

THE BAS SPEAKER

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Letter from the Editor

This is the second-to-last issue of the current volume, which means it's time to think of renewal. Rates have not been raised for several years now: still \$22 (US) for the new volume year for US members.

Upcoming Articles

David Moran's work with the dbx RTA-1 measuring the horizontal output of a variety of speakers in half-space (as well as fairly closeup room responses of a number of high-end models), and Al Foster's review of his new Audio Control real-time analyzer and the Carver Platinum Edition Amazing Loudspeaker, will appear in upcoming issues.

Contribute!

The BAS Speaker is THE place for you to express your opinions about audio or to describe experiences in audio as hobbyist, professional, or even *someone* related to a hi-fi nut! I would like to know what you think are the major milestones and flops of this past decade. I would also like to compile a list of the most popular equipment used by *BAS* members—send in a list of equipment you own and used to own, with opinions.

Criteria Used for Evaluating Speakers

I have recently spent a lot of time with Al Foster and other friends listening to various loudspeakers, including Carver's Amazing. Al and I both noted that everyone listens for different things when evaluating speakers. Some focus on ambience, others on imaging, clarity, coloration, boxiness, etc. I would like readers to send in their criteria (ranked in descending order of importance) for evaluating speakers. A summary of the responses will appear in a later issue.

I would also like your opinion of the differences in sound from electrostatics, ribbons, horns, paper cones, polypropylene cones, bextrene cones, titanium domes, aluminum domes, line sources, point sources, etc.

Open Forum

Book Review

The Audio Dictionary, by Glenn D. White. Copyright 1987 by the University of Washington Press, University of Washington, P. O. Box 50096, Seattle, Washington 98145-5096. 302 pp. \$14.95 (paperback).

So you're looking for *an* authoritative definition of "Tin Ear," eh? Or perhaps you need to know what a "noy" is, to impress that irritatingly smug audiophile friend who's always putting you down.

More usefully, this book also tells the precise way to set up two microphones in the manner prescribed by the Office de Radiodiffusion-Télévision Française, or ORTF; defines SECAM; explains the difference between matrixing and modulation; and gives a straightforward description of group delay. In short, Mr. White has written a plain-English lexicon of common and obscure audio terms and jargon.

He's done a good job, too, writing in a light, often humorous style that does not distract the reader from the explanations. For example, after discussing the differences between Berliner's and Edison's methods for making playing records (under "Gramophone"), he tells us that Eldridge Johnson, founder of the Victor Talking Machine Company, said the first Berliner discs "sounded like a partially educated parrot with a sore throat and a cold in the head."

White has been employed by Bruel and Kjaer Instruments Inc., in Seattle as their Northwest District Manager. Before joining B&K, he was a lecturer in music and engineering at the University of Washington. This book grew out of his perceiving a need for a reference to the terminology and basic concepts of sound recording, sound reinforcement, and musical acoustics. The dictionary proper is supplemented by several appendices, personal essays on various subjects, including one titled *How To Subdue a Hi-Fi Salesman*.

The value of such a dictionary is that it demystifies the field and empowers the consumer. It becomes easier to communicate, and harder to obfuscate, when everyone agrees on the meanings of words. With apologies to Bob Carver, I quote from White's definition of "autocorrelator": "Some time ago, there was a single-pass noise reduction unit called an Autocorrelator on the market. It was actually a dynamic filter and had no kinship with true autocorrelation. Such misuse of terminology should be discouraged."

You can, of course, look up dynamic filter in this book.

Oh, yes: "one noy is the noisiness of a noise for which the perceived noise level is 40PNdB (PN stands for perceived noise). The noisiness of a noise that is judged by a subject to be *n* times that of a one-noy noise is *n* noys." I won't tell you what a "mel" is; you'll have to look it up for yourself.

— Mark Fishman (Massachusetts)

Headphone Review: Beyer DT-990 Pro

[Equipment used: Technics SLP-8 Home CD Player, Crown CD-110 portable CD player, Stax Lambda Pro III, Sony MDR-CD5 & CD6 headphones, Acoustat 3, Allison One, Quad ESL (original model), ADS 910, my own subwoofers, BSR 4000 equalizer, Sherwood S5500II integrated amp, Carver M1.0ts & M500t, NAD 2200, and Dreadnaught 1000 power amps]

The Beyer DT-990 Pro headphones are among the finest dynamic headphones I have heard.

During a brief audition at summer CES I thought its sound might rival that of the Stax Lambda Pros. This would be quite a feat since it retails for about a quarter of the price and is easier to use (the Stax needs energizing along with a power amplifier). Beyer very kindly lent me a pair for review.

Having used the headphones for a while now, I conclude it is one of the best dynamic headphones. It lacks the ultimate transparency and effortless ease of the Stax, but is more open and transparent in the mid to high range than the two excellent Sonys. In the bass, it did not fare quite as well. I judged it to be a little boomy or boxy-sounding, with less deep bass, than the Sonys. The Stax has the least-colored bass (and the least-colored rest of the audio range). Since the body feels bass as much as the ears hear it, I always find headphone bass to be inadequate (I am a certified deep-bass fanatic).

I did find two minor limitations: the headband is too short (I do have a very large cranium!—however, the Stax or the Sonys fit comfortably); and its high impedance (600 ohms) limits its usage with some portable CD players (i.e., inadequate volume levels). If neither of these drawbacks concerns you, then I strongly recommend that you listen to these headphones if you are on the market for a pair in the \$200-\$500 range. I used them as a reference when I went to friends' houses to listen to their speakers. It's far more convenient than taking my Stax along. My brother (in Singapore) bought two pairs, which were airshipped to him from Germany.

On the plus side, the ear pads are extremely comfortable and looked as if they would last much longer than the Sonys, which need replacement every year or two (and are not cheap).

— Poh Ser Hsu (Massachusetts)

Good Test/Demo Recordings

My favorite demo disc is *Orchestral Works* by Virgil Thomson, Albany TROY017-2. The *Symphony on a Hymn Tune* and *Symphony No. 2* were recorded at the Wellesley Chapel by John Newton. Microphone setup was a coincident pair located about 15 feet above the podium.

The depth and specificity of the image are superb, and an accurate representation of the sound heard in the room. String seating was, left to right, violin 1, viola, cello, and violin 2.

This disc has become a standard for me for both imaging and timbral accuracy. I have played with these musicians for over 10 years, and know how their instruments sound. This recording captured them accurately. It also has a wide dynamic range.

