Toroidal Transformer, model 62050. The trans-

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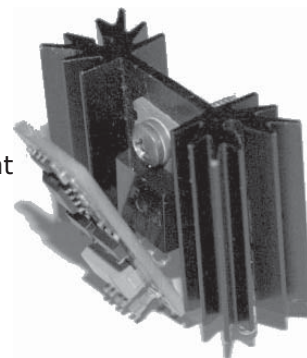
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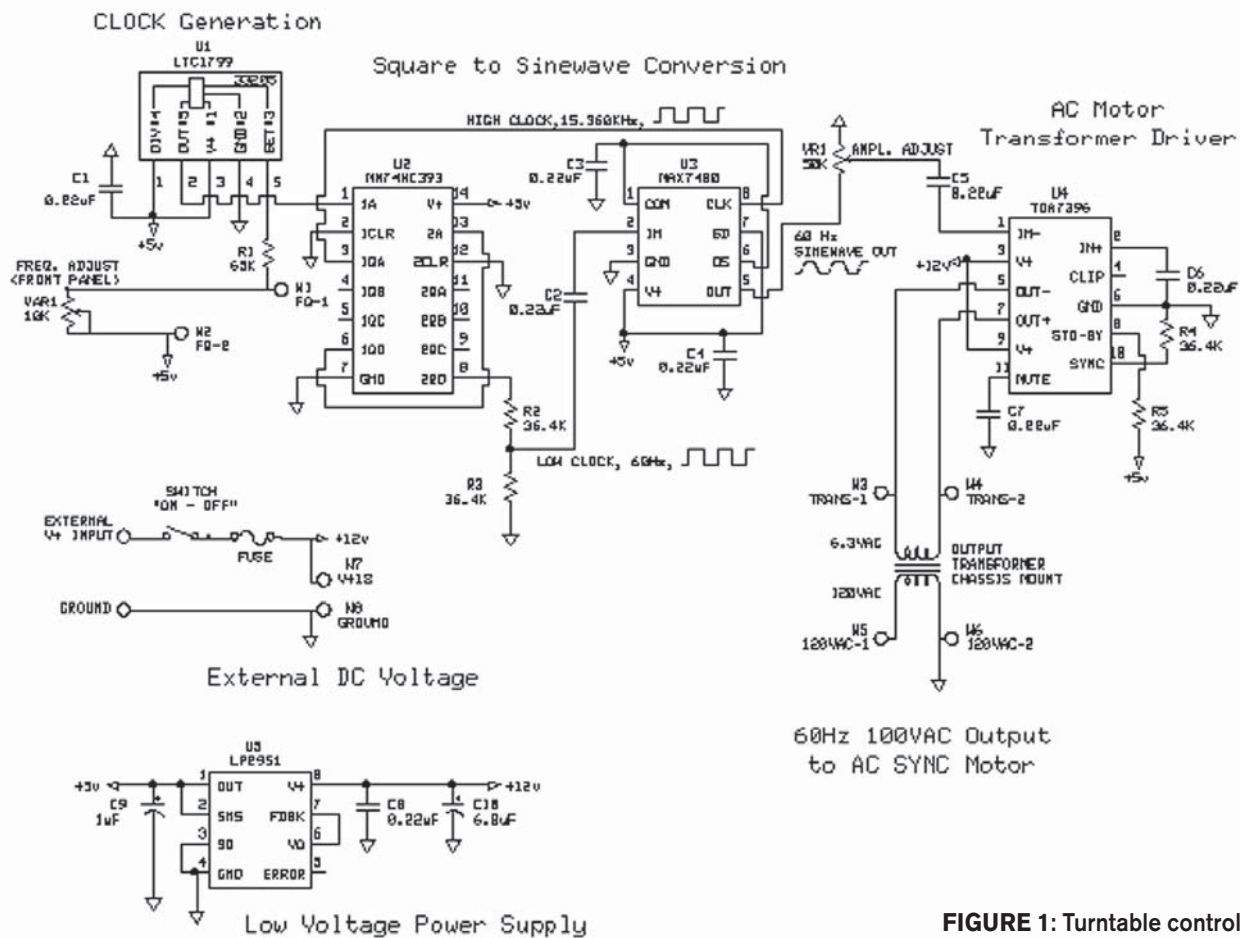


FIGURE 1: Turntable control circuit.

former is rated at 15 volt-amperes, which provides a design margin of more than 25% with respect to the motor's maximum rated power. Primary windings are 115V AC, and the secondary windings are set for 7 to 8.9V AC, depending upon the load. The datasheet for this transformer is found at reference 8.

BUILD AND OPERATIONAL MEASUREMENTS

I designed, built, and tested an initial prototype circuit board (Photo 2). Except for an error in the PCB layout, the design worked as planned when assembled outside the Radio Shack AC-Inverter enclosure. I noted no other problems. I used two potentiometers to fine-tune the circuit's final resistor values. The Hurst turntable motor operated perfectly over a frequency span of 53 to 68Hz.

I did encounter a minor glitch when I connected the output of the TDA7396 to a 10kΩ load rather than a transformer. The TDA7396's protection circuitry had kicked in and placed the amplifier in shutdown/standby mode. After troubleshooting the output fault circuit on the TDA7396, I discovered it required a

much lower load on the bridge circuit's outputs in order to function properly. I changed the output load resistor and performed initial measurements. Subsequent to passing those measurements, I connected the output transformer with a 3kΩ load simulating the motor for test purposes (Photo 3).

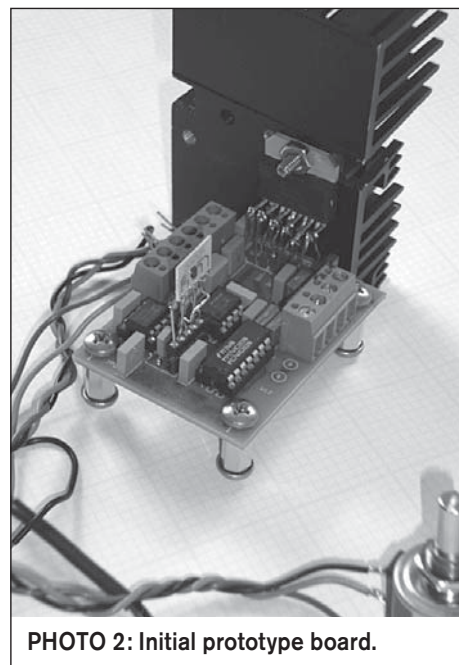


PHOTO 2: Initial prototype board.

For the final build, I decided on a simple circuit board, using "leaded" components. This presents a minor problem with the LTC1799 oscillator, which is only available in the SOT 23-5 package. I found a suitable 5-pin SIP adapter at Digi-Key, part no. 33205 (www.DigiKey.com).

I designed a long and narrow circuit board to fit within the pre-cut PCB slots inside the Radio Shack Inverter housing without any modifications. The narrow circuit board also allows clearance room for the toroidal transformer. The transformer is mounted roughly in the middle of the enclosure, leaving room for clearance between itself and the AC outlets mounted in the enclosure's endcap, and room for the circuit board on the other side.

I drilled a no. 8 size clearance countersunk hole on the bottom of the housing for attaching the toroid transformer. Although snug, there was plenty of room around the transformer for routing of internal wires and placement of the VFSMC circuit board.

Next, I drilled a 0.25" diameter clearance hole in the enclosure's second plastic endcap, adjacent to the on-off switch, to mount the 2kΩ frequency adjustment

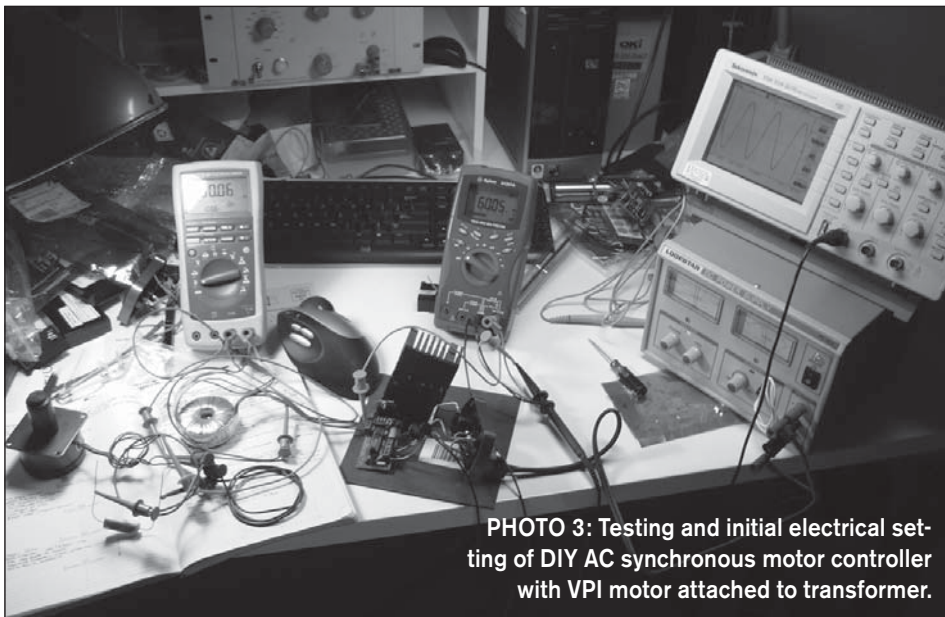


PHOTO 3: Testing and initial electrical setting of DIY AC synchronous motor controller with VPI motor attached to transformer.

potentiometer (**Photo 4**). Then I drilled a no. 8 size clearance countersunk hole into the exterior surface perpendicular to the heatsink-mounting slot (channel) inside the Inverter housing. The TDA7396 heatsink mounts up against the mounting slot and is secured in place by an $8 \times 32 \times 5/8$ Phillips head screw (**Photo 5**).

I made no other modifications to the enclosure. The DC voltage input connection was retained, along with the two AC outputs, and input fuse. I changed the fuse's value to 5A.

Note: To preclude shocks, do not connect the output transformer until after making the initial measurements to ver-

ify the proper sinewave signal is applied to the input of U4 (power amplifier).

CIRCUIT MEASUREMENTS

Pin 2 of U1 (oscillator output) and pin 1 of U2 (input MM74HC393 Dual Binary Counter) had a measured AC voltage square-wave signal of 2.48V AC at an operating frequency of 31.924kHz.

Pin 3 of U2 (A output of first counter) had a measured AC square-wave operating frequency of 15.962kHz.

Pin 2 of U3 (input MAX7480 Filter) had a measured AC Voltage square-wave signal of 1.25V AC at a frequency of 62.25Hz.

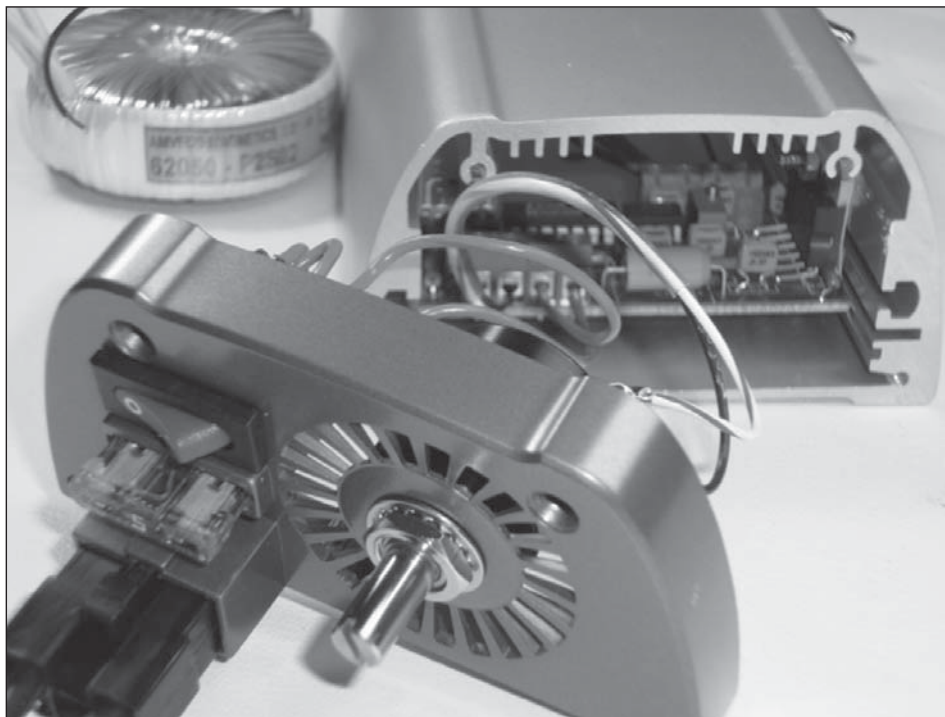


PHOTO 4: Frequency adjust potentiometer mounted to endcap and circuit board.

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PHOTO 5: Motor controller (no. 8 countersink hole for securing TDA7396 to heatsink visible on right side and frequency adjust knob visible on front).



PHOTO 6: Top view of controller.

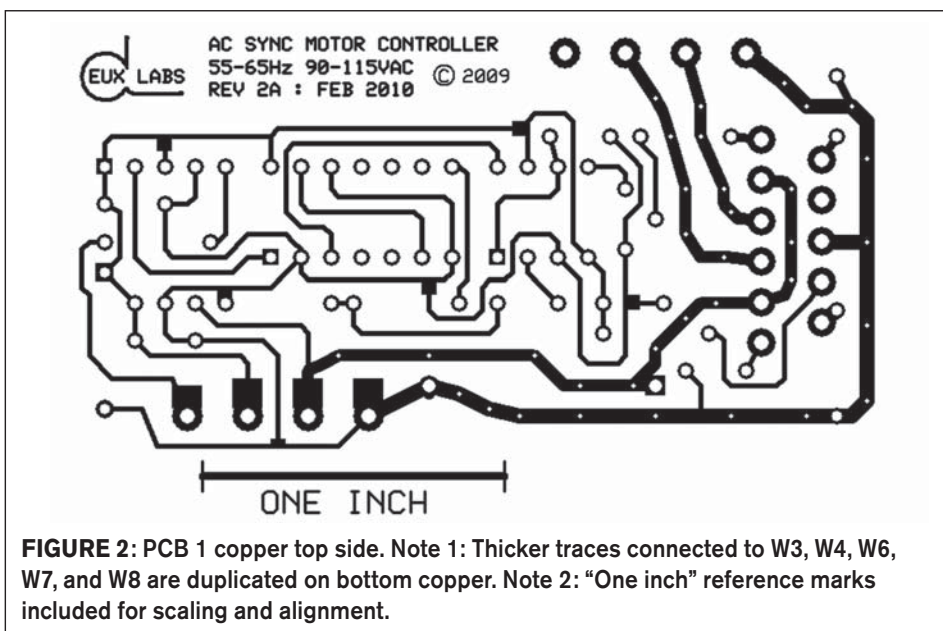


FIGURE 2: PCB 1 copper top side. Note 1: Thicker traces connected to W3, W4, W6, W7, and W8 are duplicated on bottom copper. Note 2: "One inch" reference marks included for scaling and alignment.

Subsequent to measuring pin 2 of U3, I adjusted the frequency across its full span using the 2k Ω potentiometer. Total frequency range was measured at 58.48Hz to 63.25Hz.

The sine-wave signal output of the MAX7480 filter is coupled via capacitor C5 to pin 1 of U4 (TDA7396 Power Amp). Pin 1 of U4 had a measured AC voltage of 0.5V AC following adjustment by VR1 (50k Ω amplitude adjustment).

Next, I adjusted the voltage on pin 1 of U4 (TDA7396) to 0.1V AC. I then connected the output transformer's secondaries to board connectors W3 and W4 (TDA7396 $\pm$ output pins) and placed a load resistance of 2k Ω across the transformer's 120V AC primaries.

Note: U4 has a protection circuit built into the output. Various safety measures including overtemperature, short circuit, and so on, are built into this amplifier (see datasheet), as well as a bias function that prevents the amplifier from operating without a proper load.

Caution: High voltages are lethal and may injure or harm you—even causing death. *Do not* connect the output transformer without following all safety precautions necessary for working around high voltages. This circuit is capable of outputting hundreds of mA at up to 200V AC.

As noted, I connected the U4 power amplifier's output terminals via W3 and W4 to the output toroid transformer. These outputs are not connected to ground. Transformer T1's 120V AC windings are connected to the output connectors, W5 and W6.

Caution: Note that W6 is connected to circuit ground. The AC Synchronous Motor Controller's 120V AC output is only two-wire. Follow applicable safety precautions for operating a two-wire AC circuit. As noted in Radio Shack's operating instructions for the DC-AC inverter, the ground prong of the three-prong AC receptacle is not connected.

To ensure safety, I connected a GFIC (ground fault interrupt circuit) cord to my turntable motor. You can readily acquire these at the local thrift shop for a couple of bucks. I bought a hair dryer and clipped the cord off, connecting it to the turntable's motor.

Final output voltages from U4 (TDA7396 power amp) to transformer were measured at 4.35V AC (pin 5)

and 4.27V AC (pin 7) at a frequency of 60.05Hz. With the turntable motor connected as a load, I measured the input voltage to U4 (TDA7396 power amp) pin 1 at 0.43V AC for an output of approximately 100V AC at the motor.

Subsequent to making the final output measurements and adjusting the output frequency and voltage for 60Hz and 100V AC, respectively, I de-energized the circuit and disconnected the DC wall wart. I mounted the output transformer within the enclosure and bolted it in place with a no. 8 Phillips flathead screw. Next, I carefully routed the wires between the transformer and 120V AC outlets. I then screwed the endcap to the one end of the enclosure using four self-tapping screws. *Note:* I removed these screws during disassembly of the enclosure.

Then I attached the endcap containing input power, fuse, on-off switch, and frequency adjust potentiometer to the other side of the enclosure, securing it in place with four self-tapping screws. After checking the integrity of the enclosure and circuit, I reconnected the DC wall wart power supply and powered up the VFSMC.

The output voltage measured satisfactory, and I decided to operate the VFSMC for an extended period to make sure it didn't have any long-term problems. I performed an overnight check of frequency drift and output voltage, and allowed a period of two minutes at the start to allow components to warm up.

Subsequent to this warmup, no detectable frequency drift occurred, and the output AC voltage change, as measured at the power cord of the turntable motor, was less than 1.5V. I measured a DC input voltage at 15V DC at a current of 1.2A. Again, I noted no changes overnight in the input power supply voltage or current supplying the DIY AC Synchronous Motor Controller.

Overall the unit performs very well, and I've had no problems with it. During the overnight evaluation of the AC Synchronous Motor Controller, the enclosure heated up and it felt very warm to the touch. It was not nearly as hot as the VPI motor, which almost burns you if you keep playing the records without turning it off. The VPI HW-19 Owner's

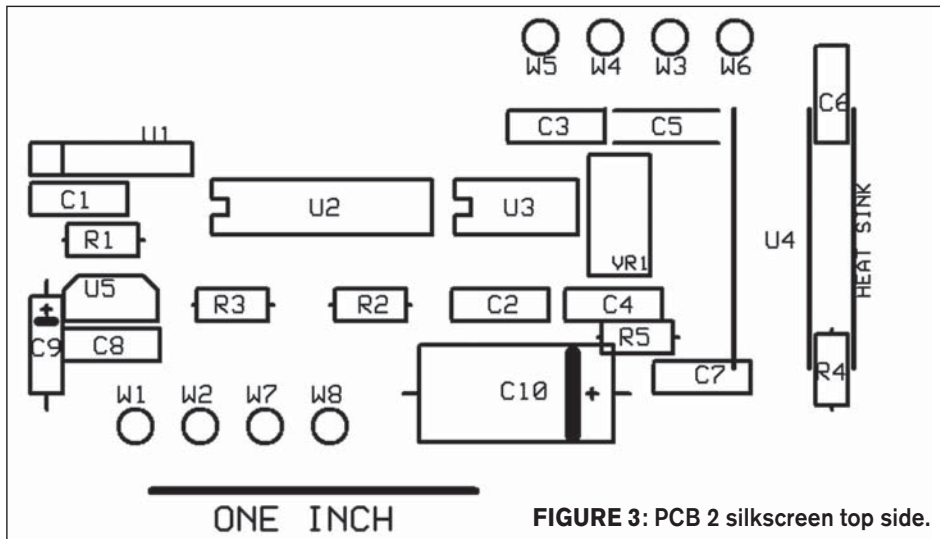


FIGURE 3: PCB 2 silkscreen top side.

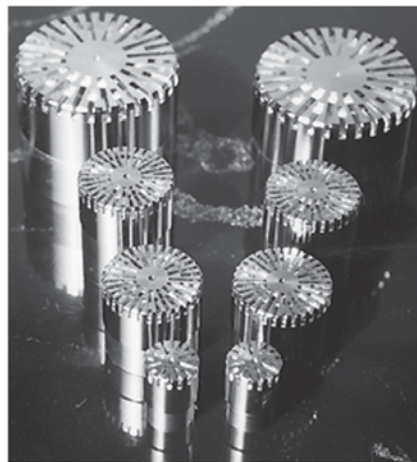
Manual indicates that the VPI motor may heat up between 30° C and 40° C above ambient during operation. I'm in the process of designing a heatsink to fit over or bolt onto the motor to help it dissipate heat. I'm very happy and pleased with the results. *ax*

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The Wretched Excess AR Turntable Renovation, Pt. 1

Bringing a venerable classic into high-end contention.



