THE BAS SPEAKER

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Letter from the Editor

We should all be grateful to Mark Fishman for having done a truly splendid job of editing the *BAS Speaker* for the past five years. I can only aspire to do as well as he did. I also wish to thank Mark for producing volume 17 number 1 while I was out of this country.

Attitude and Competence of Manufacturers

I recently had good and bad experiences with a British speaker manufacturer: Lowther. I went over to England during Christmas (returning, no less, on Pan Am's Flight 103, a few weeks after the ill-fated one), and brought back some *very* expensive PM-5A (About 20lb Alnico magnet!) full-range drive units. Unfortunately, the measured free air resonance of the units were *twice* the claimed value. I wrote to Lowther to complain. They were very kind, and sent me new diaphragm assemblies with the correct resonances. That was the good experience. Unfortunately, they did not pack the assemblies properly. Although the boxes arrived in excellent shape, the diaphragms did not—they were quite free to roll about, resulting in the voice coil formers being nicely crushed. I also had bad experiences with other speaker manufacturers: Becker (alas, no longer in existence), for example, stuffed wads of newspaper in their carton, and then pushed the woofer, cone downward, right onto the newspaper, resulting in a crushed cone.

Cost of Stereo Equipment

Having just returned from Singapore, I noted that stereos and cameras were frequently cheaper *here,* if you shop at the right places. The average price of a classical CD in Singapore was about $17-18. Singapore record shops do not have sales on classical CDs.

Interest in Bass

With the advent of CDs, interest in bass reproduction have heightened. Bert Whyte in the August 1989 issue of *Audio* talked about reproduction of the lowest bass, or rather, how few systems can reproduce them properly despite what the manufacturers may claim. Yamaha has come out with "air woofers" which in essence is a vented system driven with an amplifier with negative output impedance (to get better cone control for the same magnet size). It's an idea originally marketed by Audio-Pro. They tuned the small box to around 28Hz, very low for such a small box. As a result, it uses a very small-diameter port with consequent compression problems. The low tuning means that the port is not aiding the small woofer in reproducing mid bass. Hence the maximum output capability of the system in the mid-bass range suffers. Technics exhibited an interestingly-shaped subwoofer (some say it resembled part of the human body) at the summer CES, with a claimed cutoff of 28Hz. It's a horn-loaded system. They did not use any material with deep bass content for their demo. In line with interest in bass reproduction, this issue lists some CDs with lots of low bass, and a subwoof meeting summary.

Open Forum

Short CD Reviews

Wilson Audio WCD8416

Dvorak's *Trio in E Minor* • Francesco Trio

Musically, this is an excellent recording. However, it is plagued by a terrible high-frequency buzz in the left channel on most of the tracks. I hope it's not on the master tape and that Wilson Audio will reissue it *without* the buzz.

Wilson Audio WCD8111/8314

***Magnum Opus Volume 1 & 2* • James Welch, organist**

These were preformed on a Flentrop organ, at Saint Mark's Cathedral in Seattle. They are some of the most realistic and best sounding organ recordings I have heard, albeit *without* much sub-20Hz bass. The ambience is beautifully captured. It's amazingly quiet considering that it's not a digital recording. A must for organ fans.

Wilson Audio WCD8722

***Sonatas for Violin and Piano* • Julie Steinberg, piano, and David Abel, violin**

Likewise, this is one of the most natural recordings I have heard. A must for the audiophile. Pieces include the Brahms Sonata No. 1 and the Debussy Sonata for Violin and Piano.

Poh Ser Hsu (Massachusetts)

Bass Notes

The following are a selection of CDs with lots of good deep bass. A BSR 4000 equalizer/analyzer was used in the peak hold mode to check the highest level by frequency on each CD, and a Hitachi 20MHz dual trace oscilloscope was used to judge purity of waveform and frequency. A Fluke 8060A multimeter (with frequency counter, flat response to 100kHz, and true rms reading) was also used to determine frequency when the notes were sufficiently sustained and clean. The output from a 110Hz, 24dB/octave low-pass filter was used for the oscilloscope and the Fluke.

***Impact* 2 (Japanese Audio Society CD-3)**

[Available from DB Systems, Main St., Box 460, Rindge, NH 03461. (603) 899-5121]

The 3-meter (10-ft) Japanese drum produces high levels of 12.5Hz! For those with sub-subwoofers, you may want to try this.

Dorian DOR 90117

Mussorgsky's *Pictures at an Exhibition*

Mussorgsky's work is played here by Jean Guillou on the great organ of the Tonhalle, Zurich. It has strong deep bass fundamentals in the 19–20Hz range, albeit with a generous dose of harmonics. Hence this will sound impressive even on systems without ultra-clean deep bass. Tracks 5 and 15 (try 5 minutes into this track) are where the bass is most impressive.

Argo 414 420-2

Mendelssohn *Organ Works* • Peter Hurford, organist, on the Rieger Organ in Ratzeburg Cathedral, West Germany

This has an ultra loud 19Hz on track 8. Try it out at moderate levels first! Not responsible for blown woofers.

Argo 417 159-2

Hindemith *Organ Works* • Peter Hurford, organist, on the Rieger Organ in Ratzeburg Cathedral, West Germany

This is similar to the above Argo disc. The deep bass is at 4:45 into track 5. The bass here is 6dB louder than the highest level at any other frequency on the entire disc! Handle with care.

Philips 412 619-2

Saint-Saens *Organ Symphony* • San Francisco Symphony, Edo de Waart, conductor

This has deep bass down to 16Hz on track 2. One of my regular test discs. The purest deep bass occurs at 9:00 into track 2. Levels here are very low. Abnormally high gain is needed to play this at wall-shaking levels. Remember to turn the volume back down after the movement! This is also very satisfying musically, and sonically.