The disc is not without drawbacks—the horn section gets out of tune occasionally and the music would benefit from a larger hall.

The second disc is HFN/RR's Test CD II, which has more categories of test and more test tracks within each category than their first disc. For example, they have extended the level test to -100dB, all dithered. It also has more spot frequencies in the low bass, with tones at 17,

20, 31.5, 50, and 100Hz (subwoofers manufacturers beware).

All new are CD preemphasis, crosstalk, fade-to-noise with dither, and monotonicity tests [this disc sounds almost like a duplicate of the CBS test disc—Ed]. On the music tracks, it has some samples from the Denon anechoic orchestral recording—good for testing ambience synthesizers. As for "the dynamic range of real life," they have the Big Ben chiming 12 (want your amplifier to clip?) and some miniature cannons.

This unusually comprehensive consumer product, with tests previously found only on professional discs, may be obtained from:

HFN/RR Accessories Club
PO Box 200
MK401YH, U.K.

(About \$17 including shipping, and they take Visa, Amex, and Diners Club)

— Mark Rohr (Massachusetts)

March 1989 BAS Meeting

The equipment used during this meeting included a dbx 10/20 computerized octave equalizer/analyzer in analyze mode (calibrated mike), a 78-rpm Thorens turntable, Phase Linear preamp, Akai cassette deck, Apt preamp, dbx SF2500 speakers, Sony amp, AR turntable, David Hadaway's polarity-inverting switchbox, an oscilloscope, a Beta VCR, and a PCM decoder.

Open Forum

David Hadaway is selling the world's first semi-anechoic recording of an orchestra, released on Denon. The Toscanini Studio 8H recordings and the Sheffield recording of *Romeo and Juliet* by Leinsdorf are some of the driest recordings released prior to the Denon.

Harold Cohen of *Needle in a Haystack* in Burlington, Mass. carries drive belts and replacement styli for almost any turntable and cartridge. If necessary, they can have your stylus retipped. He also has Grado, Ortofon, Shure, and Pickering cartridges.

Election of BAS Officers

David Moran was re-elected president. Mark Fishman, Bob Zahora, Ira Leonard and Poh Ser Hsu are the new corresponding and membership secretaries, treasurer and editor of the Speaker respectively.

Meeting Feature #1:

John S. Allen on equalizing recordings

The evening's first speaker was John S. Allen, who had previously presented his work on "accidental" stereo (of multimiked historical events and speeches) to the BAS. Allen is also the translator into English of Blauert's *Spatial Hearing* (MIT Press).

Allen inherited a large collection of 78s from his father—recordings that he grew up with and loved. Unfortunately, they are not sonically acceptable to ears used to modern recordings. The microphones and/or cutters used in that era had very high-Q resonances which require narrowband EQ to tame. Allen's aim is to make acceptable-quality transcriptions of these 78s.

Many reissues of 78s are not equalized, precisely because it takes so much time and musical sensitivity. And in contrast to this detailed approach, Allen noted that Clark Johnsen applies a bare touch of broadband high-end equalization.

Allen's equipment consisted of the following:

1. A Thorens TD 124;
2. A dbx switchbox;
3. A Burwen transient-noise suppressor;
4. A modified Phase Linear 1000 noise-reduction unit;
5. A Radio Shack bass-boost box;
6. An assortment of styli with different-size tips;
7. 6-band parametric equalizers;
8. A Spectra Sound 1/3-octave equalizer.

Most of these are modified. The Thorens M124 was bought at a yard sale for \$25. The motor was mounted on the base to decrease the 120Hz hum. It is essential to minimize hum pickup because most acoustic recordings need a lot of bass boost.

The Phase Linear 1000 was modified to reduce L-R noise only.

The dbx switcher can handle 3 tape decks, 3 signal loops and an encode/decode noise-reduction unit, all at line level. Allen can monitor or copy any of 3 tape decks.

The smallest box was a Radio Shack bass booster (a variable-Q second-order lowpass filter: increasing Q beyond 0.7 boosts the frequencies just above cutoff, so a Q of 2 produces 6dB of boost, for example). It was used to boost the bass for records like Victor 78s which roll off below 100Hz. The unit was modified to have switchable settings of 30Hz (for LPs), 45Hz (for early electrical 78s), and 80Hz (for acoustical 78s).

Stylus shapes were supplied by Expert Pickups in England, who will retip your cartridge with a truncated elliptical stylus for about \$30. Allen has a set of 5 with 1.5- to 3.5-mil radii. He would select the stylus which would track on the least damaged part of the groove. He used the 2.8-mil stylus for the meeting. For newer 78s in excellent condition, he uses a Shure V15 with a 2.5-mil stylus, brush up, at 1 gram.

He used two mono 6-band parametric equalizers which can be cascaded when necessary. He acquired these and the Spectra Sound equalizer from rock groups that were disbanding.

Only parametric equalizers can produce sharp notches at the exact frequency needed to remove very narrow 15 to 20dB peaks in cutter heads and microphones used for 78s.

For example, all Victor 78s from 1932 to 1939 were made with the same RCA ribbon mikes and all have the same boom, hoot, squawk, squeal and zing at 100, 200, 400, 1k, 4k, and 6-7kHz respectively. The mikes roll off

at 8kHz. There was also a cutter-head resonance at 3kHz. The 400Hz hoot was particularly bad on woodwinds and brasses.

The period from 1939 to 1947 saw a number of technological advances. There were sharper cutter heads and the introduction of feedback to control their resonances. The mikes were also better-damped, both by air and by electrical loading. A resonator box was added and the structure of the magnetic poles was changed so that the pickup pattern was less beamy.

These latest developments in 78s were designed to produce records that were still playable with acoustic equipment, essentially a rear-view idea of technology. Micha Schattner commented that this was similar in intent to Dolby C.

Balance between air and space was about constant during the period 1947 to 1973. In all the Koussevitzky recordings made in Symphony Hall, the acoustic was the result of the mike placement. There was an audible slap echo from the empty hall. Recordings were done on the floor using a rehearsal curtain as early as 1930.

To illustrate how the 78s sound, Allen played Koussevitzky's recording of Schubert's *Unfinished* Symphony with the Boston Symphony Orchestra. The oboe sounded more like a clarinet. He played a demonstration tape which compared an equalized version of the 1947 Victor recording of Shostakovich's Ninth Symphony by Koussevitzky and the BSO with Leonard Bernstein's 1973 Columbia LP of the same piece, then the 78 without equalization. Finally, he demonstrated the effect of each of the equalizer notches.