PHOTO 1: An overall perspective shot of the completed table and Defarge arm. The woodwork, leather surfaced motorboard, and scale (approximately 18" × 18") are evident.

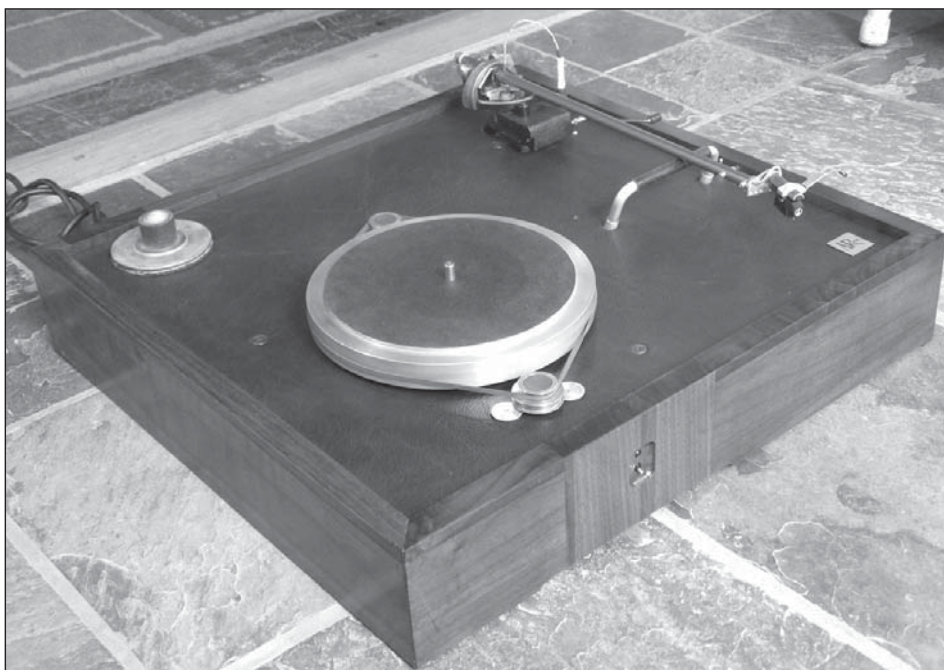


PHOTO 2: A perspective shot without the outer platter. The twin motor layout and other details are visible. That's a record weight on the left rear.

I like turntables. I mean, what's not to like? They grant you access to scads of software (LPs) which are elusive if not impossible to find on CD (although I've no real complaints about the CD format). They're technologically accessible (i.e., you can actually get under the hood and work on them), and their mechanical simplicity is appealing to the point of being engaging—charming, even.

I speak here of the iconic AR (Acoustic Research) XA manual turntable, a classic not only worth having, but worth screwing around with. That is what this project is all about: screwing around with the AR turntable until it's transmogrified into something beyond recognition. Hence the title, "Wretched Excess."

This began innocently, as most silly things do, and grew like topsy (**Photo 1**). I wound up with a table with a moderately heavier platter, but lots of damping; a table with a low contact, low clearance bearing, with a belt drive system that doesn't impose bias (lateral) force on the bearing. And a suspension system tuned a full half-octave lower than the stock XA (which is simple, really; same springs, twice as heavy). I also designed it so that the sub-chassis bounces in unison—or reasonably close—which wasn't difficult. You just need to ensure that each spring sees the same load.

This won't be a set of instructions so you can replicate this beast. I'll provide the photos and occasional figure, and describe what it is I've cobbled together, and why. If you want to build your own and have a reasonable set of tools and mechanical chops, you're all set. You'll probably want to make changes here and there, according to your own lights or cherished crackpot theories about tables, to which I say, "Have at it!"

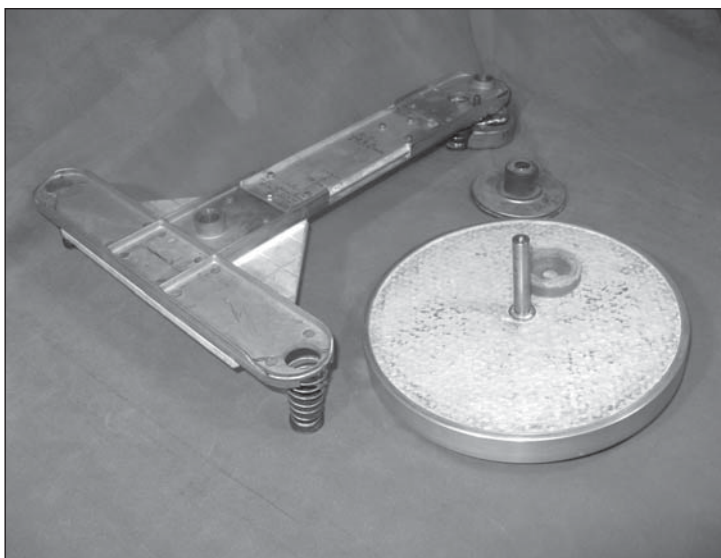


PHOTO 3: The splinted sub-chassis with stretched suspension springs, and the inner platter newly stuffed with DAP AlexPlus caulk-sand mixture and topped with a disc of backer-board. A plastic cup is used as a dust cover, and the improvised record weight is shown in the rear.

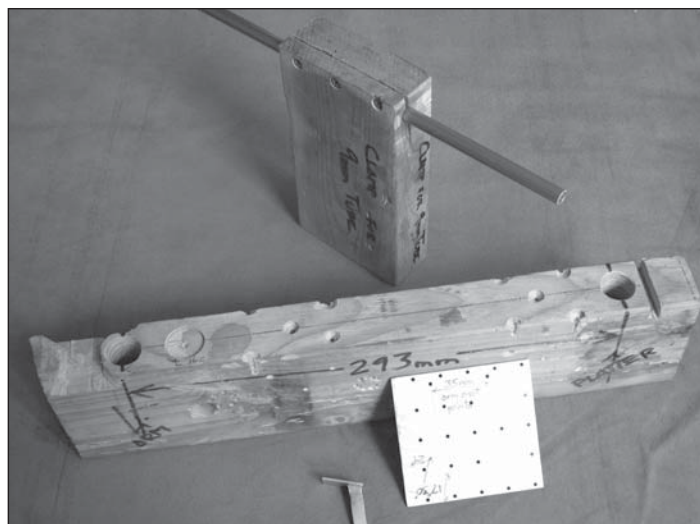


PHOTO 4: Jigs and fixtures. Front to rear are the spare offset plate and tang for the arm (I always make a spare, resigned to the likelihood of screwing one up), layout plate with offset angles, 35mm drilling jig, 2 × 4 jig for extending the sub-chassis' spindle-pivot distance to 293mm, and the 2 × 4 fixture for holding the 9mm armtube (without marring it) while working on it.

BEFORE YOU BEGIN

It's best, really, to start with two AR XA turntables. You'll need two motors and pulleys, at any rate, and the process will go better when you remodel the sub-chassis for the 12" arm (**Photo 2**). You can also select the platter pieces which have managed to survive with less damage or cosmetic insult. So find two units; who knows, one of them may still sport that lovely gravure brass "AR" badge. What you don't need or want to keep as spares you can unload on eBay.

You'll also need a small drill press, scales capable of 1kg or so, small taps (4-40 and 2-56), a dial caliper (stainless ones are cheap these days, but I prefer an old plastic example). A razor saw and numbered drill bit set will make life easier, too. I'll mention other items as I go along.

Basically, I took a stock AR XA, did surgery (sub-chassis augmentation!) on the T-bar to accommodate a 12" arm, spruced up the bearings, converted to a two-motor drive system (one belt), added mass and damping to improve isolation, and then built a new box (or plinth). And I also designed and built a 12" arm.

STARTING AT THE BOTTOM

The sub-chassis of the XA, also known as the T-bar, is an aluminum casting that accommodates the three suspension springs and bearings for the table and arm (**Photo 3**). The stocker has the bearings about 211mm apart, which is

fine for an approximately 230mm arm (offset angle approximately 24°). But to accommodate a longer arm, I cut the T-bar, and, using a bolted-in insert, extended the bearing-to-bearing distance to 293mm. I was aiming for a 291.7mm bearing-to-bearing distance, but one thing or another went wrong, and I ended up at 293mm, which mandated a 306mm arm instead of a 305mm arm (12" = 304.8mm).

It is crucial here to build a jig (**Photo 4**). You want the bearings to be exactly parallel to one another and, unless you use a jig, you're doomed to failure. The good news is, by jig I mean take a scrap of 2 × 4 and drill two holes in it to accommodate the two bearing wells, the right distance apart; clamp the pieces to the jig so they can't shift, and you're set.

Start each hole using a 3/4" bit to a depth of about 2"; then you'll need to file or sand the top out some to get a good fit. The castings aren't exactly cylindrical, they taper slightly. You'll also need to cut into the jig to clear the flanges that are cast into the T-bar, so the web sits flush against the wood.

I should mention that a drill press makes easy work of getting two good, parallel holes. And if it isn't obvious, the holes go into the narrow (2") face of the 2 × 4.

Once you have a satisfactory jig, you can clamp the two sub-chassis pieces to it and have them welded together. The

jig will keep everything aligned despite the heat of the welding.

If you're making do with one sub-chassis as I did, either you're dealing with two welds or you're bolting in a splint; the jig is equally vital.

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ABOUT THE BEARING

The AR bearing is a hard plastic disc at the bottom of a babbitt-sleeved well, filled with oil, into which fits the steel post of the table spindle, which is machined on the bottom into a round nub of about 0.08" radius. The sleeve isn't as tight as I'd like; the plastic disc can slide about, and the nub on the bottom of the spindle isn't as smooth as I'd like. What to do?

First, take both plastic discs from the table and tonearm wells. Choose the one with the most pronounced dent in it and clean it and the bearing wall to remove every trace of oil. Soak both overnight in rubbing alcohol and clean again.

You want to fix the disc on the bottom with the dent exactly in the center so that the shaft rides without touching the sides, at least on the bottom. How? With RTV silicone hi-temperature gasket maker, available at any auto parts store in 3.35 oz tubes for about \$7. I'm partial to Permatex's "Ultra Black," which'll do the job happily, oblivious to the oil. Now you just need to get the disc down there, centered.

I use the bearing shaft for this, shimmed to center it in the well using pliable tape. First, put a small dab of RTV silicone on the end of an unsharpened pencil and dab it on the bottom of the

well. Then stick the dented side of the bearing disc to the eraser, dab another mote of RTV on the undented side of the disc, and, using the pencil, carefully place the disc on the bottom of the bearing well, dented side up. Next, drop the inner platter into the bearing, so the ball nub on the bottom of the shaft seats in the dent.

Now comes the clever part: Remove the inner platter and wrap two or three turns of Teflon thread-sealer tape around the bottom of the shaft. Replace the inner platter and its bearing shaft into the bearing well. As you do, the Teflon tape will deform, evenly, around the shaft, shimming it to the center of the bearing sleeve. The nub at the bottom will settle into the dent, centering it exactly.

Let this sit for a day or so to let the RTV cure completely. To check your work, remove the bits of Teflon tape, blacken the bottom of the steel shaft with a magic marker, and spin it in the bearing a bit, then remove it to check the bottom. If you've successfully centered the bearing disc, the shaft will have turned free of the side walls and so be black all around.

The next item on the bearing agenda is eliminating play at the top of the bearing sleeve. To accomplish this, I used a ball bearing to press down the

top of the sleeve, constricting the bearing. The sleeve is about 3/8", so you're looking for a ball of about 0.75" to 0.9" in diameter. An inch is too big, and 5/8" (0.625") is too small. Just put the bearing and ball in a vise and slowly squeeze.

You'll see a bright ring at the top of the sleeve where the babbitt is peened over. Keep at it, bit by bit, until the shaft just fits (i.e., there's no clearance). Now you need to open it back up slightly so the shaft turns freely. You can do this by burnishing using a smooth metal rod, or you can abrade it open using newspaper wrapped around a round pencil. The bearing metal will rub off on the paper just like solder—or any other soft alloy—would.

This is an iterative process (i.e., squeeze, then burnish, again and again, until you're satisfied the shaft is contacting a thin ring of metal, right at the top of the bearing well). It should be close, but not binding (**Fig. 1**).

Now you have a bearing consisting of a round nub resting in a dent on the bottom, and a thin ring of contact at the top, and nothing in between. The only task left is to polish the nub. My method here was perhaps crude, but it served. Using a 1/8" bit, I drilled a very shallow hole—nothing more than a dimple, really—in the end grain of a small block of hardwood. On top of that, I layered a small square of roofing felt or tar paper, then some 300-grit wet-or-dry paper. Then I wrapped three or four turns of masking tape around the inner platter's record spindle, chucked it in the drill press, and wet the abrasive paper with some water.

Next, I lowered the nub into the dimpled paper, turned on the press at very low (about 120 RPM or so) revs, and settled in for the long haul. The whole process took about 45 minutes, what with moving to a fresh spot on the wet-or-dry paper, adding more water, changing to 400-grit, and finally adding some Bon Ami to the water to give an abrasive to slurry. This made for a nicely smoothed nub, much better than stock. The key here is patience. Don't go nuts with the pressure, don't try high revs or the thing will spin out of control, and you'll get a nicely polished bearing surface. Remove any remnants of the foam AR installed at the top of the well (a dust barrier, I suppose), tape it over to seal out debris, and you're done.

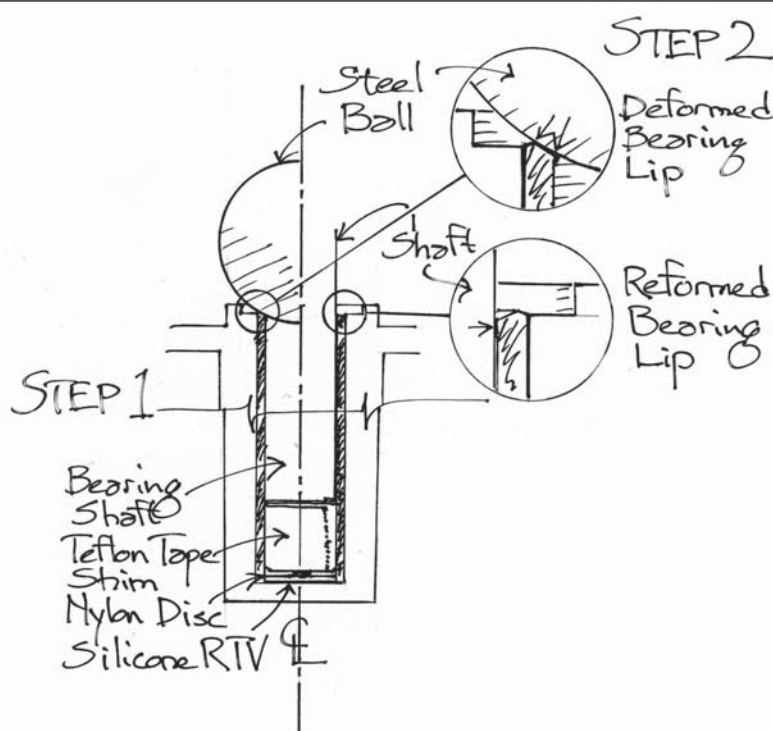


FIGURE 1: Modifying the main bearing. First, locate the dimple on the plastic disc exactly in the center with some Teflon thread-sealer tape and silicone RTV. Next, eliminate any clearance at the mouth of the bearing by deforming the lip.

PLATTER MODIFICATIONS

I left the two platter pieces pretty much alone. The outer platter I left stock. I filled up the inner platter with a mix of clean sand and DAP Alex Plus caulk and sealed it off with a disc of 1/4" thick concrete backer board (what you screw to the floor before laying ceramic tile).

You want to mix up a fairly stiff batch of sand and caulk, then weigh out six 85gm blobs. Spread each blob out in one of the six segments of the inner platter. Working from the outside in, this will give you a good, even fill, and preserve the inner platter's balance. Top off with the concrete disc, which should settle evenly in.

This process adds about 700gm to the inner platter, and goes a long way toward killing any vibration that makes its way to the piece. Because it's close to the center, it doesn't contribute much to the flywheel effect, but then again, it's right there at the bearing, so it does address bearing noise. I spun the platter by hand, put a stethoscope to the bearing and heard nothing.

The final touch was cutting a couple discs of roofing paper and gluing them to the top (using DAP) to bring the top surface of the inner platter level with the outer platter. And for what it's worth, I use a rubber mat from some forgettable Japanese table. It weighs about 200gm, so it brings the total weight to about 2.4kg (5.3 lb), which compares to the 1.5kg (3.3 lb) stock unit.

PREPARING AND HANGING THE SUB-CHASSIS

I've read about others who have worked around with the XA sub-chassis (see the work of Galo in Audio Amateur Press' *The LP Is Back*, www.audioxpress.com), and thought about it a bit, and something eventually occurred to me: Nobody seemed to be paying attention to the center of gravity of the suspended structure, in relation to the springs. If each spring saw the same mass, I reasoned, each would bounce at the same frequency, so there would be no tendency for rocking; that is, the arm end and platter end would tend to bounce in unison, in synch. For you modifiers who have had trouble dressing relatively heavy tonearm cabling, this analysis would suggest dressing the cable so its attachment

point on the sub-chassis is there at the center of gravity (again, the point being to present the same load, both resistive and reactive, to each spring).

For this table, if you draw a line from the midpoint between the two platter-end springs and the one out by the tonearm, you'll see it's 297mm long. You want the two springs on the platter end to shoulder two-thirds of the weight, so it follows that the center of gravity should be 99mm (one-third) away from the midpoint I mentioned, which puts it 62mm away from the platter and 231mm away from the tonearm pivot.

Concerning the springs, perhaps more discussion is in order. Galo, and presumably others, go in for stiffer springs to cope with a more massive suspended sub-chassis. I demur. What's the point of a heavier suspended mass if you're going to give away the resulting lower resonant frequency by stiffening the springs? I opted for the stock springs; I just stretched them out some to cope with the more massive suspended structure.

Here's how: The stock XA suspended mass is about 2.3kg (5 lb). Uncompressed, the springs are about 42mm long; compressed they measure about 22mm. That's a deflection of 20mm per 765gm (one-third of 2300gm). I wound up with a modified suspended structure of about 5.1kg, 2.7kg more than the stocker. If I want to wind up with a compressed spring about the same length as a stock XA, I need about 25mm more spring. So I stretched each spring out to 67mm; that's 42mm + 25mm, which compresses to about 22mm under the added mass. Works swell.

And considering that the suspended mass is over twice that of a stock XA, I can expect a resonant frequency just over a half octave lower than the stocker. I figure the stock XA at about 3.5Hz versus about 2.4Hz for my unit.

I also glued base washers to the bottom of the rubber and foam snubbers AR supplied. And you know that foam? It's important. If yours is in good shape, you need to keep it that way. I ensured longevity by working some RTV silicone into the foam, not filling the cells but giving the plastic a good coating so the foam doesn't rot. Don't get me going on the tragedy of foam rot.



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Jan Didden, Editor

The foam damps lateral motion of the suspended mass, which is essential because the center of mass is considerably above the suspension points (the bottom of the springs), which makes it inher-

ently unstable (i.e., tippy) without the foam to keep the whole mass centered and under control. The foam also damps vertical movement, but that's secondary; job one is keeping the sub-chassis from

flopping over to the side. I have great faith in RTV silicone (as opposed to garden-variety silicone adhesives); I assume it confers immortality on normally vulnerable foam.

SUSPENSION SETUP

Assuming you follow the same route with your suspended sub-chassis that I did (i.e., increase the suspended mass and stretch the stock springs to accommodate the heavier spring weight), here are some tips you should heed. It takes time to get everything settled, but patience and a little foresight will be rewarded.

I assume you'll be doing a trial assembly or two. On your trials be sure to center the sub-chassis over your holes cut out for the platter shaft and arm, and avoid binding between the springs' coils. Centering entails attention to detail. Make sure your motorboard is level, which will ensure your sub-chassis is hanging as it will in use. Also, load down the sub-chassis with the full weight.

Then, make a note of what's off-center, by how much, and which springs you must bend. Then do your bending, reassemble, and repeat as needed. This can be a nuisance, but getting the sub-chassis centered up pays off, especially centering the platter between the two motors. I used a very light cable between the arm and motorboard, so cable load isn't a factor for me. If you're using a heavier cable, fix it below the center of gravity and dress it from there.

If stretching the stock springs to 67mm results in binding (coils touching under load), the fix is to disassemble, stretch the springs out some more in the part of the spring that's binding, and try again. Stretching distance is 67 to 70mm, but your springs may vary. Cut and try.

For final leveling I use nickels around the edge of the platter. I use a small round bubble level on both the motorboard and the loaded platter, fiddling until both are level and I have that nickel's worth of clearance. Because I use 4mm DIBOLD covered by leather, I'm looking at a pretty thick motorboard. But when set up, the dimensions work out fine. I have about the same clearance between the motorboard and platter rim as I do between

the motorboard and sub-chassis.

If you crave more isolation than this setup gives you, be my guest. Just remember to avoid a resonance near your table's. Just guessing, this 10kg unit on a 5-10kg slab of stone or Corian, on three "Spaldeen" balls, sounds about right.

WHY TWO MOTORS?