Telarc CD80136

Dupre *Symphony in G Minor* • Michael Murray, organist, on the Royal Albert Hall organ, with the Royal Philharmonic Orchestra, Jahja Ling, conductor

This one has strong 14Hz! Try 5:35 into track 1, and about 6 minutes into track 7. Not terribly pure, but the fundamentals are certainly strong. Track 3 has continuous, fairly pure 26Hz between 4:20 to 4:55, and 6:00 to 7:00. Similarly, track 1 has clean, strong 28Hz between 1:06 and 1:12, changing to 26Hz between 1:12 and 1:24. Strong 20Hz can be felt at 5:00 into track 4.

Geffen 24233-2

Enya *Watermarks*

This is New Age music—soothing, ethereal, spacious sound, with plenty of low bass (upper 20s to low 30s). *Try* track 10 ("Longships"). It's impressive even on some non-subwoofered systems! Enya sounds almost as good on Atlantic 81842-2. Depending on which store you visit, they can be found under International (Irish), Pop, Rock, or New Age.

Windham Hill WD1060

Schonherz & **Scott *One Night in Vienna***

This has strong bass in the mid-30Hz range. Try track 1("Wishing Well"). Excellent for imaging tests as well.

Sheffield CD29

Clair Mario

Try tracks 1 ("'Til they take my heart away") and 9 ("Do you love me"). Bass is very tight and goes down to the 30Hz range. I also think that Clair has a very nice voice.

London 410 164-2

Prokofiev *Alexander Nevsky* • Cleveland Orchestra and Chorus, Ricardo Chailly, conductor

This has one of the lowest-tuned conventional-sized bass drums—around 25Hz. It is also an excellent performance, far superior to the Telarc version. Excellent soloists.

I strongly encourage readers to send in their lists of favorite CDs for *any* tests—bass, imaging, etc. I will list some CDs for testing imaging in the next volume.

— *Editor (Massachusetts)*

November 1988 BAS Meeting

Open Forum

Members who braved heavy rain to attend the Nov. 20 meeting began by debating how humidity affects the propagation of sound. (The relationship is complex, but increased humidity typically improves the transmission of treble frequencies through the air. As a result, before air-conditioning became common in concert halls, the sound of an orchestra tended to be brighter and more reverberant in the humid air of spring than in the dry, heated air of midwinter.)

President David Moran announced a spectacular dbx house-cleaning sale with very good prices to clear out inventory left over from the company's move to the West Coast. David Hadaway took orders for a group purchase of the new edition of the *Audio Cyclopedia.* Ira Leonard announced a group purchase of the Acoustical Society's new edition of Leo Beranek's classic text on acoustical measurements.

Ira also discussed several recent developments from hearing research. A new earplug for protection in noisy environments has uniform attenuation at all frequencies; ordinary earplugs attenuate highs much more than lows, producing muffled sound. A new company is making multi-band hearing aids incorporating Edgar Villchur's research on improved intelligibility; one model is surgically installed deep in the ear canal.

A common side effect of wearing earplugs or ear-canal hearing aids is that bone-conducted vibrations, such as one's footsteps, seem abnormally loud. This can be minimized with an earplug that goes deep into the ear canals, around its corners, to contact a bony support

area. Custom-molding the plug to fit your ear canal can be painful, since the canal bends. And the plugs are not easy to remove; EAR now makes earplugs with a string attached, like a tampon, to aid removal.

(This led to amusing stories about bored employees in food-processing factories dropping their earplugs into the food; so in a new model from EAR both plugs are attached to the ends of a blue plastic cord, making it easy to spot if it falls into the soup. For Kellogg's, plugs will contain small metal cores; if an earplug falls into the corn flakes, metal detectors can find it before the cereal leaves the factory.)

Mark Fishman announced the reorganization of Allison Acoustics; Roy continues as chief designer, supported by financing and management from former AR personnel. AR, meanwhile, has hired speaker designer John Buzzotta from dbx. Steve Owades reported on Philips' live-concert recording of *Elektra* by Richard Strauss, in a highly praised performance led by Ozawa—the first opera recording made in the U.S. in many years. DG has also launched a project to record Wagner's Ring cycle at the Met; one result of the devaluation of the dollar is that recording in the U.S. is becoming economically competitive again, for the first time in decades.

Meeting Feature: Elite speakers, AES Convention, Telarc recording

The evening's featured speaker was Peter Mitchell, from California, reporting on trips to Opryland in Nashville for a Pioneer speaker introduction, to Los Angeles for the fall convention of the Audio Engineering Society, and to Cincinnati for a Telarc recording session.

Pioneer Elite Speakers

Just before the AES convention, Pioneer flew a half-dozen audio journalists to the enormous Opryland Hotel in Nashville, where they introduced two new speakers for their "Elite" line of high-end equipment. In recent years the declining yen/dollar exchange rate has made mass-market hi-fi more unprofitable to sell. Some companies (Akai, Kyocera) have dropped out of the U.S. market. Others are trying to move upscale, selling higher-priced and high-tech gear, often under subsidiary brand names. Examples, besides Pioneer's Elite line, include Sony's ES series, Onkyo's Grand Integra electronics and Precise loudspeakers, Sansui's Vintage line, NAD's Monitor series, ADC's Audio Dynamics line, etc.

To attend the Elite introduction, Mitchell was flown first-class from L.A., seated near country singer Dolly Parton. The speakers were demonstrated at Masterfonic, a recording studio known for its devotion to sound quality. Masterfonic, like many large recording studios, uses monitor speakers made by Pioneer's pro division, TAD (Technical Audio Devices). The new Elite TZ-9 ($4000/pair) and TZ-7 ($1800/pr) speakers for home use were designed by H. Fukura, the engineer who designed the TAD monitors.

The Elite speakers have two noteworthy construction features. (1) Each has dual woofers, front and back, connected internally by a steel rod so that their reaction forces cancel out and little vibration is transmitted to the cabinet. (2) The midrange and tweeter are mounted on a subpanel behind the front panel. Consequently, these speakers are unusually free of cabinet resonances.

