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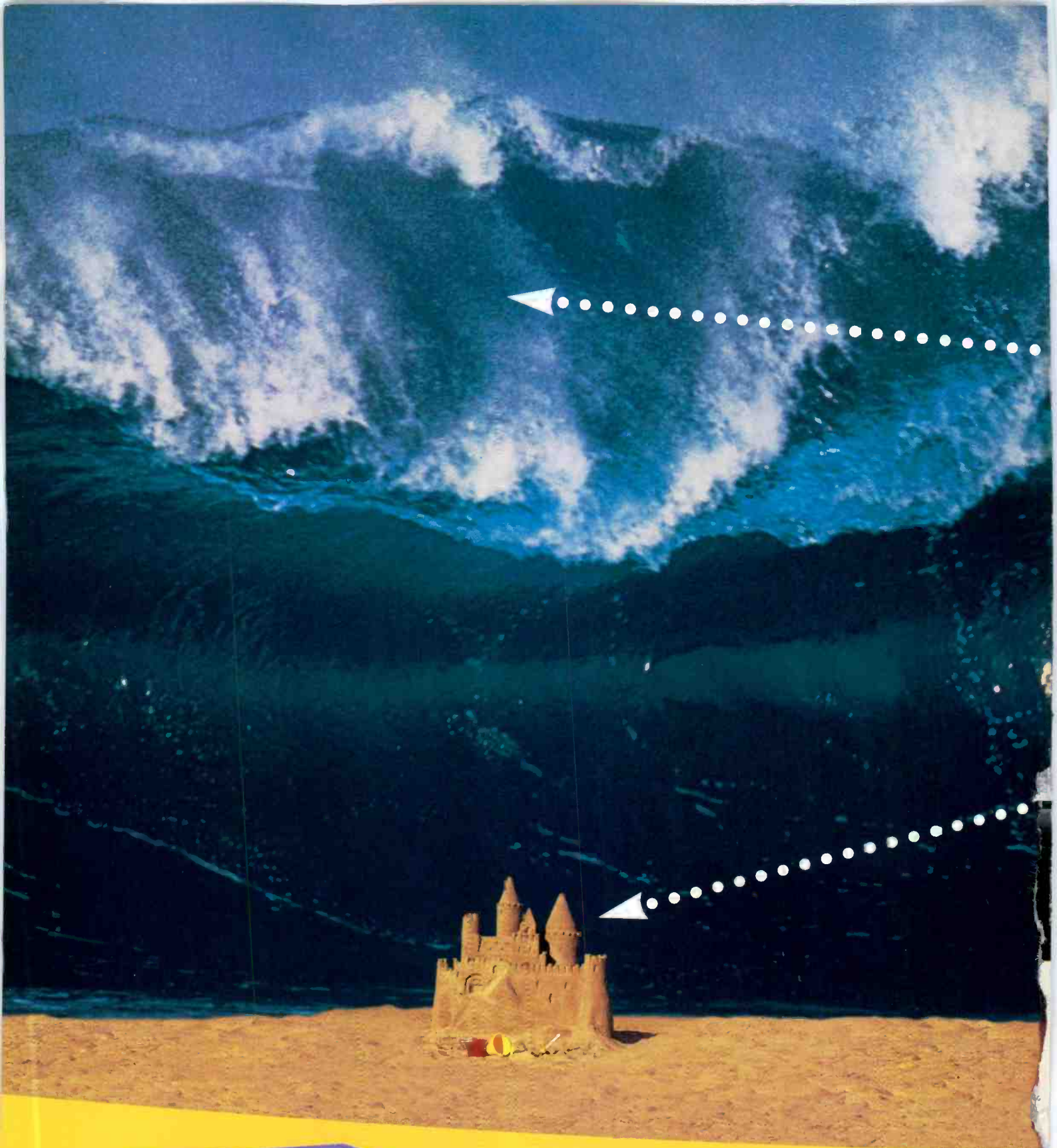

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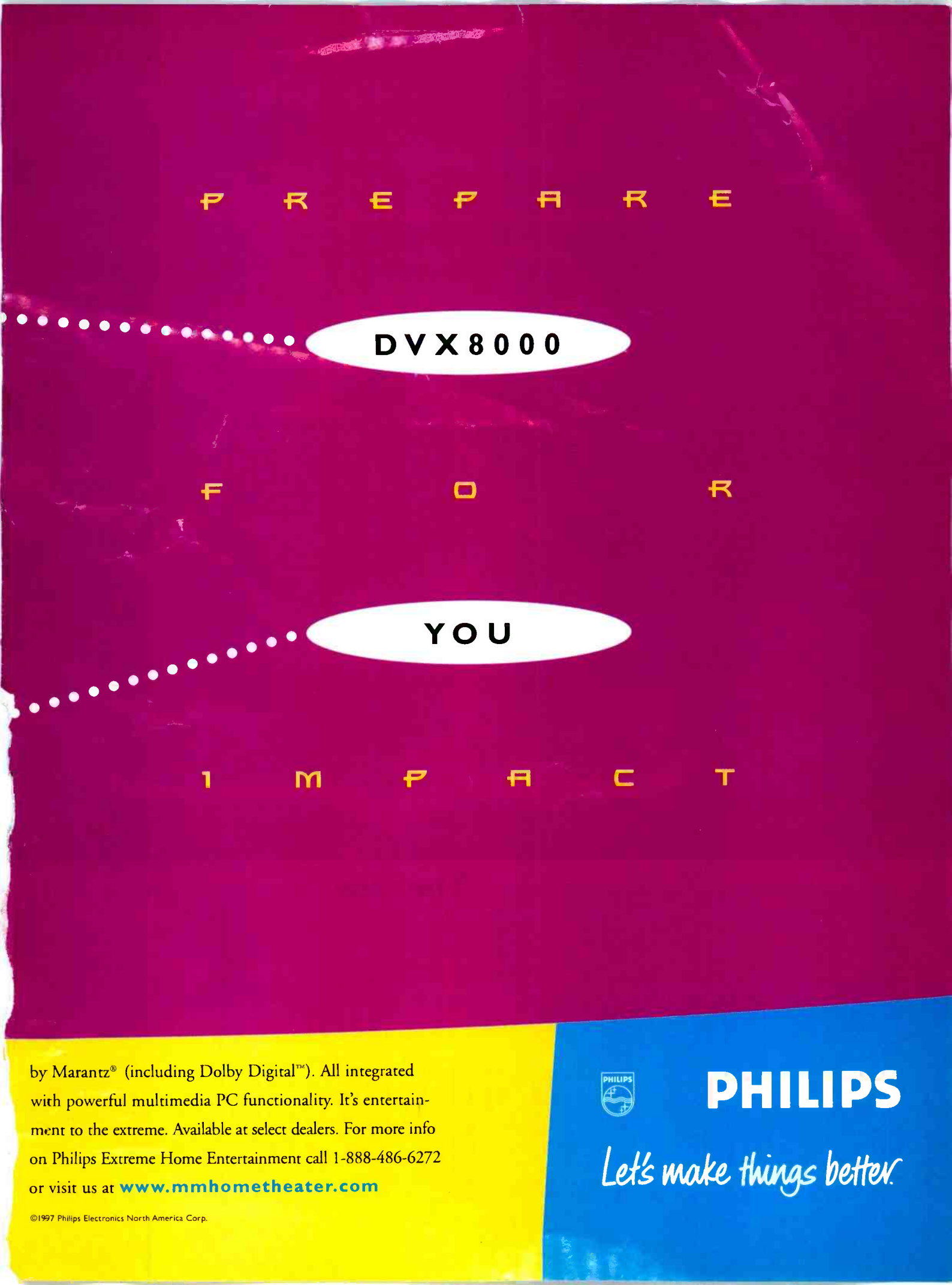

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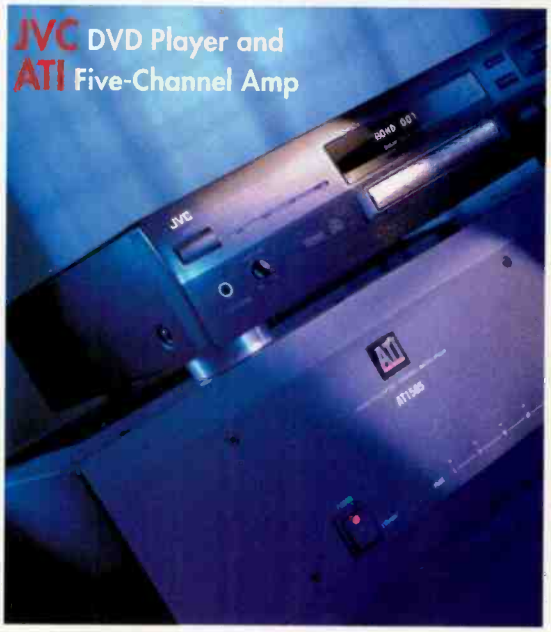

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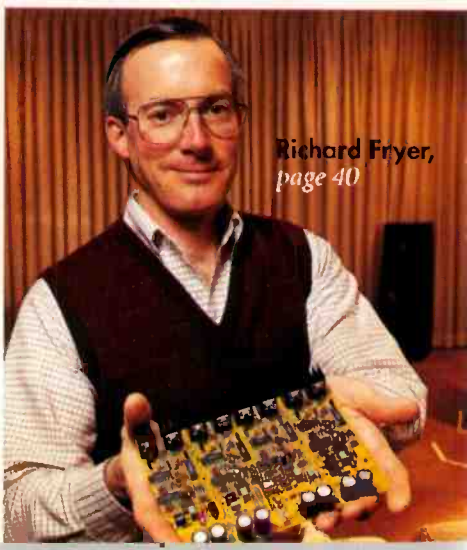

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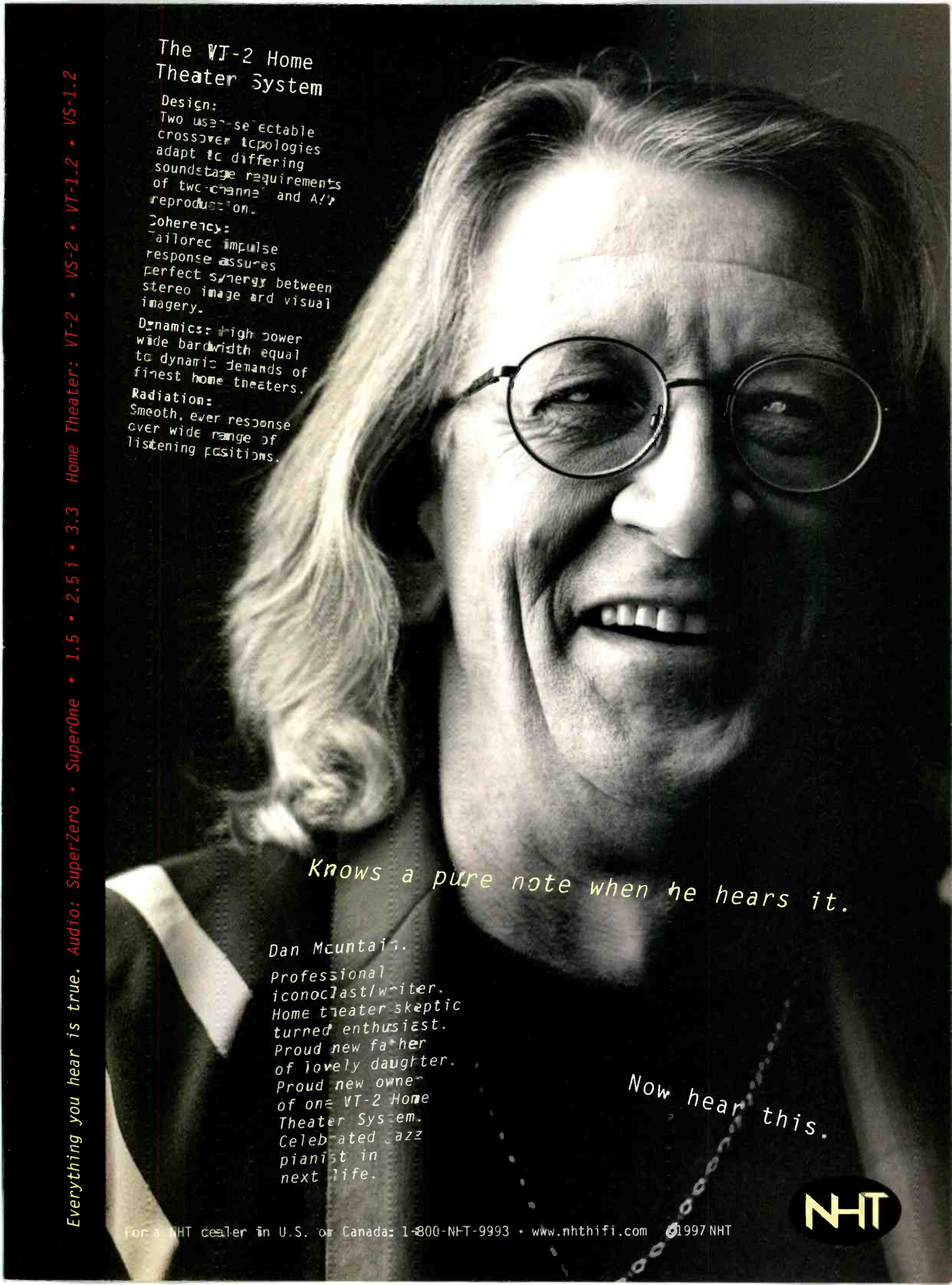
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FAST FORE-WORD

Although we saw many new products at this year's Consumer Electronics Show, it was, more than usual, a show of the future. The biggest news was digital television (DTV), set to begin a long, long rollout late this year. But there were also signs of progress on DVD-Audio, which is unquestionably the most important current initiative in the field of high-fidelity sound reproduction. And given the speed at which it now seems to be moving, I expect we will be following the subject closely throughout the year.

In January, John Eargle reported on the Sony/Philips proposal for DVD-Audio. This issue, we feature the first half of a two-part article by Meridian's Bob Stuart on the subject of high-quality digital audio coding—specifically, how to make best use of the very large data storage capacity afforded by DVD discs. He feels very strongly that DVD-Audio, properly implemented, offers an unprecedented opportunity for a music distribution format that can guarantee completely transparent audio channels for all signals and all human listeners together with much more realistic, three-dimensional spatial presentation than is possible with today's two-channel media. I very much agree. The problem is getting everyone on the same barge regarding how to do it. DVD-Audio is probably the last important new high-fidelity audio format that will come our way for many years, so it's important to get it right. Thus far, Bob's proposal is the most sensible out I've encountered.

Unfortunately, it probably won't be adopted—at least, not in toto. At CES I met with representatives of the DVD Forum's Working Group 4 (WG-4), which has responsibility for drafting the DVD-Audio standard. They outlined the proposal the committee currently is circulating for comment among DVD Forum member companies. WG-4 hopes to have a "0.9" version of the standard ready in February and a final version 1.0 in May.

The committee proposes to mandate use of as many as six PCM audio channels, which could operate at sampling rates of 44.1, 48, 88.2, or 96 kHz using word lengths of 16 to 24 bits. So you could have a very long 16-bit, 44.1-kHz, mono disc, a relatively short 24-bit, 96-kHz, six-channel disc, or any combination in between—including different sampling rates and word lengths for different channels. (There would also be provision for automated multichannel-to-two-channel downmixing according to parameters set by the artist or producer.) Essentially, this would be a superset of the PCM specifications for DVD-Video, which raises the possibility of limited backward compatibility with current DVD players. (And if a Dolby Digital version were included along with the PCM, compatibility could be guaranteed! It would be easy to fit.)

So far, it sounds pretty good, though as Stuart points out, 24-bit coding is both wasteful and potentially inimical to sonic integrity. And unless some sort of (preferably lossless) compression is used, the high sampling rates are real pit hogs as well. This is where the disappointment sets in: WG-4 says it will not specify any compression scheme. The reason? Not politically feasible. What that means is that the committee has no hope of getting everyone to agree on a particular compression system; everybody will pull in a different direction, lobbying for proprietary systems that they can charge the others licensing fees to use. It's not a fatal flaw, but it will significantly limit the format's flexibility.

A somewhat paler cloud over the enterprise is what the committee calls the disc's optional zone. Basically, disc capacity remaining after a producer has fulfilled his PCM requirement (which doesn't have to amount to much) is up for grabs. You can put anything you want in this slack area. It's another big-tent strategy, designed to win over those who would prefer something other than linear PCM coding. But having had a foretaste of this approach in DVD-Video's provisions for optional audio formats, I'm left uneasy. It opens the door to a lot of unproductive dissension and consumer confusion without yielding much of anything in return except stray marketing opportunities.

And what about a Red Book CD layer for backward compatibility with regular CD players? Also not required, says WG-4, because the committee doesn't think anyone currently can guarantee that such dual-layer discs would work in all CD players. But it could become an option if the technology can be made reliable. I have to agree on this point.

Where do we stand? I think that at worst we'll get a music medium much better than any we've had before. It's hard to be too unhappy about that, even if it turns out not to be absolutely optimum.

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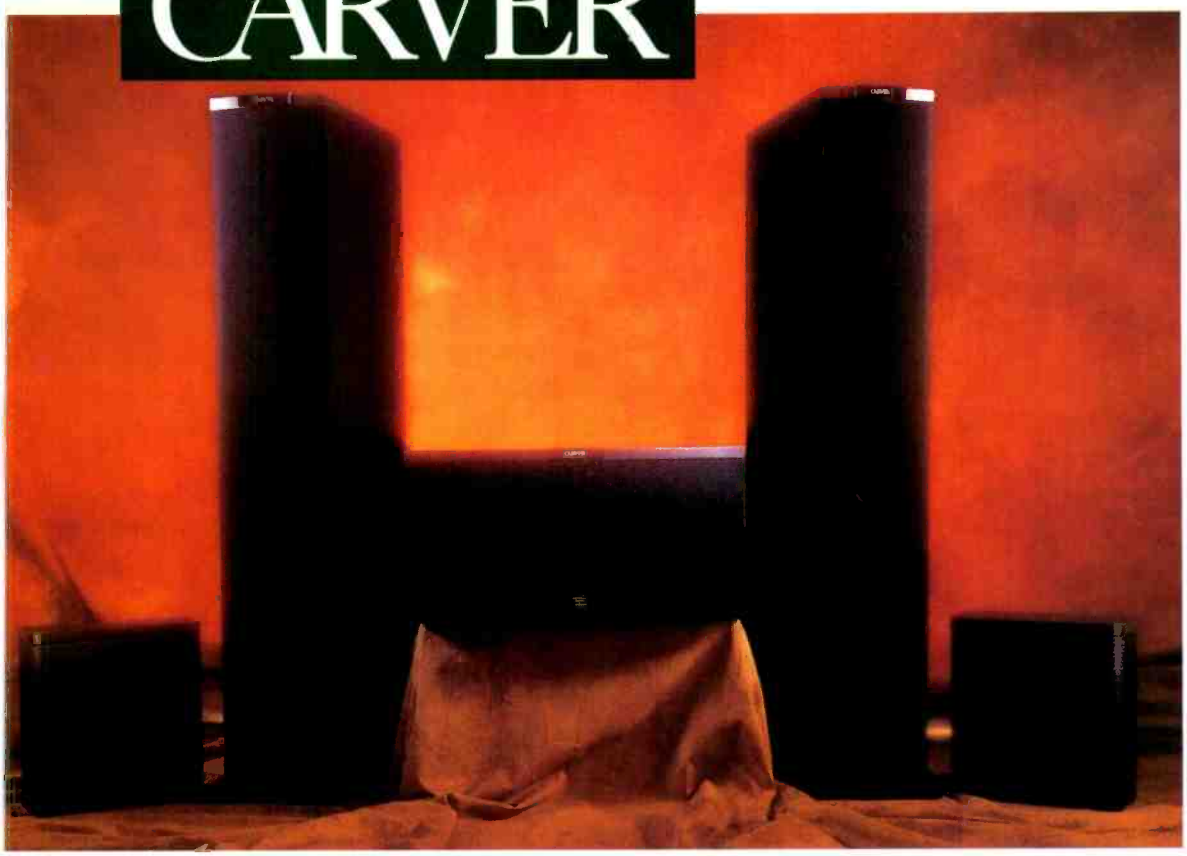

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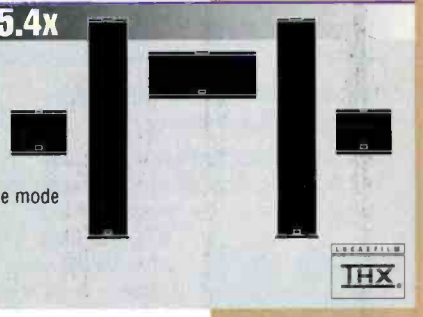

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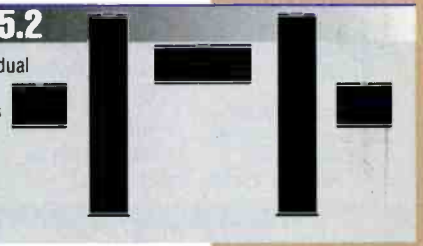

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LETTERS

Bluegrass Wine

Dear Editor:

Regarding Rob Patterson's review of Alison Krauss and Union Station's *So Long So Wrong* (September 1997), I liken a music critic to a wine taster—notice the absence here of the word "expert," as "taster" implies nothing more than something that is to be tasted. It is at this point that every taster is a critic, which implies nothing more than deciding if something tastes great, good, okay, not so good, or downright terrible.