Well, why not? What's not to like about doubling up on the motors? The classic AR XA motor is a puny (1.5W) 300 RPM synchronous unit made by A.W. Haydon Co., of Waterbury, Conn. (#A81378 and B81339). At a mere 1.5W, it doesn't take a rocket scientist to deduce that it doesn't generate a lot of torque, or draw a lot of current, which suggests that it doesn't spin off a huge 60Hz field.

The Haydon's bearings aren't anything to write home about, but they're OK. The outer case is aluminum, which is easier to fabricate but doesn't help out in shielding the outside world from the field generated by its two internal coils. On the other hand, torque is evidently adequate (the XA passed Ed Villchur's "nickel test" of torque), and the motor's top plate is steel, which, together with the internal steel bits inherent in a synchronous job, contains that 60Hz field—not perfectly or completely, but decently.

Doubling up on the motors doubles the torque, and mounting two units 180° apart while still locating them fairly distant from the cartridge's arc, and clear of the suspended sub-chassis, is easily accomplished. Other than the torque, the two motor drive completely relieves the bearing of side load. No more lateral pull from the belt mucking up the bearing. Instead of a force pulling the top of the table shaft one way, and the bottom the other, the unmolested bearing is allowed to settle in and spin in a simple, uncomplicated manner.

Other advantages of two motor drive are probably more theoretical than real,

but they're worth mentioning. Two motors 180° apart may help defeat any eccentricity that exists in the sub-platter. It also allows what I call a "Mobius Twist" to be introduced into the belt. By this I mean on the side under tension (counter-clockwise from the pulley), give the belt a half twist. Then move the other part of the half twist (the untwist) around the sub-platter so it's on the tension side of the other motor. This is said to help rumble.

Practically speaking, you can use all those old belts that had stretched out so much that they barely stayed on the pulley. Less belt "wrap" on the sub-platter may mean less vibration conducted to the sub-platter. I also find the symmetry of the configuration appealing.

I would be remiss if I didn't give a tip of the modifier's cap to Mr. Bill Firebaugh, whose Well Tempered T-table (WTT) began with screwing around with the AR XA. When *Audio* published a lengthy review of his design many years ago, they detailed the tip of the twisted belt (which, being a single motor design, entails a half twist on either side of the pulley instead of the "Mobius Twist" I use). More interesting, the WTT deals with belt-induced side load by making it into a virtue. Mr. Firebaugh used the belt to pull the top of the bearing shaft against two plastic pads and likewise with the bottom of the shaft, except the bottom pads are on the opposite side of the bearing well; voila: zero clearance bearings!

Finally, eagle-eyed readers may wonder at the motor mounting hardware I used. It looks suspicious, but isn't. I just tapped some aluminum bits I had on hand and used them for nuts. There is a rubber piece between these odd nuts and the motorboard, but I hardly think the rubber functional. The motor chassis is held fast to the aluminum face of the bottom side of the board, so there's no vibration isolation involved. There's less here than meets the eye. ■

MORE SUB-CHASSIS PREP

So much for the theory and the dampers. What about the other objects on the T-bar you see in **Photos 3** and **5**? I glued this on (using DAP, again) to add mass and prevent ringing. The hangers-on include fiberglass PCB material, chunks of concrete backer board on the bottom, and, hanging on the bottom of the bearing wells, some lead alloy flywheels accumulated from decrepit tuners over the years. I figure added mass right there at the sources of potential noise (the bearings) will help dissipate that noise. For the whole before/after story, go to **Table 1**. I should add that I accounted for the weight of an LP (pegged at 120gm) and a record weight I use (steel from some loudspeaker motors I dissected for the magnets, about 220gm).

Given the above, maybe it's worth including a word or two about tolerances. An LP weighs anywhere from just less than 100gm to 180gm for the high-dollar reissues, which introduces a ± 40 gm variation centered 62mm from the center of gravity. This variation is less than 1% of 5.1kg, so I'm not losing any sleep over this. In terms of deflection, if that 40gm were plopped down on the centerline between the two platter end springs, you're looking at half a millimeter difference in

deflection, which I can also live with, but that's worse case than the reality.

THE DRIVE SYSTEM

I use two stock AR synchronous motors (made by A.W. Haydon Co., a N. American Phillips Co.) with their respective pulleys, both filled with a mix of DAP and lead sand to add a slight flywheel effect. They're mounted 180° apart, at approximately 12:30 and 6:30 if you take the platter as a clock face. This also puts them at the greatest distance from the arc the cartridge traces and clears the sub-chassis.

The point of two motor (one belt) drive is that it avoids adding lateral force to the platter. This lets the bearing settle in and spin concentrically, as opposed to mak-

TABLE 1: COMPARATIVE MASS OF VARIOUS SUSPENDED COMPONENTS, BEFORE & AFTER

Part	Stock Mass	Modified Mass
Sub-chassis	620gm	2000gm
Platter, inner	500gm	1200gm
outer	980gm	980gm
LP	120gm	120gm
LP mat		200gm
LP weight		225gm
tonearm	180gm	350gm
Totals	2400gm	5075gm
Resonant frequency (approximately)	3.5Hz	2.4Hz

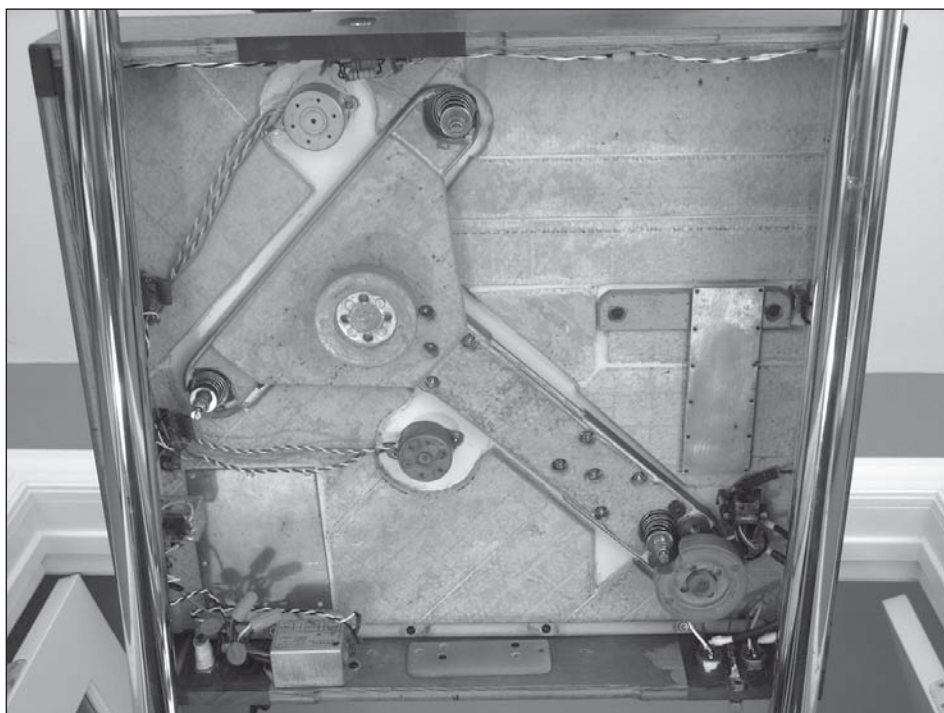
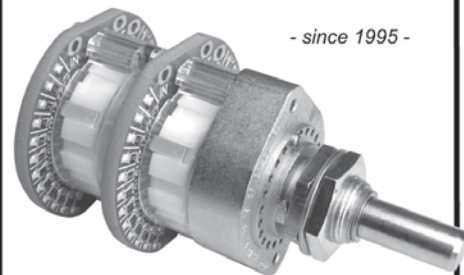


PHOTO 5: A bottom view of the completed table and arm showing the motor layout, concrete backer-board glued to both the sub-chassis and motorboard, and lead-alloy flywheels on the bottoms of both bearing walls. AC wiring at the rear includes the AC filter, varistor surge clamps, a power-switching relay, wire nuts, and so on.

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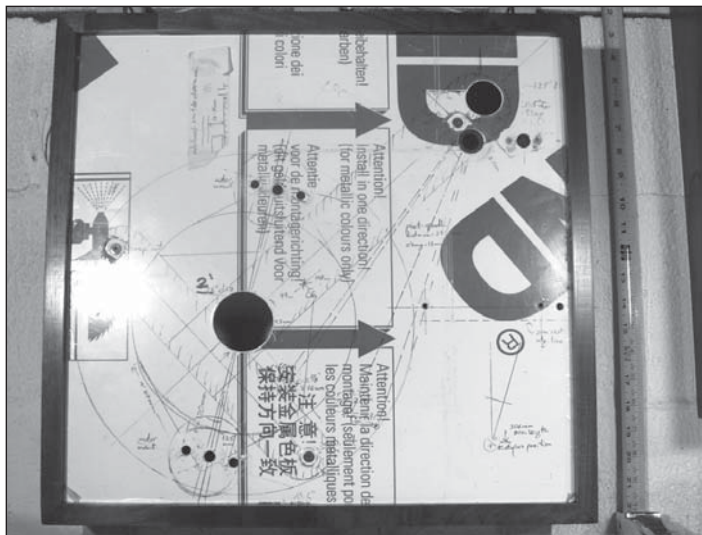


PHOTO 6: Top view of the DIBOND laminate motorboard. I just laid out everything on the film covering with a marker, drilled and fitted, peeled off the film, and I was ready to glue down leather.

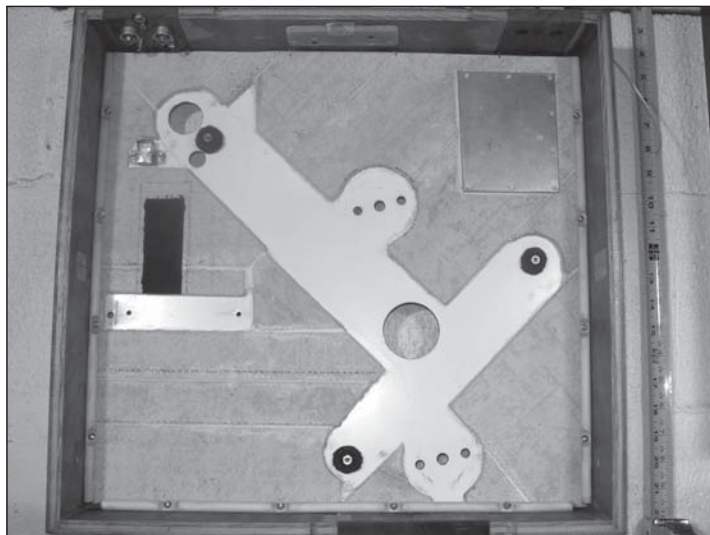


PHOTO 7: The bottom of the work-in-progress motorboard more clearly showing the concrete backer-board glued to the bottom and the method for attaching the motorboard to the wood plinth.

ing little orbits within the tolerance of its components. Plus, you get more torque to cope with the slightly heavier platter.

Everything else about the drive is stock. I've thought about fiddling with variations on the 0.1 μ F cap— $\pm 15\%$, say—to see whether the vibration drops down any. Or, I might install a series-resonant L-C filter to keep out some of the grunge on the line. If you try any of these methods, let us know by writing to the magazine.

I also used small steel caps for the motors to help shield the cartridge from any stray magnetic field. The days of steel caps for spray cans are long gone, so I needed to patch something together from the cases of some old forlorn cassette deck motors.

MOTORBOARD, PLINTH, OTHER COSMETICS

For the motorboard, I used an interesting material called DIBOND (Photo 6), which is a sandwich 4mm thick, of two layers of aluminum, each maybe 0.75mm thick, around a pretty high-density polymer—what kind I don't know. Sign makers use this, which is where I got mine, and it's not exactly cheap at about \$6 per square foot, but it's easy to work, plenty strong, and well damped, internally. You can see from the photo that it also comes with a peel-off film on one side which I used to lay everything out. I used flathead machine screws for the spring hangers, and with the DIBOND I just drilled the

holes and pressed the heads into the material, deforming it until they were flush; no countersinking needed.

I also cut and glued odd chunks of backer board to the bottom side of the motorboard (still more DAP) to add mass and damping. The board is approximately 18 in², allowing plenty of room.

I adapted the wood plinth from the boxes of some KLH Fourteen speakers, which I picked up cheap at a junk shop. One dimension was OK, but I let in other chunks of walnut (the vertical grained bits) on the front and two in the back to bring the box to a workable size. The boxes had an internal lip, so I needed to rout out the new pieces to match.

Attaching the motorboard to the plinth isn't done in the usual fashion using screws and L-brackets. I used 1" screws, inserted up from the bottom through 3/8" dowels into the wood (Photo 7). This presses the motorboard and its cover tight against the wooden lip (Fig. 2). Because the structure is almost square, I use the same size dowels, with the same screw spacing, all around.

I used leather to cover the motorboard. This glues up well with spray upholstery adhesive (peel the protective film off the DIBOND first) and is flexible enough that you can turn it over the edges of the holes for the platter spindle and arm. It looks rich, and isn't too expensive if you buy a remnant from an upholstery shop.

So much for the table. Next month, in the digital edition of *aX*, I'll address the tonearm, which I call the Defarge arm. *aX*

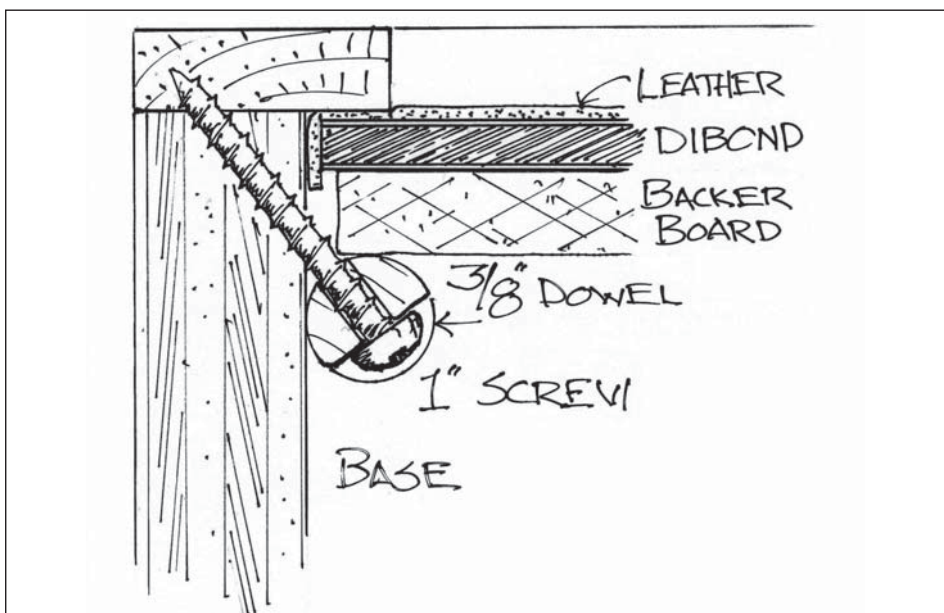


FIGURE 2: Section through the wood base and motorboard. This shows how I fixed the motorboard to the base. Accurate drilling of the pilot holes for the screws is essential. You don't want to drill through to the finished surface.

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ADVERTISER	PAGE	
ACO Pacific Inc.....	27	Mouser Electronics.....40
Antique Radio Classified.....	15	Mundorf EB GmbH.....43
Audience.....	37	OPPO Digital, Inc. 41
Audio Advancements, LLC.....	21	Parts Connexion.....9
Audio Transformers.....	13	Parts Express Int'l., Inc. CV4
Avel Lindberg.....	37	PCBCart.com.....44
Belleson.....	23	SB Acoustics.....5
Consumer Electronics Association - CES.....	7	Solen, Inc. 11
DH Labs Audio Cables.....	CV3	SRS - Stanford Research Systems.....CV2
Electra-Print Audio Co.	33	Tang Band Industries Co.,Ltd. 46
Front Panel Express, LLC.....	44	The Last Factory.....29
Goldpoint Level Controls.....	33	The Tube Store, Inc. 45
Hammond Manufacturing.....	3	Wavecor.....42
Jantzen Audio Denmark.....	6	
KAB Electro-Acoustics.....	31	CLASSIFIEDS
Linear Audio.....	31	All Electronics.....35
Madisound Loudspeakers.....	25	Audio Classics Ltd. 35
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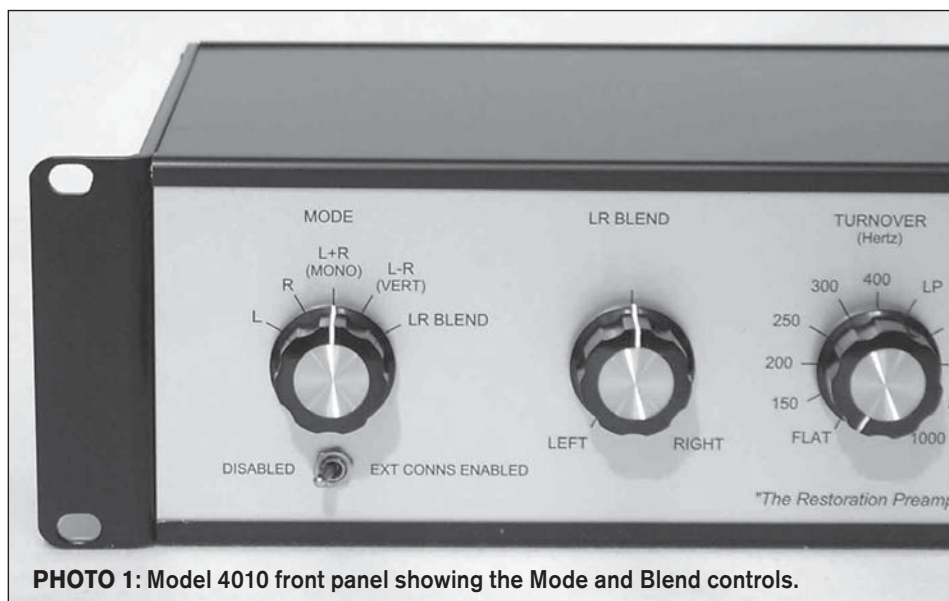


PHOTO 1: Model 4010 front panel showing the Mode and Blend controls.

The TDL® model 4010 (The Restoration Preamp™— **Photo 1**) has a control (a single-turn potentiometer) for blending the playback signals from the left and right channels for lateral-cut records. This feature, which you select with the mode switch, can help maximize the output signal-to-noise ratio (S/N) because the

noise from the left and right groove walls is usually not the same. We (Don and I) have been asked whether a blend control is useful for vertical-cut records. (In both cases a stereo pickup is used to play a mono record.) This article describes our effort to answer this question.

The pickup cartridge outputs will in both cases be $S_L + N_L$ and $S_R + N_R$

(where S is the signal and N is the noise), so at first glance it would seem that vertical blending would be useful. However, our measurements do not support this premise.

THE MEASUREMENTS

We modified a TDL® model 414 Stereo Utility Amplifier to a low-noise, unity gain, inverting amplifier with an audio bandwidth equal to or greater than the bandwidth of the 4010. We inserted it between Don's KAB Broadcast Standard turntable with a Stanton 500 cartridge and the left channel input on his 4010. The added inversion converts the blend control to vertical-cut blending. Don reports on the listening tests as follows:

"I listened to a variety of vertical-cut records from Edison, Pathe, Okeh, and Rex played at 80 RPM. I used a 3.5 mil elliptical stylus with the Edisons and an 8 mil spherical stylus with the others. I set the 4010 equalization controls to FLAT, the rumble filter to BYPASS, and the HF filter to 24.

"In my listening tests, I compared the sound of the records with the 4010 mode control set to L+R (mono) or LR blend. With the wide-groove records (non-Edison), a setting of $\pm 10^\circ$ from the center of the LR blend control had no discernible effect on the noise or distortion. As I rotated the control further to the right or left, the sound became noisier, but there was never a change in perceived distortion. In all cases, full left and full right settings sounded identical. These listening tests gave no support at all to the need for a vertical mode blending capability, at least for wide-groove records.

"Figure 1 shows the spectrum analysis of a segment of Edison Diamond Disc 8378, "Teasin" played by the Vincent Lopez Orchestra. The top line is the L+R mode, while the lower line shows the result with the LR blend mode at the center position. The difference between

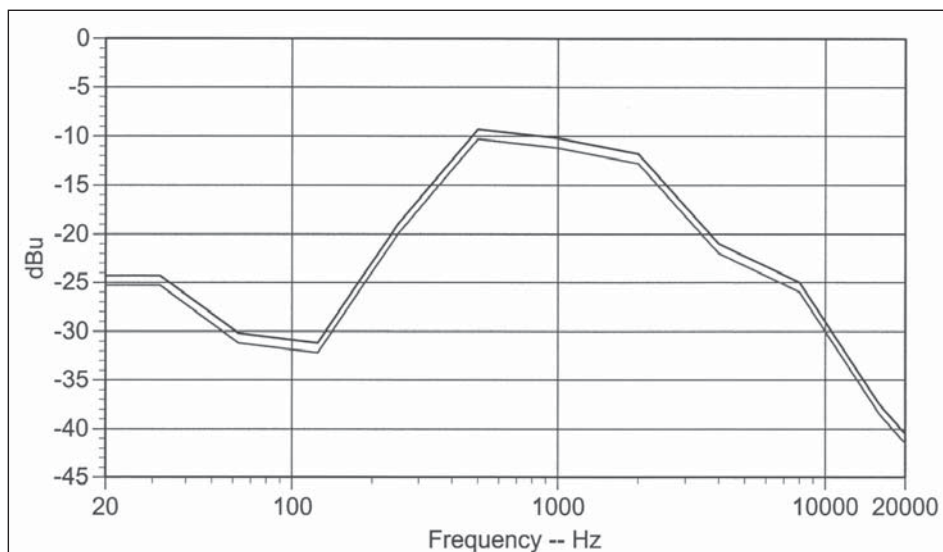


FIGURE 1: Comparison of L+R mode with LR blend control at the center (12 o'clock) position. Stanton cartridge and utility amp. The difference between the graph lines is because the LR blend gain at the center position is 1dB lower than L+R.

the two lines is 1dB at all frequencies. Again, a $\pm 10^\circ$ rotation of the LR blend control did not change the frequency spectrum, but I could hear a subtle audible effect mostly on "swishing" sounds at the one o'clock position. (I hate it when I can hear, but not see, a result!)