Subjectively, the strongest virtue of both Elite speakers was their excellent stereo imaging—precise in localization, accurately resolving differences in depth, and spacious in their overall presentation of ambience. The lack of muddying cabinet vibration may contribute to their transparent reproduction of the recorded sound stage. However, the superb imaging heard in the demo may have been due partly to its location in a studio control room whose walls were covered with absorptive material, preventing any smearing of the image by sidewall reflections. (Mitchell requested a demo in a room with more normal acoustics, but none was provided.)

A major weakness of both Elite speakers lies in the bottom octave. Their vented design works well down to about 35Hz but produces severe distortion at lower frequencies. So while the TZ-9 sounds good to the ear on most musical material, it lacks weight and "slam"—the feeling of pressure waves in the bottom octave. Mitchell suggested that this compromise arose from a cultural bias: among Japanese designers it is considered bad form to produce a speaker whose input sensitivity for a 2.83V input (= 1W @ 8 ohms or 2W at 4 ohms) is less than 90dB. The TZ-9 is rated at 91dB. Speaker designers are constrained by an inexorable physical relationship among sensitivity, box size, and bass response. British and North American speakers with good deep-bass performance have sensitivity ratings in the low to mid 80s.

Other problems were heard in the TZ-7. Its tonal balance was too lean, as if the output level of the woofer were about 2dB below the level of the midrange and tweeter. And the midrange and tweeter outputs integrate properly only on the tweeter axis, which is below seated ear level unless you slouch in a very low chair or soft sofa. At ear level in the demo, the midrange and tweeter canceled each other around the 4kHz crossover frequency, yielding an octave-wide dip in response that drastically altered harmonic relationships. Tipping the speakers back yielded smoother sound.

After listening to the Pioneer Elite speakers, the visiting audio writers were invited to hear familiar recordings in the main Masterfonics control room, using the big TAD pro monitor speakers. These are high-efficiency vented systems with beautiful burnished-wood mid/tweeter horns that are mounted high in the wall of the control room, aiming down at the engineer's position behind the recording console. Surprisingly, the recordings all sounded uncharacteristically warm and mellow. Masterfonics' own master tapes also sounded mellow.

The engineers said, and the Ivie real-time analyzer confirmed, that monitoring levels regularly peaked at

115dB SPL. The sound was loud, but it didn't bite. The analyzer showed why: the frequency response of the monitor system was smooth but had a pronounced overall spectrum tilt, with the highs 15dB lower in level than the lows. Masterfonics' chief engineer said this tilt is deliberate; it allows engineers to work all day at 115dB peak levels without burning out. Surprisingly, he said that they don't try to offset the mellow balance by making recordings brighter; they compensate mentally!

AES Convention

One of the main reasons to attend an AES convention is to see the latest developments in professional and semipro recording gear. Apogee Electronics, no relation to Apogee loudspeakers, had planned to demonstrate their new modifications for the Sony PCM-F1 family of digital recording processors; the module (including linear-phase input filters, oversampling digital playback filters, new encoders and decoders) will cost about $500. The demo was not ready for the convention, but the package will be available in the spring. Brad Meyer observed that, in view of published research by Tufts's Doug Preis, the phase shift in the original filters probably isn't audible anyway; Mitchell responded that the Preis studies were done in mono with headphones, and phase sensitivity might be different when hearing stereo via loudspeakers. Micha Shattner suggested that high-level hardness in the original filters may be due to the op amps being virtually shorted out at some frequencies by the low impedance of the filter circuit.

In the convention hotel, Bob Adams, at the time with CTI Research (formerly the DBX research lab) and now with Analog Devices, was demonstrating his 18-bit A-to-D converter, which with some added circuitry can deliver 19- or 20-bit performance. The module sells for $100 in quantity and will replace both the A-to-D converter and the anti-aliasing filter in professional digital tape recorders such as the Sony 1610 or 1630 that most CDs are mastered from. In a direct comparison the improvement in sound quality was astonishing—particularly an obvious reduction in distortion at low-to-middle recording levels. While it is also 15-20dB quieter than 16-bit converters, the main advantage of the DBX/CTI encoder appears to be its dramatically better *differential* linearity—said to be 0.02 LSB. Differential-linearity errors of up to 0.5 LSB are commonplace in 16-bit linear PCM equipment.

The circuit uses 4-bit (a stack or array of 1-bit) "flash" conversion with overdecimation at a sampling rate of 4 MHz and converts the result to 16- or 18-bit PCM for recording. Other papers at the convention described oversampling A/D converters and "delta-sigma" converters (employing a variant of delta modulation) that provide wide-range phase-linear digital coding with high sampling rates, avoiding some of the artifacts of direct 16-bit linear PCM. (A delta-sigma converter uses neither a sample/hold circuit nor an anti-aliasing filter, avoiding two obvious sources of artifacts in 16-bit linear PCM.)

For example, a paper by Malcolm Hawkesford showed how the performance of a sample-and-hold circuit is altered by the stray capacitance in FETs, capacitance that varies with signal strength. True 18- and 20-bit linear PCM encoding was shown to be effectively impossible because of the tight tolerances that would be required—such as timing jitter in the fractional-nanosecond range. 16-bit converters may have already reached their ultimate performance limit because of the parts tolerances required in the A/D circuits and the timing requirements in the associated sample-and-hold circuits. Consequently there is a trend, in professional circles as well as consumer gear, away from linear PCM and toward higher sampling rate and delta-sigma converters.

Are such improvements relevant if the final product is a 16-bit CD? Yes; they will at least ensure that the final signal has full 16-bit accuracy. (Many first-generation 16-bit recorders only operate to 14 or 15-bit accuracy.) And when a multitrack digital tape is mixed down to two channels, an additional one to two bits' worth of resolution and S/N are lost. Finally, when digital recordings become linear-phase, we may begin to hear a significant benefit from the digital playback filters in CD players.

Finial Strikes Out

For audiophiles, one of the most interesting events at the AES convention was the official launch of the laser turntable following two years of rumor, myth, and semi-private demonstrations. CTI's Finial Technology unveiled the turntable, demonstrated it to the press, announced a final retail price of $3786, and said that it would be delivered by Christmas to dealers in San Francisco, Denver, and Dallas, with expectations that dealers elsewhere (including Boston) would have it by spring. Besides announcing production plans, Finial's engineers also unraveled some of the mystery of how it uses a light beam to play an analog LP.