I don't recall a wine expert comparing a white wine to a red wine other than to put the two types in different categories to go with different foods. If the critic doesn't care for red wine, he might rate it an F compared to white wine; it's strictly an opinion based on personal preference and has nothing to do with quality.

The same goes for music. If I happen to prefer jazz to hard rock, I may have some bias against hard rock and rate jazz higher. And, likewise, with bluegrass. If I like country more than bluegrass or have a limited knowledge of bluegrass, I might not be able to give an unbiased opinion about it.

Critics have to remember that bluegrass is a style of music and that they need to make comparisons and base their ratings on what is expected within this music genre. I don't know of any rules for how many people have to be in the group or how many people have to sing, nor is there any restriction as to who it is that takes a solo. Compare bluegrass players to other bluegrass players and then make your rating. If you don't care for this style of music, you shouldn't be listening to it.

Charles G. Bockius
via e-mail

Dear Editor:

I take exception to Rob Patterson's characterization of Union Station band members Dan Tyminski and Ron Block as undistinguished singers. Although they may not have the finesse and generic softness that the public has grown used to in recent years, their vocal expression is every bit as effective, and arguably more effective, than Krauss's. Her sound has always been a band sound, and the fact that she guards that aspect of her career is more than a little admirable. It's time more musicians played music for the sake of playing *music*, not for the sake of pacifying the masses.

Mike Drudge
Class Act Entertainment
via e-mail

Dear Editor:

I read Rob Patterson's review of *So Long So Wrong*, and I'm still quivering with laughter! I never get enough of people who think they have bluegrass music figured out. Sorry, Rob, but you are *sooo* wrong. . .so long!

B. Bierhaus
via e-mail

Divx-Free Zone

Dear Editor:

I very much liked and appreciated Michael Riggs's negative response to Divx ("Fast Fore-Word," November 1997). Maybe you could start up a "Just Say No to Divx" update monthly.

Ron Hutchinson
Earlville, Ill.

Watts Up with the Sunfire?

Dear Editor:

I was honored when I learned that Don Keele would test and review my Sunfire True Subwoofer Mark II for *Audio* (November 1997). By reputation, I've known Don to be a true scientist, gentleman, and scholar. Indeed, my own testing methods were derived from his teachings, as evidenced in the *Journal of the Audio Engineering Society*.

My favorite passages in the review were: " 'Honey. . .is there a big truck in the driveway? Or are you just making that rumbling noise?' (Nope, just a Sunfire True Subwoofer)"; "Its built-in amplifier is clearly capable of 2.5 kilowatts of continuous sine wave power"; "The cone excursions and the forces they produce are downright scary";

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AudioVideo Shopper

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How does it work? It operates as two separate speakers: one a point source direct radiator with a 5 1/4" woofer and 1" tweeter, and the other a dipole with two 3 1/4" poly mid-tweeters. It has two main user-selectable modes: THX dipole or Tripole, plus six custom modes to suit the needs of any program material or room. You can even alternate between modes with a remote switcher!

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and "Few subs produce louder bass than the Sunfire, and none goes deeper." I could not ask for any greater acknowledgment or appreciation.

There are a couple of points that need clarification. The results in Table I, which showed my woofer as having almost 138% distortion at 20 Hz, were derived when Don drove the subwoofer's built-in amplifier really hard (for a good reason), calling on it to deliver 2,500,000 watts! Now, Bob's my name, and amps are my game, but 2 million watts? That's a bit much, even for one of *my* amplifiers. I think Don meant to illustrate the soft overload characteristic by overdriving it 30 dB. In any event, his intent wasn't clear because it wasn't fully explained in the table caption or accompanying text.

Regarding the Sunfire's slightly reduced output above 40 Hz, the subs that I sent to Don had their output above 40 Hz attenuated because I was just starting the changeover to the Mark II version and, for the life of me, couldn't get the new Mark II drivers to operate at full output above 40 Hz without introducing a terrible mechanical noise. Because of *Audio*'s publishing deadline, I sent off the brand-new Mark II, but with its output above 40 Hz intentionally pulled back. Within a matter of several weeks, I identified the source of the trouble (a misaligned pole piece) and corrected it. Not a single unit left this factory unable to deliver full output above 40 Hz, except the units I sent to Don. I goofed.

As I read over what I just wrote, I can't help but be struck with how intense and extreme I feel about this world of audio. Perhaps someday I will, at last, become a grownup.

Thanks to Don Keele for taking readers on a truly remarkable journey into the inner workings of my True Subwoofer.

Bob Carver
President, Sunfire Corporation
Snohomish, Wash.

A Good Bleating

Dear Editor:

In your January "Letters," reader Oliver Berliner takes to task an earlier correspondent, George Nussbaum, for suggesting that a graphic equalizer can duplicate those qualities certain producers and end-users cherish in tube amps. Berliner wrote, "Who in his right mind would want to manipulate the sound, to say nothing of introducing a distortion and noise-producing device into the system, with the effect of degrading it, in order to make it sound more lifelike?" Who indeed?

My compliments to Mr. Berliner for so succinct a characterization of what, in general, tubes contribute to euphonious distortions. An inadvertently amusing quotation aside, Berliner's stale condemnation of post-nostalgic technology collapses under the weight of contradictory evidence. Will these sentimental bleatings ever subside?

Mike Silverton
Brooklyn, N.Y.

A Current Affair

Dear Editor:

In Anthony H. Cordesman's "Auricle" on the Cinepro 3k6SE six-channel amplifier (January), he wrote, "The amp can work quite well with the 15-ampere 110-volt cir-

cuits found in virtually all homes and apartments."

I highly recommend that any incoming line voltage to your home or apartment be tested by a competent electrician. This testing should be done prior to your electricity going through any power-conditioning equipment that you may use, such as overvoltage/undervoltage protection, etc. Or you can call your electric company to find out the normal voltage supplied in your area. No supplier that I know of provides less than the normal 120-volt service. (Fluctuations will occur because of many variables, of course.)

Certainly, some old, small electric companies may still be providing 115-volt service, but I don't consider them to be anything more than a major minority.

Rodney G. Williams
Pipe Creek, Tex.

Fuzzy Logic

Dear Editor:

On the back cover of your December 1997 issue is an ad for a surround-type preamp by Lexicon. Part of the ad copy reads, "DSP runs Logic 7, the digital surround technology the critics are raving about."

I am unfamiliar with Logic 7. Apparently, it is much better than standard Dolby Surround processing. I must have inadvertently missed the issue of *Audio* that presented a clear explanation of Logic 7 and its virtues. Which issue was that? Do you intend to discuss the subject further?

Charles Willoughby
Naples, Fla.

Editor's Reply: Logic 7 is discussed briefly in Edward J. Foster's review of the Lexicon DC-1/THX in the May 1996 issue. When used to decode Dolby Surround-encoded material, Logic 7 provides independent steering of the left and right surround outputs, effectively providing stereo surround output from Dolby Surround's mono surround channel. The system also allows for use of one or two separately driven rear speakers in addition to the usual side surround speakers, with full steering of signals between the side and rear surrounds. And the surround outputs can be set for more extended high-frequency response than is provided by standard Dolby Pro Logic decoding. The overall result is a more enveloping surround sound field and more realistic panning of sounds from front to back or back to front. Logic 7 is also the basis for the DC-1's very effective "Music Surround" mode and, in a system with both side and rear surround speakers, can even enhance the surround performance of discrete 5.1-channel formats, such as Dolby Digital or DTS. Finally, it can be used to decode Logic 7-*encoded* material with directional accuracy and spatial realism approaching that of the discrete-channel surround systems.—*M.R.*

Mythogynist

Dear Editor:

Charles Butler's list of 21 audio myths ("Letters," December 1997) establishes one fact:

1. Charles Butler is *not* an audiophile.

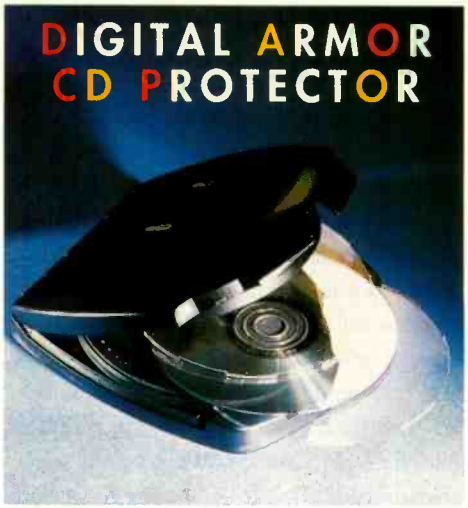
Leland A. Beaman
Vacaville, Cal.

WHAT'S NEW

Yamaha A/V Receiver

Dolby Digital (AC-3) decoding and proprietary Tri-Field Cinema DSP Processing are handled by separate IC chips in the RX-V793, which has a total of 13 music and movie theater ambience modes. The built-in amplifiers have low-impedance drive capability and provide 80 watts to each of five channels. Four A/V inputs (two with S-video jacks) and four audio inputs are included, and the AM/FM section tunes and sets the 40 strongest stations in your area. The elaborate learning remote has 13 macro-command functions and luminescent controls for reading in dim light. Price: $799. *(Yamaha, 714/522-9105)*

DIGITAL ARMOR CD PROTECTOR



When Compact Discs are roughly handled—say, in a car—the risk of abrasion and scratches increases. The CD Armor Install kit consists of a sandwich-like applicator that fastens an optically clear, polymer shield to each side of a CD by means of interlocking clasps, thereby protecting both sides of the disc. It is said to resist rugged mishandling; should damage occur, the shield can be removed and replaced for 50¢. The shielded disc is claimed to be compatible with most single- and multi-disc players and changers. The kit includes the applicator and six shield sets. Price: $19.95. *(Digital Armor, 403/265-7225)*

ARCANE AUDIO LABS MONO AMP

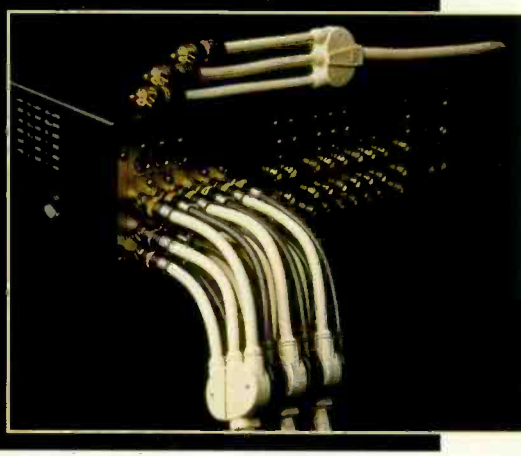
The Initiation II, a solid-state, single-ended, Class-A monaural power amp, is intended for lovers of tube components who are weary of their maintenance requirements. Rated at 30 watts into 8 ohms (36 watts into 4 ohms), the amp is said to use minimalist circuitry and enormous filter banks. The 3-dB-down points are specified at 0 Hz and 200 kHz, input sensitivity at 0.95 volt, and input impedance at 17 kilohms. Price: $2,600 per pair. *(Arcane Audio Labs, 919/848-3866)*

WRIGHT INTEGRATED AMP

Because the 16-I is a single-ended, low-feedback, Class-A design with just two tubes per channel in the signal path, Wright Audio claims it will deliver exceedingly transparent sound. Using 5881/6L6 tubes operated in partial triode mode, the amp is rated at 8 watts, peak, per channel into loads of 6 to 8 ohms. Matched-channel bass and treble controls are intended to compensate for the frequency response rolloff inherent in single-ended amps. The 16-I accepts two line-level inputs. Price: $750. *(Wright Audio, 541/343-1413)*

MONSTER CABLE A/V POD

As A/V systems become increasingly elaborate, so does the tangled nest of cables behind them. The Monster Home Theatre A/V Pod, which combines a pair of stereo audio cables and a video cable in one unit, is intended to help straighten things out. The Pod's stacking and locking mechanism enables multiple Pods to be interlocked for better cable management. Interlink 203 A/V Pod (I203 AVP) is available in white or charcoal gray. Price: $24.95 to $79.95, depending on length. *(Monster Cable, 415/871-6000)*



"Bravo, Bryston! A landmark...a reference...a triumph...a steal!" *Stereophile, May 1997*

B-60 Integrated Amplifier

The remarkably compact, Bryston B-60 Integrated Amplifier provides 60 watts per channel at 8 ohms and 100 watts per channel at 4 ohms. There are provisions for four high level inputs, (CD, Tuner, Video and Aux) in addition to one tape loop and a pre-out/main-in feature. A headphone jack is also provided.

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BRYSTON

WHAT'S NEW

CERWIN-VEGA SPEAKER

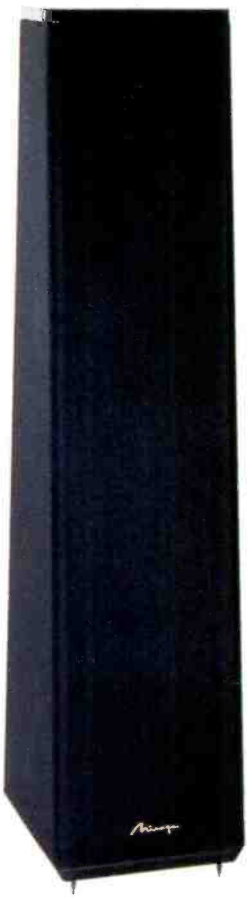
You can separately adjust tweeter and midrange output levels by using controls on the front of the E•312, a three-way ported speaker with rated sensitivity of 98 dB. The 12-inch woofer has a die-cast aluminum frame for good heat dissipation, and the 1-inch E-polymer soft-dome tweeter has a self-resetting protection circuit. Power handling is rated at 300 watts and frequency range at 28 Hz to 20 kHz. Price: $365 each. *(Cerwin-Vega, 805/584-9332)*

Polk Powered Subwoofer

According to Polk, two important benefits accrue from using a downward-firing, 8-inch driver in the PSW120: The floor provides a large baffle close to the driver for more consistent, high-output bass, and it dissipates any residual midrange information, thus impeding localization of the sub. The frequency range is specified as 35 to 150 Hz. Features include an internal 90-watt amplifier, speaker- and line-level inputs, a variable low-pass filter, and auto on/off circuitry. Price: $339. *(Polk Audio, 800/377-7655)*

NHT SPEAKER

Said to be identical in specs and sound quality to its wood/laminate-cabinet cousin, the SuperOne Xu (short for "Xtended use") has a thermoplastic enclosure. A rubber horseshoe base (the XuBase) enables the speaker to be placed and angled vertically or horizontally, and the XuBracket, a custom mounting bracket, is included at no extra cost. The SuperOne Xu is a two-way, acoustic-suspension system using a 6½-inch shielded woofer and a 1-inch soft-dome tweeter. Price: $375 per pair. *(Now Hear This, 800/648-9993)*

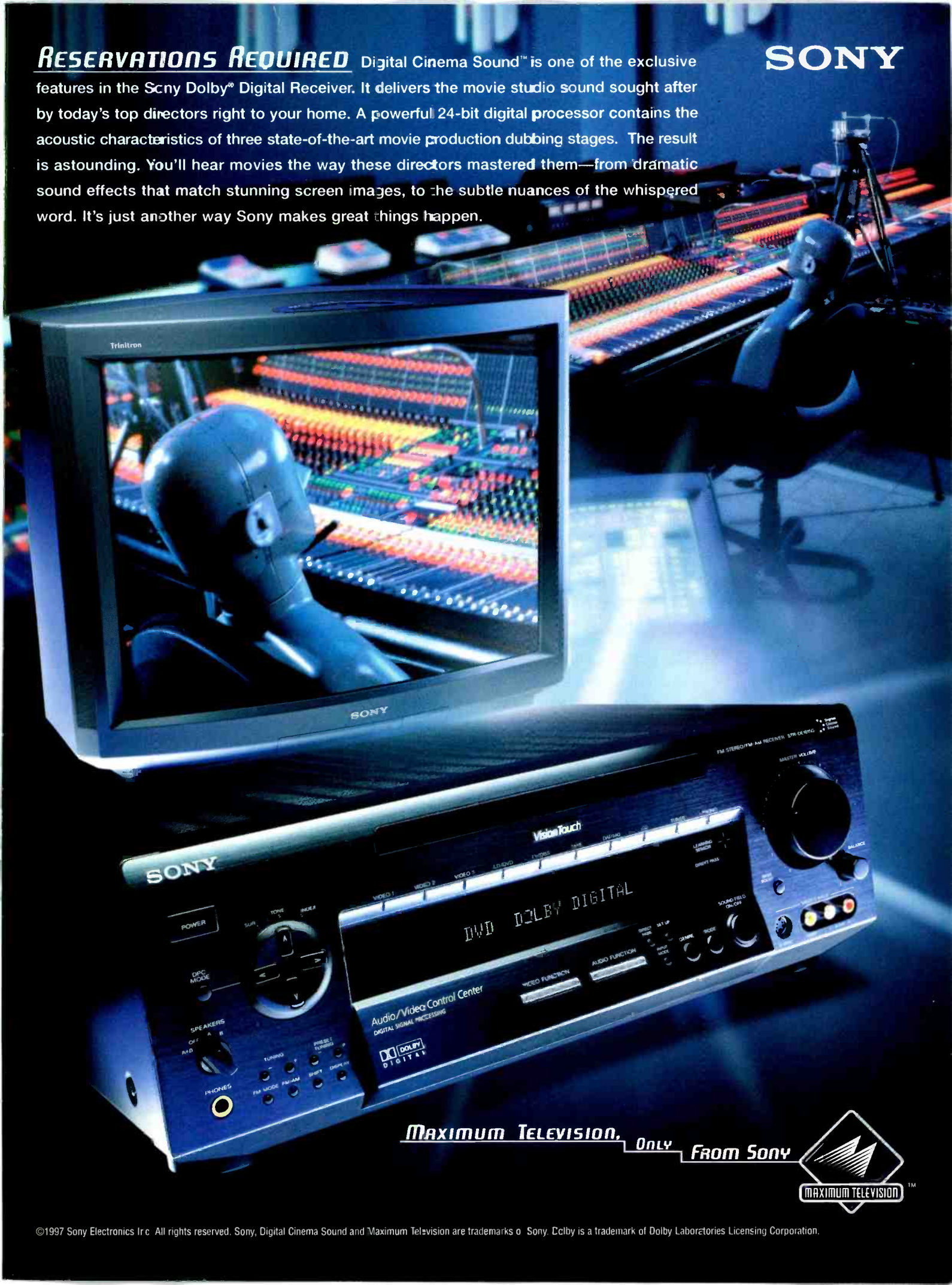


MIRAGE SPEAKER

Wide-dispersion tweeters placed opposite one another, near the shallow top of the OM-12's tapered cabinet, are said to give the speaker a uniform, cylindrical, omnidirectional radiation pattern with a sense of space and depth that surpasses that of traditional bipolar designs. A two-way vented system standing about 40 inches tall, the OM-12 uses two 1-inch titanium-dome tweeters and two 5½-inch polypropylene-cone woofers. Frequency range is specified at 32 Hz to 22 kHz. Price: $900 per pair. *(Mirage, c/o Audio Products International, 416/321-1800)*

Bose Home Theater System

The Lifestyle 8 provides a complete home theater audio system. Besides five diminutive, identical cube speakers (for main-, center-, and surround-channel duties) and an Acoustimass bass module with built-in amplification, the system includes a Lifestyle music center with an RF remote that operates through walls and floors. The music center contains a CD player, proprietary Bose Videostage steering ciruitry for decoding surround movies and enhancing stereo audio, and an FM tuner. Price: $1,500, in black or white. *(Bose, 800/444-2673)*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AUDIO CLINIC

JOSEPH GIOVANELLI

Mystery Switch

Q *I own several Sony Beta VCRs that I believe have PCM [pulse-code modulation] digital recording circuitry. There is a switch marked "PCM," but I have no idea what its purpose is. Should it be engaged during record and playback? Should it be used to play tapes that were originally recorded when the switch was not engaged? My owners' manuals for the VCRs are of no help.*—Bishop T. Hunt, Charleston, S.C.

A The PCM switch enables your Beta VCR to be used with external PCM digital adaptors, such as the Sony PCM-F1 and PCM-F701ES, which were available during the years when the Beta format was popular. The switch, when engaged, disconnects some of the VCR's video processing circuitry that isn't required in the PCM digital recording mode. In essence, it "purifies" the video pathway to receive the PCM bitstream from the external adaptor.

To my knowledge, no Sony Beta VCRs had built-in PCM digital recording circuitry, although there were several Toshiba Beta machines that included it. If you use one of the PCM adaptors, the switch should be engaged during recording and playback of PCM digital audio recordings; turn it off to play conventional Beta videotapes.