Allen equalized the recordings by ear, using timbre of the instruments as the criteria. Although his ultimate reference is his recollection of how live instruments should sound, he found it more convenient to have a modern recording of the same piece available as an instant reference when doing the equalization. The 1973 Bernstein recording he used for this example could have had reverberation added artificially. He adjusted for the timbre of the instruments. Schattner commented that Columbia recordings could not be used as a reference.

The second cassette he played was his equalization of Brad Kay's stereo re-creation of the 1932 Duke Ellington performance on Victor. The EQ was about the same as that used for the orchestral 78 Victors. It was smooth and sweet-sounding.

Allen then played Beethoven's Ninth Symphony with Koussevitzky and the Berkshire Music Festival Chorus at Tanglewood, probably recorded between 1945 and 1947. The Burwen suppressor did a wonderful job of reducing the loud pops and clicks. The recording had a bigger bass peak than the earlier recordings.

This was followed by some Koussevitzky/BSO recordings on 78 rpm vinyl that were recorded direct to wax masters. The sound of the bass was evident. There was a large peak at 100Hz. Hard to find, this had to be notched precisely to hear basses and timpani clearly.

Allen can equalize for only about 30 minutes a day; fatigue sets in after that.

There is a point beyond which further equalization does not improve the sound. With the peaks notched out, the distortion components of the peaks become apparent. Also, the background noise is now colored, with large dips in its frequency spectrum.

John Allen showed persuasively that with care, time and taste, affordable analog equipment can be used to make 78s altogether listenable—and much more pleasurable.

Meeting Feature #2: Alvin M. Foster produces a CD— for Bob Carver

The second speaker of the evening was Al Foster, a founder of the BAS.

Al has been a Carver fan for many years. He bought one of the first Phase Linear 700 amps, an early model with blue lights and only half the number of output transistors used in later units.

When Bob Carver first introduced his so-called Sonic Holography system, Al produced an LP test record designed to help people set up their playback systems to get maximum benefit from Sonic Holography. When supplies of the LP ran low recently, he decided to convert this basic product to CD and add some features.

He had three goals: to have a CD product instead of an LP because sales of LPs are in such decline; to have a polarity ("absolute phase") test; and to include a useful battery of tests accurate enough to replace some expensive test equipment.

Foster's LP and CD were designed to help people set up Sonic Holography correctly. However, it is very useful for setting up a normal stereo.

In addition, the CD also provides most signals needed for testing your system. There are spot frequencies from 16Hz to 15kHz, a 20-20kHz sinewave sweep, flatter-than-usual *stereo* pink noise, inverted-polarity test—essentially everything the average audiophile needs [who needs music?—Ed].

The voiceover on the recording is Al Southwick, another BAS member.

Al chose Nimbus from a list of four small CD producers that Ira Leonard provided, because it was the least expensive (they even had an 800 number, which made it cheaper still, as several calls were required). He got 2000 CDs including shipping from Virginia, packing, and jewel box for about \$4000. Pressing alone was \$1.40/CD, only 15 cents more than pressing an LP. The jewel box costs 30 cents.

Foster cut the cost of packaging by having only one color (black) and cut the art costs by not using half-tone photos. The glossy-paper brochure enclosure was 8 or 16 pages for 25 cents, saddle-stitched.

Overall the package cost \$2 each, with the shrink-wrap free.

Since much of his distribution is by mail (an ad is included with Carver products), Foster needed a cheap

container. He ended up with a 10-cent, self-sealing, 6x9-inch air-bubble-lined envelope.

Scott Kent did the studio work for both the LP and CD. At 6000 LPs (originally) and 2000 CDs, this is the largest production run of any recording that Kent has made. The master was transferred from a half-track Revox analog tape to a half-inch digital master. The latter had to be in Beta format. The test tones were redone digitally (using Al's sinewave generator feeding the PCM recorder) to take advantage of the low distortion and speed stability of the CD medium. Foster described the audible difference between the tones from an LP and a CD as "100%."

This master was converted to the CD format by Toby Mountain/Northeastern Digital Recording, which is right behind Spag's on Route 9 outside of Boston. They charged \$400-\$500 for the process, using Al's digital tape as a source.

Digital editing can be extremely precise. If you wanted to edit on the word "LP" in the voiceover, for example, you could edit before the L, at the beginning of the L, or at the end of the L.

Micha Schattner noted that with digital editing you don't have to vacuum up the bits of tape when you're done. This may seem a casual observation except that by not destroying the original when you edit, you can go through many more trial edits and can be much more daring in your editing.

Mark Fishman commented that single-edged razor blades were harder to find, too.

Due to the pressures of getting to market, Al Foster did not have time to add voiceover for the new tests, nor to change the existing voiceover, which refers to the "LP."

The typesetting for the CD was done by Steve Owades and Al on a personal computer. [Steve has done the elegant typesetting for *The BAS Speaker* for some 7 years

The title *Sonic Holography Demonstration-Calibration Test Disk* was written around the circumference of the disc. This was made on a Macintosh.

In fact production was easier for the CD—Al had to have the art work and jackets done separately and shipped to the pressing plant for the LP.

Audibility of Polarity Inversion—"Absolute Phase"

Al demonstrated the absolute-polarity track on his CD using David Hadaway's (DB Systems) high-quality polarity-inversion switch (with buffered inputs flat to ± 0.2 dB, gold contacts, and resistors matched to 0.1%).

Three people, including Micha Schattner, reported hearing a difference on music with the switch thrown. The test was not particularly "blind" or clean. Schattner noted that the image changed and commented that early (1957) Quad ESL speakers (at least one pair, if not more) had their terminals marked incorrectly. He himself wondered why people liked the Quads' imaging until he discovered the error and reversed the wires. Schattner further noted that on Amanda McBroom's widely used

recording *Growing Up in Hollywood Town*, her mike has opposite polarity to the mikes used for the orchestra, so you can hear either her or the orchestra "correctly," but not both.

Another member also noticed image changes and offered that the human ear hears phase in only one direction because it's essentially a single-diode rectifier.

Al commented that in order to hear subtle changes it helps to tell people what to listen for [the power of suggestion?—Ed].

All of this assumes that the rest of the system is "in phase," and may hold only for seats equidistant from the two speakers. It also assumes that your CDs have been made with correctly phased mikes so that their diaphragms and your speaker drivers move in the opposite direction, i.e., a compression pushes the mike diaphragm in and the speaker moves out to create a compression in your room.