"My next step was to listen with the blend control at the full right and full left positions. Unlike with the wide-groove recordings, I heard a difference with the Edisons. The left channel was generally 2dB louder! It occurred to me that this is just a channel imbalance. To test this, I replaced the Stanton cartridge with an Ortofon Concorde Pro fitted with a 3.3 mil truncated elliptical stylus. The full right and full left spectrums are

nearly identical. **Figure 2** shows nearly perfect channel balance.

"For another test of the channel balance thesis, I removed the utility amp and connected both turntable channels directly into the 4010. With the Stanton cartridge, listening revealed that the maximum null occurred at the one o'clock position (lower line). This is a very audible effect, and is also quite visible (**Fig. 3**). The lower line is the center position response. **Figure 4** shows this comparison using the Ortofon cartridge. The maximum null occurred at the center position (lower line). The one o'clock spectrum is the upper line. Again, these results are both audible and visible. I repeated these tests with several Edi-

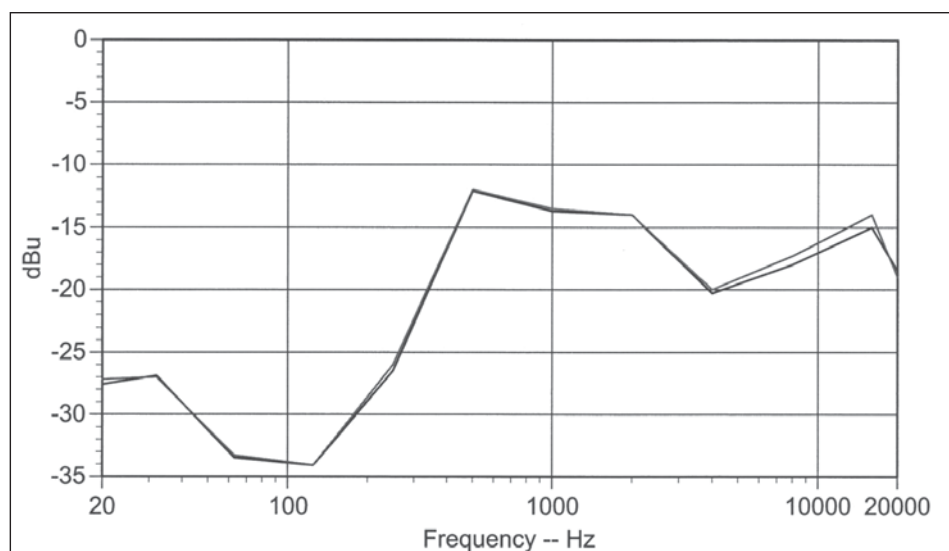


FIGURE 2: Comparison of LR blend control full left with full right. Ortofon cartridge with utility amp. This figure shows nearly perfect channel balance.

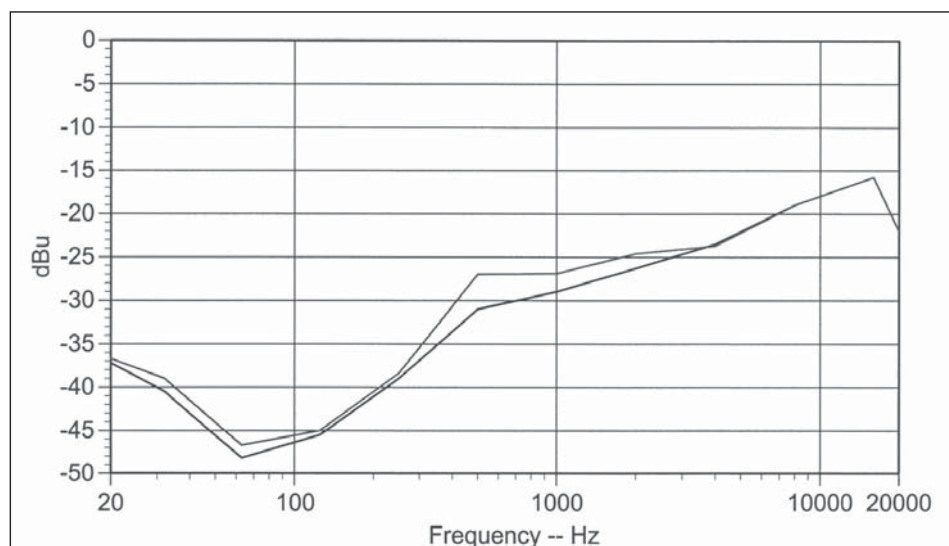


FIGURE 3: Comparison of LR blend at the center position (lower line) with the one o'clock position. Stanton cartridge with turntable connected directly to 4010 inputs. This figure shows the Stanton cartridge channel imbalance.

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"I checked the Stanton's channel balance with the 8 mil spherical stylus and it was nearly perfect, so that's why the wide-groove verticals didn't show the best-blend effect at one o'clock. I did not think that the Stanton cartridge was as unbalanced as it appeared to be in **Fig. 3**.

"I tried some other styli with interesting results. A 3.7 mil truncated elliptical stylus from ExpertStylus in the UK on a genuine Stanton cantilever and housing had excellent channel balance and sounded great with the Edisons. I also discovered that what I thought as a genuine Stanton 78 stylus was a counterfeit and had poor channel balance and a 6dB lower output than my two genuine Stanton styli, both of which had very good to excellent channel balance.

"Overall, I found no support for the use of a vertical blend control other than to compensate for cartridge/stylus channel imbalances. My listening tests suggest that vertical recordings, especially the narrow-groove Edisons, are more sensitive to these stereo cartridge imbalances than lateral recordings. I think that anyone who is doing restoration of vertical recordings should ensure accurate channel balance before converting the signal to mono."

DISCUSSION

Because the equations for the cartridge outputs are the same for both the lateral- and vertical-cut cases, a mathematical analysis will not be helpful. Instead, we looked at the "mechanics" of the two cases to arrive at a hypothesis that may explain why LR blending does not provide any benefit for vertical-cut records. This is illustrated in **Fig. 5**.

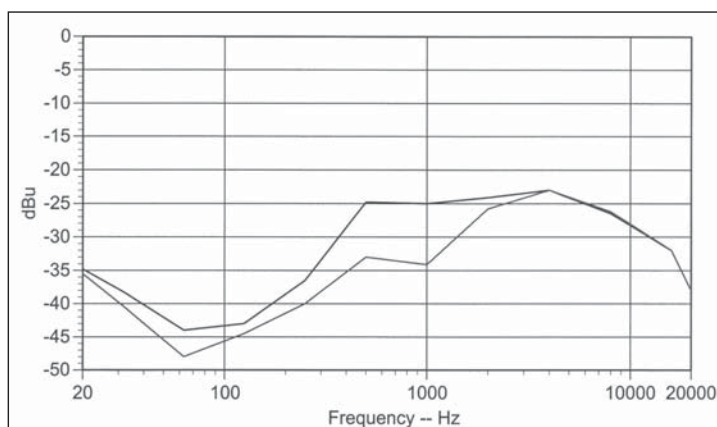


FIGURE 4: Comparison of LR blend at the center position (lower line) with the one o'clock position. Ortofon cartridge with turntable connected directly to 4010 inputs. The Ortofon cartridge has very good channel balance.

In a lateral-cut recording the grooves are "vee" shaped. The pickup stylus rides on the two groove walls, which contain the left and right signals plus noise. With a mono record, the "music" signals will ideally be the same while the left and right noise signals will

probably be different. Hence, LR blending may produce a definite noise null depending on the physical condition of the disc. We hypothesize that the "key" point here is the angle the stylus makes with the groove wall. Possibly the output noise is proportional to the tracking force of the stylus on the groove wall which is proportional to the sine of the angle of the groove walls as measured from the vertical centerline of the groove. On the other hand, a vertical-cut record has a nearly rectangular groove because all of the signal is in the groove bottom. (A small relief angle is necessary so both the cutting and playback styli can move freely in the groove.) If the output noise is proportional to the sine of the groove wall angle, then a vertical-cut recording will have less groove-wall noise. Of course, the bottom of the groove can still be noisy, but this would be present in both the left and right outputs, so blending would not be helpful.

The authors welcome questions and comments either directly or through Letters to the Editor. You can contact Don at ecg@conway-corp.net and Ron at RTip-ton@tdl-tech.com. *aX*

REFERENCES

1. You can find the Model 4010 datasheet and user guide at: <http://www.tdl-tech.com/data4010.htm>. See also, Product Review, "The Restoration Preamp," *aX* 4/09, p. 36.
2. The graphs in **Figs. 1-4** were made using the TrueRTA Real Time Audio Spectrum Analyzer software from True Audio, 387 Duncan Lane, Andersonville, TN 37705. <http://www.trueaudio.com>.
3. The "Headshell" graphics (Mag_cartridge.png) in **Fig. 5** was borrowed from the Wikipedia webpage on Stereo Pickup Cartridges.

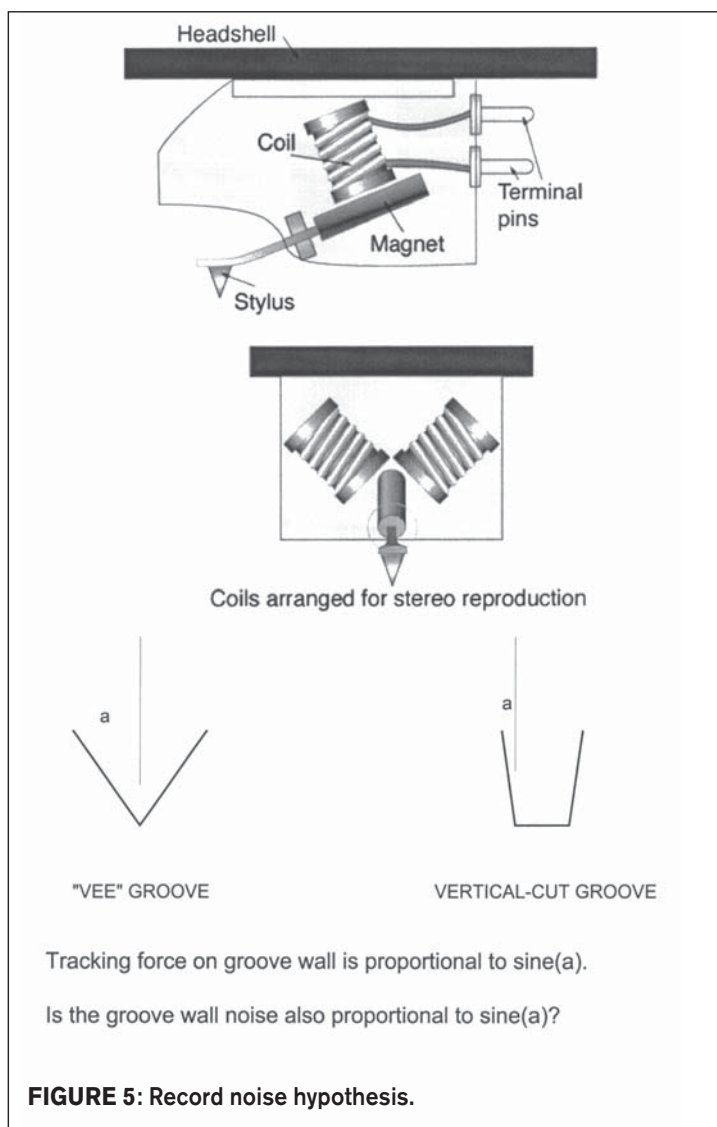


FIGURE 5: Record noise hypothesis.

Oatley Electronics K272A Headphone Amp

By Aren van Waarde

Oatley Electronics (www.oatleyelectronics.com), which sells electronic parts and used equipment in New South Wales (Australia), has launched a small range of audio kits based on tube technology. My interest was raised by glowing reviews written by Mark Houston, DIY convener of the Melbourne Audio Club¹. The kits employ subminiature valves (pentodes type 6418) made in the 1970s by the American company Raytheon for military purposes (use in cryptographic equipment)². Such valves have also been employed by the Royal Dutch Navy, and as outdated navy stocks are sold by local dumpstores at rock-bottom prices, many 6418s ended up in my junkbox. I intended to use these tubes for building a regenerative receiver, but never considered them for audio purposes until I discovered the Oatley products.

Currently, the following vacuum tube kits are available: K261 Tube Preamplifier (single gain stage, for piezo transducer, e.g., of electric guitar, AUS \$22), K270 Tube Preamplifier (like K261, but dual gain stage and volume control, AUS \$29), K272A Stereo Tube Preamplifier/Headphone Driver (AUS \$30), K281 Tube-based 5/10W Power Amplifier (AUS \$29), and K282 Tube-based Stereo RIAA Preamp (AUS \$47). I ordered the K272A and the K282. The website allows secure ordering by credit card. Customers are treated courteously: by first confirming receipt of the order and receipt of payment and then sending the goods with package number. My kits arrived within two weeks. This article offers a description of the K272A, my experiences in wielding the soldering iron, and a subjective evaluation of the sonic results.

K272A Circuit

The schematic of the K272A is shown in **Fig. 1**. As you will notice, the actual amplifier circuit is quite simple, but a few compounds have been added to provide DC power to the tube heaters and the output buffers.

The gain stage of each stereo channel consists of a single 6418 wired in triode mode (V1 and V2). Wired in this way, a 6418 will provide a voltage gain of about 7. Because the valves run at very low anode currents (between 10 and 15 μ A!), they are not capable of driving headphones directly. The amplified signal at

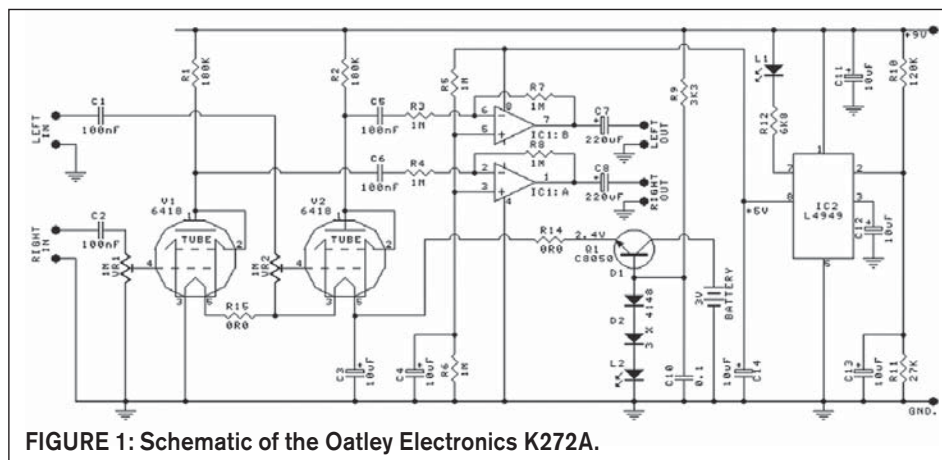


FIGURE 1: Schematic of the Oatley Electronics K272A.

their anodes is therefore fed to a stereo headphone driver chip utilizing CMOS technology (IC1). This compound is configured as a unity-gain buffer. Because it combines a high input impedance with output current drive capability, the preceding 6418 gain stage is hardly loaded, and you can connect headphones with impedances of 8 to 80 Ω to the output terminals. Voltage amplification is provided by the valves and current amplification by the integrated circuit.

The 6418 tube is a directly heated pentode designed for low anode voltages (30V maximum) and low power consumption. The valve heater requires only 10mA at 1.25V. For this reason and to eliminate mains-induced noise, Oatley Electronics decided to use batteries (alkaline cells) for feeding the K272A. The 6418 heaters are fed from two AA-type batteries. The valve anodes and output buffer receive power from a small 9V battery.

The buffer chip is a PT2308, made by Princeton Technology Corporation (www.princeton.com.tw), a company from Taiwan. It is functionally compatible to the TDA1308 and also has the same pin-out. Because it cannot operate at voltages greater than 5.5V, a low-drop series regulator (IC2) provides a clean 5V supply to IC1.

The valve heaters are fed by a one-transistor circuit. D1, D2, and LED L2 receive 2mA current from the 9V supply via resistor R9. They provide a reference voltage to transistor Q1, which supplies 2.4V, 10mA to the series-connected valve heaters. Transistor Q1 is only turned on when the 9V supply is present. Thus, you can turn the entire amplifier on and off with a single switch in the 9V supply rail. LED L1 serves as a battery voltage monitor (see below).

DESIGN CRITIQUE

The K272A circuit raised a few doubts in my mind. Note that I am a home constructor, not an EE, and my experience with tube technology is limited. Don't shoot the biologist.

1. The series configuration of the valve heaters seems a bit odd. Because the 6418 is directly heated, heater potential determines cathode bias voltage. V2 will always run at higher bias voltage (and lower anode current) than V1, and the voltage gains provided by V1 and V2 will be slightly different. Indeed, I noticed that identical tubes showed a 15 to 20% difference in anode current in the V1 and V2 positions. The resulting difference in voltage gain between both stereo channels can be easily trimmed away by carefully adjusting input potentiometers VR1 and VR2. Yet, the different bias could result in different distortion characteristics of the left and right channels.

2. I questioned the rationale of the design. What's the use of valves running at 9V B+ and anode currents of 10 to 15 μ A? Will such valves not sound as (noisy) transistors? And what's the use of a class A triode stage followed by a class AB CMOS chip? Will the sonic advantages of the triode (if any) not be offset by the sonic disadvantages of the solid-state circuit (odd-order harmonics)?

3. Finally, will such battery valves not produce huge amounts of harmonic distortion? The 6418 is not very linear. Tung-Sol—like Raytheon, a manufacturer of these tubes—specifies a total distortion of 12% (yes, twelve percent!) at the standard operating point.

However, similar designs (valve stage running at low B+ plus solid-state output buf-

fer) circulate on the Internet. They appear to originate from Korean headphone enthusiast Shin-Jeob Shin (nicknamed Sijosae) but were tried by many others, including audiophiles from the US and Germany. In Germany, the circuit topology is known as the "YAHA amplifier," the acronym standing for "Yet Another Hybrid Amp." A German friend of mine has built one and says, "Although the circuit is all wrong from an engineering perspective, it sounds good." Moreover, a tube microphone from Audio-Technica (www.audio-technica.com) with a \$600 price tag (**Photo 1**) employs a single 6814 as the active element. Thus, I thought that the K272A was worth trying. The proof of the amplifier is the listening.

CONSTRUCTION

The K272A is packed in a plastic bag containing a printed-circuit board (PCB), all electronic parts, and a construction manual. The PCB looks gorgeous. It is plated through, dual layered, solder masked, and screenprinted. Very nice! The parts supplied correspond

exactly to the bill-of-materials in the manual. Even rubber grommets are provided, though the manual specifies that these are optional and should be bought separately.

The active devices are from well-known manufacturers: two Raytheon 6418 valves in date-stamped original boxes, an L4949 IC from SGS-Thomson, a PT2308 from Princeton Technology Corporation, and a C8050 transistor from India. Compared to the PCB and active devices, the passive components were a slight disappointment. My bag contained quite ordinary (generic) parts: carbon film resistors, radial electrolytics, and foil capacitors. However, the values of all resistors deviated less than 2%, and those of all capacitors (both foil and electrolytic) less than 10% from specified values. Taking the low price of the kit into account, the quality of the components is good.

Although the manual is well written, it is not at "Heathkit level." Resistor color codes, the polarity of electrolytic capacitors, and the pin numbers of dual-in-line ICs are not explained. Also, no explanation of soldering techniques is provided. Thus, the kit is not suited for first-

time builders of electronic equipment.

However, if you have previously built any circuit with good results, you will have no problems with this one. The screen print and the soldering mask of the PCB make assembly very easy. First mount the low-profile components (resistors, diodes, IC sockets), then the capacitors, and finally the active devices. Don't hurry, take your time. Although the kit is said to require only one hour of construction time, I took an entire afternoon and worked very neatly. It will pay off later.

Sonic Results, Drawbacks, and Measurements

For initial listening tests, I used vintage Sennheiser HD465 headphones—a pair of cans that is very comfortable and allows prolonged listening but is not ideal from a sonic point of view. A Sony bitstream CD player served as music source. My initial impression of the sound of the K272A: warm, pleasant, and detailed. Organ music sounded great. On vocals and some orchestral tracks, there seemed to be an excess of bass. However, this could be a property of the headphones rather than the amp. HD465s—both the vintage yellow model and the modern, blue variety—sound rather bass-heavy.