Recording Lectures

In the March 1995 "Audioclinic," you gave advice on cleaning up poorly made lecture recordings. One reason lecture recordings are often poor is that you rarely can put mikes on stage or use stands. I have found that a single PZM microphone right at the juncture of the floor and the front wall of the hall, dead center, works wonders! Even though the mike is on the floor, the recording sounds as though the mike were right in front of the lecturer. When recording female lecturers, raising the mike about a foot from the floor seems to work a bit better. If you give it a try, I think you'll be impressed.—Norman Strong, Seattle, Wash.

I've also used PZMs successfully when recording airplanes at an air show, placing the microphone on the grass. My only problem was a loud squeak that developed in one channel; I cured it by shaking out the cricket that had hopped into the mike.—*I.B.*

Cheap vs. Pricey Microphones

Q *About 15 years ago, I began making live recordings of community choirs. I've always used good equipment: Revox open-reel machines and, more recently, DAT recorders. Until lately, I used battery-powered electret mikes that were not very expensive. My recordings sounded quite good to me and to others. However, recently I upgraded to very expensive and well-known microphones, a mixer, and a professional DAT recorder. I've found no difference in sound between the old electret mikes and the new pro models. In fact, the old mikes have a little brighter response. I can make them sound the same as the new ones by using my equalizer to decrease the treble. Do you have any thoughts on this? I have never seen anything in* Audio *on this topic.*—G. J. Hubbell, Lafayette, La.

A Most condenser mikes that I've used in my work as a recording engineer were "hot" in the highs. Typical condenser mikes (especially inexpensive electrets) tend to yield a rising high-frequency response with a peak in the region of 8 to 10 kHz. This gives the illusion of really good highs. In reality, such microphones' response may rapidly roll off above the peak. More expensive condenser mikes commonly exhibit less of this rise in the treble than cheaper models. A microphone with a smoother, flatter frequency response may sound dull after you've been accustomed to hearing the bright treble of less expensive mikes.

It's also likely your expensive mikes cover a wider frequency range than the cheaper ones. For example, how well do your cheaper mikes record low organ pedal tones? Is the midrange smooth and effortless? Is the soundstage as good? It is quite amazing how a smooth frequency response can improve the soundstage and open up the sonic environment!

I also have found that cheaper electret condenser mikes tend to generate greater internal background noise than more expensive mikes. This might not be evident in orchestral recordings, but it will be apparent when you're recording soft choral music and other quiet programs. Moreover, cheaper mikes are usually unbalanced, which makes them susceptible to hum pickup and radio frequency interference in some locations. (Based on my practical experience, I recommend that you never use an unbalanced mike in any venue with which you are unfamiliar.)

It's no surprise that you see little written about microphones; these days, only a few dedicated audiophiles record live performances, because there are so many restrictions on doing it. And that's a shame, as it has resulted in the loss of what used to be an interesting part of the audio hobby. To underscore this, except for semipro and portable DAT recorders, microphone inputs have largely been eliminated on consumer tape recorders. There was a time when no recorder would be without them.

Unusual Receiver Use

Q *My receiver's front channels are rated at 100 watts each and the surround channels at 50 watts each. My front-channel speakers need more power, so I connected a large separate power amp to the pre-out terminals for the front channels and bypassed the receiver's built-in 100-watt amplifier. I want to use the main-in terminals of the built-in amp (originally intended to drive the front channels) to power the surround channels, but the maker of the receiver says I shouldn't. I understand that this is not the usual use for pre-out/main-in terminals, but why shouldn't it work? If this idea proves impractical, all is not lost. I could still use the built-in amplifier to biamp my front speakers. I can probably use the low-pass filtered output from the receiver to drive the more powerful separate amplifier, which, in turn, would drive the woofers in the front speakers. The original amplifier could then be used for*

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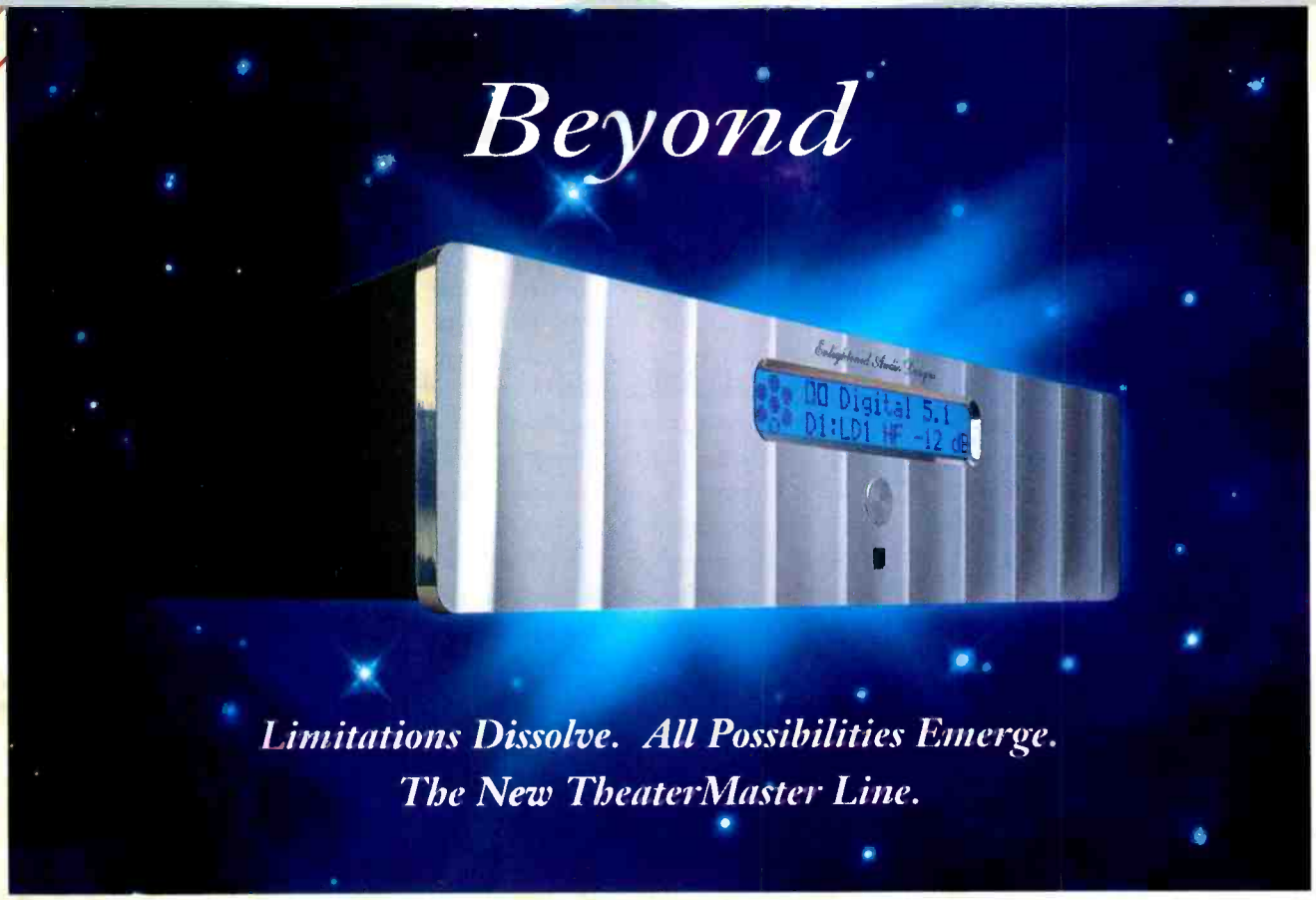

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the rest of the drivers in the front-channel speakers.—Name withheld

A Unless there is some common-coupling problem in the power-supply section of your receiver, I don't see why you can't use what are normally the front-channel amplifiers to power the surround speakers. If you try it, watch for sudden oscillations as you increase the volume to the desired level. Such oscillations could be severe enough to blow tweeters or speaker fuses or to force the protection circuitry of your equipment to shut down the receiver.

I do not expect any snags. I suppose that, as the receiver ages and bypass capacitors degrade, these problems could occur, but I doubt they will.

If you decide to use the alternative arrangement whereby you biamp your front speakers, I see no problem in doing this so long as the front speakers have the appropriate sets of binding posts for biamping. In my opinion, you have thought all of this out very well.

What's the Tweeter Eater?

Q *My new audio system has destroyed four tweeters in my right-channel speaker. The dealer suggested I place a fuse in the line to the speakers, but this didn't help. Then he installed some kind of transistor circuit in the tweeter crossover. I still have blown tweeters. Unfortunately, the speakers (and replacement tweeters) are no longer sold here. Several specialists say my amp has too little power. Sometimes I have to turn the volume control to its 1 o'clock position to get enough volume. Could the crossover network be the problem?*—William T. l'Heureux, Jr., Winter Park, Fla.

A Lacking the specifications for your components, I have no way of knowing whether your amplifier is too powerful for your speakers. I can tell you, however, that if your amplifier has *less* power than your speakers need to play at very high levels and you listen at loud volumes, you stand a chance of producing amplifier clipping, which can damage tweeters. Transient peaks will break through most protection systems, so they are of little value, especially for tweeter protection. Tweeters will not handle nearly as much power as the whole speaker system. As a rule, the high-frequency content of most programs won't cause trouble. But once the amplifier is driven into clipping, a tremendous amount of power may get through to the tweeter, possibly destroying it.

The fact that the problem always occurs in the right channel suggests that your amp's right channel is oscillating at some ultrasonic frequency or, more likely, your right-channel speaker's crossover is no longer keeping low frequencies out of the tweeter. (Excessive drive near the crossover frequency is the most common cause of tweeter failure.) Before you replace any more tweeters, find out which is the case.

To check the crossover, get a 1-watt (or larger) resistor that matches your tweeters' impedance (e.g., 4 or 8 ohms), temporarily wire it in place of one tweeter, and connect a voltmeter across the resistor. Play frequency-response test tones from a CD, and note the frequency at which the crossover's output starts to rise and the frequency at which it stops rising. Repeat this on the other speaker, and see if its crossover output is a reasonably close match.

If it is, have your amp tested to see if something is amiss in its right channel. Or connect an oscilloscope across the amp's left-channel and right-channel "hot" terminals and play a mono signal into your speakers at high volume. If your amp is free of oscillation, you should see a circle, oval, or straight line on the 'scope.

Stacking CDs

Q *Would a CD suffer damage if its playing side (the bottom) were to touch the label side of another disc? I want to stack at least two discs in a jewel box meant for a single CD. If you pop out the black holder with the disc clamp, you can accommodate three or four CDs in a jewel box.*—Anthony Hudaverdi, Santa Monica, Cal.

A No damage will result if the surfaces of the discs make *gentle* contact. Nevertheless, I don't recommend this practice. The damage will occur when you need to remove two or three discs to get to the one on the bottom. It's all too easy to bang the discs together or get fingerprints on them. And where will you keep the CD booklets? The discs may fit into the jewel box, but the notes won't. In the long run, the cost of jewel boxes designed to store two CDs will be considerably less than having to replace discs that might be irreparably damaged by stacking. A

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IVAN BERGER

BENIGN BURNOUT

Illustration: Beata Szpura

You can already buy movies on DVD for a modest $20 or so and rent them for considerably less. Soon, you may be able to buy low-priced rental discs that can be discarded after a few plays, saving the return trip to the store.

But they won't necessarily be the controversial Divx discs—not, that is, if Hide & Seek Technologies (www.hideseek.com) has anything to say about it. The Divx discs (see "Fast Fore-Word," November 1997) will require dedicated players costing about $150 to $300 more than standard DVD machines. (Tough luck if you've already bought a DVD player!) The Hide & Seek discs, on the other hand, should be compatible with any DVD player ever made.

There are two versions of the Hide & Seek technology: One makes the disc unplayable after a predetermined number of days, and the other limits the number of times you can play it. Both rely on special polymer disc coatings.

The polymer for the time-limit technology, which could also be used with CD and laserdisc, darkens once exposed to air. How long it takes for a disc to darken varies according to air density. ("We get about a 5% advantage at our mile-high altitude," said Dennis Dubé, Hide & Seek's Chief Operating Officer, from the company's Nederland, Colorado, headquarters.) Each disc would be shipped in an airtight bag and start oxidizing only when you open it. Unlike Divx discs, these can be used in as many players as you like before they self-destruct.

The play-limited disc works differently. Its polymer is darkened by the laser beam from a player's read head. Each full play will create a "disc mark" by initiating a reaction in a section of the polymer coating. The disc is designed to disallow further plays after a certain number of marks has accumulated. The polymer's molecules are tuned to the laser light's frequency, which prevents accidental darkening by ambient indoor light. (Direct sunlight might darken the disc, however, a problem Hide & Seek is attempting to overcome.) The disc-mark approach will not work for audio CDs, because it requires that a player follow software instructions on the disc to search out and count the marks, which CD players cannot do. But it should work for audio or movie DVDs and for CD-ROM and DVD-ROM computer software, because DVD players and computer drives do have that ability.

Hide & Seek's technology gets around many of the problems posed by Divx. Consumers would save the added cost of a Divx player and be spared the nuisance and expense of connecting it to a telephone line for rental renewals. This should also allay anxieties associated with the Divx central computer's careful record of what discs you watch. The only problems the Hide & Seek approaches share with Divx are the addition of yet one more disposable, nonbiodegradable item to the environment and, for video rental stores, a decrease in repeat business because customers needn't come back to return discs. Both could be addressed by having customers return used discs to the store for recycling, probably with retailers offering an incentive (such as a discount on future rentals). And if you decide to extend your rental time or want the disc to be permanently playable, it could theoretically be refreshed by a machine at the video store.

Patents are still pending, but the technology is ready to roll. How close is it to production? Says Hide & Seek's Dubé, "We're just one good investor away." A

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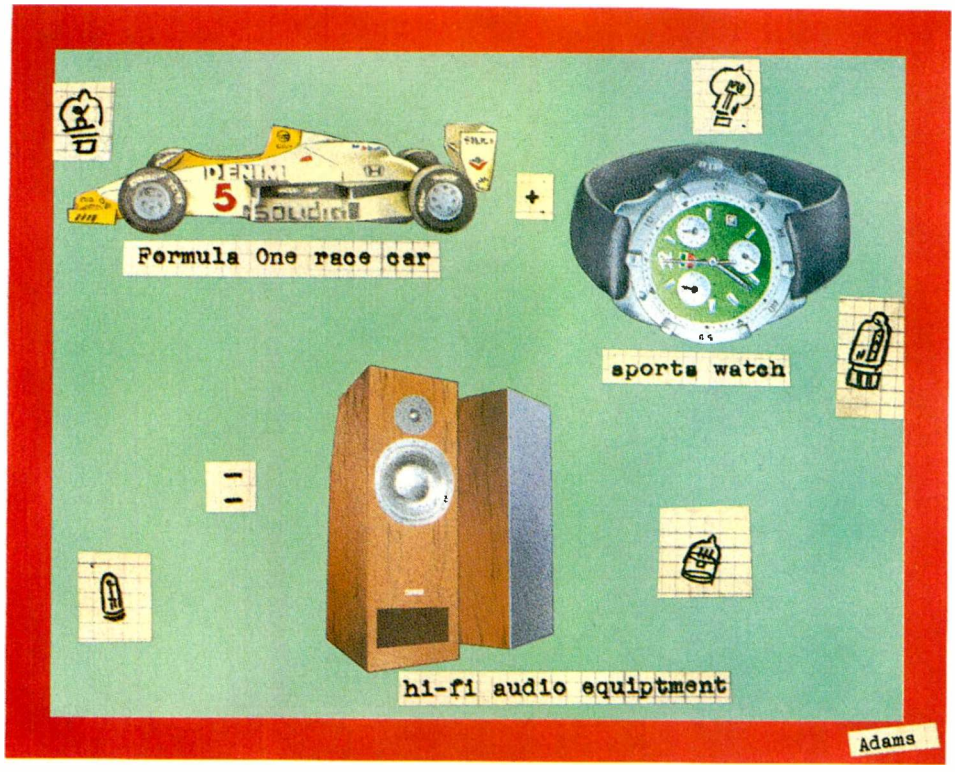

Illustration: Lisa Adams

If hi-fi manufacturers are going to play games, then perhaps musical chairs is the most appropriate. And no one plays games like the British, especially when it comes to selling the family silver. What's genuinely British (and what isn't) will forever remain moot, but the automotive world seems to have served as a role model for the dispersal of British brands.

How well this phenomenon is documented Stateside I don't know, but some of you might not be aware that the most British of all brands is up for sale and will probably be sold to a German company. (As an analogy, think of the reactions if the White House or Mount Rushmore were sold to Japan.) Yup, Rolls-Royce is about to go the way of Aston-Martin, Jaguar, Lotus, the entire Rover group (which includes MG, Triumph, and Austin-Healey), and every other brand save for teensy companies like Morgan and TVR. If you're not a reader of our sister publications *Car and Driver* and *Road & Track*, you might be wondering what this has to do with hi-fi; trust me, the link's not that tenuous. That's because the latest shift in ownership concerns an automotive enterprise with which you just might be familiar.

IMAGINE A HI-FI MANUFACTURER HAVING ACCESS TO TAG/HEUER'S MICRO-ENGINEERING SKILLS.

If it succeeds, it's a move that bodes well for the credibility of high-end audio, which, heaven knows, needs all the help it can get. But it also raises the question of why a key player in the luxury market would want to get involved with the one type of luxury product utterly devoid of appeal to the wealthy.

The British company that can look forward to a fascinating year is Cambridge Systems Technology, manufacturer of Audiolab, a brand best thought of as a latter-day Quad wannabe. For years this company has been producing highly regarded, affordable, ultra-conservative gear that competes in the middle sector. If they don't yearn for silly-money high-end wares, it's what budding audiophiles move onto after graduating from their first NAD or Rotel integrated.

And who are the new bosses? None other than the TAG/McLaren Group, parent of the world's only million-dollar GT car (move quickly if you want one, because the series is nearing its end), TAG/Heuer watches, and one of the few Formula One racing teams that even stands a chance of competing with Ferrari and Williams. Details are sketchy, but, naturally, rumors abound.

It appears that Dr. Udo Zucker, Chief Executive Officer of TAG Electronics Holdings, is a dyed-in-the-wool audiophile and the owner of a serious hi-fi system made up of mainly American high-end treasures. If this is true, then there's less of a surprise as to why a company as rich and intelligent as TAG would snap up a classy, if low-key, hi-fi manufacturer, especially when you compare financial frames of reference. Like, uh, you can add two zeros to any number and thus convert it from hi-fi levels to automotive levels. And you can be certain that whatever it cost TAG to acquire Audiolab, it's a lot less than it spends on, say, fielding a couple of cars at just one Grand Prix race. That's no reflection on Audiolab; it's a reflection on hi-fi and how Mickey Mouse it is compared with other luxury goods. When we're talking millions, the automotive guys talk hun-

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dreds of millions. Nothing to be ashamed of, but it makes you want to laugh at some of hi-fi's so-called moguls, the ones who think they're up there with Bill Gates.

Anyway, TAG/McLaren has formed a new division, the aforementioned TAG Electronics Holdings, which in turn controls Cambridge Systems Technology and TAG Electronic Systems. Udo Zucker said that the new acquisition ". . .allows me to build upon my professional interest and commitment to electronics and automotive technology in the pursuit of my personal passion for highest quality musical reproduction." This is good news from the start. How often do you see takeovers of small hi-fi brands where the new CEO actually cares about audio?

But this has to be more than a plaything for Zucker. Ron Dennis, Managing Director of the TAG/McLaren Group and the very same guy seen worrying in the pits if his drivers aren't winning, said, "I am very excited about this expansion into the field of high-quality audio equipment. I am convinced that the synergy between Cambridge Systems Technology, Ltd., and our existing electronics company, TAG Electronic Systems, Ltd., will allow us to provide the consumer market with the technical excellence and commitment to outstanding quality for which all of our companies are known."

The best take I've heard yet on both gentlemen's remarks is that TAG/McLaren is *very* serious about the high-end market. And to this outfit, high end isn't Bang & Olufsen or Sony, but the very brands that fill these pages, i.e., the major American players. And the intent is to lower price points without compromising quality.

Ordinarily, such hubris would be greeted by hoots of laughter from those audiophiles who recall other attempts by outsiders and neophytes who thought they could just walk in, throw a bunch of money on the table, and produce killer hardware that would sweep away all before it. But this time there seems to be more behind the bluster.

For starters, the executives of Cambridge Systems Technology—who have been steeped in audio for decades—remain on board. Whether or not their opinions are respected by those holding the purse strings remains to be seen, but it's unlikely that TAG would let some guy with expertise in steering and braking overrule an audio engineer. The company obviously knows how to operate as a team, as evidenced by a few wins last year, when it looked like Schumacher in the Ferrari and the eventual champion—Villeneuve in the Williams—were going to divide all of the races between them.