[Precisely two months later, at the beginning of January, the project was shelved. The initial production run of 35 players demonstrated the difficulty of aligning the player's miniaturized optical system on a production line; only 20 of the 35 worked. The price might have to be raised to $10,000 to make production profitable. That prospect might not have stopped libraries, sound-archiving institutions, or the audiophiles who are paying $13,000 for the Goldmund turntable, but it stopped Finial. Production was aborted, no players were delivered to dealers or reviewers, and the design is for sale. Finial hopes to sell the design to a company that has enough financial resources and production experience to make the laser turntable a success. Meanwhile it's just a failed dream. And since Finial has declined to lend out any of the working samples to reviewers, we may never know whether it was able to reproduce the full range of groove modulations, from overcut peaks down to background ambience.]

Mitchell's talk described the technology of the turntable in some detail. Since some of this information

has already been published in other issues of the *Speaker,* it won't all be repeated here.

One of the mysteries about the turntable was how it used a beam of light to trace the groove—especially since LPs contain musically significant groove modulations whose amplitude is smaller than the wavelength of light. The Finial system is not the interferometer that Mitchell had suspected; it simply detects the angle of reflection. A slit-like beam of light is projected across the groove so that the upper part of the beam falls on the "land" at the top of the groove, while the lower half falls on the groove wall. The reflection off the land is detected and used by a servo to maintain the optical system at a constant height above the surface of the record. The reflection off the groove wall is detected and forms the analog audio signal.

The key to the system is the "position-sensitive detectors," or PSDs. Each is a long narrow row of CCD elements similar to those in a video camera. The scanning circuits associated with the CCD array produce two voltages, one proportional to the position of a cell along the row (X) and another proportional to the intensity of the light striking that cell (I). By multiplying X times I and adding, the circuit calculates the intensity-weighted average position of the reflected image, with an accuracy of about one-tenth the width of the spot. From the geometry of the situation, it is easy to show that X is proportional to the tangent of 2A (where A is the groove-modulation angle), and for normally small angles it is linearly proportional to the groove-modulation velocity (which is what the mechanical stylus in a conventional magnetic pickup detects).

This method has one obvious limitation. The angle between the projected laser beam and its reflection is *twice* the groove modulation angle. With normal modulations this is fine, but if the groove angle exceeds 45 degrees the reflection angle exceeds 90 degrees, meaning that the reflection never makes it back across the groove to the detector. In fact, as Finial admitted, the PSD accommodates groove angles only up to 38 degrees; larger modulations are handled by a different technique. (They didn't explain it; this part of the turntable's operation remains a mystery.)

The Finial turntable has a full complement of CD-like controls that provide automatic cueing to the start of any band, elapsed- and remaining-time display, programmed random-access playback, automatic repeat, and other conveniences. And it contains a tick-and-pop suppressor that works very well. The playback speed is continuously adjustable from 33 to 50 rpm. It won't handle 78s, but there is strong demand for a future version that would—if the player ever sees the light of day. Would the laser turntable be popular among audiophiles? Mitchell and Moran guessed that it might get the same reception as the Shure V-15 cartridge, respected for its accuracy but lacking the euphonious qualities of the best MC pickups. (This prompted Micha Shattner to observe that in comparing two pickups that are identical except for stylus shape—conical vs. van den Hul—the main difference, surprisingly, seemed not to be in the highs but in low/midrange definition, perhaps because of a difference in the way the stylus sinks into the groove wall.)

Blind listening tests

David Clark organized blind listening tests at the AES convention. In one, three amplifiers were compared (a Crown pro model, a VTL tube amp, and a Threshold FET amp), driving large Infinity speakers. In another, Belden 10-gauge and Monster M1000 speaker cable were compared. In a third, Peter Sutheim switched varying amounts of phase shift and nonlinear distortion into the signal path. About half of the total population of engineers guessed correctly in the amp and cable comparisons, a result consistent with random guessing. But a small subset of listeners scored very high, supporting their own claim to hear cable and amp differences reliably.

At the end of the convention these results were discussed by panelists seated left to right as follows: Noel Lee (Monster), Michael Fremer *(The Absolute Sound),* Ian Eales (a cable believer), Peter Sutheim, Eugene Pitts, Richard Greiner, and Floyd Toole. Clark said this seating order was accidental, but nobody believed him. The two-hour discussion was argumentative, unrevealing, and inconclusive. Audience "questions" were mostly speeches defending pro or anti ideologies. The only agreement that emerged was that people who report hearing cable and amp differences should become part of a controlled testing program to find out what they are hearing.

One interesting point emerged from the panel discussion: Monster doesn't design cables, it's just a marketing company. Monster hires outside consultants like Bruce Brisson to design cables; Noel Lee listens to prototype designs and makes decisions purely by subjective listening. Apparently he is one of those people acutely sensitive to cable differences. When he hears a design that he likes, Monster farms out the production to a wire-manufacturing company. So it's not surprising that Monster has never tried to document any scientific basis for its performance claims; the company has no engineering staff or measuring labs. Noel Lee knows of no measurement that correlates with the differences that he hears; he referred questions on that subject to a consultant, a youngish Oriental who claimed that audible differences among cables are due to measured differences in time dispersion on the order of 0.1 microsecond. Brisson's ads for his MIT cables make the same claim, but that time-scale corresponds to frequencies around 10 MHz, not to audio. Monster's current marketing campaign for microphone cable is based on testimonials from recognized engineers who have tried the cable and liked it.