Distortion Tests

Al also demonstrated the use of the spot sinewaves for testing distortion.

With an inexpensive (\$300) oscilloscope you can get a lot of useful information using the test CD as a precision source. Al commented that distortion is about 3% when visual distortion of the waveform sets in. The useful thing about this is that you can then use the data to help calibrate your ears. [CAUTION: do not test amplifier clipping with your speakers connected or you will cook your speakers and possibly your ears.—cd]

As a demonstration, Al fed the 24Hz signal to the dbx speakers. Since 24Hz is more than an octave below the cutoff of the vented 6-inch woofers, it produced mainly distortion, with more third-harmonic than second-. It was very easy to see the distortion on the oscilloscope. The 16Hz signal is just below the range of the Ivie real-time analyzer we used, but it was evident that the output at 80Hz (the fifth harmonic) was greater than at 32 and 48Hz.

Contents of the CD

Track 1 is a spoken introduction.

Track 2 tests interchannel polarity using Al Southwick's voice recorded in and out of phase. This method was taken from the Shure V15 test records and is the best way that Al has found. However, he noted that David Hadaway's broadband noise is also very good.

The third track is absolute polarity. The signal was a halfwave-rectified sinewave with the negative half removed. You can view the signal with an oscilloscope. It is similar to that used in the Wood experiments to demonstrate the audibility of absolute polarity, as referred to Clark Johnsen in his book, *The Wood Effect*. The CBS test record uses a pulse for this test.

Tracks 4, 5, and 6 are for checking frequency response and distortion. Track 4 has six spot frequencies from 50Hz to 15kHz, track 5 is 24Hz (index 2) and 16Hz (index 3), and track 6 is a 20Hz to 20kHz sinewave log sweep.

Track 7 is for electrical balance and was originally suggested by Peter Mitchell on *Shoptalk*. The left and right signals are out of phase so if you switch to mono and the preamp is electrically balanced, then you get a null. (This also depends on where in the circuit the balance control is relative to the mono switch: if it is after the blending of the two channels, then changing the balance will not change the depth of the null obtained.)

In the Carver 4000 the balance controls are before the mono switch.

Tracks 8-14 are primarily useful for setting up specific Carver products. Track 8 is autocorrelator adjustment, track 9 is peak-unlimiter adjustment, track 10 is for time delay and echo density. The Carver preamp can be used to add a simple delay, but too much sounds like a ringing spring.

Track 11 is the introduction to tracks 12, 13, and 14. Track 12 is filtered noise bursts for setting up stereophony and sonic holography. Your head is in the right place when the sound bounces back and forth between the two speakers.

The last test track contains stereo pink noise—two uncorrelated channels, from separate generators. Pink noise in almost all other test records is mono [and in at least one case, the Denon and HFN/RR I, is seriously inaccurate in the bass, and in other cases seems a bit off above 10kHz; the Foster/Carver is flat across the audio band within 1dB (± 0.5)—all this according to the dbx RTA-1, which is accurate to within less than half that.—Pub] Stereo pink noise eliminates venetian-blind effects or comb filtering when feeding and measuring both speakers. [It also yields smoother and approximately 3dB less-warm bass response below approximately 200Hz for most speaker systems in most rooms.—Pub]

Some pleasant drily recorded jazz (two versions) concludes this handy disc.

The Carver CD test record is available from Al Foster's Supply, PO Box 211, Boston, MA 02126. It is an inexpensive source of test signals, and you should try it. [IMPORTANT NOTE: at the meeting, while we were playing the CD's 15kHz tone over the SF 2500s with their four 1/2-inch tweeters, someone said "Turn it up, I can't hear it." I reflexively—stupidly—did so and instantly cooked all of them. I trust this word to the wise is sufficient.—Pub]

Carl Deneke (Texas)

May 1989 BAS Meeting

Open Forum

Mark Fishman gave details on how to attend a special AES/SMPTE/BAS lecture tour of Symphony Hall, conducted by famed acoustician Leo Beranek. Al Foster and Peter Mitchell reported that Tom Holman has developed a THX system for home use, containing EQ and Dolby

surround-sound decoding adapted to provide in the home the same subjective perception that is heard in one of the 300-plus THX-equipped movie theaters. Incidentally, Holman's development of the THX sound system for theaters puts him in competition with another BAS member, John Allen, whose Klipsch-based HPS-4000 is the "other" high-quality sound system for theaters. Bose Corp. is also getting into this area, with speakers and subwoofers based on the acoustic-wave "cannon." There's plenty of area for improvement: according to a member involved in studying such things, only two percent of the nation's 26,000 theaters have a decent sound system.

David Moran mentioned that the Pro products division of DBX is being sold to AKG in Stamford CT. Since AKG previously bought Ursa Major and Orban, it will have a broad line of signal processors to sell besides its fine Austria-built microphones. Moran also said that the consumer products division of DBX was being phased out. (A DBX representative at CES denied this two weeks later but admitted that the big DBX pre and power amplifiers were no longer being made and would be sold only from inventory; there's an ample stock in the warehouse to meet expected demand.)

Meanwhile Bob Adams, developer of the high-resolution DBX A/D converter, now works at Analog Devices. Since Analog has also hired Dave Welland, who worked with Adams at DBX and then developed in Texas an 11MHz 2-bit oversampling converter, Analog may become a major force in high-quality oversampling A/D converters. Several other ex-DBX engineers are now working at Bose. Meanwhile Carillon, the company that bought DBX and moved it to California, has cash-flow problems and has failed to pay many debts owed to individuals and companies that supplied parts and services to DBX. If you own a DBX product that needs repair, Carillon may not have anyone who knows how.

John Sunier's *Audiophile Edition* having been canceled by WCRB; the program's only New England outlet is now the AM station at 790kHz, WAAZ, in Providence, Saturdays at 1 p.m. Acting membership secretary Frank Farlow was looking for an address for a Robert Peterson, and also for the text of the amendments to our bylaws as adopted last year (both were later found).

A member showed an example of the latest trend in audio, desktop hi-fi, in this case a little "Nakamichi" system listing for \$700. (It's made in Taiwan; Micha Shattner observed that the only part that is really from Nakamichi is the nameplate.) When it was turned on David Hadaway suggested that the holes in the speakers must be "midrange-reflex" ports, since there was no bass. Similar mini-systems are coming from a half-dozen companies.