As for the Audiolab crew, they now will have access to technology waaaay beyond the resources of most high-end companies. Between TAG/Heuer watches and the motoring interests, the company has a world-class reputation for digital technology, computer systems, engineering, and materials.

Think about the possibilities. Imagine a hi-fi manufacturer having access to TAG/Heuer's micro-engineering skills. If you've ever looked inside a wristwatch, you know that what audiophiles consider immaculately finished would be deemed embarrassingly crude by Swiss watchmaker standards. Next, imagine that the same hi-fi manufacturer also has access to McLaren's experience with carbon fiber, rare alloys, communications, heat transmission, plastics, ergonomics—the list goes on. One little birdie even told me that Peter Stevens, designer of the McLaren F1 and other automotive treasures, might be part of the team. If that's true, it won't be just the Italians who have hi-fi with styling to die for.

STAN CURTIS DECLARED THAT QUAD WOULD BE RETURNED TO ITS POSITION AT THE APEX OF BRITISH AUDIO.

Those of us who have been around the audio world for a decade or more have seen industry giants come and go, megacorporations whose leaders thought they could acquire a high-end audio company or two and rattle every cage at the Consumer Electronics Show. Inevitably, they've slithered away with their tails between their legs—the actual cost, though, being utterly insignificant to them. The only victims? The companies they bought and then discarded. For a number of reasons, I suspect that the TAG/McLaren move will be different. And I fervently hope so, because TAG/McLaren has greater potential for getting high-end audio known to more people with the requisite disposable incomes (such as everyone on earth who has a TAG/Heuer wristwatch) than, say, a nightly spot on Letterman.

Meanwhile, not a million miles away in a different part of Cambridge, Quad has found itself with yet another owner. The Verity Group (owner of Mission, Cyrus, NXT, and Roksan) divested itself of the revered brand in record time, contrary to statements that it would restore Quad to its former glory. Now preoccupied with NXT flat-panel speaker technology, Verity has sold Quad and the equally venerable Wharfedale to a new group, Pointfield, Ltd. Just describing who owns what would fill this entire column, so I'll spare you the list of shareholders and jump straight to the nitty-gritty.

Quad will be operating under the direct control of Stan Curtis, whose past efforts include involvement with Cambridge Audio (nothing to do with Cambridge Systems Technology) and design work for Rotel, Monrio, and too many other brands to mention. Stan is one of the British hi-fi industry's fixtures, a key player in the 1970s boom. And, fortunately, he has a much better sense of—and respect for—history than do so many others who acquire legendary brands on a lark. At a recent press dinner, in front of more than 40 witnesses, Curtis declared that Quad would be returned to its position at the apex of British audio, that the standards set by founder Peter Walker would again be adhered to, and that the legendary repair facilities would be restored. And he made enough other promises to bring a tear to the eye of any vintage hi-fi enthusiast.

Seated next to one of the industry's most skeptical journalists and reminded constantly during Stan's speech that "We've heard it all before" and "How can [you] be so x@!#! naive," I still let wishful thinking dispel my own cynicism. Certain demonstrations of Stan's faith included the announcement of a new distributor for the brand in the United States, M. Rothman and Co. (800/227-7491), which already distributes Wharfedale, to ensure that Quad is well represented in the world's most important market. He let slip that three new electrostatic speakers and a line of electronics would be launched. He even told the assembled hacks that he also plans to revive the once-great Leak brand as a line of high-end tube amplifiers.

Yes, "We've heard it all before." But a part of me just can't help hoping that, this time, we're not being flimflammed. A

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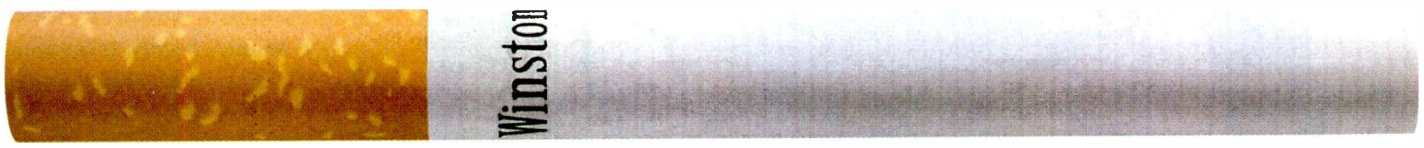

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HELL BENT FOR LEATHER

Illustration: Philippe Lechien

Have you ever noticed how much of the hard-core audiophile trip has heavy S&M connotations? In company names alone, there's Threshold (of Pain). (Mistress) Allison Acoustics. And what about Joseph (and His Amazing Technicolor Sensory Deprivation Hood) Audio? It's all just a little bit disconcerting, if you ask me.

I was at a party the other night, and this guy named Horst was asking me about how I tweaked my system for the best sound.

"I spike my speakers to the floor so they pierce the carpet," I said, as his eyes brightened.

"Saaay, what kind of speakers you got?" he asked me.

"Well, they're big and black, but you know, you need to break in your speakers for the best. . ."

Horst cut me off excitedly and asked me what kind of cabinet my gear was stored in, so I explained to him that I stack my components in a rack. A steel rack, actually, filled with many a pound of sand inside so that it won't vibrate when I play my Edith Piaf records.

I didn't get a chance to tell Horst about the Solo ($995), Sonus Faber's center-channel speaker, which Sumiko recently sent me. If you're trying to minimize the S&M quotient in your own system, the Italian-made Solo won't make things any easier for you: It's the world's first all-leather-wrapped center-channel speaker! Every inch of it, from the front panel to the back, is wrapped in deep, sumptuous, pebbled black leather. Lean close and sniff—I said, lean close and *sniff*, worm!—and you get that nice, rich, new-leather-jacket smell. There's no chrome zipper up the side, but there ought to be.

THE BLACK-LEATHER SOLO SOUNDS VERY S&M—SMOOTH AND MUSICAL.

Now, many Sonus Faber speakers over the years have featured a stylish wrap of this same black pebbled leather up and over the front and rear; for instance, the two-way $1,850/pair Sonus Faber Concertos I reviewed in the June 1997 issue had this beautiful wrap, capped on the sides with piano-black lacquered wood. But the Solo is Sonus's first totally leather-wrapped speaker. The company says that beyond the obvious cosmetic benefit, the leather is quite effective at damping cabinet resonances. Sonus even extends the leather into the cabinet's driver cutouts to act as a built-in gasket instead of using the usual thin layer of foam.

The Solo is a two-way design, with a ¾-inch silk-dome tweeter between a pair of 7-inch Cellulose Carbonium woofers. In keeping with Sonus Faber's longstanding philosophy concerning crossover filter design and system coherency, the Solo divvies up the signal between the tweeter and the woofers with a first-order (6-dB/octave) crossover. I expected such a crossover would curtail a center-channel speaker's output capability (because of tweeter overload) and would create a more pronounced difference in timbre than usual for off-center listeners, a common problem when

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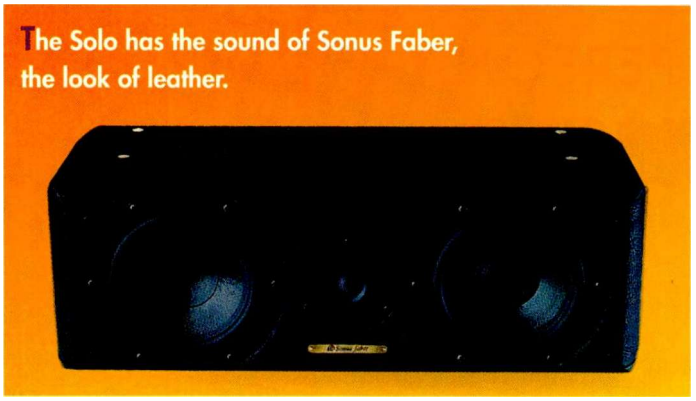

The Solo has the sound of Sonus Faber, the look of leather.

several people are watching a movie together. But the Solo went nicely loud without strain, and I didn't notice any more egregious timbre differences as I moved off center than I have from other center-channel speakers featuring more conventional second- and third-order crossovers. Sonus terms the Solo's crossover an "attenuated 1st-order" design, so perhaps there is some additional protective rolloff farther out of the passbands.

In a system with a pair of Sonus Faber's $1,850/pair Concerto bookshelf speakers, a pair of the smaller $995/pair Concertinos for the surrounds, and a monstrous $4,000 REL Stentor II powered subwoofer, the Solo sounded every bit a true, blue-blooded Sonus Faber. For the $7,840 you'd pay for this Sonus/REL rig, you could buy a Home THX speaker system and rock the rafters with action flicks galore. But that's not really what the Sonus/REL sound is all about. This is a system for an audiophile who wants to fill an elegantly outfitted room, one that's small or medium in size, with a sound field that's much more musically rich and complex than he'd get from even the best cinema-oriented systems.

You'd expect a black leather center channel to shout at you or even default your DVDs to the German-language soundtrack. But the Solo sounds very S&M—smooth and musical. And the timbre match with the Concertos is right on the money, unlike a lot of high-end speaker lines' center-channel models. Owners of Sonus Faber speakers who've been waiting for a matching center channel will be thrilled by the Solo, while the rest of us will have to make do till black leather becomes as common an optional finish as cherry or rosewood. *(Sonus Faber, c/o Sumiko, 510/843-4500.)*

Ever notice how it's the wackiest, most problematic products that get the most attention from audiophiles and the magazines, while the quiet, no-hassle gear that does everything you would want in the way of sound and performance gets completely ignored? Single-ended tube amps were all the rage a year or so ago, and everyone whooped it up and danced around the fire, singing songs about the Triode Revolution until the buzz wore off and the realization set in that 7 watts doesn't begin to cut it, even for very efficient speakers, and that blowing Chinese output tubes every few weeks is a drag, not a privilege. So the pages of *Audiomart* choked on a deluge of ads for used single-ended tube amps, and the horde moved on.

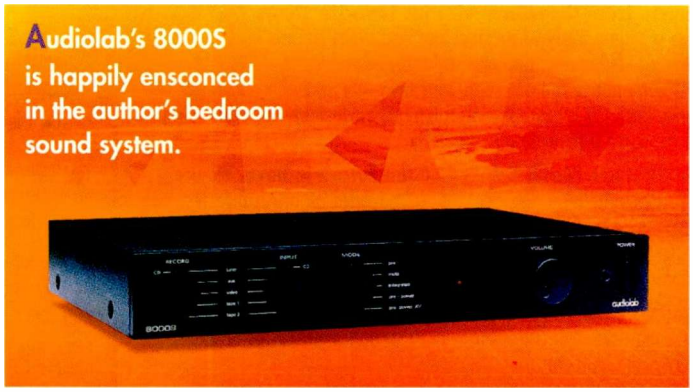
THE SONUS FABER SOLO IS THE WORLD'S FIRST ALL-LEATHER-WRAPPED CENTER-CHANNEL SPEAKER.

I thought about all this the other day as I realized I'd been using the Audiolab 8000S integrated amp I'd been sent for review for, well, a long time without ever getting around to writing it up. Normally I get a new product in, unbox it, give it a few days' worth of break-in in my bedroom system, and then move it down to the living room for the review. But with the Audiolab, I just left it in the bedroom and kept listening to it play Coltrane and Monk every night and Elvis and Iggy every morning. For the better part of a year.

Now, part of the reason I left the Audiolab hooked up in my bedroom system is because it's one of the few truly high-end integrated amps I know of with remote control. I've had more than a few A/V receivers in the bedroom system before, but even with the pleasures of remote control, the sound just wasn't there. So when I finally got to have my high-end cake and remote-control it too, I was so happy I didn't want to break the system up, even for a few weeks. Call me selfish, but hey, that's what love does to a reviewer.

The British-built $1,095 8000S can be thought of as an updated and more future-leaning version of Audiolab's classic 8000A integrated amplifier (which is still available in a Mk. III version for $895). Both are solidly engineered, great-sounding 60-watt stereo integrated amps, but whereas the 8000A looks back at the days of LP records and two-channel stereo, the 8000S is designed to ease into home theater surround without giving up any of the 8000-series sound quality.

The 8000S trades off the 8000A's phono stage for a five-position "Mode" switch that lets you change the way its preamp and amp sections link together. The five positions are: "PRE" (which shuts down the amp section and turns the 8000S into a stand-alone preamp), "Mute," "Integrated" (which links the preamp and amp together internally and disconnects the rear panel's preamp-out and amp-in jacks), "PRE-Power" (which also links the preamp and amp internally but activates the preamp-out jacks for feeding signals to a powered sub), and "PRE Power AV." It's that last mode that makes the 8000S so cool for home theater: It cuts the internal link from preamp to amp and activates the preamp-out and amp-in jacks, turning the Audiolab into an independent preamp and amp that happen to share the same box. Thus, you can hook up an external surround processor and feed two channels of its output back to the Audiolab's amp section. And you can then use the "Mode" switch to jump back and forth be-


Audiolab's 8000S is happily ensconced in the author's bedroom sound system.

tween surround sound and purist two-channel stereo with the signal path remaining entirely within the Audiolab.

The 8000S has six line-level inputs and three tape loops. Its input, volume, and muting controls (but not, strangely, power on/off or "Mode") are duplicated on the supplied remote, which can also control CD players that answer the RC-5 mating call of Philips/Magnavox/Marantz models. Other features include gold-plated connectors, precision metal-film resistors, film caps, and a fully discrete preamp section. Internal construction is excellent, especially for British-built high-end gear, where a spot o' dodginess is considered charming.

FOR JUST OVER A GRAND, THE 8000S IS THE BEST INTEGRATED AMP I'VE HAD THE PLEASURE OF LIVING WITH.

So what's the real reason I left the Audiolab in my bedroom system for 10 months (make that 10 months plus, because it's going right back there as soon as I finish writing this)? Because for just over a grand, the 8000S is the best integrated amp I've had the pleasure of living with. It's solidly built, sounds cleaner and more neutral than most of the boutique crap that clogs the high-end salons, and ohh, that wonderful remote control for when Daddy wants to dial in "A Love Supreme" at just the right level for 2 a.m. without getting out of bed. And when I finally break down and put a TV in my bedroom, I can hook up the Audiolab for surround and still keep that clean, grain-free sound for my late-night music. *(Audiolab, c/o Artech, 514/631-6448.)*

News Flash: Just as I was finishing up this column, it was announced that legendary Grand Prix car-racing company TAG McLaren had bought Audiolab's parent company, Cambridge Systems Technology, Ltd., in order to extend its reach to the high-end audio market. Industry pundits expect Audiolab to continue its healthy growth under McLaren's stewardship [see "Mondo Audio"], but you know what this really means, don't you?

Leather-covered remotes! A

PART 1

digital audio for the future

BY J. ROBERT STUART

Sound starts as a vibration in air, and we perceive it through a hearing mechanism that is not exclusively analog in operation. But since, at any sensible scale, the vibrations can be considered an analog signal, there has been considerable debate over why what starts and ends as an analog air-pressure signal should be stored digitally. The overwhelming reason to store and transmit information digitally is that it can be conveyed without loss or the introduction of interference. It can even (as we will see later) be manipulated in a way that avoids many of the distortions introduced by analog processing. This somewhat obvious point is often overlooked. Analog storage or transmission methods always introduce distortion and noise that cannot be removed and also threaten the time structure of the sounds through wow or flutter effects.

Digital audio has progressed on this basis, and on the assumption that we can convert transparently from analog to digital and back again. A number of experiments have demonstrated this possibility to varying degrees, but it has also become fairly well understood that badly executed digital audio can introduce distinctive problems of its own.

The Compact Disc was the first carrier to really bring digital audio into the home, and its development has taught us a lot. But as digital audio has progressed, we have evolved the capability to record and play back with resolution exceeding that of the standard Red Book CD—two channels of 16-bit linear PCM audio sampled at 44.1 kHz—and current studio practice recognizes this Red Book channel as a bottleneck. High-quality recordings are routinely made and edited using equipment whose performance potential is considerably higher than that of CD.

Along the way, some interesting ideas have been proposed to try to maximize the potential of CD with respect to the capabilities of the human auditory system. One is noise shaping. This technique was first proposed by Michael Gerzon and Peter Craven in 1989 and has been successfully embodied in Meridian's 618 and 518 processors, Sony's Super Bit Mapping (SBM) system, and elsewhere. Noise shaping has been used on maybe a few thousand titles, but these include some of the very finest-sounding CDs available today. Other proposals were interesting but didn't get off the ground: subtractive dither, for example, and schemes to add bandwidth or channels to CDs.

I have felt strongly for some time that we are on the threshold of the most fantastic opportunity in audio. It comes from two directions. First, psychoacoustic theory and audio engineering may have progressed to the point where we know how to define a

J. ROBERT STUART IS CHAIRMAN AND TECHNICAL DIRECTOR OF MERIDIAN AUDIO AND CHAIRMAN OF THE ACOUSTIC RENAISSANCE FOR AUDIO, AN ORGANIZATION FOUNDED TO CAMPAIGN FOR ESTABLISHMENT OF A DVD-AUDIO STANDARD THAT WOULD ASSURE THE HIGHEST POSSIBLE QUALITY OF SOUND REPRODUCTION.

PHOTOGRAPH: DAVID HAMSLEY

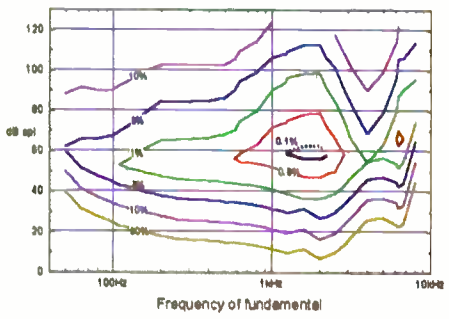


Fig. 1—Detectability contours for second-harmonic distortion. The SPL is of the fundamental frequency; inside a contour, distortion of the marked percentage should be audible.

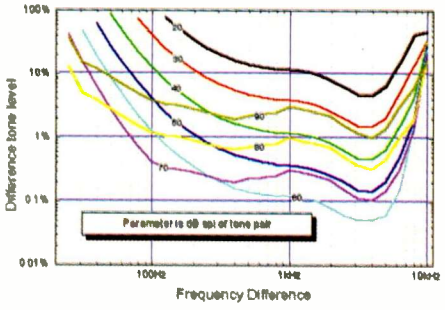


Fig. 2—Predicted detectability of a difference tone produced by IM distortion.

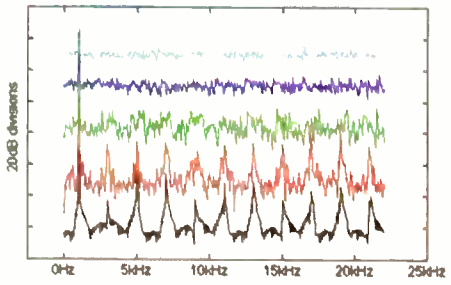


Fig. 3—FFT analyses of undithered 16-bit quantization of a 1-kHz tone at -20, -40, -60, -80, and -90 dBFS. Curves offset by 25 dB.

recording system that can be truly transparent as far as the human listener is concerned. Second, we will soon see the evolution of a high-density audio format, related to DVD, that will have, if it is used wisely, the data capacity to achieve the transparency we seek.

THE MEASURE OF THE MEDIUM

I am firmly convinced that this next-generation audio distribution format should be capable of delivering every sound to which a human can respond. Achieving that requires: sufficient linearity (i.e., low enough distortion), sufficient dynamic range (i.e., low enough noise), sufficient frequency range, sufficient channels to convey three-dimensional sound, and sufficient temporal accuracy (wow, flutter, jitter).

The Acoustic Renaissance for Audio (ARA) has suggested that a carrier intended to convey everything humans can hear requires: dimensionality (full spherical reproduction, including height), a frequency range from DC to 26 kHz *in air* (the in-air qualification matters), and a dynamic range from below the audibility threshold to 120 dB SPL.

Before delving deeper into these questions, we need to make a small diversion.

DIGITAL AUDIO GATEWAYS

Even among audio engineers, there has been considerable misunderstanding about digital audio, about the sampling theory, and about how PCM works at the functional level. Some of these misunderstandings persist even today. Topping the list of *erroneous* assertions are: (1) PCM cannot resolve detail smaller than the LSB (least-significant bit), and (2) PCM cannot resolve time to less than the sampling period.

Let's examine the first assertion. What is suggested is that because (for example) a 16-bit system defines 64k (65,536) steps, the smallest signal that can be registered is 1/65,536, or about –96 dBFS. Loss of signals because they are smaller than the smallest step, or LSB, is a process known as truncation. Now, you *can* arrange for a PCM channel to truncate data below the LSB, but no engineer worth his salt has worked like that for more than 10 years. One of the great discoveries in PCM was that adding a small random noise (called dither) can prevent truncation of signals below the LSB. Even more important was the realization that there is a *right* sort of random noise to add and that when the right dither is used the resolution of the digital system becomes *infinite*. What results from a sensible quantization or digital operation, then, is not signal plus a highly correlated truncation distortion but the signal and a benign low-level hiss. In practical terms, the resolution is limited by our own ability to detect sounds behind noise. Consequently, we have no problem measuring (or hearing) signals of –110 dBFS in a well-designed 16-bit channel.