Jack Mullin Historical Exhibit

Entering Germany at the end of World War II, Sgt. Jack Mullin of the Army Signal Corps discovered Magnetophon tape decks, the first recorders that used ac bias

to reduce distortion and deliver natural, lifelike sound. He shipped two back to the U.S. in disassembled form, helped Ampex to develop working copies (funded by singer Bing Crosby, who wanted to prerecord his radio show), and later worked on the first video recorders. Besides playing a major role in audio history, Mullin has collected audio equipment from Edison cylinder machines to the present, which was exhibited at the AES. (The exhibit showed, for instance, the dramatic difference in sound quality between acoustic and electrical recordings made in the mid-1920s.) Efforts are now underway to find space to store Mullin's and other collections of classic audio gear until permanent museum arrangements can be made.

(People interested in audio history might enjoy the article on sound recording, written by Peter Mitchell, in the new edition of Grolier's Academic American Encyclopedia; it's available in most public libraries and in electronic form via CompuServe, other database services, and CD-ROM disc.)

AES Papers

Digital EQ. Matsushita engineers, concerned about the phase shifts in analog equalizers (especially in the sharp 1/3 octave equalizers used by sound-system installers), devised a digital EQ processor that provides independent control of amplitude and phase. As one result, they described a process to provide any desired group delay. (First make a filter that produces the desired group delay curve; this may have a weird amplitude response. Then do a complementary digital filter whose amplitude response cancels the first filter, leaving the desired group delay with flat response.) This could be used to cancel the low-frequency group delay that is associated with the fundamental resonance of a speaker. Laurie Fincham at KEF recommends moving the bass cutoff of speakers to below 20Hz in order to linearize the audible group delay in 30-60Hz range; with Matsushita's scheme even a bass-reflex speaker could produce better-measuring transients.

Anechoic orchestra. If you're experimenting with electronic reverberation (concert hall in a box), it's difficult to separate the effects of the processor from the real hall reverb already present in most recordings. So Denon constructed a temporary 33x47x11 foot anechoic chamber and recorded a 91-piece symphony orchestra within it. Outputs of 29 mikes were recorded on a Mitsubishi 32-track digital recorder using spaced omnis, an ORTF array, and various multi-mike mixdowns. Denon has issued this anechoic recording on a CD, unfortunately priced at $50. It can be ordered through David Hadaway of DB Systems.

The Video Harp. This product, described in an AES paper, is a new control device for electronic circuits. It was developed at Wright-Patterson Air Force base in Dayton, Ohio as a spinoff from research into control systems for military use. It consists of two triangular plexiglas panels, about three feet on each edge, joined in a narrow V. The panels are edge-lit, and detectors are arrayed along the opposite edge of each panel, so that when you touch the surface of the panel your fingers cast shadows on the detectors—at positions that depend on the location of your touch.

Thus, as in the Finial turntable, this is a system of position-sensing detectors. But in this case the position sensors generate MIDI signals to control the circuits of a synthesizer. The panels are suspended vertically in front of the player, so that by varying the location of the hands on the panels the player can control pitch with the right hand and expression (timbre, dynamics, and note-shaping) with the left hand. Another example of your Defense dollars at work....

Athena. Floyd Toole presented a progress report on the NRC's Athena project, studying the effects of reflected off-axis sound. (Arrays of small speakers are used to simulate reflections.) Initial results confirm expectations, except for one: the threshold of perception of reflections is spectrum-independent, i.e. the same for broadband and narrow-band sound. (Sound-system installers who use TEF analyzers to detect unwanted reflections may be misled; the analyzer will show a much larger spike with broadband energy than with a narrow-band problem.)

RPG. Not surprisingly, a paper by the producer of RPG diffusers documents how the placement of diffusors in a listening room dramatically suppresses discrete early reflections and provides a smooth envelope of diffuse reflections, improving imaging and minimizing flutter echo. Polar patterns versus frequency were measured for the Apogee Diva, B&W Matrix 801/II, and Ohm Walsh 5. The Apogee is a dipole below 500Hz, but at higher frequencies its radiation pattern becomes irregular.

Binaural. Duane Cooper, a professor at the University of Illinois who was one of the scientific inventors of quad and time-delay-ambience reproduction two decades ago, has designed a system of electronic "shufflers" and acoustic-crosstalk cancelers that provide satisfying two-speaker playback of binaural recordings. Filters that match the ears' irregular pinna response require very precise listener positioning on the stereo axis; smoother filters broaden the seating area while still providing good speaker imaging. Another paper at the same session, by David Griesinger, described his experiments with a shuffler and EQ to provide effective speaker playback of binaural recordings; this circuit is included in the Lexicon CP-1 processor.

Griesinger's paper on the development of the CP-1 stressed a basic goal: to increase the level of lateral energy, i.e. reduced interaural correlation, which is the basis of "spatial impression." He did many listening experiments studying the variation of spatial impression with speaker placement; his results confirm Mitchell's view, presented in the Audio/Pulse owner's manual *(1977)* and a 1978 *Stereo Review* article, that the optimum placement for ambience speakers is on the side walls, not behind the listener.

Telarc

Monster Cable flew three writers to Cincinnati as part of a promotional campaign for microphone cable. Telarc's recording setup is totally wired with Monster, from the microphones through the console (internally rewired with Monster interconnect) to the speakers. The weekend trip included a Saturday evening concert and a Sunday taping session. Since it was Halloween weekend, all the music was associated with death: Mussourgsky's *Night on Bald Mountain,* the cave scene from Grieg's *Peer Gynt,* the Saint-Saens funeral march that served as the theme of Alfred Hitchcock's TV show, etc.

The bass drum was quite modest in size, smaller than the one the BSO uses, but its sound was as prominent in the hall as it is in Telarc recordings. The hall's sound is warm and bass-heavy, and the stage shell acts as a giant megaphone. Telarc's principal bass contribution seems to be precise placement and orientation of the bass drum at stage center to ensure that stage-area reflections reinforce rather than cancel its output. The drum was hit on its rear diaphragm, launching positive-pressure waves into the hall. (When a bass drum is struck on the front, much of the initial wavefront is a rarefaction.)