Martin Polon reported on the AES Digital Conference in Toronto. The collected papers from the conference will be well worth reading when published in book form, but Polon felt a lack of the lively dialog and interaction that the industry needs. Many engineers from IBM, AT&T, Motorola, Texas Instruments, and Next

(Steve Jobs' new computer company) were there, reflecting the direction that pro audio is moving toward—computer-based work-stations for digital signal-processing and editing. And there was much discussion of optical disk storage of digitized audio. In a nutshell, audio is being taken over by computer nerds.

Peter Mitchell brought assorted news and trivia from California and Europe. Yamaha's approach to tiny stereo, called AST (active servo technology) [later renamed YST because of trademark conflicts with a company named AST], is not original but uses 1978 circuitry licensed from AudioPro of Sweden. The driving amplifier is arranged to have a frequency-dependent negative output impedance that cancels the impedance of the woofer; then, since the woofer's resonant behavior no longer controls its low-end response, other circuits can shape the bass response as desired, getting extended bass from a small box. Since the amp and woofer are married, this is not a general-purpose idea; its use is limited to compact systems, wide-range table radios, and powered subwoofers.

Enid Lumley fans take note: the sound waves that you're listening to may also be vibrating your interconnect cables, so "acoustic resonance" of cables is a problem crying out for a treatment, especially for cables using PVC, polyethylene, or teflon. (Note: we're talking about the insulation here, not the wire conductor itself.) Presumably the sound waves cause slight momentary compression of the insulation, modulating its dielectric constant, and thus altering the sound. A company called Infra Noise-Laboratories has a solution: a "tuning belt" for cables—a natural leather wrapper, saturated with a synthetic damping liquid, that you wrap around your patch cords. One member asked whether it would work with fiber-optic cables. [This seemed like a good joke; but later studies have shown that vibration of fiber-optic digital interconnects, used between CD transports and outboard D/A converters, may product timing jitter that can subtly alter the sound.]

A report in the Japanese trade magazine *JEI* revealed why the small Technics portable DAT recorder didn't sound as good as its MASH encoders promised: when Matsushita reworked its circuitry to produce the Panasonic 250 pro version, they found that the consumer model's input electronics were subject to overloading on transients. The pro version doesn't have that problem and is reputed to be one of the best-sounding digital recorders around. However, Micha Shattner observed that the Technics and Panasonic portable DATs have been less reliable than Sony's portable DAT. Micha also warned about Aiwa-made *Excel* gray-market import DAT recorders that suffer from gross distortion.

A new type of rechargeable battery will be coming to market soon: nickel hydride, claimed to have 50% more capacity than a Nicad of the same size, much quicker charging, more charge/discharge cycles, and none of the memory affect that has been a headache with Nicad. An AA cell will have 1.2 volts, 1000mA-hours of capacity (double the capacity of a NiCad), and 3-ampere maxi-

mum discharge current. (Nicads are still better for applications requiring very high peak current output.) Speaking of batteries, in response to a query several members enthusiastically endorsed using pairs of 9V batteries to power the classic Advent microphone preamp.

David Hadaway reported that the price of blue LEDs has dropped from \$40 to the \$1 range, raising hopes for a bright large-screen flat-panel TV in this century. David brought demo/test records for sale, including the Denon anechoic orchestra CD and the Reference Recordings video laserdisc. (These and several other valuable test discs can be mail-ordered from DB Systems.)

Steve Owades noted that for a recent recording of Haitink conducting the BSO in *Daphnis et Chloe*, Philips used a total of 62 microphones (which may be a new world record), recording onto a 24-track Sony digital machine. Every woodwind instrument had its own accent mike. Owades also observed that in the Philips live-performance recording of Ozawa and the BSO in *Elektra* by Richard Strauss (for which Owades sang in the chorus), swordfight sounds were added to the recording later; when members of the chorus first heard the CD they thought the recording was defective because of these extraneous noises.

Mitchell concluded by reporting more evidence for a trend that he described the preceding November: that we are witnessing the end of linear PCM as the usual method of encoding and decoding digital audio. Linear PCM will continue to be used for digital storage (because it is the standard for CDs and DATs as well as for professional tapes); but techniques based on delta modulation and pulse-width modulation will soon be the dominant means of encoding and decoding. For example a new Sanyo chip (used in low-price CD players from several companies, including NAD) splits the CD's 16-bit codes three ways: PCM for bits 1-9, PWM for bits 10-13 and level-shifting for bits 13-16, achieving good linearity at very low cost. The MASH sigma-delta converter, first used in Technics DATs, will soon be used in CD players as well, competing with the Philips "bitstream" sigma-delta D/A converter.

Meeting feature: Allison Acoustics

Roy Allison is well-known to, and much admired by, BAS members. After many years as plant manager and speaker designer for Acoustic Research, Roy launched his own company about fifteen years ago. His speakers are best known for three characteristics: (1) a transferable five-year "full" warranty (most product warranties have "limited" liability and are not transferable); (2) very wide high-frequency dispersion, thanks to a unique tweeter designed and made by Allison—a rare thing these days when most speaker companies buy drivers from Japan or Europe; and (3) a set of design principles, also used by Snell and a few other manufacturers besides Allison, that enable a speaker to deliver remark-

ably uniform mid-bass response, avoiding the notch caused by out-of-phase boundary reflections.

Allison began his presentation by discussing the recent reorganization of his company. His original partners, Abe Hoffman and Sumner Bennett, wanted to retire from the speaker business and pursue other interests, so their shares of the company were bought by Bob Barr (from AR) and two other colleagues. With fresh financing and new energy, Allison is now prepared to expand his market both here and abroad. For example, at Barr's urging, Allison is now producing a line of speakers with front-facing drivers in rectangular boxes, designed to appeal to buyers (and dealers) who may be put off by the unconventional look of Allison's existing "CD" models. All but the smallest of the new speakers employ Allison drivers. The largest, AL130, uses push-pull 8" woofers that cancel asymmetric distortion (an idea first seen in Allison's top-of-the-line IC20). The AL120 and AL125 use dual 6" woofers, one operating only below 100Hz.

Allison is also making a mini sub/sat system, priced at \$499 including bass module. The satellites feature an Allison tweeter with a 4" mid-woofer that is usable to 85Hz, a bit lower than usual; best results are obtained with the easily hidden common-bass module, containing an 8" dual voice-coil woofer that operates below 150Hz.