As regards temporal accuracy (assertion 2), if the signal is processed incorrectly (i.e., truncated), the time resolution is indeed limited to the sampling period divided by the number of quantization levels—34.6 picoseconds for CD audio. We are again saved, however, as application of the correct dither makes the temporal resolution effectively infinite as well.

So, we have established the core point, that wherever audio is quantized (as in an analog-to-digital converter) or requantized (as in a filter or other DSP process), there is a right way and a wrong way to do it. Neglect of the quantization effects will lead to highly audible distortion. However—and this is perhaps the most fundamental point of all—if the quantization is performed using the right dither, then the only consequence of the digitization is effectively the addition of a white, uncorrelated, benign, random noise floor. The level of the noise depends on the number of the bits in the channel, and that is that!

LINEARITY

Linear, uniform PCM channels do not introduce distortion if suitable dither is applied at every stage where the audio is processed (i.e., modified rather than transmitted). It is possible to quantize and then process a signal without introducing anything that we would commonly refer to or hear as a distortion.

But this is not to say that all digital systems are distortion-free, nor that all equipment has been correctly designed; had it been, there would be much less discussion about analog versus digital! The important point is that because it *can* be done perfectly, we should assume in designing a new carrier that it *has been* rather than make allowance for needless bad practice.

The reason for this preamble is that truncation-type distortions are of high order and so are far more likely to be audibly offensive than is a low level of uncorrelated random noise, which is a consequence of a good digital process and does not produce nonlinearity. In a well-designed, modern

audio system, the significant nonlinearities (distortions) should arise only in the transducers and analog electronics, not in the PCM channel.

With that in mind, let us take one more short diversion, this time into the question of how much distortion we are able to hear. It has been well established that the amount of distortion we can hear depends on its order—i.e., whether it is second harmonic, third harmonic, etc. And because the human hearing system itself is quite nonlinear, it also depends on how loud the main sound is.

Many of the examples in this article are evaluated using a computer model of auditory detection that I have developed over the years. This auditory model includes a step that calculates internal beats, or distortion products, in the hearing system. Figure 1 hints at the potential of such a tool. It shows a contour map estimating regions for detectability of pure second-harmonic distortion in mono presentation. The figure shows that at low loudness levels our ability to hear the added harmonic component is controlled by the absolute hearing threshold. Maximum acuity occurs in the medium ground, corresponding to about 60 dB SPL. At this level, maximum acuity is estimated at around 1 to 2 kHz, where a 0.1% second-harmonic addition just reaches threshold. As sound pressure level increases, the broadening of the ear's cochlear filters and internal distortion reduce acuity.

> The audibility of distortion depends on its order and on the frequency and level of the sound.

Systems that introduce harmonic distortions also create intermodulation. Figure 2 illustrates the predicted detectability of intermodulation distortion, in this case of a first-order difference tone resulting from nonlinear processing. The horizontal axis is the frequency difference between one tone fixed at 10 kHz and an equal-amplitude tone at higher frequency. As with the harmonic example, we see that as the combination level is increased from 20 dB SPL, acuity rises rapidly, with maximum sensitivity again occurring around 60 dB SPL.

PRECISION AND DYNAMIC RANGE

Distortion can be introduced at analog-to-digital (A/D) or digital-to-analog (D/A) gateways or in analog peripherals. However, in a uniformly sampled, uniformly quantized digital channel, the bits maintain a precise 2:1 relationship. The potential for introducing distortion arises in nontrivial signal processing (including filtering and level changes) and in word-length truncation or rounding. But as we've noted, the nonlinear quantization distortion that results from truncation or rounding can be avoided completely by using appropriate dither in each nontrivial process.

Let us look at the distortion introduced by basic quantization more closely. Figure 3 shows level-dependent distortion produced in an undithered quantizer. The original signal, a 1-kHz sine wave, is attenuated in steps to show the effect of a fade on the output of an undithered 16-bit quantizer. At high signal levels, the quantization error is noise-like, whereas at low levels it is highly structured. It is hard to imagine that the structured distortion produced by truncation would not be audible.

On the other hand, dithered quantization introduces uncorrelated noise. Figure 4 shows FFT measurements of a –90 dBFS, 1-kHz signal subjected to 16-bit quantization with and without dither. In each case the signal appears at about the same level. With dither, we see a smooth noise spectrum—the benign-sounding "error" introduced by correct quantization. Without dither, the signal is very rich in unwanted odd harmonics; the resulting total harmonic distortion (THD) is 27%.

Broadly speaking, truncated, rounded, and dithered quantizations introduce errors of similar total power but different composition. Through most of this article, I assume good practice and consider dynamic range and precision together. In a correctly engineered digital channel, the consequence of each quantization or requantization (word-length reduction or filtering, for example) is the successive addition of benign noise.

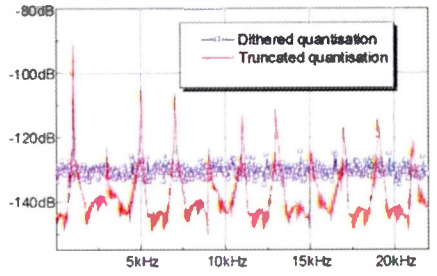


Fig. 4—FFT analyses of a -90 dBFS, 1-kHz tone quantized to 16 bits with and without correct dither.

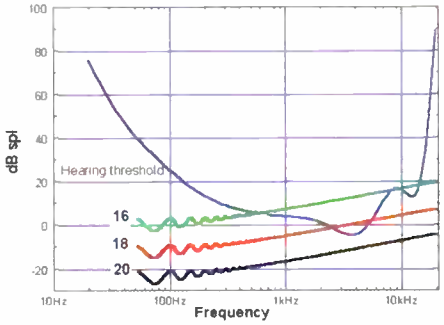


Fig. 5—Audible significance of the noise created by single, dithered 16-, 18-, and 20-bit quantizations, assuming a full-scale signal can reach 120 dB SPL.

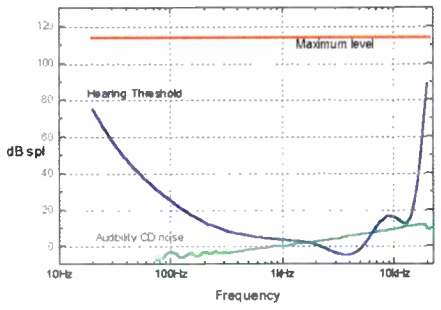


Fig. 6—Dynamic range of CD. The average human hearing threshold is included for reference.

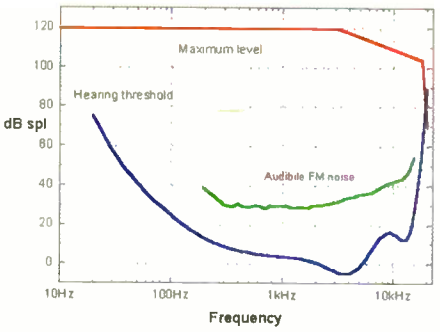


Fig. 7—Dynamic range of FM radio.

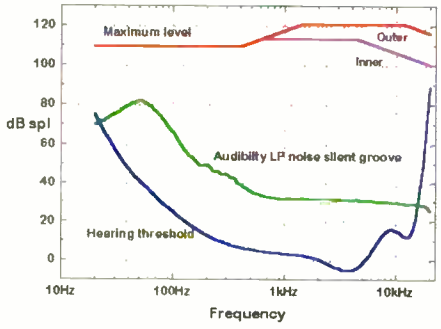


Fig. 8—Dynamic range of LP phonograph records. Maximum levels are plotted for both inner and outer grooves.

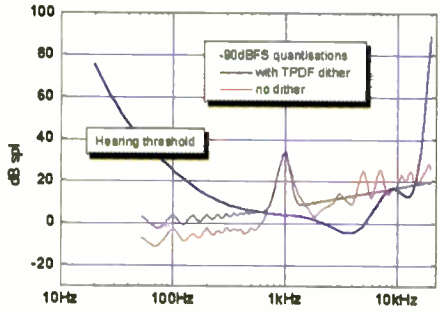


Fig. 9—Audible significance of dithered and undithered 16-bit, 44.1-kHz quantization of a 1-kHz tone at -90 dBFS (30 dB SPL, assuming 0 dBFS equals 120 dB SPL).

Figure 5 shows the base noise level for 44.1-kHz sampling in 16-, 18-, and 20-bit channels. The noise is plotted, however, not in terms of spectral density (–137 dBFS/Hz with 16 bits) but in terms of audible significance to human listeners. The effect of the noise rises with frequency because of the effect of the filters in the human ear. The significance of the noise is plotted against an SPL reference that assumes the acoustic gain at replay will allow a full-scale digital signal to reach 120 dB SPL (a probable worst case). The average hearing threshold is also shown; wherever the noise curve is above the threshold, it may be audible. The magnitude and frequency range of the above-threshold spectrum indicates how it will sound. In the 16-bit example, then, the component of noise between 700 Hz and 13 kHz should be audible in the absence of masking signals, whereas audibility is predicted between 2 and 6 kHz in the 18-bit example. This graph also suggests that for delivery, a 20-bit channel should have adequate dynamic range.

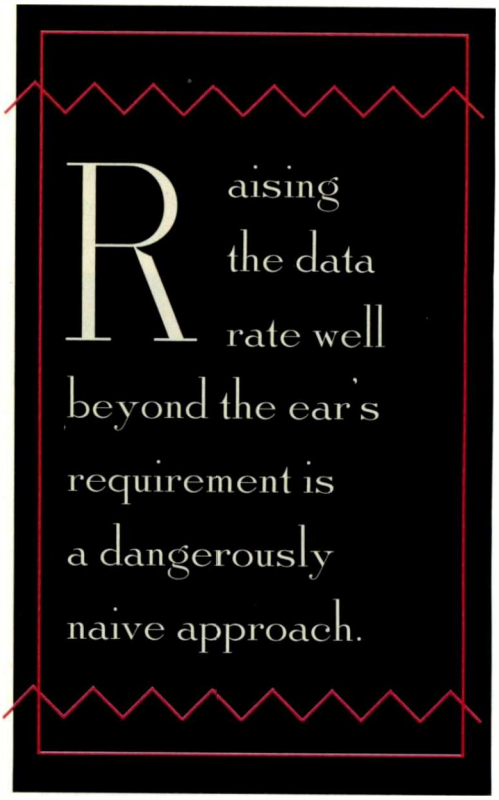
DISTRIBUTION FORMATS

A distribution format, or carrier, is a means by which recorded music is conveyed to the public. Examples would include radio, TV, CD, and so forth. Normally a distribution channel has a limited (and fixed) rate of data delivery. But because the cost of computer data storage has been falling so fast, there is a temptation these days to regard data rates and quantity as relatively free goods.

Such a supposition might imply that the safest way to design a high-resolution recording system or carrier is to use considerably more data to represent the sound than prevailing psychoacoustic theory would suggest necessary. This is a dangerously naive approach, however, as it may lead to poor engineering decisions.

The quality of an audio chain reflects the degree to which it can maintain transparency. Any loss of quality will be due to an error introduced. The error may be any failure in linearity, dynamic range, frequency range, energy storage, or time structure. We would like to approach transparency in each of the measures of audio given earlier. Obviously, we could ensure transparency by overengineering every aspect (assuming that we know how to), but that would increase the data rate of the audio signal in the channel.

Given that every digital distribution channel has a bit budget, a designer attempting to overengineer is likely to fall into the trap of choosing, for whatever reason, to oversatisfy one requirement at the expense of others, thereby creating an unbalanced solution. In the context of DVD-Audio, this could easily be done by, for example, providing excessive bandwidth or precision. Neither choice is inherently wrong, but in the real world of storage or distribution, either is likely to reduce the number of channels available for three-dimensional representation. Here we could argue that replacing CD quality with two-channel transparency, without considering the benefits of multichannel, would be a flawed choice for most listeners.



The ARA list presented earlier suggests that it is sufficient to deliver an audio bandwidth of 26 kHz and that precision of at least 20 bits should be used for well-implemented linear PCM channels. Beyond those points, it was felt that further benefits would not accrue until the sound delivered had, by whatever means, been rendered fully three-dimensional.

Having decided what we need in the distribution channel, the question arises of what coding to use. The simplest channel design is one in which all the data in the original recording appears on the disc, which is how very early CDs and some audiophile recordings were made. More often, the original master requires editing, a process that is performed in a digital signal processor whose word size exceeds that of

the original (to preserve linearity). In the end, however, it may be necessary to reduce the original's word length in order to fit the signal onto the carrier. This is commonly the case today when 20-bit master recordings must be shortened to 16 bits for CD.

With a maximum reproduction level of (again) approximately 120 dB SPL, Fig. 6 shows the working region for CD. The notable features are a maximum signal level that is uniform with frequency and a smooth, but potentially audible, noise floor. Because the noise floor of a 16-bit channel can be audible, quantization distortions may, in principle, also be audible. For comparison purposes, I have included plots of the working regions for FM radio (Fig. 7) and vinyl LP (Fig. 8). These analog formats have nonuniform maximum level capability and suffer from substantially higher noise.

REAL-WORLD CD CHANNELS

Let's go back to the earlier example of the incorrectly quantized –90 dBFS, 1-kHz tone and the resulting distortion components. Figure 9 shows the modelled auditory significance of the measurement given in Fig. 4. (Here again, and in all subsequent figures, the acoustic gain is set so as to permit a full-scale digital signal to generate 120 dB SPL at the listening position.) This plot is quite telling: It predicts, for example, that the harmonics generated by the undithered quantization will be significantly detectable right up to 15 kHz. The curve for the undithered quantization reveals that the distortion cannot be masked by the signal tone. It is also noteworthy that the harmonic at 5 kHz is nearly 30 dB above threshold. This implies that there may be circumstances in which the error will be detectable with relatively conservative acoustic gains (lower volume settings).

Single undithered truncations at the 16-bit level are regrettably all too common in practice. Not only do inadvertent truncations arise in the digital filters of very many A/D and D/A converters, but the editing and mastering processes often include level shifts, mixing events, or DC filtering processes that have not been dithered correctly. Thus, there have been reasonable grounds to criticize the sound of some digital recordings, even though this particular defect can be avoided by combining good engineering with good practice.

Figure 10 represents the audible significance of a channel in which a correctly dithered quantization (perhaps in shortening a word from 20 to 16 bits) is followed by a minor undithered process, in this case a 0.5-dB attenuation. You can see how just one undithered process can degrade a correctly converted signal: An audibly raised and granular noise floor is highly probable.

Figure 11 shows how this effect could operate in practice. The upper curve represents the audible significance of the same –90 dBFS tone with all the errors introduced by an original, "correct" 16-bit quantization followed by four undithered signal-processing operations. Four operations may seem like a lot, but this figure actually illustrates a common case in which everyday A/D and D/A converters are used. (As has been mentioned, the digital filters in such converters are rarely dithered.) The upper curve may be taken as a base line of current bad practice in CD recording/playback. For historical context, see Fig. 12, which includes the audible significance of the noise in a silent LP groove.

In many ways, the pity for PCM to date has been that it is so robust, which is to say that the sound survives the kind of abuse illustrated in Fig. 11 because it is superficially the same. If we were to introduce truncation errors like this in other types of digital processing, chaos might well ensue. (Among other things, computer programs would refuse to run.) Indeed, compressed audio formats that require bit-accurate delivery cannot tolerate the sort of abuse that poor design has brought so routinely to PCM audio.

This analysis of the dynamic range capability of the 16-bit, 44.1-kHz CD channel makes certain things very clear: Undithered quantizations can produce distortions, which are likely to be readily detectable and also quite unpleasant. Undithered quantization of low-level signals will produce high and odd-order harmonics. Undithered quantizations routinely arise in the current CD recording and replay chain, and great care is required if a recording is to be captured, edited, mastered, and replayed without any error arising.

The basic noise floor of the 16-bit channel suggests that it can be guaranteed inaudible only when the maximum SPL is less than 100 dB, as implied by Fig. 5.

20-BIT PCM

Figure 5 also predicts that basic 20-bit channel noise would be inaudible. Figure 13 investigates the suitability of a 20-bit recording and replay chain. The channel's

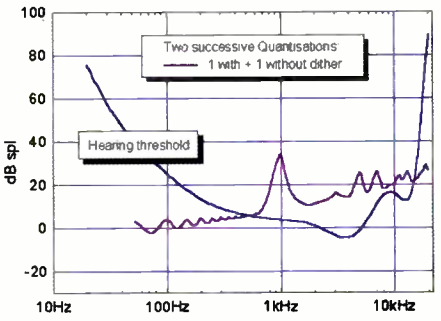


Fig. 10—Audible significance of an undithered, 16-bit requantization of a 1-kHz, -90 dBFS tone already correctly quantized to 16 bits at 44.1 kHz.

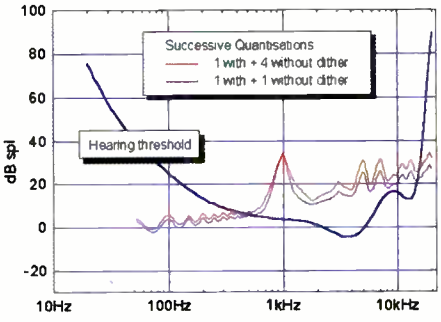


Fig. 11—Audible significance of one (lower) and four (upper) successive, undithered, 16-bit requantizations of a 1-kHz, -90 dBFS tone already correctly quantized to 16 bits at 44.1 kHz.

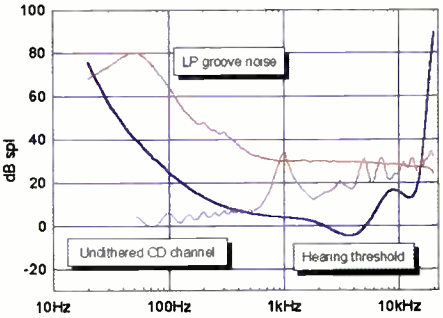


Fig. 12—Audible significance of four undithered 16-bit requantizations of a 1-kHz, -90 dBFS tone already correctly quantized to 16 bits at 44.1 kHz, contrasted with the audible significance of LP groove noise.

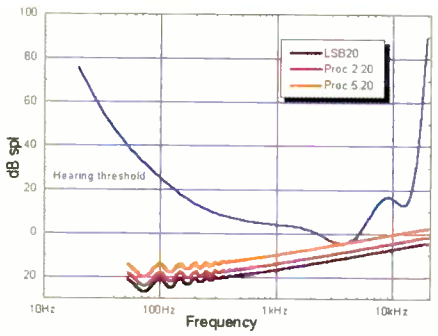


Fig. 13—Audible significance of the noise created by one, two, and five successive, dithered, 20-bit quantizations.

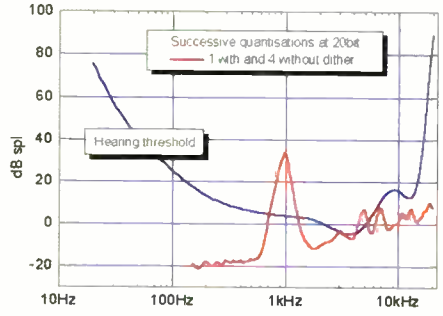


Fig. 14—Audible significance of four successive, undithered 20-bit requantizations of a 1-kHz, -90 dBFS tone already correctly quantized to 20 bits at 44.1 kHz.

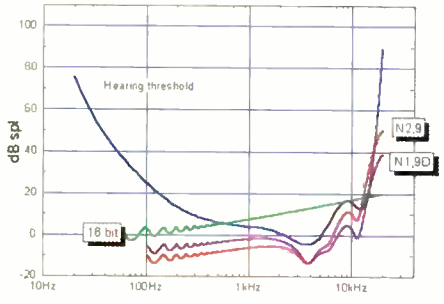


Fig. 15—Audible significance of a simple 16-bit, dithered quantization plus two examples with noise shaping applied.

basic noise is shown, as is the steady increase in the noise floor that takes place when the signal is operated on in the channel. The curves represent the effects of one, two, and five dithered quantizations, resulting from one and four operations subsequent to the initial conversion. In fact, a modern system using 20-bit resolution throughout will probably perform a minimum of five operations over and above the original quantization process itself, because the A/D and D/A converters will usually contain two cascaded digital anti-aliasing or oversampling filters.

The data used in Fig. 13 suggests that a 20-bit channel (if engineered correctly) should be capable of providing a transparent and subjectively noiseless sound reproduction chain. This assertion is reinforced by Fig. 14, in which the signal processing postulated in Fig. 11 (a sequence of five quantizations, only the first of which is dithered) is recalculated for a 20-bit channel. This is significant abuse, but it still appears that the distortion components should be barely audible. This is important because it puts an upper limit on the resolution required in a distribution channel.

24-BIT PCM

There is no convincing argument for using 24-bit data in a distribution format. Figure 13 clearly implies that the noise floor and resolution limit of a 24-bit channel will be 24 dB greater than is necessary.