Ambience-wise, the hall is a bit too dead with an audience but is virtually ideal for recording when empty. Music Hall has heavily upholstered seats with a soft, absorbent exterior; consequently the acoustics, unlike Boston's Symphony Hall and Sanders Theater, don't become excessively live when the audience goes home. Jack Renner and conductor Erich Kunzel credit the hall's acoustics for the success of their recordings, and Telarc wants to install a permanent monitoring room in Cincinnati's Music Hall for use with recording projects other than the Pops.

The orchestra was recorded with three omnidirectional mikes on tall stands at the lip of the stage (surprisingly close to the front of the orchestra), plus two ambience mikes on very tall stands in the cross-aisle, halfway back in the hall. For pops repertoire the main mikes are mounted relatively low and close, eight or nine feet above the stage floor and just behind the conductor, to enhance detail. For all-classical repertoire they are moved a foot higher and a few inches farther away, to achieve a more blended sound. Spot mikes may be added to bring out certain instruments in some movie/TV music. For recent recordings with chorus (e.g. *The Sound of Music),* the chorus was placed in audience seats, just behind the main mikes, so no accent mikes were needed for the chorus. Renner agrees that some of his European recordings, especially in England, are too reverberant and diffuse; the halls had so much reverb that they couldn't be tamed. (Those halls work better with the cardioid and figure-eight mikes that British engineers favor).

The monitoring room was a converted ladies' lounge, about twice the size of a typical living room (and with double the ceiling height). ADS 1530 speakers were located a foot or two from the front wall, with ASC Tube Traps standing in the front corners. Absorptive panels were mounted between the speakers and on the side walls to kill reflections. A six-foot tall array of RPG diffusors spanned the width of the room behind the engineers, a few feet in front of the back wall. The digital processors and whirring VTRs were installed behind the wall of diffusers. They included a Soundstream, a Sony PCM-1630 with UMatic VCR, a PCM-F1 with Beta, and an experimental machine. The F1 tape has actually been used in several recordings when both the main and backup tapes failed. (And after successfully using the Colossus digital recorder twice, Telarc tried it several more times but found its sonic performance erratic.)

Engineer Jack Renner is responsible for the entire setup; then he just monitors during recording, while producer Bob Woods and conductor Kunzel make all decisions on retakes. Renner and editor Elaine Martone monitored via speakers to judge overall balance and pacing, while Woods monitored via Sony headphones to detect tiny performance flaws. For most of the recording just five mike inputs were used, and the rear ambience were mixed in at a very low level. The only change during the music was an occasional slight tweaking of the left-channel level and high-frequency EQ (to keep violins from being drowned out during heavy brass passages). How good was the sound? Like a very good hi-fi system; it did not have the magically "real" feeling that is sometimes obtained with a state-of-the-art audiophile system. Traditionally it has been assumed that recording engineers hear their recordings better than consumers do, but the opposite is more and more the case.

Most of the Pops selections, such as TV scores and relatively brief classical items, were recorded in one or two takes apiece. Complex classical material like Mussorgsky's *Night on Bald Mountain* took about 40 takes, many in the difficult section near the end where instruments enter in pairs and Woods wanted exact intonation and ensemble timing for each entry. Lots of work will be done on a digital editor by Elaine Martone to put this recording into final shape.

— *Peter Mitchell (California)*

December 1988 BAS Meeting

David Moran called the meeting to order at the Transportation Systems Center in Cambridge with a welcome to several newcomers. The presentation planned for the evening: a new subwoofer design by Poh Ser *Hsu* (with a pair of dbx 2500s used as satellites).

dbx is not completely going out of business, by the way; the consumer, speaker, and pro lines will continue. The OEM component business has been sold (since this meeting) to THAT Corporation (named for the principals, who are Les Tyler, Gary Hebert, and Paul Travaline), and the sale of pro to AKG (less the RTA-1!) is inching toward completion.

Open Forum

The CD linearity controversy continues. Although many of the new generation of converters can be adjusted (called "trimming") for low-level linearity, and some manufacturers (e.g., NAD) claim they do this, recent reviews of CD players by Julian Hirsch and Ken Pohlmann indicate that even many high-end players deviate badly by the time they reach -80dB. All this may become academic eventually, however, because the next generation of CD players will not use conventional D/A converters.

Both Philips and Technics (and probably others) are developing D/A conversion systems which use many-times resampling and high-order noise-shaping math to reduce the number of bits required in the numbers-to-voltage conversion stage. Since it is cheaper to maintain accurate high-speed clocks than to build and adjust linear 16-bit converters, the odds are that the coming generations of CD players will be both less expensive and more accurate. A side benefit of the high bit rates used in these circuits will be gentler (kindler and gentler?) analog filtering, and thus less phase shift.

Mark Fishman read a letter from Walt Wilson informing us of the death of longtime BAS member Elbert Drazy. Elbert had been retired from Bell Labs, and some years ago had arranged for BAS members to buy copies of stereo recordings of Stokowsky and the Philadelphia Orchestra which had been made in the 1930s by the Labs. He also had an intense interest in theater organs, and was our principal liaison with the American Theatre Organ Society. He was instrumental (forgive me) in the restoration of the Wurlitzer in the auditorium at Babson College.

David Weinberg, reporting for Al Southwick, said that many European CDs manufactured by PDO for Polygram (Archive, DGG, Philips, Decca/London) "are so translucent they're almost transparent." They also show lots of pinholes in the (thin) reflective coating. Some of them track fine; others produce little "ticks" on some players; and still others won't track at all on some players. Even the error-concealment circuits give up on occasion.

Stereophile canceled their proposed High-End Show in Washington, DC. The rumor is they discovered that there are no high-end dealers in DC (Weinberg concurred).

Moran told a story illustrating one of the many differences between audio manufacturing in the USA and in Japan. When equipment was made in Newton, Mass, (talking about dbx) Moran could get manuals printed at his favorite South Boston printer, "and I could get as many as I wanted until someone looked at the PO and said, 'No.' So we always had extras, whether in my office (which was all three-dimensional filing) or the customer-service guy's office. The dbx 10/20 was made by Kyocera, and they would print one manual per carton. I often faxed them asking for extra manuals, and never got them. If we sold a dealer return of anything made in Japan, we had to make a photocopy of the manual."