A speaker-protection device that Allison has been including in his speakers to protect them from accidental burnout (due to accident, amplifier failure, or simple owner abuse) is now available as a separate product called Power Shield. It is a solid-state device that has a low series resistance (0.1 to 0.2 ohm) at normal operating levels, but when fed too much current its resistance rises sharply to about 200 ohms, abruptly dropping the sound level and protecting the speaker.

It consists of two metal plates separated by a thin layer of polyurethane foam in which many ferrite particles are embedded. Normally the particles are in close contact, providing a low-resistance conductive path; but above a certain current level the foam heats up and expands, separating the particles and cutting off the flow of current. Unlike a fuse, it automatically resets when it cools, saving you the hassle of going to a store to buy a replacement. Allison said that the ferrite particles are in such good contact that no low-level rectification or other sonic impairment can be either measured or heard.

Larger Allison speakers contain two Power Shields, one with a high-current threshold for the woofer and a one with a lower cutoff current for the midrange and tweeter. Since Allison Acoustics started using these protectors in its speakers, warranty claims have fallen nearly to zero. Sold separately, Power Shields will be available in versions rated for five different continuous-power levels, at \$40/pair. If they protect a costly pair of speakers without altering the sound, they may be the greatest insurance bargain in hi-fi.

Various CDs were played to demonstrate three of the new Allison speakers. Each model has good bass and power-handling for its size, but they did not all sound

alike tonally—an apparent departure from earlier Allison custom. (Previous Allison designs have a strong family resemblance, differing mainly in bass extension and maximum acoustic output.) One of the CDs was Titanic Ti-164, the second CD produced by Mitchell and Brad Meyer featuring James Johnson playing Bach; after hearing Johnson's compelling performance of the Toccata and Fugue in C minor (recorded in a single unedited take), several members bought copies of the disc.

— Peter W. Mitchell (California)

August 1989 BAS Meeting

Open Forum

Mark Fishman reported that after 12 years his FM tuner finally died, and in looking for a repair outfit, he found that Henry Niklas had reopened Stereo Lab at 337 Cambridge Street in Cambridge, out toward Lechmere. His old shop, in Harvard Square, had burned down over a year ago when there was an electrical fire in the ancient wooden structure. The phone number is the same.

Harold and Judy Cohen, proprietors of Needle in a Haystack in Burlington, mentioned that they also repair or arrange for repair of a wide variety of components as well as offer service contracts.

Ken Rudnick, because he was selling an older 8mm camcorder in order to buy a newer one, led a discussion of the merits of various camcorders. He pointed out that, contrary to popular impression, you do not have to dub the tape to watch it; the camera can be used as a playback system. The camera weighs about 4 lbs, which makes it easy to carry. Each tape can record for up to 2 hours at standard speed, unlike VHS-C, and the audio is FM rather than low-speed edge-track. There are mono and stereo models plus a high-end version, with stereo digital sound.

Fishman quoted Frank van Alstine, as reprinted in the September *Audio*, to the effect that if your electronics is not load-sensitive, then changing the cables won't change the sound. "Magic is easier to understand" than engineering, he said [of all smoke-blowing gurus to say that!—Pub], and few are willing to cry "Bullshit!" when hearing claims for magical cable properties.

Audio magazine, by the way, has found another speaker reviewer, Don Keele Jr., who almost rivals the late Richard Heyser for impenetrable, interminable prose and testing. He has added radiation-pattern measurements, which Moran felt was a good thing.

This same issue of *Audio* has an interview with audio-test-record and sound-effects pioneer Emory Cook, a wonderful piece worth reading.

Moran mentioned that *CD Review* (formerly *Digital Audio*) has engaged him to do speaker reviews. In the first full-scale reviews (September 1989) they printed the articles such that the explanation of the complicated

curves came afterward, instead of before. Worse, he made a computational error in error-correcting and plotting out the curves, so the scale on the graphs is wrong. Instead of 5dB per division it should say 8-9dB per division, and the treble above 3kHz or so is approximately 1dB/octave soft. The curves thus look smoother and less flat at the top than they should, but the shapes are otherwise correct.

Julian Hirsch's recent review (in *Stereo Review*) of Allison's new AL 120, which has two woofers, one of them inverted into the cabinet, suffered a major error. Hirsch measured the bass response of the system by placing the microphone halfway between the woofers. But they do not cover the same frequency range, as he had assumed, nor are they the same distance -from the floor, so his data and comments do not accurately describe the bass or midrange performance of the system.

Sony's MDR-CD6 headphones came out on top of *Consumer Reports's* headphone study. This is an on-the-ear phone (the pads rest *on* the pinna) with decent isolation. It can be found for less than \$80 by mail. A1 Southwick has a set and has been very pleased, except that they keep sliding off his head [I am also very pleased with them, and they do not slide off my head. My major complaint is that the ear pads need to be replaced every two years or less depending on how well you treat them.—Ed]

Meeting Feature:

The Sound of the Woodstock Festival (or, A Thousand Watts of Peace and Light)

Twenty and more years ago, as Moran reminisced in his introduction to the guests, all summer long you could go to outdoor concerts, large and small, all over the country. It didn't cost much, and best of all it confirmed your sense, if you were born in 1947 (plus or minus 3dB), that there was no one else in the universe but people your own age and experience and values. It was a very pleasant way to pass the era.

In the summer of 1969, which saw the moonwalk and other now symbolic but then real events, a friend of Moran's in the East asked him if he wanted to come out and go up to Bethel, NY, for the big concert. He replied, "No, thanks, I hear it's going to be really crowded." When he got to dbx, in 1982, one of the first tales he heard was about the guy in the marketing department who had helped with the sound at the Woodstock festival. In fact, if you've seen the movie, you might recall that at one point someone yells, "Harold, turn up the mike." Our guests this evening were Harold Cohen, sans mike; his wife of 11 years, Judy Bernstein-Cohen; and venerable sound man Bill Hanley.

Harold said that he had never followed the sale of a camcorder before, and while his wife was setting up the posters and props, he joked, "Every sound man needs a roadie." ("You'll suffer for that," she shot back.)

Harold introduced Bill as the owner of Hanley Sound, the company responsible for all the sound that came off

the main stage at Woodstock. This included the sound system and the recordings used for the film and the records. Bill's younger brother, Terry, worked for him at one time.