Thus, I switched to Grado SR125, which is my best dynamic headphone (www.gradolabs.com). The 6418s had been in use for ten hours or so and were "burned in." With good CDs, the K272A/Grado combination produced excellent sound: a fine bass (powerful and deep but not overblown), detailed mid-range, sweet top-end. Tonal colors of string instruments and vocals of male and female soloists were naturally represented. Many small, previously unnoticed details of recordings were revealed. The message of singers in a choir was more clearly intelligible than with other headphone amplifiers which I own, and sibilants were not artificially emphasized.

In direct A/B comparisons, the K272A sounded better than the G4OEP (3/08 aX, p. 36) and even slightly better than the Stor class A amplifier (6/03 aX, p. 30). Less "electronic," more "lifelike." I spent many pleasant hours of listening to audiophile CDs from BIS, Brilliant Classics, Chandos, DG, Telarc, and Virgin Classics (to mention just a few). Yet, it is not all gold that glitters. There are a few drawbacks (as usual). In my opinion, these

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are minor, but you may judge differently.

First, 6418 valves are very microphonic. Oatley advises kit builders to mount two rubber grommets on each 6418 to damp resonances (**Photo 2**). Do this *before* you solder the tubes on the PCB, not afterward! Although the grommets are effective, this treatment is only partially successful. Touching the PCB or hitting the table on which it stands results in a high, whistling sound which persists for more than 30 seconds. Apparently, this peculiar form of microphony is typical for subminiature "hearing-aid" valves. I have encountered it in DIY projects of my own which used German (Telefunken 5672), American (Raytheon 6088, 6418), and Russian (1SH18B, 1SH24B, 1SH29B, 1SH37B) subminis.

In order to reduce microphony further, you could mount the PCB and tube assembly on springs or suspended in soft plastic foam. Also you could internally damp the cabinet with bitumen pads. If the board is securely mounted, well screened and not touched, the amp is dead quiet and does not produce any audible hum or noise in the absence of a music signal.

Second, the K272A is susceptible to hum

induction when the valves are out in the open or the PCB is placed in a wooden cabinet. During initial listening tests involving the bare PCB on my desk (close to two computers!), I had to carefully orient wires in order to avoid interference. Small movements of a wire could transform a quiet amp into a humming bastard, and vice versa.

Thus, I decided to mount the amp in a plastic cabinet internally covered with copper foil connected to circuit ground. The resulting Faraday shield has strongly reduced its tendency to pick up spurious signals. In the shielded cabinet, hum induction no longer occurs. Yet, the use of mobile phones in its close vicinity results in an audible signal. Shielding has not abolished the sensitivity to powerful RF signals, probably because the interconnects or the headphone cord act as antennae.

Third, the use of batteries limits the time of operation. Oatley specifies that when you use alkaline cells (2 AA for the heaters and 1 E-block for B+), the AA batteries will last 250 and the E-block 70 hours. It is, of course, possible to use six series-connected AA cells rather than an



PHOTO 1: The Audio Technica AT3060 tube microphone.

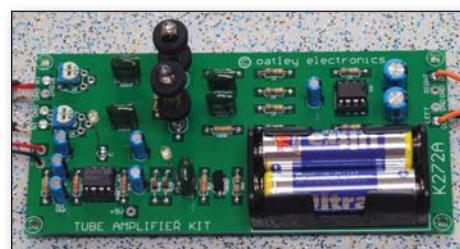


PHOTO 2: K272A circuit board. Note the rubber grommets used to dampen valve microphony. The AA cells on the PCB supply power to the heaters. The additional 9V battery is not visible.

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E-block, which will result in longer battery life.

The two high-efficiency LEDs on the PCB (L1 and L2 in **Fig. 1**) serve as battery monitors. Normally, L1 will light briefly (for about 1 second) after the amp has been switched on (charging time of C14). When the supply voltage drops below 6.8V, the LED will remain on continuously. A permanently lit L1 indicates that the E-block should be replaced.

In my opinion, it is wise to replace the battery a little earlier. My ears tell me that with a new 9V battery, the K272A sounds better than with a battery whose voltage has dropped below 7.5V. At low battery voltages (thus, at low anode voltage of the valves) the 6418 stage may become overloaded in heavily modulated passages, resulting in audible distortion. A fellow audiophile from Malaysia runs his K272A from a 12V car battery and claims excellent results with such an overkill power supply.

If the AA batteries are in good condition, LED L2 will be shining brightly. Thus, L2 serves as a "power on" indicator. When the battery voltage approaches 2.0V, the LED will extinguish. Even when L2 is dimly lit, the filament voltage is still at an acceptable value. You should then replace the AA batteries soon.

Fourth, because there is no resistor running from the negative pole of C7 and C8 to ground, the amp produces a minor transient during switch-on and a rather strong transient (click in the headphones) during switch-off. It will not damage either your pre-

cious ears or cans, but it is slightly annoying.

Fifth, the K272A can drive sensitive headphones nicely but it is less suited for power-hungry cans. The Grado SR125 (32Ω, 98dB/mW) and Sennheiser HD465 (60Ω) worked well, but a third headphone which I tried, an orthodynamic Yamaha HP1 (150Ω, 93dB/mW), performed suboptimally. Although adequate volumes could be reached, the amp worked close to its limits and it sounded rather strained. In contrast to the Grado SR125, the Yamaha HP1 performed better on the Stor amp than on the Oatley product.

Maximal bandwidth of the amplifier is 10Hz to 50kHz (-3dB). The square wave response looks nice, with no signs of instability or visible ringing, some tilting at low frequencies because of the capacitor coupling, and some rounding of the edges at high frequencies (10kHz or greater). Voltage gain is 7 (input controls turned fully clockwise), and the output is limited to 3V peak-to-peak. With Grado and Sennheiser phones, very high volume levels are possible (higher than my ears will tolerate).

Oatley Electronics writes: "This low cost tube preamplifier lets you experience 'tube sound'." They could also have written "great sound!" For the asking price of 30 Australian dollars, the K272A is an absolute bargain. And it does not involve any dangerous voltages. But switch off your mobile phones (or move to the Australian desert).

Notes

1. Mark Houston's review of a previous version of the K272A can be found at the following URL: <http://diyaudioprojects.com/Tubes/6418-Tube-Preamplifier-Kit/>
2. For more information about the use of subminiature valves type 6088 and 6814 in cryptographic equipment, see the KWR-37 website, <http://www.jproc.ca/crypto/kwr37.html>.

Manufacturer's response:

An excellent review, thank you! We respect Mr. van Waarde's opinion and welcome constructive criticisms. I recall answering somebody a long time ago about the filament being connected in series. Here is some of the text for your consideration:

If VR2 were connected directly to ground, the grid of V2 would effectively have a bias voltage of at least -1.2V with respect to pin 3 of the cathode, thus possibly cutting the tube off. The way it is connected in the kit, the Grid to Pin 3 of the Cathode voltage is 0V, same as the first stage. The only difference between the two stages is that effectively the second stage has a lower supply voltage and thus produces a slightly lower gain. The gains can be balanced by adjusting VR1 and VR2.

If the filaments were connected in parallel, the supply current would almost double. The two stages would now be identical in appearance, but their gains would be different anyway, as no two tubes are the same?

Branko Justic

Manager

Oatley Electronics Pty Ltd.

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PHASE SPLITTER

Chris Paul's letter "More Impedance Tests" in the October 2009 (p. 42) issue raises a few questions as well as interpretations. When measuring the active output impedance of a generator or source (**Fig. 1**), varying the load is a simple and effective method. Measure the voltage across a known load, e_1 , then calculate the current, i_1 . Change the value of the load and repeat the measurements for e_2 and i_2 . Then r_g is equal to $(e_1 - e_2)/(i_1 - i_2)$. This method is easily applied to the split-load phase splitter. **Figure 2** illustrates the equivalent circuit for the phase splitter. It is very similar to Mr. Paul's Fig. 1 except that the grounds are shown connected at point A for clarity.

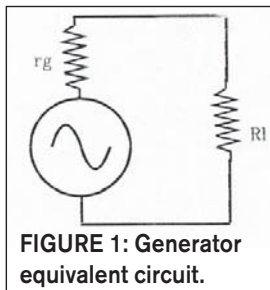


FIGURE 1: Generator equivalent circuit.

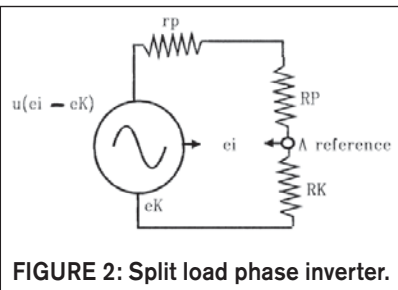


FIGURE 2: Split load phase inverter.

This is a typical feedback amplifier; note that if point A is moved up to the top of R_P , it is a cathode follower, and if A is moved to the bottom of R_K , the circuit is a standard grounded cathode amplifier; as shown it is a feedback amplifier. To determine gains, plate, or cathode currents and output impedances, some things need to be defined.

1. B, feedback factor. $B = R_K/(R_K + R_P)$. Negative feedback B is negative.
2. R_{lt} , total plate load. $R_{lt} = R_K + R_P$.
3. A, gain without feedback. $A = u * R_{lt}/(r_p + R_{lt})$.
4. A', gain with feedback. $A' = A/(1 - B*A)$. Because B is negative the denominator is more easily written as $(1 + B*A)$.
5. A_k , cathode gain. $A_k = A*B$, plate gain is then $A_p = A' - A_k$.
6. In a triode when grid current is not drawn, $i_k = i_p$.
7. e_k , cathode voltage. $e_k = e_i * A_k$ and $e_p = e_i * A_p$.
8. i_k , cathode current. $i_k = e_k/R_K$. $i_p = i_k$.

This will allow a full low-frequency evaluation of the phase inverter at the plate current and voltages that the tube characteristics are given. For example, using the characteristics given for a 6SN7GTB, $u = 20$, $r_p = 7700\Omega$, and $g_m = 2600S$. With $R_P = 10000\Omega$, $R_K = 10000\Omega$, and $e_i = 10V$.

- | | |
|--------------------------------------|--------------------------------------|
| (1) $R_K = R_P = 10000\Omega$ | (2) $R_K = R_P = 9000\Omega$ |
| 1. $B = 0.5$ | 1. $B = 0.5$ |
| 2. $A = 14.44$ | 2. $A = 14.0078$ |
| 3. $A' = 1.75669$ | 3. $A' = 1.750124$ |
| 4. $A_k = 0.878345$ | 4. $A_k = 0.875062$ |
| 5. $A_p = 0.878345$ | 5. $A_p = 0.875062$ |
| 6. $e_k = e_p = 8.78345V$ | 6. $e_k = e_p = 8.75062$ |
| 7. $i_k = i_p = 8.78345 * 10^{-4} a$ | 7. $i_k = i_p = 9.72291 * 10^{-4} a$ |

Comparing the cathode or plate voltages of (1) and (2), the delta is $0.03283V$; doing the same for the i_k 's, the delta is $0.93946 * 10^{-4}$. Solving for the output resistance, $R_o = 349\Omega$ for the cathode and plate R_o . This is the special case shown in the *Radio Designer's Handbook*, 4th Edition (RDHB4), page 330, eq. 34a and is only valid when the total impedance of the cathode load equals the total impedance of the plate load resulting in a B of 0.5. Note that using the values of u , r_p , R_K , and R_P used for (1) above in equation 34a results in a value of 338Ω .

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If RP is decreased to 9000Ω while RK remains at 10000Ω, the following results are obtained.

1. B = 0.52632
2. A = 14.23221
3. A' = 1.67621
4. Ak = 0.882223
5. Ap = 0.793987
6. ek = 8.82223V
7. ep = 7.93987V
8. ik = ip = 8.8223*10⁻⁴ a

Comparing the plate voltage and current with those of (1) above, the delta ep is 0.84358V and the delta ip is 0.03995*10⁻⁴, then the plate Ro = 211159Ω. This approximates the results of equation 30, page 330 of the *RDHB4*, which applies when only the plate output impedance is under test. Note that in this case B is no longer 0.5 and the plate circuit acts as though the feedback was a current feedback. When using the values used in (1) above, equation 30 results in a value of 190000Ω for the plate Ro.

Repeating the above for changes in RK only, by setting RK to 9000Ω and leaving RP at 10000Ω, results in a value of 846Ω for the cathode output impedance. Equation 31 on page 330 of the *RDHB4* results in 843Ω.

Evaluating the characteristics of the split-load phase inverter using feedback theory is a rather simple effort and provides a dynamic analysis of the system; for example, the reduction in distortion generated by the tube is A'/A, or in the case above, about 1/8. The equations, 30, 31, and 34a on page 330 of the *RDHB4* are accurate when used for their purpose—Equation 30, when evaluating changes in plate loading only; Equation 31, when evaluating changes in cathode loading only; and Equation 34a when evaluating identical changes in plate and cathode loading. In each case identical initial plate and cathode loads are assumed.

C. R. Morton

corneliusm@cox.net

Chris Paul responds:

Mr. Morton has presented a method for analyzing circuit parameters that we can call Network and Feedback Analysis (N&FA). It has a computational simplicity that the Algebraic Method (AM) I used does not. However, N&FA does not produce expressions that give insight as to how each individual circuit component contributes to a circuit parameter. And it forces you to repeat much of the procedure each time you

change a single circuit component, whereas the AM requires only the recalculation of a single expression for each parameter.

Finally, as I described in my letter, the AM affords a means of verifying that its derived expressions are consistent with the original conservation of current equations for the circuit as written down by simple inspection. I am unaware of a similar check for N&FA, but different circumstances will favor the use of either the AM or N&FA as the user sees fit.

Recall that a general definition of the impedance between two points in a circuit is the voltage change across those points caused by a test current flowing through them, divided by that test current. This is in accord with Mr. Morton's (e1-e2)/(i1-i2). He creates a test current in a circuit with voltages already present by combining 90K loads with 10K Rps and Rks to make 9K.

But the (i1-i2) change in test current he uses is not that through the 90K load resistor, but rather the change in total triode current. This means that the impedances he calculates are those looking into the triode portion of the circuit, or the Electrode impedance (EZ). To calculate the Total Circuit impedance (TCZ) including, for instance, the contribution of Rp at the plate as I did, use the change in current flowing out of the total circuit under test, which is that flowing through the 90K load resistor, 0 - ep2/90K.

Mr. Morton addresses EZ's Zp' from plate (P) to ground, Zk' from cathode (K) to ground, and Zpk' between the P and K. When the calculations for Zp' and Zk' are repeated in a spreadsheet to strip out errors due to cumulative hand calculations, the results agree perfectly with the EZ portions from my letter and with those of *RDHB4*, if the *RDHB4* equation (30) expression is corrected to rp + (1 + u)Rk. (Yes, *gasp*, *RDHB4* contains an error! You'll find the correct expression in the Priesman paper and in many other places, or you can simply derive it yourself.)

But immersion in a spreadsheet still leaves Z_{pk}' unequal to *RDHB4* eq (34a) = Ro, to which it was compared. There are several reasons for this. First, Ro is a TCZ, not an EZ. Second, Ro can be shown by derivation to be exactly half the TCZ from plate to cathode. (This should not be a surprise, since *RDHB4* does not claim that Ro is the impedance between the plate and cathode.) Third, the voltage term in the N&FA Zpk' should actually be delta_e = (ep1 - ek1) - (ep2 - ek2), the change in voltage between the plate and cathode. And for that expression to work properly, Ap in the

spreadsheet would need to be changed to the negative of what was given, to reflect the fact that ek and ep are, in fact, negatives of one another in a balanced cathodyne.

For a choice of $(ik1-ik2) = (ip1-ip2)$ for $(i1-i2)$, the result of this Zpk' EZ calculation equals $2rp/(u + 2)$. If the change in test load current $(0 - (ep2-ek2))/(2 \times 90K)$ were chosen instead, the TCZ result Zpk across the plate and cathode would be in accord with $(2rp/(2 + u)) || (Rk + Rp)$, as long as $Rk = Rp$.

I strongly urge anyone employing N&FA to use a spreadsheet to avoid the accumulation of numerical errors that occur with the truncations of intermediate results that are so tempting with hand calculations. If one is not available, you should at least retain all intermediate calculations to a good degree of precision.

Finally, measuring impedances by connecting a load works fine when a signal is available, but is useless when it isn't, as with amplifier inputs. The solution that works for both inputs and outputs is to shut off all signal sources, and to then route a test current signal through the circuit points under test. The ratio of the voltage that arises across those points to the test current is always the impedance between those points. *aX*

STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION

(Required by U.S.C. 3685.) Date of filing: September 30, 2010. Title of Publication: AUDIOXPRESS. Publication Number: 1548-6028. Frequency of Issue: Monthly. Annual Subscription Price: \$50.00. Location of the headquarters or general business offices of the publisher: Audio Amateur Inc., PO Box 876, Peterborough, NH 03458-0876.

Publisher: Edward T. Dell, Jr., PO Box 876, Peterborough, NH 03458-0876. Assistant Publisher: Dennis Brisson, PO Box 876, Peterborough, NH 03458-0876. Owner: Audio Amateur Inc., PO Box 876, Peterborough, NH 03458-0876.

Stockholders owning or holding 1 percent or more of the total amount of stock: Edward T. Dell, Jr., PO Box 876, Peterborough, NH 03458-0876. Known bondholders, mortgages or other securities: None.

	Average # copies each issue during preceding 12 months	Single nearest to filing date
Total # copies printed	9,333	9,800
Mailed Subscriptions	3,220	2,832
Sales Through Dealers Counter Sales and other		
Non-USPS distribution	3,014	3,101
Free Distribution (complimentary)	2,054	3,400
Total distribution	8,288	9,333
Copies not distributed	1,045	467
Total	9,333	9,800

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Ron Tipton ("All About Stroboscopes," p. 18, and "Vertical-Cut Blending," p. 36) has degrees in electrical engineering from New Mexico State University and is retired from an engineering position at White Sands Missile Range. In 1957 he started Testronic Development Laboratory (now TDL Technology, Inc.) to develop audio electronics. During the 1960s and 70s, TDL built active filters and pseudo-random noise generators for well known companies such as

Bose Corp. and Acoustic Research. He is still the TDL president and principal designer.

Joel Hatch ("Turntable Speed Control," p. 22) served in the US Navy from 1975–1981 as an electronic technician (nuclear). He then attended Ohio State University, receiving a BA in biochemistry and an MS in nuclear engineering (instrumentation). While working at OSU's reactor lab, Mr. Hatch completely renovated and updated the reactor's safety and control system's old 50s/60s era "tube" nuclear electronics into solid-state/ICs. In 1993, Mr. Hatch left OSU and worked several years for the Air Force developing test methods and procedures for electro-optic components used in air and spaceflight with emphasis on nuclear survivability. Mr. Hatch returned to Ohio in late 1997 and continued to work in the fields of space and satellite technology evaluating and testing electro-optic and solid-state analog/digital/mixed components for use in cosmic radiation environments. Currently, Mr. Hatch works as a reliability engineer for a large telecommunications company developing tests and verifying operation of telecom amplifiers in extreme environmental stress conditions, and continues as a consultant in the nuclear and space radiation effects field.

Tom Yeago ("The Wretched Excess AR Turntable Renovation: Pt. 1," p. 28), who obviously has too much free time, reports that he has been a buff since puberty, or thereabouts. A Virginian (the Shenandoah Valley), Tom's formal training is in economics, a.k.a the dismal science. Besides noodling about in hi-fi matters, he also devised a complete reorganization scheme to fix the shamefully inadequate public school system, in case you're interested.

Don Walizer ("Vertical-Cut Blending," p. 36) resides in Arizona.

Aren van Waarde (Review: Oatley Electronics K272A Headphone Amp, p. 39) is a biochemist working in the field of medical imaging (positron emission tomography). He has worked as a Ph.D. student and a postdoc at several universities (including Leiden and Yale Universities) before accepting tenure at the University of Groningen. His passion for audio started on his ninth birthday when his parents gave him a Philips kit. Most of his current audio equipment (loudspeakers, radios, tuners, pre- and power amps, both tube and solid-state) is homemade.

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CEDIA 2010: Value(?) on Display in Three Dimensions

By David J. Weinberg

CEDIA (www.CEDIA.net) claimed 20,700 attendees (the audited count is not yet available), compared with 22,000 last year, and that almost 20% of the attendees were at their first CEDIA, which means that many who attended last year did not return. These numbers included exhibitors and members of the press.

The show floor, with more than 450 exhibits (90 were first-time CEDIA exhibitors), was never heavily crowded. According to reports, many dealers and custom installers were searching for ways to expand their businesses beyond their core offerings.

About 150 courses were offered, with a special deal: instead of paying for each course, you could attend all the courses you wanted for \$400. About a third of the courses were business-related, covering all facets of how to build and manage your custom installer business such as design/management/customer documentation; how to relate to and work with customers, architects, builders, interior designers, and so on; customer service; social networking; and selling (“What Women Want—Selling Home Entertainment Systems That Benefit Her Lifestyle”).

Technical courses included basic math for technicians, various aspects of home theater and home control design/build/adjustment, technician certification prep courses, wired/wireless technologies, troubleshooting, AC power including grounding and conditioning, and more. I attended about

half a dozen, none of which had attendance as large as I perceived at previous CEDIA Expos.