Another story: the dbx TX-1 tuner manual says that dbx did not include "one of those silly wire dipole antennas" because the serious music-listener should not be using one. Unfortunately, Kitaron, who packed the box, did not read the manual and included one of those silly wire dipoles....

Al Foster promised to tell us at a future meeting about the process he went through to convert the setup/test LP for Carver's Sonic Holography (which he had been selling) to a CD. The new CD version has four additional tests, and is more convenient to use than the LP. In addition to stereo pink noise, one of the new tests is of a half-wave rectified sinewave, useful for checking the audibility of polarity inversion.

Ira Leonard reported that he had spoken with Henry Kloss, and Cambridge SoundWorks is doing well. Sales are meeting projections and advertising is continuing.

Meanwhile, Boston Acoustics and Allison Acoustics are selling three-box (as opposed to the Cambridge SoundWorks four-box) systems, with only one woofer. The Allison woofer has two voice coils, however, obviating the need for electrical summing of the two bass channels.

Meeting Feature: A Towering Subwoofer

Continuing the line of discussion, Moran pointed out that this evening we had a four-piece system, "with some of it hidden Bose-style, or Kloss-style." BAS member Poh Ser Hsu has been designing subwoofers for several years. He started off this evening's presentation by addressing the issue of delay in the reproduction of bass which has often been raised in the high-end press. A recent AES paper by engineers at the Finnish Broadcasting Company, titled "Perceptibility of Direction and Time-Delay Errors in Subwoofer Reproduction," directly answers the questions raised by Peter Mitchell in the November meeting.

Mitchell had said that many people are quite sensitive to delays, so that if the output from a woofer were delayed relative to higher frequencies, the bass would sound muddy and otherwise less lifelike. Since bandlimited systems of any kind tend to delay some frequencies more than others, there is a natural delay in woofers due to their low-frequency cutoff. Vented systems cut off more sharply than sealed ones and have greater delay in the extreme bass.

A crossover network introduces additional delay in the form of phase shift between the low- and high-frequency sections. For a 24dB/octave Linkwitz-Reilly network, said Poh Ser, there is a full wavelength (360 degrees) of relative phase shift between the sections. At a 100Hz crossover, this equals 10ms of delay. Note that the filter outputs have the same polarity, but tone bursts will show the delay differential.

Mitchell had offered this as a reason that he found vented systems to be less satisfactory than sealed ones.

The Finnish paper reported a study of 24dB/octave crossovers at 100Hz and at 200Hz, with an adjustable delay unit switchable between the satellites and the subwoofers. It seems that delay is more detectable on speech than music, for starters. Also, it was found that the amount of tolerable delay was roughly inversely proportional to the crossover frequency.

With a 100Hz crossover, there was an audible change in the sound by adding a 15ms delay to the satellites (placing the subwoofers 5ms "ahead" of the satellites). However, if the delay was added to the woofers, an additional 45ms of delay (making a total of 55ms) was required for audibility. With a 200Hz crossover, the allowable additional delays became 9 and 22ms respectively. So, said Poh Ser, by choosing a lower crossover frequency, the designer can reduce the audibility of any given amount of delay.

Turning to his current subwoofer design, Poh Ser explained that his goal was to reduce both distortion and enclosure size while retaining high acoustic output at low frequencies. The new subwoofer has *half* the internal volume of his previous design (4 cu. ft. instead of 8), yet has 5dB more output at 3% distortion.

Poh Ser's approach was to mount *two* 12" drivers facing each other at the same end of a cylindrical enclosure. This presents each driver with a "virtual enclosure" which is twice the apparent volume of the real one (each driver "sees" only half the pressure in the enclosure, hence each driver thinks that it is operating in an enclosure which is twice as big). Also, by mounting them facing each other, even-order distortion products are mostly eliminated. By choosing drivers with very little odd order-harmonics in the operating range, very low distortion is achieved. On the flip side of the coin, efficiency is 3dB lower. Luckily, power is cheap these days, and the woofers used can handle very high power.

Like all Poh Ser's designs, this is a vented system (for efficiency and more important, *higher maximum output at the lowest frequencies).* In a direct comparison, it put out more 16-20Hz than a Hartley 24" woofer, the latter developing a rubbing voice coil during the test). The port is a large diameter (6 inches) tube, with the opening at the bottom. (The drivers are mounted at the top.) Poh Ser commented that most commercial systems use too small a port, resulting in compression and "chuffing" noises due to the extreme velocity of the air in the port. 18-inch woofers are frequently coupled with a 4-inch port (in an $80,000 system, for example). Poh Ser told us that his system is usable from any normal subwoofer crossover frequency—"200Hz, 100Hz, 50Hz, 30Hz"—down to below 19Hz, where it is "1 or 2dB down." It still has substantial output at 16Hz.

There is less bass boost applied to equalize this system than was used in his first design. The peak boost occurs around 20Hz, and is only 3dB relative to the "high" bass (above 30Hz or so), compared with 6dB boost of the first design. There is also a 12dB/octave infrasonic filter, so the net rolloff rate below cutoff is 36dB/octave. The maximum output he has measured from this particular pair of subwoofers is 116dB at 16Hz with under 3% distortion. This was in a 33'x14'x7.5' basement, the subwoofers against the middle of the front wall (i.e. about 5 feet from the corners), measured about 10 feet from the speakers, at normal ear level. It was measured by Ira using his Ivie and the CBS test disc. He did not measure the corresponding input power, so we did not have an efficiency figure. Poh Ser did say that the theoretical *efficiency* of the system is about 87dB/watt at 1 meter (87db/watt at 1 meter in half space corresponds to a little under 2mW acoustic output, i.e., slightly under 0.2 percent efficiency).