Hanley Sound handled the Newport Jazz and Folk Festivals and President Johnson's inauguration, in 1965: the company was geared to do large, outdoor events. In fact, they were the largest sound-reinforcement company in the country at that time. Their equipment was used in the Fillmore East, in New York, the Boston Tea Party on Berkeley Street, Paul's Mall, the Jazz Workshop, and several others. Also, Bill handled road sound for many of the groups that appeared at Woodstock.

After the New York Times reviewed a Joan Baez concert in Madison Square Garden and gave the sound system as good a review as the concert, Hanley Sound became the prime contractor for the Garden. "These were fun times, because the IBEW had control of the house and on stage belonged to the IA, and we were a non-union company, not a nice place to be. We once had a three-hour meeting because one of our *guys* flicked a McIntosh 3500 back on a dolly when he saw it start to fall."

Live recording was another specialty, but do not judge Hanley by the Woodstock LP. Warner allowed Lee Osborne, one of the Hanley engineers, to go to California and work on the film sound, which is probably why it won an Academy Award for documentary sound. They had no control over the LP sound, however, even though it came from the same tape, and Bill and Harold think the LP is awful in comparison. Judy was business manager for Hanley Sound at the time.

Woodstock the festival did not take place in Woodstock the town. The organizers never got permits for that. They did get permits to hold it in Walkill, a town just outside of Woodstock, and had posters printed. (Harold showed us one he had gotten from John Roberts, one of the producers.) The poster advertised "An Aquarian Exposition"; Woodstock, you recall, was supposed to be more than "just a rock concert." There were tickets printed for the Walkill site, at \$8 per day. The Walkill permits were rescinded, however, so the concert had to move again.

Max Yasgur, who owned a 600-acre dairy farm, heard that the Walkill permits were rescinded, and called Roberts. He said that for \$75,000 he would rent his farm to the festival. Since the date was fast approaching, that's where they went.

Michael Lang, who lived in Woodstock, was the prime mover of the festival. He hooked up with Mel Lawrence, who had promoted the Miami Pops Festival the year before, for which Hanley Sound had done sound. Also involved was Stan Goldstein, grounds coordinator, who enlisted the Hog Farm and communes to provide security and other "good deeds." They were headed by Wavy Gravy.

John Morris booked all the acts and handled scheduling; Chip Monck was the announcer and lighting designer (he also did the concert lighting design for *The*

Rose). He has since done work with Bette Midler and with the Rolling Stones.

There were many others involved, of course, too many to list here. If you are interested, there's a good book you should get, by Joel Makower, called simply *Woodstock The Oral History*.

The Recordings

Bill Hanley told us that they used two eight-track Scullys to make the tapes. They had Langevin mixers, like the ones that the Tonight show used until two years ago.

The recording console was about 150 feet away from the stage and around a hill, so it was hard to get information about what was at each mike.

Bill's experience doing live recording was at Newport, where there were separate mikes for live sound and recording for a while. A performer would walk up to a mike and the sound would go dead because he was talking to a recording mike. So Bill insisted on having total control of the sound, and he would give tapes to the recording companies afterward:

There was a Nagra used for synch, which was sent to the cameras that did the filming, instead of the other way around.

When Jimi Hendrix was the last act up, at 7 or 7:30 in the morning, Harold wanted to find out what the system was capable of, so he started calling for level checks on the amps. He compressed the signal into the Nagra so the levels stayed constant—but he did wake people up.

Judy pointed out that no one involved in producing the records had been at Woodstock. The Mobile Fidelity CDs, released a few years ago, were a different mix from the Warner release. When the film was done, not only did Lee Osborne help with the mix, he went to theaters to help align and certify the sound systems. Without Bill and Judy getting that in the contract, no one would have paid such attention to the sound of the film, either.

Reportedly, Warner has released a new set of CDs, completely remastered. As of this August meeting, no one had seen (or heard) it. Warner has the master tapes, from the festival.

Only one tape was taken out of the set. Janis Joplin's manager didn't feel her performance was up to snuff, and he took away the master of her performance. That's why she isn't on any of the records or in the film.

The Sound System

The monitor speakers used at Woodstock were C55s by JBL, with horns, powered by Crown DC300s. The main system was driven by McIntosh amps.

One thing that took Bill a while to understand about rock groups was how much a part of the act was dependent on controlled distortion. He had always believed in low-distortion, clean sound, as he had done for jazz festivals, so he had to learn to let the groups produce the sound just as they wanted.

In answer to a question, Bill said that since the musicians have taken over the business, the quality of sound coverage in the audience is not as important as pleasing

the artist. The field has become filled with amateurs who might check the sound at one or two places, and concentrate on the stage monitors. Very little attention is paid now to keeping the sound paths clear, so it gets muffled.

One audience member recalled helping Bill do a sound check for Peter, Paul, and Mary. Peter Yarrow would keep jumping down from the stage, running out into an empty hall, trying to hear what the sound was like, and giving Bill instructions on how to mix.

Harold said that they had an honest 10,000 watts rms available at Woodstock, primarily of McIntosh 275s and 3500s. These were all-tube, transformer-output devices. Everything was rackmounted and fan-cooled. Hanley had refrigerated vans which could double the output of an amp by running it at -30 degrees ambient. They used unbalanced inputs with extra shielding, because they found that transformers tended to pick up hum. At Woodstock, they put preamps on stage and ran line-level signals back to the mix console. Separate mixes were done for the eight-tracks and the PA sound. The Nagra got the PA for reference only. The mikes were split conventionally, so you couldn't pick a "wrong" mike.

More than one member of the audience complimented Hanley on the quality of his concert sound, having been to some of his concerts in years past.

Bill told us that the towers were well-grounded, so they were not concerned about the prospect of lightning. What they were concerned about was mud. The footings of the towers were in mud, and the concern was for the safety of the audience in case one should fall. This is why there were frequent announcements for people to get off the towers.

In the three weeks before the concert, 200 telephone poles were driven to bring in 440V 3-phase ac. They did have a backup generator, but it was "noisy as hell."

The tops of the sound towers were at the same height as the rear of the site, which was sloped, a natural amphitheater. The sound system was planned for an attendance of 200,000 and was the largest system ever put together up to that time. Two sets of towers were used, a lower set in front with speakers aimed downward at the audience, and a taller set with speakers aimed almost straight back at the hill, to cover the rear part of the crowd.

As noted, there were about 10,000 watts at Woodstock. Today, Clair Brothers would use 150,000-200,000 watts, which is only about 12dB more, and they throw much of that away in 1/3-octave equalizers. What a modern system does better is cover the sides of the audience. There would probably be little difference in coverage within the main area.