I learned that a second edition of the CEDIA Technical Reference manual is under development. I strongly suggest waiting until that second edition has been released. See my review of the first edition in the May/April '10 issue. CEDIA published a *2010 Electronic Systems Contractors Licensing and Regulatory Reference Directory*, which delineates by US state and Canadian province the licenses needed to legally perform custom installation work, and licensing organizations that issue them.

There was no new hardware or software that stood out from the crowd.

Display marketing focused on 3D. At least one manufacturer had “universal” 3D glasses, but would not lend them for a floor tour to see how universal they were.

Naturally, 3D panels and projectors were widely displayed. However, there are four mutually exclusive 3D display technologies under development, three of which require each viewer to wear glasses that only work with one of them. Psychovisual focus-distance conflicts cause headaches and nausea in some viewers, which 3D-movie creators will need to learn to avoid. Many consumers have recently bought new high-definition displays, Blu-ray players, and HDMI cables, and they likely will be reluctant to replace those so soon and at higher cost than their previous purchases.

Thus, 3D is an unsettled landscape

that needs domesticating and standardization before the risk of planting the soon-to-be-rejected technological seed in your home is low enough to warrant the expense. Embedded computers have become commonplace, as has consumer acceptance of networks, wireless audio and video, and so on.

PRESENTATIONS AND COURSES

The third annual **Pre-Game Show** featured the dynamic duo of Michael Heiss (CE industry consultant and member of CEDIA's technology council) and Richard Green (integrator, and director of CEDIA's technology council). During this preview session, Heiss and Green discussed the show's purpose and what to look for on the show floor to keep the custom installer/integrator businesses healthy and profitable.

These businesses need to focus on what they can offer that justifies the extra cost at a time when most of the equipment is commoditized and the economy has severely limited corporate and personal discretionary expenditure. Businesses need to effectively aim at the right market. Custom installers can install those readily available boxes and set them up to deliver the multimedia experience that the consumer can't get by himself.

Heiss/Green agreed that for survival and growth, custom installers/integrators should focus on retrofits, commercial jobs, and energy management. Green said, “Energy is the new audio [and] is what's changing our industry.”

Heiss added that achieving higher green credits for the homeowner will require looking beyond energy efficiency to other product aspects such as packaging and installation elements, all of which can add or subtract LEED points.

For A/V and whole-home control and automation, there were many iThings and Android-based touch pads and apps (especially the Samsung Galaxy; <http://GalaxyS.SamsungMobile.com>; Heiss called it a very good Android-based tablet). Crestron offers an iPad sleeve that adds hard buttons to complement the iPad's soft buttons.

The Radio Frequency for Consumer Electronics (RF4CE) consortium has merged with the ZigBee Alliance (www.ZigBee.org) to push for inclusion of RF remote control in consumer electronics devices, to make multi-room and hidden systems easier to control from afar. They pointed to wireless and network/Internet connectivity as critical to new and retrofit installations.

Nuage Nine (www.NuageNine.com) has partnered with Crestron (www.Crestron.com) to offer remote monitoring and error prediction/discovery for home systems. A competitor is ihiji's (pronounced "eye-he-gee"; www.ihiji.com) invasion, which is a cloud-based remote monitoring solution.

With respect to distribution, networking, and connectivity, not everything can be accessed from the cloud. Because of the complexity of home networks, A/V systems, and the desire for wireless, integrators should seriously consider enterprise-grade wireless network solutions over consumer-grade models. Powerline networking (such as products from Russound—www.Russound.com—and Nuvo Technologies—www.NuvoTechnologies.com) and MoCA (Multimedia over Coax Alliance; www.MoCAAlliance.org) offer other ways to network a home with minimal additional wiring,

especially because so many products require live Internet access.

Naturally 3D will be everywhere, but "there are still questions about when, how, and where." There are some "universal" 3D-glasses, but each of the 3D technologies suffers from problems that can confuse the 3D-glasses, such as crossed sequencing (each image to the wrong eye) or image crosstalk when tilting your head to the side. There is no source for 4k (4096 × 2160) content to reach the consumer.

HDMI is changing how they identify capabilities (see "HDMI Hot Seat," below). Look for the feature list, not the version ID. You need HDMI 1.4a compliance for 3D, but only for sending control data to the display (the metadata), not for the 3D video data. Also, every device in the HDMI chain must support the features required for a function or it probably will not work. Be aware that some of the HDMI extenders on the market employ lossy video compression, degrading video image quality.

HDMI v1.4a added: the ability to send 3D-video control signals to tell the display the 3D-video frame format and to control display and 3D-glasses switching (some 3D signaling might work on HDMIv1.3-compliant devices, but it is not guaranteed), an *optional* audio return channel (ARC; sends the audio from the display back to an A/V receiver or audio processor), an *optional* HDMI Ethernet channel, *optional* features for automotive and portable device applications, and standardized HDMI cable labeling. Category 1 cables will be labeled "Standard" and category 2 cables will be labeled "High Speed."

For ARC and/or HEC to work, *all* of the equipment connected together must support the feature. HEC requires special cables. ARC and/or HEC might not be supported on all ports on a given product.

Another HDMIv1.4a *optional* capability is consumer electronics control (CEC)—it is not a replacement for home networking, it either works or not, and what it does will differ among products depending on implementation. The next HDMI version is under development, but is not expected to be released for about two years.

The Digital Entertainment Content Ecosystem (DECE) has introduced Ultraviolet (www.UVVU.com), a brand name for the consortium's cloud-based digital rights management (DRM) system. Users will be able to create an account in which to store their Ultraviolet-licensed digital entertainment content, then access it from all their devices anywhere, anytime. The system is not yet ready for prime time; however, the major studios and TV networks have signed up.

Motion-sensing control for gaming (similar to motion-sensing light switches, but much more sophisticated) has arrived; no hand-held or worn controller is necessary. This technology pulls the gamer off the couch to provide physically active interaction with the game on the screen.

Heiss's **New Technologies Update** complemented the Pre-Game show.

For over-the-air DTV, Heiss has found that the Philips PHDTV1 Silver-Sensor indoor antenna (about \$80 at www.Amazon.com; designed for UHF channel reception—channels 14-51) works well. However, DTV is not available everywhere in the US because thousands of low-power analog transmitters are still on the air. How soon they will be required to convert to digital transmission is not yet known.

3D will likely come to the home at some point, but there are questions about how many consumers will soon replace their recently bought HDTVs with one that displays 3D content, and

how many people will choose to buy and wear 3D-glasses for long stretches of viewing time. There will be little 3D content available to consumers for quite a while. Sports is in the lead in creating 3D content for home viewing.

Sony issued a disclaimer that if you update your Playstation 3 with the firmware version that supports 3D, the Blu-ray audio will only play back as Dolby Digital or DTS lossy-encoded 2.0- or 5.1-channel formats; Dolby True HD and DTS-HD Master Audio soundtracks will not play back. Sony has not explained why this is so, but speculation is that the Playstation 3's processing power is insufficient to simultaneously support 3D-video and high-resolution audio playback.

Video distribution is migrating from disc and hard-disk-drive-based systems toward streaming services as the industry recognizes that they are in the "content consumption business." However, DVD and Blu-ray discs will not become extinct any time soon, as they deliver the highest quality video and audio available to the consumer.

Wireless—"cutting the cord"—requires a broadband Internet connection, and has led to "over the top" (no computer required) access to streaming content. There are many free/fee boxes/services that support catch-up viewing, including Hulu (www.Hulu.com), Chumby (www.Chumby.com), Zinc.TV (www.Zinc.tv), Boxee (www.Boxee.tv), Verismo's VuNow STB (<http://VerismoNetworks.com/>), Popcorn Hour (www.PopcornHour.com), and Sezmi (www.Sezmi.com). There are limits on what programming each service delivers. Much of the content is standard-definition video, and much of the HD content offers two-channel audio instead of surround sound. Connection speed and each service's server-farm capabilities affect the quality of service. Caution is suggested

because some of these and other companies offering such services are likely to go out of business.

Sezmi is especially good for time-shifted viewing. A Sezmi TV-everywhere subscription gives access to the supported channels and programs on all of the subscriber's devices. It is a cleaner variation on the Slingbox (www.Slingbox.com), especially when multiple simultaneous viewing is the household rule.

HDMI

The **HDMI Hot Seat** panel discussion was moderated by Michael Heiss. Jim Chase (HDMI Licensing director of technology; www.HDMI.org), Eric Bodley (Perfect Path's consumer electronics VP and GM; www.PerfectPath.com), John Marshall (Wireless HD Consortium chairman; www.WirelessHD.org), Leslie Chard (WHDI president; www.WHDI.org), and Mark Stockfisch (Quantum Data VP and CTO; www.QuantumData.com) discussed and debated various problems and solutions. Heiss declared that despite claims for DisplayPort, which is primarily for computer system applications, HDMI is not in danger of extinction.

Chase emphasized that for each piece of equipment (such as a Blu-ray player, A/V receiver, or display) it is more important to understand which HDMI features are supported than the version ID. This is especially true since the release of HDMI 1.3, because the specifications for that and newer versions include *optional* functions, many of which are not included in a manufacturer's model by choice—giving manufacturers a way to manage the costs of their products and differentiate them from those of their competitors. It also can easily cause two products to legitimately claim compliance with the same HDMI version, but be incompatible because *optional* features needed by one

are not supported by the other. This problem led to a change so that by the end of 2010 HDMI version IDs will no longer be used, instead employing logos to identify the speed and options supported by a product. Five logos are shown on the HDMI website, which offers a download of the guidelines for each.

Stockfisch reported that Quantum Data is making HDMI test tools with the ability to test for HDMI 1.4a features including 3D performance and compliance. Whether journalists, reviewers, and consumers will be able to access Quantum Data's database of test results is as yet unspecified.

Marshall clarified that Wireless HD is "HDMI over wireless, *not* wireless HD"—the distinction coming from the 60GHz technology (based on the IEEE 802.15.3c specification) used to transmit the HDMI signal carrying "multi-channel audio, intelligent format and control data, and lossless HD video up to 1920 × 1080p60 with Hollywood-approved content protection...within a room at distances up to ten meters" [from the Wireless HD website]. He said Wireless HD technology supports up to 4k × 2k video [about 4× the pixel count of 1920 × 1080] and that the specification is accepted as a global standard. He claimed that WiFi is moving to the 5GHz band and that the future of wireless A/V is in the 60GHz band [at least within a room].

Chard spoke of the wireless home digital interface (WHDI) standard versus Wireless HD. WHDI, an RF-based technology that operates in the 5GHz band and is similar to IEEE 802.11n technology, supports uncompressed [versus losslessly compressed] HD video up to 1920 × 1080p60 (while supporting HDCP v2.0) [and presumably audio] to displays "throughout the home" [from the WHDI website]. They claim <1ms latency end-to-end.

The WHDI website clarified the difference between WHDI and DLNA (Digital Living Network Alliance trade organization): “WHDI and DLNA are complementary protocols. DLNA defines the delivery of compressed media over an IP network (wired or wireless) whereas WHDI enables delivery of uncompressed HD content/video from HD video sources such as gaming consoles, PCs, BD players and set-top-boxes to displays.” In both cases, wireless latency might become an issue for time-sensitive interactive applications such as gaming.

There was no discussion of how the consumer can select an HDMI cable to ensure it will work. Some assurance can be inferred from the presence of an official HDMI logo on the cable, but that still doesn’t prove that the length of cable purchased was compliance tested. [There have been cases where a shorter length cable passed compliance testing and the certification was extended by the cable manufacturer’s marketing to all lengths in that series.]

[A source of reasonably priced, possibly well-made HDMI cables and adapters is Blue Jeans Cable (www.BlueJeansCable.com). They use Belden, Canare, or Tartan cable (clearly identifying which for each product), having the assembly performed in China. From their website: “As with all of our products, we offer a simple and easy return policy. If for any reason you’re not completely satisfied, just return the cables, undamaged, within 30 days and we’ll refund your purchase price in full.”]

3D

“**HD 3D-TV: What You Must Know**” was Michael Heiss’s approach to explaining in-home 3D video’s history, status, and idiosyncrasies. “3D is here, whether we like it or not,” and is a world-wide phenomenon. Heiss recommended Mark Schubin’s website www.SchubinCafe.com

as an excellent source of information on video, including 3D.

There are issues with 3D as a concept, independent of the implementation:

- Vergence (the distance from the viewer where both eyes point to place the object; see <http://en.Wikipedia.org/wiki/Vergence>) versus the focal distance (the distance from the viewer’s eyes where they focus to a sharp image); when these don’t match, nausea has occurred. The conflict comes from the eye focusing at the screen while the stereoscopic image tells the brain that the object is either in front of or behind the screen.
- Changing your viewing angle changes the 3D effect because the left-right image spacing changes with angle.
- [The interocular distance varies among people, thus altering the effectiveness of the stereoscopic effect.]
- [Approximately 7% of the population can’t see stereoscopically.]

Sports and movies will take the lead in developing 3D content, but the majority of programming will be in 2D for a very long time. Content created for and shot in 3D (such as most of *Avatar*) will be much more visually effective in 3D than content created and shot in 2D and then processed for 3D presentation (such as Tim Burton’s *Alice in Wonderland*).

The 3D formats for Blu-ray discs have been standardized: frame-packed, 1920 × 1080p24 or 1280 × 720p60 (for example, the left-eye image would be the odd-numbered frames, while the right-eye image would be the even-numbered frames. The display processes and presents the images as appropriate for its 3D-display technology). The Blu-ray player and display must support HDMIv1.4a with 3D-option for the 3D content’s auto-switching metadata to reach and control the display.

The 3D-content’s audio data delivery is the same as under HDMIv1.3, but if the A/V receiver’s or surround processor’s HDMI connections are v1.3, there might be a playback problem.

There are some 3D ancillary feature issues with Sony Playstation 3s (no details given).

There are two 3D video-frame-compatible formats: side-by-side and over/under. In the side-by-side 3D frame format, each 1920 × 1080 video frame is made of a 960 × 1080 left-eye image beside a 960 × 1080 right-eye image, thus reducing the image’s horizontal resolution by half. In the over/under 3D frame format, each 1920 × 1080 video frame comprises a 1920 × 540 left-eye image above a 1920 × 540 right-eye image, thus reducing the vertical resolution by half. Satellite and cable systems will distribute 3D in the side-by-side frame format.

A trade-off for home 3D viewing is between conventional panel displays (with adequate frame refresh rates, 3D-processing, and active-shutter 3D-glasses) and polarized panel displays (which are more expensive to manufacture but use less costly 3D-glasses). One size of 3D-glasses does not fit all people, especially kids versus adults. Plus, none of the 3D-glasses are easily worn by people who wear glasses.

Another problem is that the 3D-glasses from one display manufacturer might not work with another manufacturer’s display, even using the same 3D-glasses technology. For example, one informal test showed that Panasonic 3D-glasses worked with a Samsung display, but Samsung’s 3D-glasses did not work with Panasonic displays. The cost of active-shutter 3D-glasses is quite high, especially considering that you need a pair for each person in your audience.

Two of the “universal” 3D-glasses are XpanD (**Photo 1**) (www.XpanDCine.com)

ma.com; an IR-based system; \$130 on www.Amazon.com) and Monster Cable's (www.MonsterCable.com) Monster Vision Max (**Photo 2**) 3D glasses (an RF-based system; \$250srp for one pair with transmitter; \$150srp for additional glasses). A problem with IR-based 3D-glasses is that high ambient light can cause them to malfunction.

There are 3D kits for computers that include a 3D-video card, software, an emitter to control the 3D-glasses, and a pair of active-shutter 3D-glasses. The monitor must have at least 1680 × 1050 or 1920 × 1080 resolution and support a refresh rate of at least 120Hz. Between alternating the presentation of an image to each eye and the inherent light-attenuation of the 3D-glasses, the 3D image is much darker than conventional 2D images, requiring much brighter displays that must automatically lower their light output when switched back to 2D viewing.

There are two types of polarized passive 3D-glasses: horizontal/vertical (head tilting will cause image crosstalk) and circular (one eye-glass clockwise polarized, the other eye-glass counterclockwise polarized; head-tilting will not cause crosstalk). If you can use passive 3D-glasses, www.AmericanPaperOptics.com has low prices. MicroVision Optical (www.MVO3D.com) offers more stylish passive 3D-glasses.

Three vendors (not specified) showed autostereoscopic (no glasses needed) displays at the IFA Berlin 2010 consumer electronics trade show (www.IFA-Berlin.com), but the viewing angle was rather limited and it will be years before commercially practical large-screen autostereoscopic 3D-displays will become available. [Toshiba exhibited an autostereoscopic panel display at CEATAC in Tokyo in early October 2010.]

DISPLAY CALIBRATION

Joel Silver's (Imaging Science Foundation—ISF; www.ImagingScience.com) **Display Device Calibration** stepped through the basic sequence to get the most accurate image the display is capable of delivering. Silver emphasized that the vividness of the out-of-the-box image is designed to sell the set in the store next to its competitors, and that it is *not* an accurate image. He also said that many displays cannot be properly calibrated because of inaccurate primary colors (red, green, and blue) and/or an incomplete set of necessary adjustments. He reminded attendees that no matter what the display technology, all video standards and production are based on CRT characteristics, so other display technologies must be designed, manufactured, and adjusted to emulate those characteristics or they *cannot* display an accurate image.

Silver noted that content cannot be used for display calibration because

of the artistic license taken with color by content creators. [One example is *CSI: Miami*, which intentionally gives its images a golden tint.] Test images and test equipment are necessary for proper calibration. Test images can be from a generator or a test/setup disc (which can be a good idea because it allows compensation for inaccuracies in the player's processing). If using a generator, it is best to set up the display directly from the generator, then feed the generator to any external video processor and tweak the setup, then use the primary source (such as a Blu-ray player and test disc) for final adjustment.

He spoke about room lighting: the need to keep room light off the screen; the need for a little light in an otherwise totally dark room if the display is especially bright; the fact that colors other than neutral gray within the viewers' sight will shift their perception of colors on the screen. He pointed out that



PHOTO 1: X-PAND universal 3D glasses.



PHOTO 2: 3D glasses from Monster Vision.

a separate calibration setup is required for dark-room and for daylight viewing, because most people have their display in a multipurpose room.

Silver and others worked with SpectraCal (www.SpectraCal.com) in the development of the highly regarded CalMAN video calibration software that works with a wide variety of color sensors and PCs (it does not run on Mac OS X). SpectraCal sells the software alone or in packages with various hardware, and will do their best to help it work with your existing hardware. A free evaluation copy is available for download.

There are various licenses (roughly \$200-2000, depending on the license and included functions); for specific pricing request a quote. [Terry Paulin used CalMAN for his projector reviews in the July/August/September 2010 *Widescreen Review*, and the data presentations, as well as the reviews, were the best I recall in a home theater magazine. Video gurus Charles Poynton (www.Poynton.com) and Raymond Soneira (founder/CEO/president of DisplayMate; www.DisplayMate.com) are regular contributors to SpectraCal's free enewsletter.]

Silver reminded attendees that in 8-bit consumer digital video, PC-video from black to white covers digital 0-255, while video (SD and HD via TV, DVD, Blu-ray, and so on) covers digital 16-235. That must be taken into account during setup if the display is used for both types of sources. Many displays and Blu-ray/DVD players limit their digital video range strictly to 16-235, thus clipping required (and allowed) headroom and toeroom.

His first action was to eliminate almost every display's out-of-the-box overscan [typically 1-3%, which reduces displayed-image resolution by about a third]; sometimes this can be corrected in the user menus, but more often access to the service menus is required.

He then set the black level (remember that the brightness control adjusts black level; the contrast control adjusts white level) using the PLUGE pattern (picture line-up and generation equipment; a name from long ago, courtesy of the BBC).

Using a different pattern (one with fine black lines on a white background), he adjusted the sharpness to the balance point between softening the image and adding artifacts (which look a bit like ghosting or a glowing edge). There are additional steps, which are available from ISF's test disc and many other sources. He cautioned that many of the adjustments interact, so it requires an iterative process to get the best image from a display.

Silver said that the gamma (the curve of each color's transition from black to white) is quite variable, even among the pixels of a display, making it difficult if not impossible to get a uniform gray field over the whole screen. LCD technology typically displays an S-shaped gamma that should be, but is not always, corrected by the display's manufacturer because such correction tends to reduce the screen's maximum light output.

HOME THEATER

Floyd Toole repeated his three-part series: **"Home Theater Audio and Acoustics,"** with much of the content also in his book: *Sound Reproduction: The Acoustics and Psychoacoustics of Loudspeakers in Rooms* (\$47 at www.Amazon.com). Part one started with a review of the physical and perceptual aspects of sound—waves in air, speed, wavelength, and frequency—followed by the complications added by the room and room treatments—resonances, reflections, speaker directivity, and so forth.

Graphs accompanied his explanation that because wavelengths get shorter as frequency increases, a driver (woofer, midrange, or tweeter) becomes more di-

rectional toward the top of its frequency range. Starting with the assumption that the loudspeaker was designed for the flattest on-axis frequency response, this causes the loudspeaker's off-axis frequency response to be degraded. Thus, if this loudspeaker is pointed straight ahead and the listener is positioned off-axis (as is usually the case), the first sound the listener hears is not very good, and the second sound reaching the listener (reflected off the near-side wall) is even worse, partially because the wall typically does not reflect all frequencies equally. His point is that it might be better to aim the speaker's best sound directly at the listener, even though that might make the second-heard sound even worse, a condition that equalization and speaker repositioning cannot fix; get a better speaker.