The woofers have a voice-coil resistance of 5 ohms (at dc). Since they are paralleled, the minimum impedance presented to an amplifier is under 3 ohms (at the port resonance, around 18Hz)—quite low. This results in a fairly high sensitivity. However, if you are worried about the low impedance combined with a possible large phase angle at low frequencies, Poh Ser suggested that the drivers could be wired in series instead of parallel, raising the minimum impedance to over 10 ohms. "The sensitivity would of course be lower by 6dB." Efficiency is clearly unaffected.

Poh Ser uses Carver amplifiers at home, by the way (several M1.0ts and an M500t). He used his Carver M500t for driving the subwoofers at this meeting. (It has excellent meters, which allowed us to estimate the power fed to the woofers during the demonstration. The meters were calibrated before being brought to the meeting.) It appeared to drive the under-3-ohm load of the subwoofers without any audible distress, and remained quite cool.

Each channel—Poh Ser recommends dual subwoofers—can handle 300 watts long-term average power. He has not yet melted a driver.

Demonstrations followed, beginning with a Hindemith organ selection (on Argo) in which Poh Ser said that the bass was louder (by about 6dB) than the rest of the spectrum (measured using a spectrum analyzer in peak-hold mode and playing through the entire disc). With approximately 150 watts in, Ira Leonard reported that we were getting about 110dB out. "It's almost all around 19Hz, too," Poh Ser told us. When the selection was first played, Al Foster was heard to exclaim, "Wow!"

Without the subwoofers and crossover, the dbx 2500s distorted badly on this track, because they were being driven well below their port resonance, which is 1-1/2 octaves higher. Admittedly an unusual case, this is nevertheless a good example of what happens to an *unprotected* vented system below resonance, as it becomes uncontrolled (Note that in the case of Poh Ser's subwoofers, the built-in high-pass filter prevents such behavior by filtering out below-resonance signals). [Also note that single 6" sealed 50Hz-resonance woofers would "distort badly" when overdriven at 19Hz.—DRM]

Of course we heard Poh Ser's favorite demo CD, the Philips recording of Saint-Saens' *Organ Symphony* (Edo

de Waart conducting). This is a disc Poh Ser uses to test loudspeakers for good behavior when fed a 16Hz tone. Many speakers produce significant second and third harmonics; a well-behaved system will produce 16Hz and very little else, mostly at a diminished level (e.g., the Allison IC-20, with -3dB at 28Hz, produced too low an output at 16Hz for it to be felt, but also produced negligible harmonics). These subwoofers produced an amazing sense of pressure on ears and other parts of the body, but very little in the way of audible distortion on these extreme inputs.

The room at the Transportation Systems Center where we meet is mostly brick- and concrete-walled. There are a few windows, set in shallow niches of brick, and some thin curtains. The floor is carpeted with short-pile office carpet, and the ceiling has some so-called acoustic tiling. It is a relatively low ceiling for the width and length of the room. Ira commented on its solidity, as nothing rattled or shook even as we pumped large amounts of bass out of the relatively unobtrusive cylinders. "Not a typical home," suggested Al.

Ira offered up a percussive, progressive jazz recording which featured a bass trombone and some enthusiastic drumming. As you might expect, the impact was palpable.

There isn't too much one can ask about extremely deep bass. Is it loud? Is it undistorted? Does it mesh well with the midbass, midrange, and highs in your system? The answer to all three questions in this case was yes, I thought. Poh Ser has managed the high-end rolloff of his woofers so that there was very little audible distress from pushing 12" drivers too high; and he has managed the overall design very conservatively so that the system can produce awesome levels at very low frequencies, also without audible distress from either the drivers or the amplifiers. Some listeners might experience a different sort of distress from prolonged exposure to the performance of which these subwoofers are capable.

With the aid of a test CD, Ira (sitting about 1/3 of the way down the fairly large room) announced that a 16Hz input to the subwoofers (which is *below* the cutoff of the subwoofers) produced an overall SPL of 105dB at his microphone while the second harmonic, 32Hz, was only 80dB. (This was measured on the same Ivie used at Poh Ser's house, which cannot measure 16Hz directly because it is below the lowest filter in the unit. The 16Hz level is judged from the SPL meter part of the Ivie. A direct feed of the 16Hz tone into the Ivie showed an overall level of 125dB producing only a 90dB reading on the lowest band. This means that 16Hz was 35dB down on the low skirt of the filter.)

With 31Hz being produced at 110dB by the subwoofers, the second harmonic (62Hz) was more than 36dB below that, and thus unmeasurable on the Ivie. This is extremely low distortion for such high levels. (Note that vented systems have the *lowest* distortion at the vent resonance frequency—18Hz in this case. The tests were deliberately carried out at fairly high distortion points.)

At this point, Poh Ser pulled back the curtains which had been hiding his cylinders. They are somewhat taller than an average person, and quite narrow, for a *net* internal volume of 4 cubic feet each (the large port takes up another cu ft or so). The prototypes were standard construction tubing finished in black, with the drivers exposed at the top. Obviously the finished versions will be much nicer to look at.

While the tubing did not appear rigid when pressed from the side, Poh Ser pointed out that internal pressure will act evenly on the whole surface of the cylinder, and the shape alone makes the enclosure extremely rigid under such stresses. Moreover, Poh Ser has ordered special tubes with twice the wall thickness for future units.

The experience of clean, loud, low bass is unusual and exciting. While much music does not have substantial energy below 40Hz, and so a good "full-range" system is adequate most of the time, there is a significant amount of 19th- and 20th-century music with extreme bass. In concert, or with a good recording and subwoofers, most of this energy is not heard but felt. Without this total involvement in the music, reproduction in the home cannot completely re-create the live experience.

Until you have felt such bass, you don't know what you are missing; once having felt it, you'll not forget.

— *Mark P. Fishman (Massachusetts)*

Advertisements

For Sale

Leach Super Amp, mono, 300 watts: $850. One (1) Dahlquist LP-1 Low Bass crossover (mod by PAC, Lynbrook, NY), mint: $400. Telephone (516) 489-8094, or write B.V. Pisha, 380 Front Street, Apt. 4K, Hempstead, NY 11550.