Why do it, then? One reason would be to provide more data for the subsequent DSP operations to work with. This reasoning is superficially correct. However, I think it is unlikely that A/D converters capable of delivering a 133-dB signal-to-noise ratio will ever be made, and therefore a 24-bit channel would be kept busy conveying its own input noise! Furthermore, the majority of DSP systems and interfaces use a 24-bit word length. It is very, very difficult at present to guarantee transparency when performing nontrivial DSP operations on 24-bit data in a 24-bit processing environment. Obviously we could develop DSP processors capable of handling longer words, but why should we? Not only is the combination of well-handled, carefully delivered 20-bit data and a 24-bit processing environment good enough, but to deliver anything more is virtually to guarantee a higher risk of inadvertent truncation in the average replay chain.

But there's a more pragmatic reason not to distribute 24-bit data: It is virtually certain that the overwhelming majority of DVD players will not pass 24-bit data correctly. Even if they were to use 24-bit conversion, truncation is almost guaranteed, whereas 20-bit data in the same pathway will pass virtually unscathed.

NOISE SHAPING AND PRE-EMPHASIS

It is possible to exploit the frequency-dependent human hearing threshold by shaping quantization and dither so that the resulting noise floor is less audible.

Figure 15 shows how the Meridian 518 (an in-band noise shaper) can make a 16-bit transmission channel's *subjective* noise floor more equivalent to that of a rectangular (unshaped) 20-bit channel. If such a channel is to be useful, the resolution of the links in the chain before and after the noise-shaped channel must be adequate. In simple terms, this means mastering and playing back using well-designed converters offering at least 20-bit resolution.

It was the view of the ARA committee that noise shaping can be a linear process and that it deserves serious consideration when distribution channels are to be matched to data-rate limitations.

FREQUENCY RANGE

Up to this point, the graphs I've presented have been based on the standard hearing threshold. However, individuals can have somewhat different thresholds; the minimum audible field has a standard deviation of approximately 10 dB. Some individuals' thresholds are as low as –20 dB SPL at 4 kHz. Similarly, although the high-frequency response cutoff rate is always rapid, certain people can detect 24 kHz.

Figure 16 shows how hearing thresholds can vary. This graph still suggests that a well-engineered, 20-bit channel should be adequate, bearing in mind that very few rooms, no recording venues, and no microphones genuinely approach the quietness of the 20-bit noise floor.

Figure 17 adds the frequency response of a typical D/A converter at 44.1 kHz. This diagram defines the working region of a Red Book CD channel.

DO WE NEED MORE THAN 44.1 kHz?

The high-frequency region of Fig. 17 is shown in detail in Fig. 18. It can be seen that an average listener will find little to criticize regarding the DAC's in-band amplitude response. To acute listeners, a 44.1-kHz sampling rate (even with the extremely narrow transition band shown) means a potential

loss of extreme high frequencies (between 20 and 22 kHz). Increasing the sampling rate to 48 kHz does a lot to remedy this.

However, the significance of this has to be questioned. Although there is an area of intersection between the channel frequency responses and the hearing thresholds, this region is all above 100 dB SPL. I know of no program material that has any significant content above 20 kHz *and* 100 dB SPL!

Numerous anecdotes suggest that a wider frequency response "sounds better." It has often been suggested that a lower cutoff rate would give a more appropriate phase response and that the in-band response ripple produced by the kind of linear-phase, steep-slope filter illustrated in Fig. 17 (DAC) and Fig. 19 (ADC) can prove unexpectedly easy to detect. A commonly proposed explanation is that the shallower high-frequency response rolloffs of analog tape recorders account for a preferred sound quality.

> Evidence, anecdotal as well as real, suggests that 44.1-kHz sampling is not adequate.

It has also been suggested that the pre-ringing produced by the very steep, linear-phase filters used so far for digital audio can smear arrival-time detection and alter stereo imaging. This pre-ringing shows up in many reviews of CD players. It can be significantly reduced by making the filter less steep (which could be done by increasing the sampling rate) or by not using a linear-phase characteristic.

The research literature contributes very little to this discussion. One well-performed set of experiments by Ohashi has, however, strongly indicated that certain program material may benefit from a system frequency response extending beyond 50 kHz.

The real problem facing researchers is that these experiments are extremely difficult to do. Ultra-high-frequency effects cannot be investigated using existing hardware: Microphones, recorders, filters, amplifiers, and tweeters would all need to be redeveloped. It is difficult to alter just one parameter, and experiments are hampered by the fact that an ultra-high-frequency-capable chain has yet to be developed to the same level of performance as the current reference.

What can be concluded is that there is some real evidence—and a lot of anecdotal evidence—to suggest that the 20-kHz bandwidth provided by a PCM channel using a sampling rate of 44.1 kHz is not completely adequate. There is also considerable support for the observation that 48-kHz digital audio sounds better than the same system operated at 44.1 kHz. This suggests that the 44.1-kHz system undershoots by at least 10%.

My own opinion is that the evidence fails to discriminate between the *result* of the filtering (genuine listener response to audio content above 20 kHz in air) and *side effects* of the filtering implementation. A very recent report of certain experiments suggests that, indeed, the side effects are the real culprit.

I have experienced listening tests demonstrating that the sound is degraded by the presence of normal (undithered) digital anti-alias and anti-image filters. I am also aware of careful listening tests indicating that any ultrasonic (i.e., above 20 kHz) content conveyed by 96-kHz sampling is not detectable either in the context of the original signal or on its own.

Other listening tests I have witnessed have made it quite clear that the sound quality of a chain is generally regarded as better when it runs at 96 kHz than when it runs at 48 kHz and that the difference observed is "in the bass." Why should this be? Two mechanisms are suggested: aliasing distortion and digital-filter artifacts.

Figures 17 and 19 show the frequency responses of commonly used D/A and A/D converters. In each case, the stop-band attenuation of 80 to 100 dB seems impressive. But if we invert the curve, we can see that a detectable in-band aliasing product may be generated by signals in the transition region.

Most people listening to PCM signals are listening to channels that do not preserve transparency in the digital filters themselves. Another way of putting this is that we cannot yet reliably discriminate between

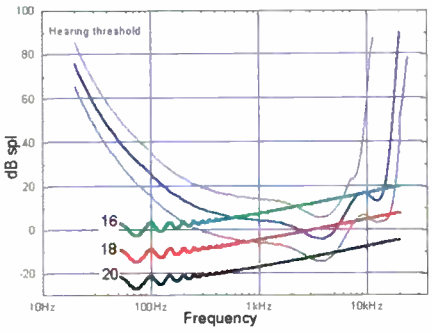


Fig. 16—As Fig. 5, but showing variation created by different hearing thresholds.

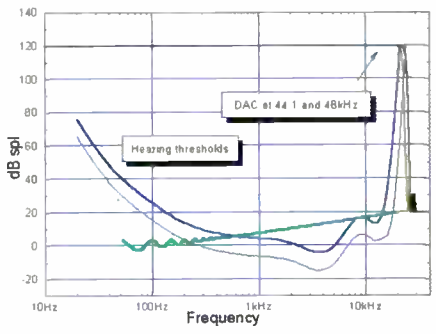


Fig. 17—Frequency response at 44.1 and 48 kHz against the audible significance of a dithered 16-bit noise floor and average and acute hearing thresholds.

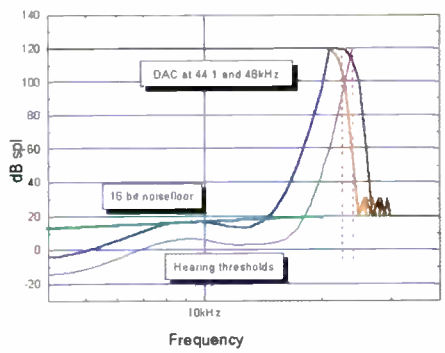


Fig. 18—Detail of the high-frequency range in Fig. 17.

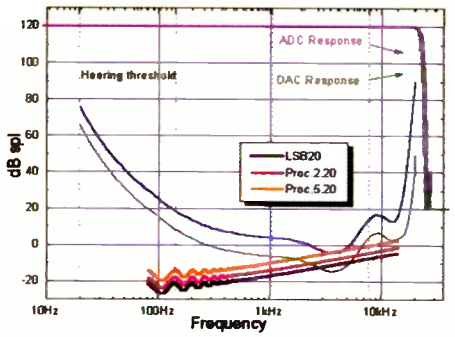


Fig. 19—Useful operating region of a well-engineered 20-bit channel. The audible significance of noise created by one, two, and five successive, dithered quantizations is shown against acute and average hearing thresholds.

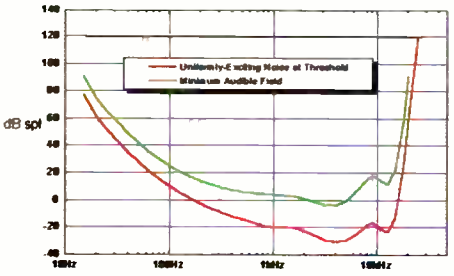


Fig. 20—The average human hearing threshold above a corresponding plot for the spectrum of the most intense in-band sound that cannot be heard.

the phase, ripple, bandwidth, and quantization side effects produced by the anti-aliasing and oversampling filters.

Many of the listening experiences that have raised questions about the high-frequency response of the Red Book CD channel have involved band-limited material, speakers without significant ultrasonic response, and listeners who have a self-declared lack of acuity at very high frequencies. It therefore seems probable that we should concentrate even harder on the methods used to limit the bandwidth rather than spending too much time considering the rapidly diminishing potential of program content above 20 kHz.

This conclusion supports the development of high-resolution recording systems that capture the original at a sampling rate higher than 48 kHz but do not necessarily distribute at so high a rate. Such a system might, for example, benefit from the anti-aliasing filters in a 96-kHz ADC at capture but use different filtering means to distribute at 48 kHz, thereby reaping most of the benefits that could have been obtained by using a chain that operated at 96 kHz throughout. Interestingly, this is exactly how current DVD players work when playing a DVD containing 96-kHz PCM audio. The signal is carried at 96 kHz on the disc, but because there are not yet standards for a 96-kHz digital output, the players downsample to 48 kHz (and usually 20 bits).

PSYCHOACOUSTIC DATA

There is very little hard evidence to suggest that it is important to reproduce sounds above 25 kHz. Instead, there tends to be a general impression that a wider bandwidth can give rise to fewer in-band problems. Yet a few points must be raised before dismissing audible content above 20 kHz as unimportant.

The frequency response of the outer and middle ear has a fast cutoff rate resulting from combined rolloff in the acoustics of the meatus (the external ear canal) and in mechanical transmission. There also appears to be an auditory filter cutoff in the cochlea (inner ear) itself. The cochlea operates "top-down," so the first auditory filter is the highest in frequency. This filter centers on approximately 15 kHz, and extrapolation from known data suggests that it should have a noise bandwidth of approximately 3 kHz. Middle-ear transmission loss seems to prevent the cochlea from being excited efficiently above 20 kHz.

Bone-conduction tests using ultrasonics have shown that ultrasonic excitation ends up in this first "bin." Any information arriving above 15 kHz therefore ends up here, and its energy will accumulate toward detection. It is possible that in some ears a stimulus of moderate intensity but of wide bandwidth may modify perception or detection in this band, so that the effective noise bandwidth could be wider than 3 kHz.

The late Michael Gerzon surmised that any in-air content above 20 to 25 kHz derived its significance from nonlinearity in the hearing transmission and that combinations of otherwise inaudible components could be detected through any resulting in-band intermodulation products. There is a powerful caution against this idea, however. As far as I know, music spectra that have measured content above 20 kHz always exhibit that content at such a low SPL that it is unlikely the (presumably even) lower SPL difference distortion products would be detectable and not masked by the main content.

WHAT SHOULD THE SAMPLING RATE BE?

Why should we not provide more bandwidth? The argument is simply economic: A wider bandwidth requires a higher data rate. For a given carrier, a higher data rate reduces playing time or the number of channels that can be conveyed.

To get another perspective on this question, we will take an interesting detour, but it requires acquaintance with two new concepts. The upper curve in Fig. 20 shows the familiar human hearing threshold. Current psychoacoustic theory considers that this hearing threshold derives from two mechanisms. First, the threshold curve's bathtub shape is due essentially to the mechanical or acoustical response of the outer, middle, and inner ear. Second, the threshold level itself is determined by internal noise. The hearing system provides a continuous background noise, which is of neural or physiological origin and which determines the quietest sounds we can detect. Obviously, we do not hear this background noise because the brain normally adapts to ignore it!

However, if we were trying to understand human hearing as a communication channel, this noise floor is one of the important parameters. Now, the threshold shape is not what engineers call the noise spectrum but is, instead, the effect of that spectrum. The difference comes from the fact that the human cochlea behaves as though it has a bank of internal filters. These filters are approximately one-third of an octave wide above 1 kHz, and the effect of these filters is to accumulate all the noise around them. If we calculate the noise spectrum that has the *effect* of the hearing threshold, we get the lower curve in Fig. 20.

This plot shows a noise spectrum that has three fascinating properties. (1) A noise exhibiting this spectral density will be undetectable or, when its level is raised, will be equally detectable at all frequencies; it is uniformly exciting at threshold. (2) This noise spectrum, just below threshold, is the most intense in-band sound that we *cannot*

hear. (3) The "threshold noise-spectral-density (NSD)" curve is analagous to the internal noise of the hearing system.

Taking this last point, we make a further step. Since Fig. 20 shows the effective noise floor of the hearing system, we can now attempt to specify a PCM channel that has the same properties (in order to estimate the information requirements of human hearing). The point is that if we can model the human hearing communication channel, then that channel *must*—by common sense—be the *minimum* channel we should use to convey audio transparently.

Figure 21 replots this auditory threshold on a decibel-versus-linear-frequency basis, i.e., a "Shannon plot." The area bounded by the noise floor, maximum level (headroom), and maximum frequency in such a plot is a measure of the information or data capacity of the channel. When the noise floor and headroom are flat, we call it a rectangular channel. According to Shannon's theory and to the Gerzon-Craven criterion for noise shaping, this floor can be represented by an optimum minimum channel using noise shaping that conveys 11 bits at a sampling rate of 52 kHz. This straightforward analysis overlooks the fact that if only 11 bits are used, there will be no opportunity for any processing whatsoever and no guard band to allow for differences in system or room frequency response or between human listeners. In a sense, the 52-kHz, 11-bit combination describes the minimum PCM channel, using noise shaping, capable of replicating the information received by the ear. Transmission channels need to exceed that performance, so we can argue convincingly that a 58-kHz sampling rate with 14 bits ought to be adequate if in-band noise shaping is used.

> For five or more channels, transparency can be assured with 58-kHz, 20-bit linear PCM coding.

More interestingly, this simple analysis tells us that 52 kHz is the absolute minimum desirable sampling frequency. For comparison, Fig. 21 shows the channel space occupied by CD audio. It also includes the noise-spectral density of an 18.2-bit, 96-kHz channel without noise shaping, the minimum noise floor that suggests transparency at that sampling rate.

The conclusion, then, is that both psychoacoustic analysis and experience tell us that the minimum *rectangular* channel necessary to ensure transparency uses linear PCM with 18.2-bit samples at 58 kHz. The dynamic range must be increased according to the number of processes taking place before and after delivery, and the number of channels feeding into the room, so that we may converge on 20 bits at 58 kHz for five or more channels.

SAMPLING-RATE ISSUES

If we were to be forced, right now, to specify a channel immune to criticism, we would have to: (1) Increase the sampling rate by a margin sufficient to move the phase, ripple, and transition regions further away from the human audibility cutoff. One could probably make a sensible argument for PCM sampled at 66.15 kHz (44.1 kHz times 1.5). The potential response is shown in Fig. 22. (2) Increase the word leng h (to 20 bits, for example) so that the audible significance of quantizations, whether performed correctly or incorrectly, will be minimal. Of course, with a higher sampling rate it is not strictly necessary to use a word length exceeding 16 bits. This is because the operating region of a 16-bit, 88.2-kHz (or higher, such as 96-kHz or even 192-kHz) channel includes a large, safely inaudible region within which noise shaping can be exploited.

Given that material recorded at high sampling rates will need to be downsampled for some applications (CD, for example), there are strong arguments for maintaining integer relationships with existing sampling rates—which suggests that 88.2 or 96 kHz should be adopted. This would not be an efficient way to convey the relatively small extra bandwidth thought to be needed, but the impact of using these higher rates can be substantially reduced by using lossless compression (packing). Although there is a small lobby that suggests even higher sampling rates should be used, such as 192 kHz, I disagree. When 88.2- or 96-kHz channels have been correctly designed in terms of transmission, filtering, and so forth, higher rates simply will not offer any benefit.

I realize that by expressing the requirements of transparent audio transmission I am nailing a flag to the mast and lay myself open to all manner of attack! However, this analysis has been based on the best understanding to date on this question, and we should exceed these requirements *only* when there is no detrimental cost to doing so. A

Next issue: Part 2 concludes with a look at how transparent PCM audio coding could be implemented for DVD-Audio.

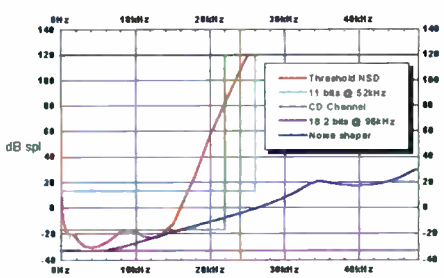


Fig. 21—A "Shannon plot" of the uniformly exciting noise threshold versus the characteristics of various PCM channels.

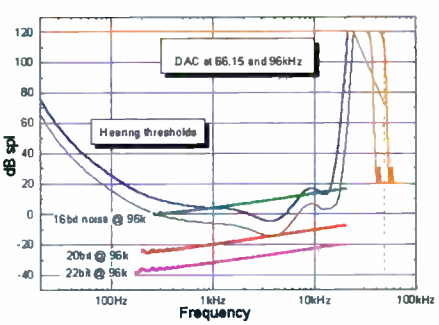
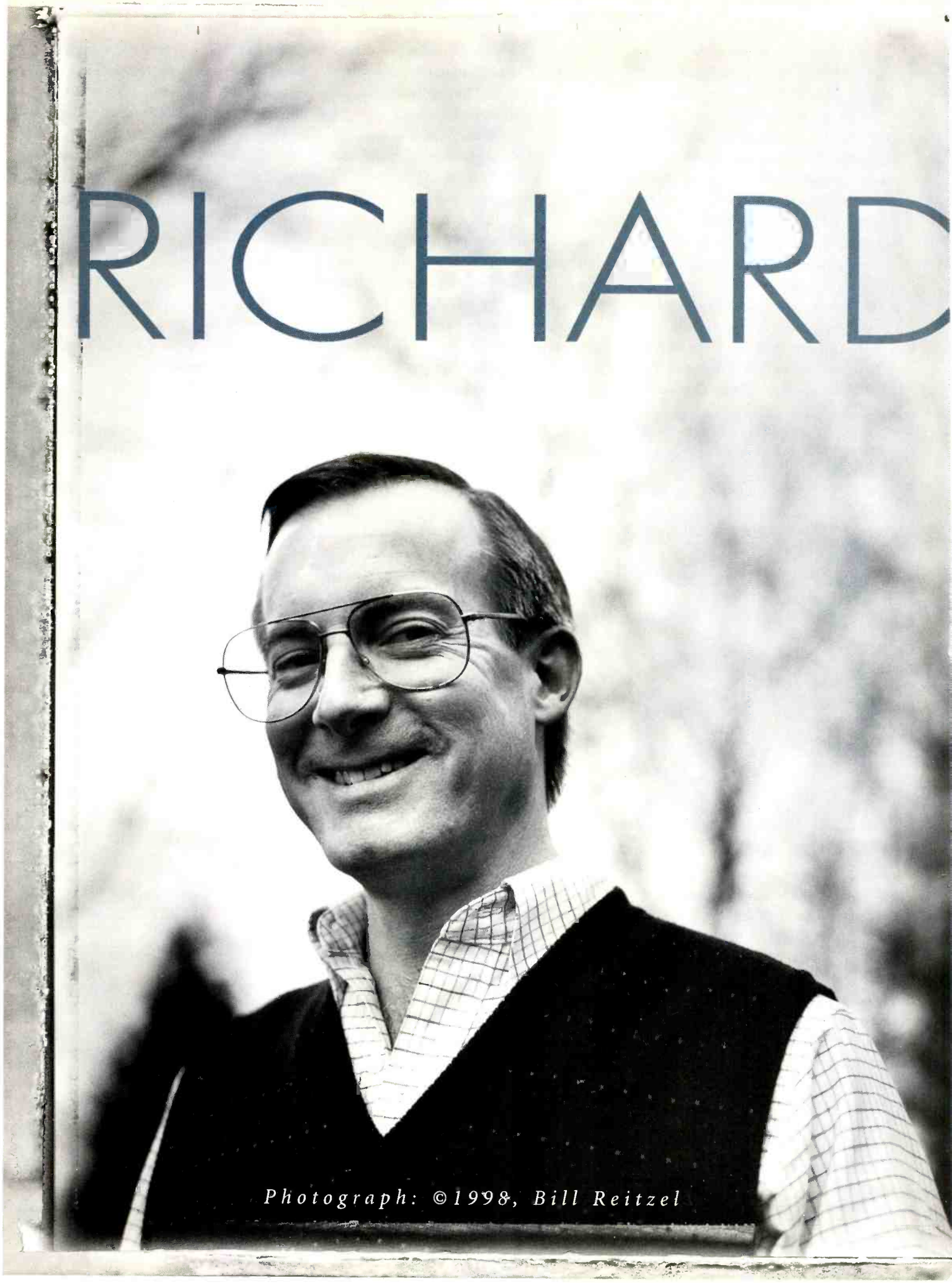


Fig. 22—Characteristics of PCM channels using various word lengths and sampling rates, plotted against acute and average hearing thresholds.