A traditional approach to deal with a loudspeaker's poor off-axis sound is to attenuate the near-side-wall reflected sound with an absorber. However, they are usually acoustic foam no more than 1" thick (roughly equal to 2"-thick sculptured acoustic foam). An acoustic fiberglass board absorber 1"-thick has no beneficial effect below about 1kHz, which effectively turns down the tweeter; a 2"-thick board has no beneficial effect below about 500Hz, which affects the midrange and tweeter. In neither case does that fix the problem; it still leaves a substantial mismatch between the first and second sounds reaching the listener. For absorption to be an effective broadband attenuator, it must reach down to no higher than 300Hz, which requires at least 3"-thick acoustic fiberglass, mineral wool, or open-cell acoustic foam. Rigid boards become somewhat reflective at high frequencies and at grazing angles.

Absorption and diffusion are beneficial if applied to the right problem and located correctly. Vertically oriented hemicylindrical or triangular

shapes stretched floor-to-ceiling will scatter sound down to 200Hz if they are about 12" deep. Toole cautioned to leave space between adjacent panels for maximum effect. Irregularities along the walls are beneficial.

Acoustic research has shown that lateral reflections are important for a pleasant spatial sensation. In home theaters, some of these sounds come from the side- and rear-channel speakers.

Toole emphasized that the loudspeaker and room it is in are a system, and interactions must be recognized and issues addressed. At low frequencies, the power response of a speaker is most representative of what we hear, while at high frequencies the speaker's on-axis frequency response is its most important characteristic, assuming it is aimed at the listener. Over the range from several hundred Hz to several kHz—"the bandwidth providing timbral identity for voices and musical instruments"—both characteristics affect the perceived sound.

He discussed room modes, acknowledging that with stud-and-drywall construction the room mode effect isn't as severe as theory predicts. He also stated that there is no ideal set of room dimensions because rooms are not perfectly rectangular and not all types of room modes are equally audible [due to construction differences]. Multiple speakers, such as in a stereo or multichannel system, tend to attenuate the overall severity of room mode effects [although there likely will be differences in the sound from each speaker]. Toole showed that in a room with the listener centrally located and speakers placed in compliance with the ITU-R BS.775 circular layout, there will be three different bass responses: one from the center channel, one from the left and right channels, and another from the left-surround and right-surround channels; thus the sound varies

as its location is panned.

Toole explained why he recommends using multiple subwoofers, and that his research has shown the simplest placement is in the four corners to improve the uniformity of bass for multiple listeners.

He described blind listening tests of speakers in small rooms and that while people like different sound, they tend to like the same speakers in well-designed and run blind listening tests, preferring those that have a relatively flat on-axis frequency response plus $\pm 30^\circ$ and $\pm 60^\circ$ off-axis responses that is fairly similar to the on-axis response and not much lower in level.

He is of the opinion that audio playback systems should have calibrated playback levels because our perception of bass and treble loudness changes with level, as shown by the Fletcher-Munson curves. Such playback calibration in the studio and in the home will help the consumer hear the same tonal balance as created in the studio.

Part two of his course covered multichannel sound and system configurations, with a section on amplifiers and speaker characteristics. In Toole's words, at its conclusion, "participants should be able to express in general terms the requirements for a surround-sound system optimized for a given room and audience size; summarize the requirements for specific loudspeakers to deliver good sound and the appropriate directional and spatial illusions of multichannel music and movies; distinguish between those specifications that are important and those that are not informative; and decide on the key elements of a home theater system [such as] loudspeakers, amplifiers, wiring, based on an analysis of the customer's needs and the restrictions imposed by the realities of the room."

Toole broke down the "basic dimensions of listening" into sound quality/timbre (bandwidth, spectral balance,

dynamic range, freedom from distortion), localization (horizontal, vertical, and distance, including phantom sources, for all listeners) and spatial dimensions (apparent source width [ASW], listener envelopment [LEV], and immersion). He discussed the similarities and differences between what we want in home theaters versus concert halls.

He emphasized the importance of the center channel for movie sound, plus the envelopment and immersion that comes from adding the side and rear surround channels, noting that in a home theater the lateral portion of the reflected sound, especially from about $30\text{--}110^\circ$ off-axis left and right of the listener, is more important for the sense of envelopment than a diffuse sound field; reflected sounds from directly in front of or behind the listener contribute little to a sense of spaciousness. Toole went into extensive detail. He described the variety of sources and lossy/lossless codecs, including upmixing from two to multichannel playback.

Toole talked about various seating and speaker layouts, plus the use of in-surface speakers (he does not recommend ceiling speakers, even when tilted to aim the tweeters toward the listeners). "Architects make it difficult" was his introduction to laying out a multichannel system in odd-shaped multipurpose rooms.

The presentation turned to explaining various speaker designs from electrostatics through horns ("modern horns don't honk,...they give us some control over where the sound goes, they can play very loud" with relatively less power, and "the low distortion and power compression allows for comfortable listening at very high sound levels").

Toole spoke about speaker impedance, which is anything but simple, and the effect of speaker wire impedance, acknowledging that there is more to wire than its resistance in that there is "the

profit from selling exotic wires”; wire never fails, so there is no warranty concern; “the performance claims for exotic wires are boundless, and explanations stretch the laws of physics”; and “if the customer believes, he or she will hear, so satisfaction is almost guaranteed.” He said that “almost all power amps can reveal audible differences between speakers, but others can cause audible differences that should not be there.” He dealt with the damping factor and amplifier power requirement calculations.

Part three expanded on room acoustics, choosing loudspeakers, subwoofer number and placement, and other related topics, including problems with center-channel horizontal MTM designs, the origin of the dipole surround speaker design, and how to minimize seat-to-seat bass variations. He showed a graph of “an audio journalist/reviewer’s room” (not mine!) that with a single subwoofer exhibited wildly rough frequency response over 20-80Hz, with seat-to-seat variations among the five seats exceeding 10dB. With four corner-located subwoofers and sound field management, the seat-to-seat variations dropped to a maximum of about 3dB, and the much smaller frequency response anomalies could then easily be corrected with relatively simple equalization.

A point he emphasized: “a sad statement about a mature [audio] industry [is that] there is more useful and reliable information on the side of a tire than in most loudspeaker specifications.” This course is so extensive and thorough that attendees should be given an exam and earn college credits!

GROUND LOOPS

Bill Whitlock’s (Jensen Transformers’ president) “**Understanding, Finding & Eliminating Ground Loops**” course is even better with his latest revisions and added content. From his course handout: “A cable is a source of

potential trouble connecting two other sources of potential trouble. This joke among electronic system engineers is worth keeping in mind. Any *signal* accumulates *noise* as it flows through the equipment and cables in a system. Once noise contaminates a signal, it’s essentially impossible to remove it without altering or degrading the original signal. For this reason, no system can be quieter than its noisiest link. Noise and interference must be prevented along the entire signal path. Delivering a signal from one box to another may seem simple, but when it comes to noise, the signal *interface* is usually the danger zone, not the equipment’s internal signal processing.” From this concise introduction, Whitlock walked attendees through the ways and paths noise can take to get into a system. He explained how to diagnose the source of each problem, and how to prevent it.

As in all his classes, he emphasized that bypassing the third-wire ground in a power cord or outlet violates NEC rules and increases the safety risk to technicians and consumers, plus it will void insurance coverage if a fire results. He debunked myths related to wiring, grounding, and noise sources, explaining that all grounds are not equal (even two terra firma grounds several feet apart will have a measurable voltage between them) and that a heavier ground wire will not solve the problem. Another myth is the idea of impedance-matching for audio interconnect cables, showing that the goal is to transfer voltage, not power, and that termination for audio is not necessary until cable lengths exceed about 4,000’.

He pointed out that 10’ of #12 speaker wire will exhibit substantial impedance above the audio band, and an induced current can cause audible noise voltage to be fed back through the amplifier’s feedback circuit, getting amplified and delivered to the speak-

ers. He showed a spectrum of leakage noise-current flow in a 3nF capacitor fed by a typical AC outlet, with the level jagged but overall rather flat out to beyond 1MHz.

Whitlock described the noise problems in an unbalanced interface and how a balanced interface, which he clearly and properly defined as equal impedance from each leg to circuit ground (including the source-output and the load-input circuitry), eliminates the cause of the common-mode interference. (The often-used definition that a “balanced interface” is one in which each conductor is equal in voltage but opposite in polarity to the other is absolutely incorrect.) He explained that the resistor tolerances in line drivers seriously degrade the potential common-mode rejection ratio (CMRR); for example: “the CMRR of the widely used [Analog Devices’] SSM-2141 will degrade some 25dB with only a 1Ω imbalance,” which can happen using even 1%-tolerance resistors. He also discussed the XLR pin-1 problem’s causes and methods of prevention.

In discussing RFI, Whitlock explained the appropriate use of ferrite “clamshell” cores, which provide little help below about 20MHz. Also covered was a straightforward procedure for stepping back through an equipment chain to find the source of noise seen or heard at the system’s output.

He talked about power isolation, filters, and “balanced power,” explaining that in his experience treatments to “cleanse or purify” the AC power feed offer marginal improvement, and that “even balanced power proponents admit that actual noise reduction is usually under 10dB and rarely exceeds 15dB.”

Whitlock is a proponent of series power-line noise suppression, such as in products by Surge-X (**Photo 3**) (www.SurgeEx.com). With parallel power-line suppression devices (which typical-

ly are MOVs between the hot, neutral, and ground lines), during a power-line surge or spike very high current will be induced in the safety ground wire, substantially raising the ground voltage at the equipment (leading to high ground-voltage differences between interconnected equipment plugged into different outlets) and potentially causing equipment damage. White papers and additional information on these and related topics are available on the Jensen Transformers website (www.Jensen-Transformers.com).

VIDEO, AUDIO AND SYSTEM CONTROL

The CEDIA Technology Council and Harman sponsored the **Future Technology Pavilion**, which was “to showcase and highlight emerging trends and cutting-edge technologies in the home from the bedroom to the garage” (from the CEDIA show directory). In addition to home theater, the pavilion included areas devoted to home health monitoring/care and energy management.

The future of displays was represented by **NanoLumens's** (www.NanoLumens.com) 112" (diagonal; 8' wide) flexible display (LEDs on polymer substrate, <1" thick, ~80lbs; \$75,000) that can be wrapped around poles or otherwise rolled up (**Photo 4**). The company can manufacture these displays in a wide variety of sizes with different pixel pitches; the 416 × 224-pixel display in the pavilion had a 6mm pixel pitch (pitch can range over 4-10mm) in a 16:9 aspect ratio (pixel counts depend on pixel pitch and screen size). It was designed for viewing from at least 15'. This display was adjusted for a maximum white level of 500nits (146ftL), but can deliver up to 1100nits (321ftL), which is necessary for outdoor viewing.

The pavilion housed a custom-built home theater (about 16 D-Box

motion chairs, a Digital Projection 2D/3D projector, a Stewart screen, XpanD 3D-glasses, a 9.1-channel audio system, and more) to give attendees a taste of the possibilities; the image looked nice, but the sound was far too sibilant.

Procella Audio (www.Procella-Audio.com) and **THX** sponsored a small THX-certified screening room that was built off-site by Epic Home Cinema, then dismantled and resurrected on the show floor. I believe it housed two rows of five large leather-bound seats (they can scale the room design from 2-40 seats). Sitting in the front row right seat (the sweet spot was second row center), I heard too much bottom on voices, and too much sibilance. A strummed bass didn't sound realistic.

Da-lite (www.DaLite.com) and **Joe Kane Productions** (JKP; www.VideoEssentials.com) have expanded the JKP Affinity screen series to three models, with gains of 0.6, 0.9, and 1.1. The smaller the screen, the more concentrated the light from the projector, so a lower-gain screen should be used to keep the black level down (resulting in higher effective contrast). Also, if a digital cinema projector (which generates much more light output than a home theater projector) is used, a lower-gain screen is necessary even for large screens to keep the black level down to an acceptable value. The JKP Affinity models are known for accuracy of color rendering over the entire gray scale range (black to white), excellent uniformity of color and brightness versus viewing angle (neither color shift



PHOTO 3: The Surge-X surge eliminator and power conditioner.



PHOTO 4: NanoLumens's 112" flexible display.

nor visible hot-spotting), plus freedom from video image noise usually caused by interaction between the pixelated projected image and screen graininess.

Sharp (www.SharpUSA.com) boasted of the added yellow primary in its Aquos Quattron models (**Photo 5**), which support 3D viewing with active-shutter glasses (two come with each display, additional glasses sell for \$200/srp) that can allow one user to watch the 3D video while the other watches the same program in 2D. The yellow primary might expand the color palette for photos and PowerPoint presentations, but it is not correct for video, which is strictly based on specific red, green, and blue primary colors. Sharp also boasted that the LED backlighting technique used in these models delivers 1.8× the light output of traditional LED backlighting; this is less than one f-stop and will only partially offset the light output lost when viewing 3D. Sharp also released a 3D-ready DLP projector, as well as new Blu-ray player models that can play 3D

Blu-ray discs and access content from Netflix, VUDU, and Pandora via a wireless LAN connection.

JVC (www.JVC.com) exhibited a 3D-enabled D-ILA projector.

Accell (www.AccellCables.com) introduced a line of HDMI cables with swiveling connectors that bend and twist, making it easier to fit the connectors between equipment and the wall. Their ProUltra Supreme cables are certified compliant with the HDMI High Speed specification.

Crestron's (www.Crestron.com) Core 3 control system line is based on Microsoft's CE-build OS, Crestron-customized. It supports object-oriented programming and prebuilt function objects to simplify dealer programming and shorten programming time. The technology distributes audio, video, and control over Cat5e cable. Core 3 supports the ITU-T H.264/MPEG-4 AVC video codec standard, but not VC-1 (SMPTE 421 video codec standard). The surround processing in the

Procise series products is from Audyssey and supports 7.3 channels.

Speakercraft (www.SpeakerCraft.com) is well-known for their in-wall/in-ceiling speakers, and has continued development of their NIRV control system, developing an app instead of offering touchscreen controllers. They also have added box loudspeakers to their catalog. These changes led to their show theme: "Love Your Choices."

More important than the product announcements was Speakercraft president Jeremy Burkhardt's report that over the past few years more than 15% of their retail installers and dealers have gone out of business. He proclaimed his outspoken belief that in order to survive, the custom installation industry must begin aiming products at a younger consumer, such as products that make listening to music a social escapade rather than an isolationist experience. As a corollary, he recommended that dealers and equipment manufacturers change their focus toward individuals' music devices as the center of the home music system. If they don't change, he predicted that high-end dealers will survive but mid-level dealers/installers will disappear. He pointed to the commercial marketplace as having great potential for expansion of the custom installer business.

LOUDSPEAKERS, EARPHONES, AND RELATED PRODUCTS

I typically don't listen to loudspeakers at any show because of the unknown variables including the room and unfamiliar source material. I made an exception at the recommendation of associates and to follow up on a product I had heard at CES last January.

Atlantic Technology's (www.AtlanticTechnology.com) AT-1 H-PAS model 81 tower speakers (\$2500/pr) sounded better-balanced than my CES recollection, taking into account it was in a different room with source material



PHOTO 5: The Sharp Aquos Quattron display.

I am not familiar with. I perceived a slight edge to the midfrequencies—plucked guitar-strings didn't sound right—and cymbals sounded a bit constricted. The male voice and tenor sax sounded OK, but the piano didn't sound natural. I still think the bass is too strong, but it should be marketable. The H-PAS technology incorporates an internal bass trap and a vent to get more apparent bass from two 5.25" midrange/woofers, with the range above the 2500Hz crossover frequency coming from a 1" silk-dome tweeter. They claim that the -3dB low frequency point is at 31Hz. The model 82 is a smaller version for which they claim a 39Hz -3dB point, from which I heard too much low end to a female singer's voice and a somewhat boxy sound.

Sandy Gross has founded his third speaker company: **GoldenEar** (www.GoldenEar.com). Gross had made quite a name for himself over the decades, having cofounded Polk Audio in 1972 and been the key designer for some of its most respected speakers. He repeated that accomplishment by cofounding Definitive Technology in 1990, serving as its president until he retired in 2009. Circumstances and his enjoyment in designing speakers led to the creation of GoldenEar, which offers seven models (two of which are horizontal versions of two others) and three different 5.1-channel systems with and without separate powered subwoofers (\$1750-3500srp). All of the products are designed and engineered in North America, but built in the Far East. In the US, the products are distributed exclusively to specialty stores; there will be no Internet or big-box retailers.

At CEDIA he showed the Triton Two tower speaker (\$2500srp/pr) that includes a built-in 1200W powered subwoofer. The tweeter is an evolution of the Heil tweeter, which Gross calls a high-velocity folded ribbon (HVFR) de-

sign. I liked the sound from the Triton Twos, in stereo. Gross played a recording of a soprano with flute and violin accompaniment, at a reasonable level; the soprano sounded like she was standing just behind the plane of the speakers, which were a couple feet forward of the front wall. A chorus from the Rutter *Requiem (Lux Aeterna)* (Reference Recording's RR-57 HDCD; \$17 at www.ReferenceRecordings.com) sounded a bit weak right in the center between the speakers; I don't know why. The overall sound field seemed very slightly behind the speakers, but not at all objectionable.

Current Audio (www.CurrentAudio.com) has upgraded their in-surface speaker cans to have a two-hour fire rating, which they claim that some local fire codes require for certain types of facilities. This reduces installation costs, because one-hour rated cans require dry-wall fire-rated boxes to be built around them to meet that code requirement.

Denon's (<http://USA.Denon.com>) AH-NC800 (\$350srp) over-the-ear dual-noise-canceling headphones (**Photo 6**) are claimed to offer 40dB noise



PHOTO 6: Denon's AH-NC800 headphones.

reduction by employing feed-forward and feedback circuitry.

Smyth Research (www.SmythResearch.com) was back with their Realiser A8, a box with eight analog inputs and outputs that allows calibration of your earphones to sound quite close to what you hear from your speakers at your prime listening position, in two-channel and surround. Calibration requires very small microphones be inserted into your ear canals. Calibration settings can be stored on a removable SD card, plus there is internal storage for 64 room/listener measurement sets (about 3MB each) and 64 headphone/listener measurement sets (about 32kB each). The box and head tracker sells for \$2600 (\$3360 with a pair of Stax SR-202 headphones). This is great technology for location recordists and musicians, many of whom don't have studios but have had their calibrations performed at one or more of their favorite studios so they can have that sound while creating, recording, or mixing their music. It has also proven useful to studio people who take work home, so the sound remains the same.

OTHER PRODUCTS OF INTEREST

Disney's **World of Wonder** (WOW) home theater calibration disc is available in a one disc (DVD: \$30; Blu-ray: \$35) or two disc set (packaged with *Visions: Inspired by Nature* disc; DVD: \$35; Blu-ray: \$40). Much additional information is at <http://DisneyDVD.DisneyGo.com/disney-wow-world-of-wonder.html>.

EPILOGUE

I've reported on what I found interesting at CEDIA Expo 2010, but there was much more that would likely have interested others. CEDIA Expo will be in Indianapolis, September 7-11, 2011. I'll be there. How about you? *ax*

Try, Try Again

By Barry Fox

In 1982, right at the end of the golden age of vinyl, Teldec (the company jointly owned by Telefunken and Decca) experimented with a completely different way of cutting hi-fi LPs, called Direct Metal Mastering (DMM). This had spun off from the work done by Teldec, at a semi-secret lab in North London run by Decca's respected recording engineer Tony Griffiths, on TeD—a floppy video disc. The TeD video disc had a superfine hill-and-dale groove cut in a flimsy plastic disc about the size of an EP. The disc spun at 1500 rpm and played ten minutes of color video when tracked by a mechanical sled-shaped stylus.

Panasonic killed TeD with Visc, a rigid 12" LP that worked in much the same way as TeD to deliver an hour of color video from each side of the disc. Visc was mind-bogglingly clever but was soon killed by JVC's VHD, which used a grooveless conductive plastics disc tracked by a capacitive stylus, and by RCA's CED Selectavision which used a grooved capacitance disc. Both came to market but were soon killed by Philips' Laservision/Laserdisc, the optical video disc that later spawned CD, DVD, and Blu-ray.

But when TeD died, Teldec adapted the video disc cutting system to audio mastering. The object of DMM was to eliminate the perennial problems with master lacquers, such as faulty blanks and blemishes caused by the first stages of electroplating. With DMM, a diamond stylus cuts the groove directly into an amorphous copper metal coating on a blank stainless steel disc. There is no memory effect—relaxation of the

plastic with high frequency loss—and the first stage of electroplating is taken out of the process, which reduces the risk of plating errors. DMM also made it possible to pack grooves tighter, thereby increasing playing time by 15%.

The heads which cut soft lacquer need several hundred watts of driving power, so you can imagine what it takes to cut copper metal. Teldec used a modified Neumann stereo cutting head, and, to help the stylus cut through the metal, superimposed an ultrasonic signal of around 70kHz on the audio signal being recorded. This acted in much the same way as the bias in a tape recorder, which shakes up the magnetic particles. The bias signal used for the DMM process mechanically excited the diamond-cutting stylus.

In July 1982 Teldec offered to license the system to any record company, for a one-off fee. Between 1982 and 1986, Melodiya, Virgin, and PR records each signed to use the system.