The videotapes that have been released of the documentary film have been letterboxed in the more recent release, at least in the sections where split-screen work was done. Also, the tapes have stereo soundtracks, so the sound should be like what was on the film rather than like the album mix.

The PA sound was handled with two-way speakers, similar to what was installed at Fenway Park in 1969 by Hanley Sound. The cabinets were, quite efficient and very directional. The horns were single-cell, designed for long throw.

Bill told us that the second set of towers, pointing back at the hill, was fed from a clipper and compressor so that the level could be kept as high as possible. LA2As and Volumaxes were both used. The behavior curve of the LA2A is similar to that of the dbx OverEasy compressor-limiter series.

What it was Like

Harold left Boston (Hanscom Field) at 2 on the morning the concert was to start to be backup man, with the console and some extra limiters that the sound crew wanted. He arrived at Monticello airport at about 4 a.m.. The airport had just been opened two weeks-before, and when Judy had flown in, five days earlier, the FAA had asked them to circle the airport a few times so they could get a fix with radar from two other sites. The FAA needed to know where the field was!

During the whole concert, there was no working control tower at Monticello. Landing was done by sight and by radioing announcements of plans to land. If no other pilot responded, you could land. This applied to the helicopters, the Army, the National Guard, the networks.

The helicopters were busy ferrying acts to the concert site, where a helipad had been marked out with Christmas-tree lights. Harold was therefore stuck at the airport for five or six hours, until Scott Holden came out on his motorcycle. The console and one limiter fit on the bike, and Harold had to wait for a lift from an NBC crew he knew.

Harold knew the crew because in 1968 he had done some work at the White House. When they saw him, they asked if they could get a sound feed. "My reply was, can I get a ride on your helicopter?"

This was just about at the start of the concert, and as they came over the rise to the farm, Harold could see that "there was an honest 350,000 to 400,000 people there."

While he was talking, Harold passed around several items of memorabilia, including a program booklet from the festival—each act had a separate page—and a copy of *Life* magazine chock full of pictures of the concert. Many of these items, and more, were on display at the Needle in a Haystack Audio-Video Service Center in Burlington, Mass., which he and Judy own.

Some of what Harold showed us were commemorative items, issued in conjunction with the publication of Makower's book.

In one of the posters, a picture of the audience taken from the stage, Harold pointed out the 50-foot scaffolding with SuperTroopers on top that had been erected for the concert. There was additional scaffolding, in two sections, of 50 and 30 feet, for the sound systems.

In addition to her business background, Judy was also the first editor of Pro Sound News, and a marketing per-

son at dbx. She usually leaves more-technical stuff to Harold and Bill, and in this case addressed herself to the human side of things at the festival. She noted that Makower's book was a real triumph of setting forth the experiences of those who were there without imposing authorial judgment on the material.

As an example of people-oriented detail, she said, how did they know how many porta-johns to get? At the start they were expecting about 25,000 people. So they called all the porta-john people and said, we're having this event, 25,000 people, such and such a date. "Just a minute," and in the background they'd hear, "Sam, how many porta-johns do we have for August 20th?" "65." And the guy would come back, "You need 65." Wherever they would call, that's what they got. They ended up talking to the Army, because no one else knew.

In Judy's words, the people who put on this event—the Langs, the Hanleys, the Cohens, everyone—"were consummate professionals, and that is the only reason you didn't have a disaster. They not only did their jobs, they moved over to help the next guy. That, of course, was never documented until this book, because for 20 years they've been talking about the rock stars."

People ask what were the greatest things about Woodstock. One was Country Joe and the Fish, "mobilizing the crowd with one word." The other was Jimi Hendrix closing the concert [beautifully turning the national anthem, in Pauline Kael's words, into an air-raid drill—Pub]. And as long as there was music, people were delighted. The minute the music stopped, you could see the audience recognized they were sitting in mud, they were wet, they were hungry. And the drugs.

The Bethel site had to be prepared in only three weeks. Meetings had been held for months, but the site, the insurance, the money arrangements came down to the last minute. Michael Lang was really a hippie at the time. John Roberts came from the Colgate-Palmolive family. These were a bunch of rich kids playing around who created something that they were barely prepared to handle.

As outside contractors, Hanley Sound became the stepchild. "We kept asking, 'Where's the money?' They kept saying, 'There'll be a movie, but we don't have a contract.'" Twenty years later, Stan Goldstein created another Woodstock logo, with the dove of peace killed by an arrow labeled WB, to show where it all went.

Judy also showed us her Woodstock jacket, still stained with red clay from the festival.

And then she told her parable of the loaves and fishes.

As you have heard, food was in short supply. Judy had rented a Dodge camper because she knew that, once on-site, they weren't leaving. And came Saturday afternoon and the sound crew wasn't getting any food. The day before, they had delivered a tray "with about 9 loaves of bread. I opened up the cabinet, and there were two 7-ounce cans of tuna fish. Great. I never go anywhere without Hellman's mayonnaise, and I had a huge bag of potato chips. So we had 25 sandwiches from two

7-ounce cans of tuna fish, plus the chips. It didn't taste bad." ("Gritty," recalled Harold.)

Clearly, even after 20 years, the Woodstock festival still reaches out and marks people who were there—and many of us who were not.

— Mark Fishman (Massachusetts)

Advertisements

Wanted

Old Hi Fi/Stereo Buyers' Guides from the '60s and earlier; and raw speakers, particularly full-range units (including coaxials or triaxials) from the '60s or earlier; Jensen G610s, Altec 604s, EV 15TRX from the 1954–1957 era (with 8 inch diameter magnets) are good examples. Collecting them for my speaker museum! Poh Ser Hsu, 2 Eden Street, Chelsea MA 02150. Telephone (617) 266-0500 (w), (617) 884-8250 (h).

For Sale

One pair dbx Soundfield 1As (28 drivers, controller usable on its own as well); oak; \$1500;

One pair dbx Soundfield Tens, oak (I think); call for price; negotiable;

One pair Cambridge SoundWorks satellites (satellites only); perfect for side/rear speakers; \$200; supplied with complete frequency-response measurements;

One pair Allison AL 120s, in walnut vinyl, the current "house speaker" for BAS meetings; fully warrantied for five years; tremendous value; supplied with complete frequency-response and bass–THD measurements; call for price.

All speakers in very good condition or better. For information, details, opinions etc. call David Moran, (617) 259-9343 evenings.