RICHARD



Photograph: ©1998, Bill Reitzel

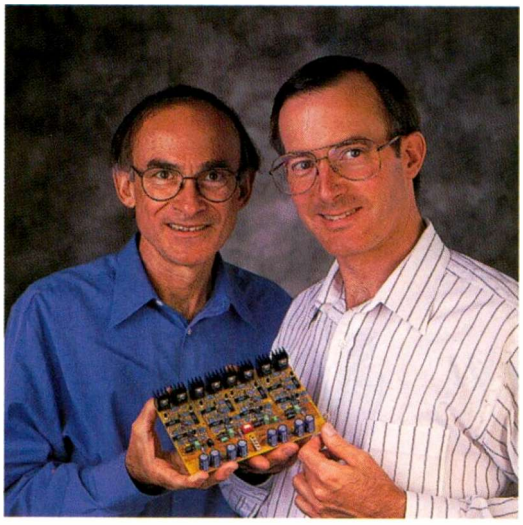
FRYER

by David Lander

Shedding Light on Spectral

Though Spectral Audio has been producing audio components for more than two decades, readers of U.S. hi-fi magazines may find their mental picture of the company a bit ghost-like. Limited press coverage in this country is almost certainly the reason. American writers, Spectral founder and owner Richard Fryer explains, have been reluctant to review entire systems. Yet that's precisely the way Fryer says his products need to be tested. They are, he emphasizes, designed to perform together and can be judged fairly only as an ensemble.

The son of a physicist doing government work, Fryer was born in Los Alamos, New Mexico, in 1953. Soon after, the family moved to California, where Professor Edward Fryer's work—Rick's father taught at Stanford University and Pomona College—led to his son's spending a good deal of time on and around college campuses. The milieu, one in which a lot of questions are asked and ideas shared, had a lasting effect on him, Rick Fryer reasons.



Richard Fryer (right) and Keith Johnson, Spectral's Director of Engineering

Fryer's route to the high-end audio summit led him to jobs in high-end retailing (at a Los Angeles shop called 2001 Sound Odyssey) and manufacturing (with speaker maker ESS). He also worked in publishing, at a small audiophile magazine, *Sound Advice*, where he established test procedures and reviewed equipment. (And where he worked with Damien Martin, who was to become a partner in Spectral and its first engineer.) Eventually, Fryer found his way to Northern California's high-technology epicenter, Silicon Valley, where he put down corporate roots and continued his quest for the ultimate in music-reproducing techniques.

To be able to reproduce a loud bang, and then just settle into absolute silence, you need extremely fast circuits.

As for the company name, it has nothing whatsoever to do with ectoplasm or phantasmagoria. Spectral, Fryer explains, is a reference to the spectrum from DC to light, an allusion to the extremely wide bandwidth of the products that wear the brand. It's also meant to suggest the lucency and uncountable colors of music, which Rick Fryer has devoted his career to reproducing for serious listeners.—*D.L.*

I've heard that when you were working on prototypes for what would become the MS-1 preamp, the first component to carry the Spectral name, you made a walkabout into other fields to find out about more advanced technologies than those being used in the audio industry. Tell me a bit about that.

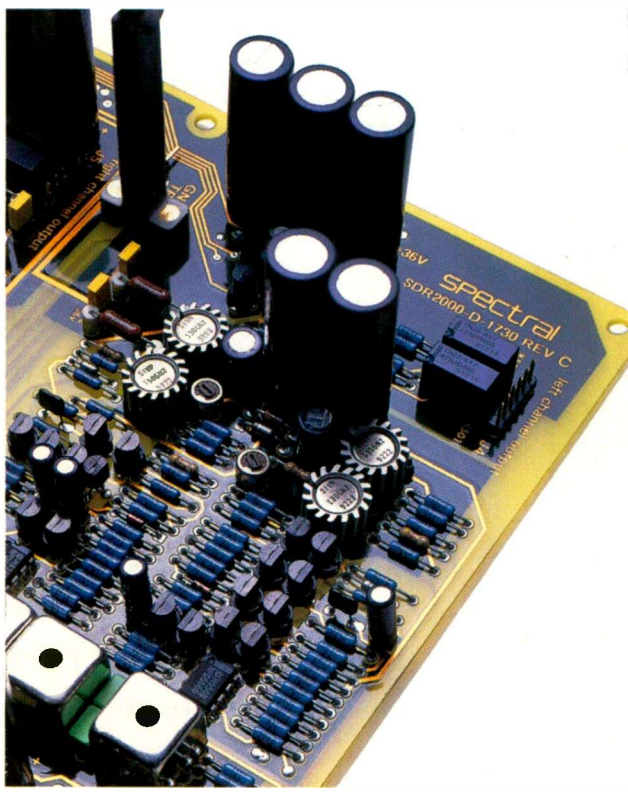
It exposed me to the cutting edge. There's a considerable difference between what is done in fields like radio, communications, and microwave—and computers certainly—and what is done even in what we would consider perfectionist audio. High-technology people, engineers, will tell you that there can be a 10-year trickle-down effect before processes, components, and technologies developed for state-of-the-art areas begin to make their appearance in consumer electronics, mostly for two reasons. Truly, cost constraints are operating here; in many of these technologies, getting the performance is the issue, not the price. The other reason is simply familiarity.

And you didn't want to wait 10 years.

I felt that some of these techniques—certainly not all, but some—begged to be used in high-end audio design.

How did you choose to use them?

We started with a preamplifier design that we could take to an instrumentation level, and we developed that design with the best possible discrete parts. We



did this in a facility that was tremendously rich in instrumentation capability, in an extremely successful Bay Area computer firm.

What was it called?

Four Phase Systems. The company's gone now, but they were building advanced process-control computers—industrial computers. In the '70s, companies such as Hewlett-Packard and Tektronix were developing some of their finest instruments. We were very interested in applying some of these instruments and measurement techniques. When we reviewed products at *Sound Advice*, we were fascinated that the great preamplifiers of the day sounded nothing alike. Bill Johnson had a marvelous achievement in his SP-2 and SP-3 preamps, and Mark Levinson and his engineer, John Curl, had a breakthrough product in the JC-2 preamplifier. But there was no commonality in terms of the sonic and aesthetic experience of these high-end products. That raises several questions. What is accuracy? What's the truth here? Is it something in between, or is it something else entirely? I think, at first, our motivation was purely scientific curiosity. Because without having something better, something as a reference, we couldn't get to the truth. We needed something superior, so we developed a reference preamplifier that was not subject to commercial constraints, that we felt served as a better reference than commercially available products. At first we didn't see it as commercial; we treated it as test instrumentation. If a resistor cost $4, that's what it cost. We knew the precision was higher; we knew it was better. We could get better rise time, and it was quieter.

How often did your experimentation get you closer to what you considered sonic truth?

Well, many times it didn't. We went through tremendous periods of experimentation. We threw everything against the wall to see if it would stick, so to speak. At first, we weren't sure what the sonic consequences would be. No one had attempted this, so there wasn't a body of information. But we were pretty confident that our work would yield significant results.

Since the MS-1 cost about $1,600 at a time when other high-end preamps were in the $650 to $850 range, the first of those results proved expensive.

It did. Embarrassingly so. This was not our style and not what we wanted, but, at the end of the day, you added up the parts and the processes, and it was an expensive, hand-built instrument.

But people bought it.

Yes. More than we imagined. The dealers found out about the MS-1 very quickly, and it launched the company. We have to credit a couple of other companies for having developed dealers who could hear the difference and did care. All of this is a tree falling in the forest if people don't care.

What specific aspects of reproduced music do you think listeners should care about? What sonic attributes concern you most?

Things like transparency. Spatial things. Resolving the detail, large and small, of a recording. Listening involvement and excitement and communication in a recorded performance tend to recede or become more subtle when they're not absolutely optimized. There's something that says, "I'm not really here. I'm not sound occupying a real space." But when you listen to a microphone feed, many times you get this electrifying feeling of being there. We asked ourselves, why isn't that sense of being there captured more completely in high-end systems?

Spectral's DMC-20 Reference preamplifier and its modular circuit board

What did your research lead you to conclude?

Some very basic things have come out. As well as linearity and other conventional factors that audio designers talk about, the factors that make these subtle and involving things occur are essentially related to speed and settling time. To be able to reproduce a loud bang and, suddenly, after that, have no memory of events, just a settling to absolute

When you listen to a live microphone feed, many times you get this electrifying feeling of being there.

silence as if nothing had happened, you need circuits that are extremely fast. Until you hear the phenomenon demonstrated, you don't always make the tie-in. But from the turn of the century, and particularly through the War years, there was quite a bit of research done at the major American universities—the military funded much of the experimentation—that clearly confirmed many phase-related relationships. The initiation response in the ear's hair cells is at least 10 times faster than the bandwidth being sent through the middle ear, meaning that the ear is sensitive to some form of wavefront or initialization information that can be called phase or time-arrival. We need very fast circuits that settle very quickly and completely from a musical event; you don't want a signal artifact that remains after the event. That's why we need the speed.

We want to provide as much information, in a linear fashion, as can possibly be retrieved from a recording.

You've said that Spectral does more volume in Europe than in the United States.

Yes. You can argue that there is a sensitivity and refinement in music appreciation in Europe, where the bigger-hammer approach is not as respected as it is in some other markets. The idea that bigger is better is not always espoused in more sophisticated urban areas. That does dovetail with what we find interesting. On some levels, we develop products to satisfy our own sensitivities. Having been around high-end equipment a good deal of our lives, we're ready for something that shows refinement and musical capability. And this doesn't come from a bigger hammer; it comes from the ability to satisfy the ear, and the ear is voracious for detail and the sense of place. We want to provide as much information, in a linear fashion, as is possible to retrieve from a recording. Nothing less and nothing more. This requires very high-performance circuitry capable of great subtlety. It does not mean big; it means, when you need the resolving power, it's there.

You also insist on using discrete circuitry much of the time. Why?

For critical signal applications, we've found over the years that integrated circuits simply don't meet our quality standards, although we're constantly evaluating new parts and, to everyone's credit, they're getting better and better. Still, in the rigorous evaluations that we do, they simply can't pass the microphone feed accurately. There's so much musical information and life that's lost, even with the most premium integrated-circuit amplifiers, that ICs are not up to our needs in a critical signal application. Nevertheless, there are applications for servos and for less critical parts of the signal path where these can be perfectly workable.

Another of Spectral's defining traits is that you emphasize a systems approach that extends as far as the cable. How did this develop?

Spectral, during the early '80s, had already come up with the concepts of fast-settling, high-speed amplifiers and preamplifiers, but the interfaces, so to speak, were at a level of crudeness that did not allow us to push ahead. We met Bruce Brisson, then a consultant for Monster Cable, and engaged him to help us with this technical problem [an arrangement that led to the founding of Musical Interface Technologies, commonly called MIT]. Basically, like microwave designers or people involved in radio and high-speed analog signal work, we needed tuned systems. A cable that was more than a wire, one that was actually terminated as a low-pass filter, was a key breakthrough that allowed high-speed amplifier circuits to be stable and practical for home audio use. By defining the cable as a low-pass filter, Bruce was able to achieve a level of transient resolution—transient accuracy—that was simply unknown before. With this cable technology, we can produce very-high-frequency square waves with remarkable fidelity and achieve things that amplifiers couldn't do in the past in terms of rise and settling times. It opens the door to a degree of transparency, at

The SDR-2000 Reference D/A converter

both low and high levels, that isn't possible with slower circuits. It does, however, require a commitment to full system integration, something that historically hasn't been done much in audio, even high-end. In the technology fields, there's never any argument about how instruments can be used together and optimized. You rarely think of a measurement system or a high-performance microwave system without looking at the component parts and how they integrate and work together. In component audio, we're clearly endorsing that, too, but typically the industry falls short in the optimization. Why? Well, a lot of it probably comes down to commercial need; certainly many audiophiles derive tremendous satisfaction from mixing and matching components themselves. The only problem with this is, as we get into high-performance audio products, these designs are intrinsically complex and the interactions subtle and sonically significant. Mismatching of high-end components is, unfortunately, all too common.

You maintain a close relationship with Reference Recordings. In your view, it appears, the systems approach goes beyond products and extends to companies that work together.

It does, because no single audio company alone can make an assault this wide on the state of the art without having collaborators. We couldn't have this successful systems approach without MIT, which developed the cable solutions that allowed us to pursue very-high-speed applications. And we could not evaluate these circuits for their musical accuracy without fundamental experience in making recordings and comparing the sound to the microphone feed. Those things are critical to a product that addresses the issue of what accuracy in music reproduction is.

Have you never been tempted to put Spectral into the speaker business?

People who have followed us have regularly seen Spectral speaker prototypes in our displays, but these are to prompt and to excite. It's very important that we understand there's no one ideal speaker, there's no one ideal speaker technology. If we could have a wish for these transducers, it would be that they be fast, articulate, well-settling, well-behaved, and powerful, so that subtlety, transparency, and spatiality are resolved from a good recording. Whether it's a big speaker or a little speaker, a planar or a ribbon, there's the capability to do this. We would not be able to address all those technologies, and we're very interested in supporting a diversity.

I gather Damien Martin, your first engineer, is no longer involved in Spectral.

Not for many years. He's involved in other audio products. He came out of school as an electrical engineer and also was a very talented film student. His contributions to the field give you some sense of how engineers can be now, that they can have a humanistic background and not be merely meter readers. The New Age audio engineer is someone who has to bridge a number of philosophies and areas of specialization.

That seems to describe Keith Johnson, who now does your engineering. When did his involvement with Spectral begin?

Keith has been involved for many, many years. When Damien Martin started his own company in the mid-

SDR-3000
Reference
CD transport

'80s, Keith assumed full engineering control. I'd known him for years. He lived in Southern California and was one of these dear people that many of my friends knew. He became involved with Tam Henderson at Reference Recordings after RR had produced maybe two recordings. That relationship with Reference Recordings exists to this day and is a foundation for our development technology.

Please say a bit more about that aspect of developing your products. You have mentioned the importance of the microphone feed.

A cable that serves as a tuned low-pass filter allows high-speed circuits to be stable and practical for home audio.

When there's so little consensus as to accuracy in these state-of-the-art products—every system you hear is quite different—and when you interpose one of these components or systems between you and a microphone feed and it changes the sound substantially, you have to ask, what is this doing to a recording? There's tremen-

dous tuning that goes on, not only in audio components—preamps, power amps, turntables, etc.—but in cables and accessories. All of these can change the sound, and change isn't intrinsically good. You have to ask yourself, when is it more completely faithful to the source? This is a much harder question, and answering it consistently demands particular references. A remembrance of the concert hall is not enough. In perceptual psychology, you begin to understand the tunability of the ear, selective memory, and the ear's ability to adapt. And, of course, we all hear somewhat differently. When you have a number of tuning options in a circuit and don't know which one is right (or are concerned that your observer biases are going to intervene), you have to go to a higher level and make a choice that's more objectively based.

Fryer's emphasis on discrete circuitry is based on exhaustive component testing.

We think that, imperfect as it is, the best basis for choice is the live music experience, and particularly what the microphones capture as a feed. We may or may not be able to capture the sound of the concert hall, which is a function of the miking and that sort of thing. But we can, to a great degree, use the source of a recording as a reference for comparing components that are put in the chain. If possible, we want to get our circuits into the recording chain and listen to the contributions or subtractions. We do that by inserting the circuits during live recording events on an experimental basis or by inserting them between the microphone feed and loudspeakers. Compared to any recording, the microphone feed is so extraordinarily rich, detailed, spatial, and subtle that to develop high-end audio on the basis of a recording is an obscene compromise. There is no comparison to what is done under live conditions—the energy, the subtlety, the million-to-one ratio in dynamics. This is all possible with a live musical event, but not with playback. Anything that affects the complete dimensional and dynamic package of sound from the microphones should be looked upon suspiciously, even if it sounds better to you. It can take years to develop an audio component this way—constantly taking the circuits out to the site, listening under live conditions, coming back and making the changes, and also using original lacquers and masters as a reference. But it can ultimately lead you to a level of sonic refinement that is not otherwise possible.

There's no comparison to what is done under live conditions—the energy, the subtlety, the million-to-one ratio in dynamics.

Let's move on to the introduction of CDs and CD players, an event you've described as a "trauma," and Spectral's response to it.

CD was a mid-fi medium, a commercial medium with tremendous sex appeal and convenience that addressed almost none of the issues of precision and resolution that Spectral has been involved in. We began to realize that the mainstream industry was not going to address the issues of digital artifacts and digital compromise because of CD's widespread acceptance. In those days, there was no one in the mainstream who said there was anything wrong with digital. We had to roll up our sleeves and get started, and at that point—shortly after the first Compact Disc recordings and players were introduced—there weren't even names for the digital distortions. We lost no time in putting our engineering resources to work on a high-end digital playback system. The result of that work, which Keith Johnson headed, was the SDR-1000, which probably lays claim to being the first from-the-ground-up American Compact Disc player. Previously, CD players were modified with output sections or various tweaks. This was the first time that high-performance discrete circuitry, balanced decoding, conjugate filters in the digital and analog domains, and direct-clocked conversion were used.

The SDR-1000 was introduced nearly a decade ago. More recently, Keith was involved in devising High Definition Compatible Digital encoding. Do you want to comment on what HDCD does for Compact Disc reproduction?

Pacific Microsonics [the company that developed the system, where Keith Johnson is also chief engineer] can make its own statement about what HDCD does, but the antecedents, without question, can be found in Spectral's original digital products. That is the research foundation for the HDCD system that Keith later developed. A

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1990- "Cambridge SoundWorks shows signs of becoming the L.L. Bean of hi-fi." **- *Twice***

1991- "By selling direct at an attractive price, Cambridge SoundWorks could sell for as much as 40% less." **- *CD Review***

1991- "The Cambridge SoundWorks lineup can be compared only with much larger speakers at substantially higher prices." **-*Stereo Review***

1993- "Selling direct allows Cambridge SoundWorks to price speakers hundreds of dollars below the competition." **-*Inc.***

1996- "The only speakers you'll ever need." **- *PC Magazine***

1997- "Unless competitors rise to the Cambridge challenge and begin introducing truly stunning speakers, they will continue to be tossed to the curb." **- *Boot***

1997- "Go with the name you can trust." **- *PC Computing***

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EQUIPMENT **PROFILE**

EDWARD J. FOSTER

JVC XV-D2000BK DVD PLAYER

The JVC XV-D2000BK is a DVD player with 5.1-channel analog output capability from its Dolby Digital (AC-3) decoder. It can play DVDs, Video CDs, and music CDs, except for those of the recordable variety (CD-Rs). (The manual warns that playing CD-Rs might damage them.) It can handle just about any audio format: 16-bit/44.1-kHz linear PCM for CDs, AC-3, and 16-bit/48-kHz to 24-bit/96-kHz linear PCM for DVDs.

The XV-D2000BK has totally separate audio and video paths, to minimize crosstalk and thereby ensure high sound and picture quality. (It also uses separate power supplies for the analog and digital circuitry.) On the video side, it uses a 10-bit, 27-MHz oversampling video DAC that is claimed to reduce aliasing and yield optimum dynamic range. Both S-video and composite-video connections are provided.

On the audio side, the player has JVC's proprietary PEM (Pulse Edge Modulation) D/A converter, basically a one-bit DAC with quasi-fourth-order Victor Advanced Noise Shaping (VANS). A newly developed 96-kHz version of JVC's K2 interface is said to eliminate jitter and "ripples" and to reduce digital distortion. Although the D2000 has a built-in Dolby Digital decoder, it also has outputs for digital audio bitstreams, PCM or AC-3, for downstream decoding and conversion.

It would be hard to miss the JVC XV-D2000BK's distinctive front panel in a DVD-player lineup. And its display is one of the most informative around. A fluorescent dot-matrix panel shows track number and time, a string of three LEDs tells you what audio format is being played ("Dolby Digital 5.1," "Linear PCM," or "96KHz Sampling"). Illuminated legends ("L," "C," "R," "LFE," "LS," "S," and "RS") supplement these lights, telling you which channels are active ("S," in this case, stands for a monaural surround channel, as found in Dolby Surround matrixed soundtracks). An additional LED ("Resume") glows when a point on the disc you may wish to return to has been stored in memory.