By 1985 the hi-fi press was already worrying that the high-frequency bias might cause audible "beat" effects. There was talk of DMM cuts having a certain characteristic "sound." And by then the record companies were cutting back on LP production, in favor of CDs.

Not daunted, Teldec came up with a modified system for direct cutting Compact Disc masters. DMM CD was unveiled at the Los Angeles Audio Engineering Society Convention in November 1986. But DMM CD also stalled. It proved difficult in practice to cut metal masters with a pit shape that accurately mimics the pits produced by the

conventional technique of laser-cutting and etching a glass master coated with photo-sensitive material. The difference in pit shape can confuse the laser optics in some domestic players.

Mechanically cutting CD masters would now be a pointless exercise. But perhaps the time is now right for someone to try DMM LP mastering again.

STORAGE RIGHTS

If you're using a home server to store high-quality audio, spare a thought for a recent court case in the US.

The Hollywood studios have won a \$4.5 million punishment payment from RealNetworks—the US company behind RealAudio compression—for selling \$30 software called RealDVD that rips copy-protected optical discs to hard disc.

Don't think this doesn't matter to you just because you don't want to rip video. Blu-ray is a very high-quality music disc, but its AACs anti-rip system and regional coding lock sound and vision far tighter than DVD or CD.

Indeed it was the promise of Blu-ray's allegedly un-hackable protection that appealed to the software industry after DVD's allegedly un-hackable CSS was hacked by a schoolkid. As we in Europe saw when Nelson Riddle's classic score for the 1966 Batman movie was released as an audio-only "extra" on a Blu-ray disc only in the US, regional coding for video can tie up audio content as well.

Imerge (www.imerge.co.uk) pretty much invented the hard drive music store product category. "We developed the first audio server in the 1990s and

lost our way in 2006-7. But we now have a new team and have now sold over 25,000 servers,” said CEO Cameron Wade earlier this year when Imerge launched its new servers and XiVa online music store, in partnership with 7Digital.

Owners of Imerge server boxes use a computer to access a web page, sign up for the XiVa download service, and enter credit card details. They can then use the server’s remote control to make click purchases from over 8 million music titles. Virtually all recorded music is offered, with only a few notable exceptions such as Beatles tracks and AC/DC, because of industry holdouts. Prices range from between 70 and 90p per track and from £5 to £11 per album.

There is no DRM (digital rights management). Once purchased and downloaded to the server, music can be copied freely to other devices. Users can also download the same tracks three times. The hard disc uses an auto backup system called RAID to prevent content loss, and if the whole server is stolen, the owner can cancel its credit authorization and download the purchased tracks again.

But the music is MP3 at 320kbps (or below), which is CD quality or below. So the option to rip is vital.

“The key difference,” said Imerge about the server, “is the new Blu-ray drive, which also allows users to store and play back content from Blu-ray discs. The integral drive reads content from CDs, DVDs, and Blu-ray discs to store on hard drives for convenient access.”

Is this legal, though?

“We ship the product without the ability to record, as the manufacturer cannot be seen to be actively advocating 3rd party software that can be construed as contentious. We run a comprehensive certification program for our dealers and partners worldwide which runs through the setup and installation of the product. Part of that

installation training walks the dealer through adding 3rd party software on behalf of the end user. Once this is complete, the unit is then ready to rip DVDs from the slot loading drive, and also Blu-Ray in the same manner.”

Imerge reckons that Real came unstuck because the company took a CSS license and the ripped copy was still protected. Because the Imerge server does not come with pre-installed rip software, it is legally “clean” as sold. Although dealers and custom installers may advise customers on the installation of ripping software, the final installation step is always done by owners who press the install-confirm button in the privacy of their own homes.

I was waiting and watching to see what the music and movie companies would say about this. But events have overtaken the issue. Imerge has now closed down.

There was no official announcement but an insider tells me:

“Imerge is owned by a US group called Nortek. Nortek filed for Chapter 22 towards the end of last year, and a couple of months ago announced a restructuring/downsizing program that involved separating itself from the businesses it owns outside of the US (that, of course, includes Imerge, which has been based in Cambridge since the company’s formation in the 1990s).

“For the past couple of months, Imerge has been attempting to negotiate a management buyout (MBO), with financial backing from a Saudi group. All concerned fully expected the deal to go through; negotiations were at an advanced stage and we were simply waiting to hear that the deal had been sealed. However, out of the blue, Nortek decided to pull the plug on negotiations and instead enter into an ‘orderly wind-down’ of Imerge.

“Right up until a few days ago, Cameron Wade, Imerge’s CEO, was work-

ing very hard trying to resurrect a deal, but it was not to be.

“I will never understand why Nortek decided to pull out of negotiations at the last minute. A strong offer was made and all indications were that it would be accepted, yet Nortek chose to close the company rather than take the deal that was on the table. From Imerge’s point of view, the order books were full, the product lineup was stronger than ever, and there were many more exciting innovations to come through 2010. The issues that have led to this sad state of affairs belong to Nortek, not Imerge; the MBO would have put Imerge’s destiny into its own hands, but it was not to be. It really is such a waste.

“Of course, Nortek may still decide to sell Imerge’s assets at a later date.”

Personally I wonder whether Nortek’s lawyers worried about what the music and movie companies might do about the ripping function on which Imerge’s business model was based. *ax*

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Barry Fox (“Try, Try Again”) reports on the audio industry as columnist for the British publication *Hi-Fi News*. His commentary appears in every issue of *Multi Media Manufacturer*.

2010 *audioXpress* Index

SUBJECT INDEX

Amplifiers

- "Preamp Muting Circuit," Mike Danbury, *aX Digital*, March.
- "The BTO," Dick Crawford, July, p. 5.
- "The Metz Preamp," Reinhard Metz, Aug., p. 5.
- "LM12 Amplifier," J.R. Laughlin, *aX Digital*, Oct.
- "The Brick," Raj K. Gorkhali, Oct., p. 6.
- "Power Amp Kits for Beginners," Ed Simon, Nov., p. 16.

Audio Aid

- "The Cable Caddy," Jan Didden, Jan., p. 37.
- "Bridge to a Voltage Doubler," Neal A. Haight, Feb., p. 5.

Audio News

- aX Digital*, April.
- aX Digital*, May.
- aX Digital*, June.
- aX Digital*, Sept.
- aX Digital*, Oct.

Book Reviews

- Current-Driving of Loudspeakers*, reviewed by Joseph DeMarinis, July, p. 18.

Circuit Design Tips and Techniques

- "The Sweet Spot," Nelson Pass, Jan., p. 8.
- "AC Filters. . . and Other Noisy Issues," Darcy E. Staggs, Jan., p. 34.
- "Designing for Everyone," Bard Kallestad, July, p. 14.
- "Designing Enclosures with Sketchup," Bill Fitzmaurice, Oct., p. 36.
- "Ground Loop Basics By Example," *aX Digital*, Nov.

Editorials

- "Champagne Fidelity," Jan Didden, *aX Digital*, June.
- "Why Should You Change Your Sub to Digital," Ed Dell, June, p. 26.
- "How Are We Doing?," Ed Dell, Dec., p. 6.

Loudspeakers

- "Laminated MDF Three-Way Speaker System," Anastasios Fiakas, Feb., p. 6.
- "The 69 Line," Ken Bird, March, p. 6.
- "Synthesized Bass," Bohdan Raczynski, March, p. 20.
- "Stuffing And Sound Speed," Cornelius Morton, April, p. 12.
- "Tang Band Full-Range System," G.R. Koonce, May, p. 4.
- "A Three-Way Tri-Amp Center-Channel System," Andreas Schilloff, June, p. 5.
- "A Loudspeaker That Can Play Square Waves?," Bohdan Raczynski, June, p. 11.
- "The Fire Stick Speakers," Ken Bird, July, p. 10.
- "A Continuous-Time Active Filter," Ramkumar Ramaswamy, Aug., p. 14.
- "A Tang Band 3" System," G.R. Koonce, Aug., p. 23.
- "The Mustang Speaker," Claude Goeuriot, Sept., p. 6.
- "Low-Frequency Horn Speaker," Rich Johnson, Sept., p. 18.
- "The Low Profile Tuba," Bill Fitzmaurice, Sept., p. 28.
- "A Subwoofer for the Reflection," George Danavaras, Sept., p. 36.

Measurements

OPPO BDP-83 Blu-Ray Disc Player, measured by Chuck Hansen, *aX Digital*, Sept.

Miscellaneous

"Power Supply Spreadsheet," Paul Stamler, *aX Digital*, March.

"Making Better Circuit Cards," Ed Simon, *aX Digital*, April.

"Future Technological Workforce," David Weinberg, *aX Digital*, July.

Music Reviews

"Super Fidelity," by John Sunier, *aX Digital*, May.

"Jazz Track," by John Shand, *aX Digital*, June.

"Super Fidelity," by John Sunier, *aX Digital*, July.

Product Reviews

"Comparing Speakers," Howard Ferstler, Jan., p. 38.

Swans M3 Speaker, reviewed by Howard Ferstler, Feb., p. 18.

Dayton T1503A Subwoofer, reviewed by Tom Nousaine, Feb., p. 23.

Personal Digital Recorders: Part 1, reviewed by Keith Levkoff, March, p. 10.

DPA SMK 4060 Stereo Microphone Kit, reviewed by Alvin Foster, March, p. 24.

PS Audio Power Plant Premier, reviewed by Gary Galo, *aX Digital*, April.

Personal Digital Recorders, Part 2, reviewed by Keith Levkoff, April, p. 14.

Lehmann Black Cube SE Phono Preamplifier, reviewed by Tom Lyle, April, p. 26.

TDL Tuneable Stereo Rumble Filter, reviewed by Don Walizer, May, p. 27.

THAT's Balanced Line Drivers and Receivers, reviewed by Gary Galo, *aX Digital*, June.

Bryston BCD-1 CD Player, reviewed by James T. Frane, June, p. 22.

Emotiva XPA-2 Power Amplifier, reviewed by Tom Lyle, July, p. 24.

OPPO BDP-83 Blu-Ray Disc Player, reviewed by Gary Galo, *aX Digital*, Aug.

Personal Digital Recorders, Pt. 3, reviewed by Keith Levkoff, *aX Digital*, Sept.

Jelco JL-45 Cueing Mechanism, reviewed by Gary Galo, Oct., p. 29.

Infinity C336 Speaker, reviewed by David Rich, *aX Digital*, Nov.

JBL LSR6325 Biampified Studio Monitor, reviewed by Tom Nousaine, Nov., p. 26.

Oatley Electronics K272A Headphone Amp, reviewed by Aren van Waarde, Dec., p. 39.

Profiles

"We Interview Nelson Pass," Jan Didden, *aX Digital*, May.

"aX Visits A.J. van den Hul," Jan Didden, *aX Digital*, Nov.

Receivers

"The 'Modern Homodyne'," Aren van Waarde, Oct., p. 16.

"Eliminating Speaker Reflections with Digital Filters," Richard K. Mains, Oct., p. 24.

Show Reports

"Burning Amplifier 2009," Jan Didden, Jan., p. 31.

"New York AES 2009," Gary Galo, *aX Digital*, June.

"CES 2010—Changes Abound," David Weinberg, *aX Digital*, Aug.

"Munich Hi-End Show," Ward Maas, *aX Digital*, Oct.

"CEDIA 2010," David J. Weinberg, *aX Digital*, Dec.

Sound Solutions

"Trials of Finding the Music," Barry Fox, *aX Digital*, May.

"MS on Audio, Demos New & Old, Wall Wart Madness," Barry Fox, *aX Digital*, July.

"Audio On The Avenue," David Rich, *aX Digital*, July.

"Audio On The Avenue," David Rich, *aX Digital*, Oct.

"Try, Try Again," Barry Fox, *aX Digital*, Dec.

Tubes

"15 Watts per Channel for Less Than \$150," Bruce Brown, Jan., p. 22.

“Borbely RIAA with Tubes Revisited,” Joe Tritschler, Jan., p. 27.
“A 25W OTL Tube Amplifier,” Tim Mellow, Feb., p. 12.
“Portable Tube Preamp,” Gregory L. Charvat, March, p. 16.
“4D32 SE Power Amp,” Karin Preeda, April, p. 6.
“Visiting Thailand’s DIY Tube Enthusiasts,” Karin Preeda, May, p. 9.
“The Optimized SRPP Amp, Part 1,” Merlin Blencowe, May, p. 13.
“Amplifier Comparison Using Oscilloscope Waveform Plots,” Kent Smith, May, p. 20.
“The Optimized SRPP Amp, Part 2,” Merlin Blencowe, June, p. 18.
“Signal Current Loops & Power Signal Interaction,” Richard Sears, aX Digital, Aug.
“A 50W Pure Triode Power Amplifier,” Chi C. Wong, Aug., p. 18.
“A Push-Pull 7591 Power Amp,” Karin Preeda, Nov., p. 6.
“The Split Load Phase Inverter Revisited,” Cornelius Morton, Nov., p. 20.

Turntables

“A Power Sine Generator for Turntables,” Claude Goeuriot, Nov., p. 10.
“Turntable Speed Control,” Joel Hatch, Dec., p. 22.
“All About Stroboscopes,” Ron Tipton, Dec., p. 18.
“A Dual 701 Turntable Tune-Up,” Tom Perazella, Dec., p. 8.
“Vertical-Cut Blending,” Ron Tipton and Don Walizer, Dec., p. 36.
“The Wretched Excess AR Turntable Renovation, Pt. 1,” Tom Yeago, Dec., p. 28.

AUTHOR INDEX

Bird, Ken

“The 69 Line,” March, p. 6.
“The Fire Stick Speakers,” July, p. 10.

Blencowe, Merlin

“The Optimized SRPP Amp, Part 1,” May, p. 13.
“The Optimized SRPP Amp, Part 2,” June, p. 18.

Brown, Bruce

“15 Watts per Channel for Less Than \$150,” Jan., p. 22.

Charvat, Gregory L.

“Portable Tube Preamp,” March, p. 16.

Crawford, Dick

“The BTO,” July, p. 5.

Danavaras, George

“A Subwoofer for the Reflection,” Sept., p. 36.

Danbury, Mike

“Preamp Muting Circuit,” aX Digital, March.

Dell, Ed

“Why Should You Change Your Sub to Digital,” June, p. 26.
“How Are We Doing?,” Dec., p. 6.

DeMarinis, Joseph

Book Review: *Current-Driving of Loudspeakers*, July, p. 18.

Didden, Jan

“Burning Amplifier 2009,” Jan., p. 31.
“The Cable Caddy,” Jan., p. 37.
“We Interview Nelson Pass,” aX Digital, May.
“Champagne Fidelity,” aX Digital, June.
“aX Visits A.J. van Den Hul,” aX Digital, Nov.

Ferstler, Howard

“Comparing Speakers,” Jan., p. 38.
Review: Swans M3 Speaker, Feb., p. 18.

Fiakas, Anastasios

“Laminated MDF Three-Way Speaker System,” Feb., p. 6.

Fitzmaurice, Bill

"The Low Profile Tuba," Sept., p. 28.

"Designing Enclosures with Sketchup," Oct., p. 36.

Foster, Alvin

Review: DPA SMK 4060 Stereo Microphone Kit, March, p. 24.

Fox, Barry

"Trials of Finding The Music," aX Digital, May.

"MS on Audio, Demos New & Old, Wall Wart Madness," aX Digital, July.

"Try, Try Again," aX Digital, Dec.

Frane, James T.

Review: Bryston BCD-1 CD Player, June, p. 22.

Galo, Gary

Review: PS Audio Power Plant Premier, aX Digital, April.

"New York AES 2009," aX Digital, June.

Review: THAT's Balanced Line Drivers and Receivers, aX Digital, June.

Review: OPPO BDP-83 Blu-Ray Disc Player, aX Digital, Aug.

Review: Jelco JL-45 Cueing Mechanism, Oct., p. 29.

Goeuriot, Claude

"The Mustang Speaker," Sept., p. 6.

"A Power Sine Generator for Turntables," Nov., p. 10.

Gorkhali, Raj K.

"The Brick," Oct., p. 6.

Haight, Neal A.

"Bridge to a Voltage Doubler," Feb., p. 5.

Hansen, Chuck

Measurements for OPPO BDP-83 Blu-Ray Disc Player, aX Digital, Sept.

Hatch, Joel

"Turntable Speed Control," Dec., p. 22.

Johnson, Rich

"Low-Frequency Horn Speaker," Sept., p. 18.

Kallestad, Bard

"Designing for Everyone," July, p. 14.

Koonce, G.R.

"Tang Band Full-Range System," May, p. 4.

"A Tang Band 3" System," Aug., p. 23.

Laughlin, J.R.

"LM12 Amplifier," aX Digital, Oct.

Levkoff, Keith

Review: Personal Digital Recorders: Part 1, March, p. 10.

Review: Personal Digital Recorders, Part 2, April, p. 14.

Review: Personal Digital Recorders, Pt. 3, aX Digital, Sept.

Lyle, Tom

Review: Lehmann Black Cube SE Phono Preamplifier, April, p. 26.

Review: Emotiva XPA-2 Power Amplifier, July, p. 24.

Mains, Richard K.

"Eliminating Speaker Reflections with Digital Filters," Oct., p. 24.

Mass, Ward

"Munich Hi-End Show," aX Digital, Oct.

Mellow, Tim

"A 25W OTL Tube Amplifier," Feb., p. 12.

Metz, Reinhard

"The Metz Preamp," Aug., p. 5.

Morton, Cornelius

"Stuffing and Sound Speed," April, p. 12.

"The Split Load Phase Inverter Revisited," Nov., p. 20.

Nousaine, Tom

Review: Dayton T1503A Subwoofer, Feb., p. 23.

Review: JBL LSR6325 Bi-amplified Studio Monitor, Nov., p. 26.

Pass, Nelson

"The Sweet Spot," Jan., p. 8.

Perazella, Tom

"A Dual 701 Turntable Tune-Up," Dec., p. 8.

Preeda, Karin

"4D32 SE Power Amp," April, p. 6.

"Visiting Thailand's DIY Tube Enthusiasts," May, p. 9.

"A Push-Pull 7591 Power Amp," Nov., p. 6.

Raczynski, Bohdan

"Synthesized Bass," March, p. 20.

"A Loudspeaker That Can Play Square Waves?," June, p. 11.

Ramaswamy, Ramkumar

"A Continuous-Time Active Filter," Aug., p. 14.

Reeve, Bill

"Ground Loop Basics By Example," aX Digital, Nov.

Rich, David

"Audio On The Avenue," aX Digital, July.

"Audio On The Avenue," aX Digital, Oct.

Review: Infinity C336 Speaker, aX Digital, Nov.

Schilloff, Andreas

"A Three-Way Tri-Amp Center-Channel System," June, p. 5.

Sears, Richard

"Signal Current Loops & Power Signal Interaction," aX Digital, Aug.

Shand, John

"Jazz Track," aX Digital, June.

Simon, Ed

"Making Better Circuit Cards," aX Digital, April.

"Power Amp Kits for Beginners," Nov., p. 16.

Smith, Kent

"Amplifier Comparison Using Oscilloscope Waveform Plots," May, p. 20.

Staggs, Darcy E.

"AC Filters. . . and Other Noisy Issues," Jan., p. 34.

Stamler, Paul

"Power Supply Spreadsheet," aX Digital, March.

Sunier, John

"Super Fidelity," aX Digital, May.

"Super Fidelity," aX Digital, July.

Tipton, Ron

"All About Stroboscopes," Dec., p. 18.

"Vertical-Cut Blending" (with Don Walizer), Dec., p. 36

Tritschler, Joe

"Borbely RIAA with Tubes Revisited," Jan., p. 27.

van Waarde, Aren

"The "Modern Homodyne"," Oct., p. 16.

Review: Oatley Electronics K272A Headphone Amp, Dec., p. 39.

Walizer, Don

Review: TDL Tuneable Stereo Rumble Filter, May, p. 27.

"Vertical-Cut Blending" (with Ron Tipton), Dec., p. 36

Weinberg, David

"Future Technological Workforce," aX Digital, July.

"CES 2010—Changes Abound," aX Digital, Aug.

"CEDIA 2010," aX Digital, Dec.

Wong, Chi C.

"A 50W Pure Triode Power Amplifier," Aug., p. 18.

Yeago, Tom

"The Wretched Excess AR Turntable Renovation, Pt. 1," Dec., p. 28.

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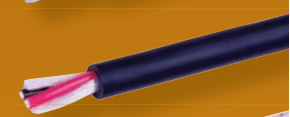


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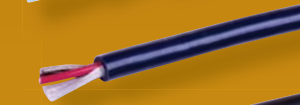
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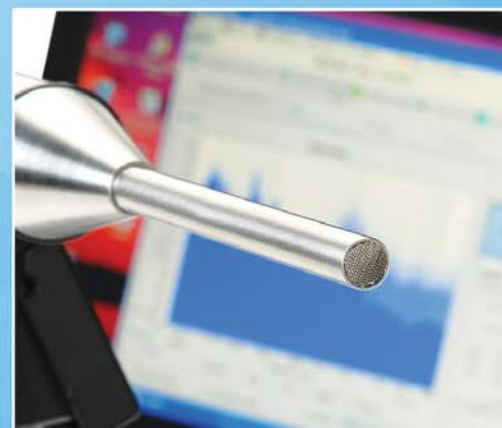
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