The "Standby" light above the "Power" switch glows when the player is plugged in but not turned on. When the player is operating, the light extinguishes, leaving the main display and format lights to serve as "on" indicators. A red bar below the display and above the disc tray blinks when the tray is opening or closing and while the disc's table of contents is being read. If the disc is a CD, the bar's light goes off; if it's a DVD, the bar continues to glow.

THE JVC XV-D2000BK'S DISTINCTIVE AND INFORMATIVE FRONT PANEL WOULD BE HARD TO MISS.

Below the "Power" switch is a gold-plated headphone jack. Next to the jack is a "Phones Level" control, rather unusual on a DVD player but nice for private listening. To the right of the display is a fairly complete set of control buttons, not only for basic transport operation (play, stop, bidirectional skip/search, and eject) but for system operation, too. One of the system-control buttons activates the "On Screen" display, while four others, arranged in a rectangle, move the on-screen cursor. "DVD Menu" brings the disc's menu, if any, to the screen; "Enter" executes whatever menu item

Dimensions: 17⅛ in. W x 4⅜ in. H x 12⅞ in. D (43.5 cm x 11.2 cm x 32.8 cm).
Weight: 10.6 lbs. (4.8 kg).
Price: $999.95.
Company Address: 41 Slater Dr., Elmwood Park, N.J. 07407; 201/794-3900; www.jvc-america.com.

Photos: Michael Groen

you've selected with the cursor keys. The only pause control is on the supplied remote; aside from that, you can operate the D2000 quite nicely from the panel.

The RM-SVD2000U remote JVC ships with the XV-D2000BK has been preprogrammed with the control codes for a variety of TVs, cable TV boxes, and satellite TV receivers but not, surprisingly, with the codes of any VCRs. (Is JVC, the inventor of both VHS and S-VHS, trying to tell us something?) I found the remote's layout very logical: DVD transport and main functional controls are near the base of the unit, multi-use controls toward the forward end.

The remote's complement of DVD transport controls includes pause and "Step" (JVC's nomenclature for frame advance). If "On Screen" has been pressed, touching the "Title Menu" and "DVD Menu" bars will bring them up, if the disc carries those menus. (If it doesn't, the international entry-forbidden symbol, a circle with diagonal bar, appears.) You can go back to the previous menu by tapping "Return." Commands are selected from the on-screen menus with the remote's cursor control, an oval four-way rocker, and a curved "Enter" bar.

Forward of the remote's transport controls are three small buttons. "Resume" stores the location of a point on the disc to which you may want to return. "Angle" changes the camera angle, on DVDs that support that feature. And "Sub-Title" toggles subtitles, if any, on and off. (Subtitle language is selected via on-screen menus.) At the far right of this row of buttons is a slide switch that determines whether the multipurpose buttons control your DVD player, TV, or cable ("CATV") box; four rockers separate this row from the numeric pad. The rockers control slow-motion speed (½, ⅓, ¼, ⅛, 1/16, or 1/32 of normal), sequentially change channels, adjust the volume of a TV, and adjust the volume of a JVC amplifier or receiver. The numeric pad has 12 keys: "0" through "10" and a "+10" key (that can be pressed multiple times to access higher numbers). The pad is used to enter channel numbers and the title, track, or chapter numbers on discs.

THE JVC OFFERS GOOD VIDEO, NICE MENUING, AND VERSATILE AUDIO AND VIDEO OUTPUTS.

In front of the numeric keypad are two rows of buttons. The four larger controls open and close the DVD tray and turn the DVD player, your TV, and your cable box or satellite receiver on and off. The three smaller controls are for entering the manufacturer's code for non-JVC equipment ("Set"), muting your TV, and toggling between the TV's tuner and its video input.

The JVC XV-D2000BK's rear panel covers all the bases. There's a "2CH" pair of gold-plated RCA jacks for analog stereo output (and for matrixed Dolby Surround signals from Dolby Surround DVD soundtracks and CDs or Dolby Digital 5.1 DVD soundtracks), six more gilded RCAs (for analog front, surround, and subwoofer signals decoded from Dolby Digital 5.1 soundtracks), Toslink and coaxial jacks for "PCM/Dolby Digital" digital audio outputs, composite- and S-video jacks, and a pair of "AV Compulink" jacks that daisy-chain the D2000 with other JVC components for system-wide control. A slide switch on this panel ("Attenuator") drops the level at the "2CH" jacks by 6 dB; another ("Normal/Gain Plus") raises the subwoofer output by a like amount. All RCA jacks are gold-plated to ensure reliable contact.

The XV-D2000BK has a two-page menu for system setup. The "On Screen" key elicits this menu if no disc is loaded or if a DVD is loaded but not playing. The first preference screen permits you to choose the menu, audio, and subtitle languages separately. In addition, it offers a choice of aspect ratio and the option of turning off the three on-screen guide icons that show which DVD special features are available in any given

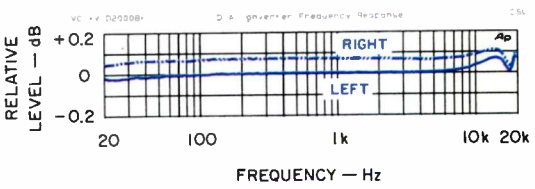


Fig. 1—Frequency response at "2CH" outputs.

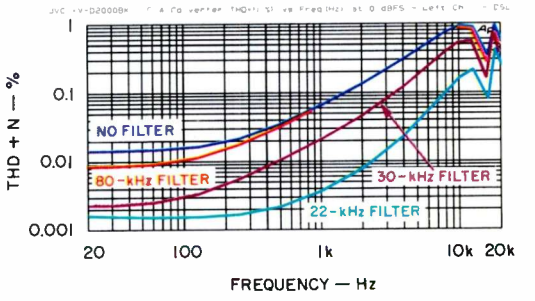


Fig. 2—THD + N vs. frequency; see text.

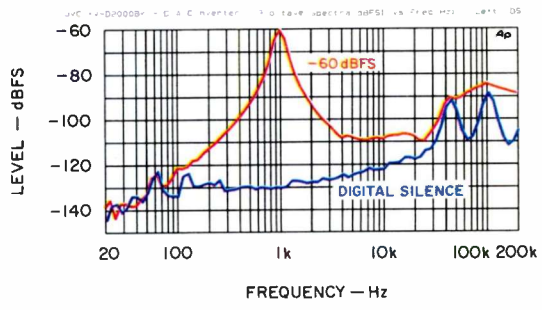


Fig. 3—Noise spectra.

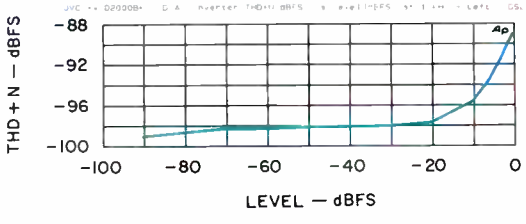


Fig. 4—THD + N vs. level at "2CH" outputs.

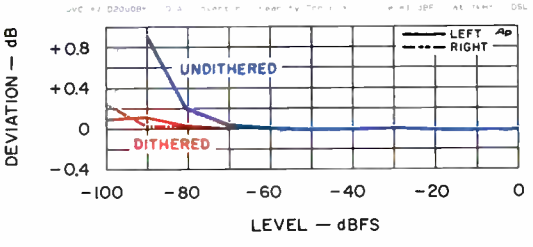


Fig. 5—Deviation from linearity.

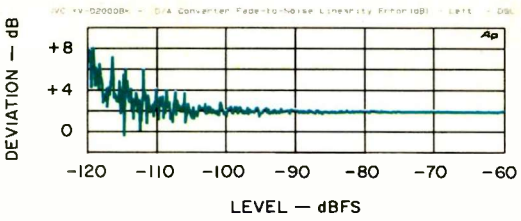


Fig. 6—Fade-to-noise test.

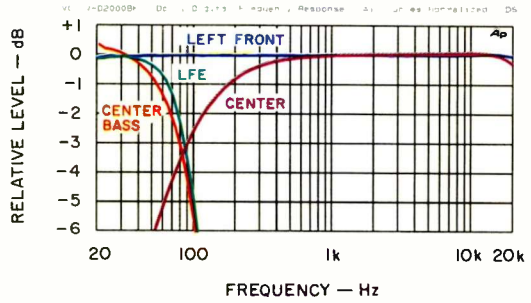


Fig. 7—Frequency response at Dolby Digital outputs.

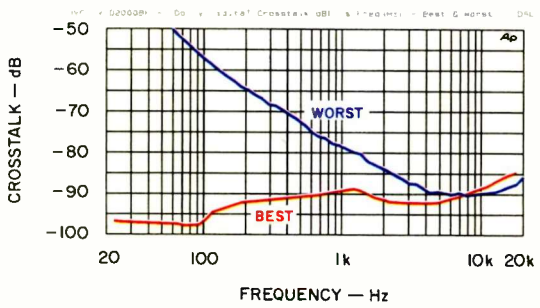


Fig. 8—Crosstalk at Dolby Digital outputs.

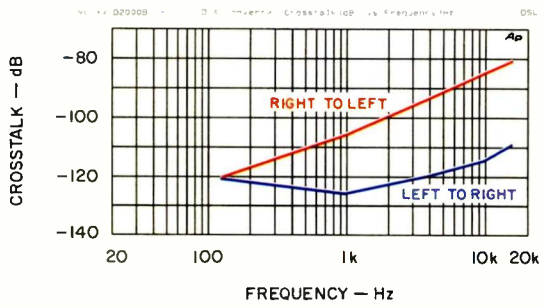


Fig. 9—Crosstalk at "2CH" outputs.

Its logical layout makes the JVC's button-studded remote control easy to operate.

scene. (Scenes recorded from multiple angles are indicated by a movie-camera icon, scenes with multiple soundtrack languages are indicated by a circle followed by two half circles, and multiple subtitle languages are indicated by a TV-screen outline with four dots across its bottom.)

The second setup page lets you set the "AV Compulink" mode, choose PCM-only or PCM and AC-3 digital output, and tell the internal Dolby Digital decoder whether your system includes a center speaker and surround speakers. It also enables you to direct bass energy to a subwoofer or to the left and right front speakers ("Bass Redirect").

If a disc is playing, the "On Screen" key brings up different menus, depending on the type of disc (DVD, Video CD, or audio CD) and its capabilities. For example, random play is available with an audio CD but not with a DVD.

The choice of menu options is, of course, greatest with DVD. Depending on the features implemented on the DVD you're playing, you'd use this menu to select camera angles and audio and subtitle languages, to search the disc by time or chapter number, and to repeat chapters, titles, or marked portions of the disc ("A-B Repeat"). You can also use it to adjust video resolution, selecting a sharp or soft image or activating video noise reduction—a feature I can see no need for with DVD. This menu permits you to toggle Dolby Digital audio compression on and off, for quiet late-night viewing or full dynamic range. You can also select whether the "2CH" jacks deliver a Dolby Surround matrixed downmix from 5.1-channel soundtracks (for downstream Dolby Pro Logic decoding), plain stereo (to feed a tape recorder or an amp or receiver that lacks a Pro Logic decoder), or are silenced (you'd silence them when the 5.1-channel analog outputs are in use, since the other settings redirect the audio to the "2CH" outputs).

DVD's "Parental Lock" screen is independent of all others and is accessible only via the remote. Fortunately, JVC's complete, well-written owner's manual guides you through the D2000's intricacies.

Measurements

Following my usual practice when evaluating DVD players that have 5.1-channel analog output capability, I tested audio performance at both the "2CH" analog output (using the CBS CD-1 test CD) and at the six surround sound outputs (using Dolby Laboratories' test DVD). The CBS disc contains a far more complete set of tests for D/A converters than the DVD does, but the latter enables me to evaluate surround-channel response, crosstalk, and so forth. For most measurements, I used the normal setting of the XV-D2000BK's subwoofer-gain and "Attenuator" switches. I did check output level with the alternative settings of each switch and established that the former raised the subwoofer output's level by 6 dB and the latter cut the "2CH" output level by the same amount, as specified.

THE DOLBY DIGITAL DECODER'S CONTROLS ARE MINIMAL, BUT ITS PERFORMANCE IS QUITE GOOD.

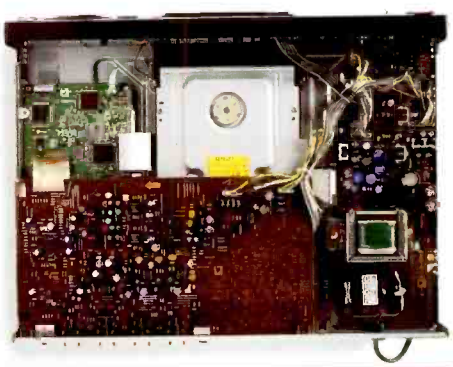
Converter frequency response, measured at the "2CH" output and plotted with an expanded relative level scale, is shown in Fig. 1. As you can see, it's extremely good. The total spread is within 0.1 dB, and there are just two filter ripples at the high end.

The output levels were well matched—within ±0.035 dB! Output level (2.25 volts) was typical of today's converters, albeit a bit more than the quasi-standard 2.0 volts. Should this bother a downstream component (and I sincerely doubt it will), you can always switch on the attenuator and drop the level by half. Output impedance, at 680 ohms, was fine. Because the XV-D2000BK has a headphone output, I figured I might as well give it a try; it proved remarkably good, providing plenty of output for both

high- and low-impedance headsets (see "Measured Data").

I did a double take when I measured converter total harmonic distortion plus noise (THD + N) versus frequency at 0 dBFS. In the bass, THD + N was admirably low—well under 0.002% out to a few hundred hertz. But then it started to climb. . .and climb. . .and climb; at 12.5 kHz, it had grown a hundredfold, to 0.2%, and reached almost 0.44% at 18 kHz, the penultimate test frequency. What was going on?

The measurements just cited were made with a 22-kHz low-pass filter; THD + N measurements on digital products are usually made with such a filter in the analysis loop to exclude noise and distortion above the audible range. The filter is meant to remove residual carrier and ultrasonic "beat" products, but, of course, the filter slope is not infinite so some ultrasonic noise and distortion do get through. A spectrum analysis showed me that, as I suspected, the "distortion" was mainly the result of intermodulation between the signal and the sampling frequency, yielding spurious beat tones at the differences between the signal and sampling frequencies. Even when the beat frequency was fairly far above the analysis filter's 22-kHz cutoff, the intermodulation was so strong that enough energy got through to lift the curve above the noise floor. At low test frequencies, the beat was so close to the sampling rate (44.1 kHz) that it was well attenuated and the measurement bottomed out on noise. That seemed to explain the shape of the curve.



THE D/A CONVERTER'S FREQUENCY RESPONSE WAS EXTREMELY GOOD, WITH ONLY MINIMAL FILTER RIPPLES.

To verify my theory, I widened the analysis filter to 30 kHz and then to 80 kHz; next, I essentially removed it entirely so that the analysis bandwidth was greater than 500 kHz. With each increase in bandwidth, the measured THD + N (Fig. 2) was higher in the bass and began its rise at a lower frequency than with 22-kHz filtration. All intermodulation products are included in the 80-kHz bandwidth, which is higher than the sampling rate; sure enough, this curve lies still higher in level and tops out at around 0.9%. Increasing the bandwidth further doesn't change matters except in the deep bass, where the distortion is low and the curve bottoms on noise. The 500-kHz curve lies a little higher than the 80-kHz curve in the deep bass, because there's more noise power in a 500-kHz bandwidth than in an 80-kHz bandwidth. The fact that the curve still lies lower in the bass than in the treble shows that the effect is frequency-sensitive, so my theory doesn't explain everything that is going on.

I repeated the test on the main front outputs of the 5.1-channel array, and the results were the same. And, since left and right channels produced essentially identical results whether measured at the "2CH" jacks or at the main front outputs; I decided to present only the data taken on the left "2CH" output.

The bottom curve in Fig. 3 is a third-octave analysis of output noise when playing the digital "silence" track of the CD-1 test

MEASURED DATA

PCM AUDIO

Line Output Level: Attenuator off, 2.25 V; attenuator on, 1.13 V.

Channel Balance: ±0.035 dB.

Line Output Impedance: 680 ohms.

Headphone Output Level: Maximum voltage, 4.14 V; maximum power, 19.5 mW into 600 ohms or 27.7 mW into 50 ohms.

Headphone Output Impedance: 125 ohms.

Frequency Response: 20 Hz to 20 kHz, +0.08, –0.02 dB.

THD + N at 0 dBFS: Less than 0.437%, 20 Hz to 20 kHz (see text).

THD + N at 1 kHz: Below –88.9 dBFS from 0 to –90 dBFS and below –97.7 dBFS from –30 to –90 dBFS.

Maximum Linearity Error: Undithered recording, 0.94 dB to –90 dBFS; dithered recording, 0.25 dB to –100 dBFS

S/N Ratio: A-weighted, 112.2 dB; CCIR-weighted, 109.2 dB.

Quantization Noise: –97.2 dBFS.

Dynamic Range: Unweighted, 97.9 dB; A-weighted, 100 dB; CCIR-weighted, 95.8 dB.

Channel Separation: Greater than 80.6 dB, 125 Hz to 16 kHz.

DOLBY DIGITAL (AC-3) AUDIO

Channel Balance, Relative to Left Front Output: Right front, center, and surround channels, within +0.06, –0.94 dB.

Frequency Response: Main channels, 20 Hz to 20 kHz, +0.05, –0.08 dB; center channel, 300 Hz to 20 kHz, +0.02, –0.37 dB (–3 dB at 90 Hz); surround channels, 280 Hz to 20 kHz, +0.02, –0.43 dB (–3 dB at 90 Hz); LFE channel, below 20 Hz to 89 Hz, +0, –3 dB (–6 dB below 20 Hz and at 110 Hz).

THD + N for 0-dBFS Signal: Main channels, 0.004% at 1 kHz; center channel, 0.0116% at 1 kHz; surround channels, 0.0192% at 1 kHz; LFE channel, 0.0021% at 30 Hz.

Channel Separation, 100 Hz to 10 kHz: 57.4 dB or greater.

DVD VIDEO

Luminance Frequency Response: +0, –1.1 dB, 0.5 to 4.2 MHz.

Luminance Level: +0.2 dB.

Chroma Level: +3.7 dB.

Gray-Scale Linearity: Perfect.

Chroma Phase Accuracy: Perfect.

Chroma Differential Gain: None.

Chroma Differential Phase: 0°.

disc. It was taken on the left "2CH" output; the results on the right channel were essentially equivalent. The curve reveals far more carrier leakage at 44.1 kHz than usual. A second, slightly stronger peak also appears in the curve; however, it's not at the second harmonic of the carrier (as would be expected) but closer to 100 kHz. Strange. On the positive side, there is relatively little noise within the audio band and very little hum. As a result, the signal-to-noise ratio was an admirable 112.2 dB, A-weighted, and 109.2 dB based on CCIR weighting.

THE XV-D2000BK'S SIGNAL-TO-NOISE RATIO WAS ADMIRABLE AND ITS DYNAMIC RANGE FIRST-RATE.

The top curve in Fig. 3 shows the output spectrum when reproducing a 1-kHz tone at –60 dBFS. You can still see traces of the carrier and the 100-kHz component seen earlier; the rising spectrum is typical of noise-shaped conversion. Dynamic range, which is measured using this same test signal, was first-rate: 100 dB, A-weighted, 97.9 dB unweighted, and 95.8 dB, CCIR-weighted.

Although the shape of the THD + N versus frequency curves gave cause for alarm, that of the THD + N versus level curve (Fig. 4) is unremarkable, and the actual distortion measurements are very low. Following normal practice, I obtained this data by using a 22-kHz low-pass analysis filter and a 1-kHz test signal. As you can see, THD + N drops from quite good (–88.9 dBFS) with a 0-dBFS signal to very good (no greater than –97.7 dBFS) for signal levels at and below –30 dBFS.

JVC's PEM D/A converter proved to be exceedingly linear, which is apparent in Figs. 5 and 6. With a dithered signal, the D2000's maximum linearity error is only 0.25 dB at –100 dBFS (Fig. 5). And the fade-to-noise plot (Fig. 6) is among the best I've ever obtained.

So, what gives? Here we have a converter that is exceedingly linear, admirably free of both quantization noise (–97.2 dBFS) and random noise, has excellent dynamic range, yet has disturbingly high levels of measured "THD + N" when fed high-frequency signals. My guess—and that's all that it is—is that we're seeing the effects of imbalance in the pulse-edge modulator. Pulse-edge-modulation DACs transform digital signals into analog by generating pulses at a constant rate but controlling the timing (placement) of the pulse edges with the digital information. This varies the pulse width and, therefore, the energy that the pulse stream contains. The energy is integrated by a low-pass filter and produces the analog output. Many other "one-bit" converters use the digital signal to vary the pulse rate but keep pulse width and amplitude constant.

Turning to the Dolby Digital performance characteristics, I was quite surprised to find that the JVC XV-D2000BK offers little in the way of bass management and lacks the usual setup controls. There's no option to choose whether the surround and center speakers are "Large" or "Small"; if they're used, they're considered "Small" and bass is redirected to the subwoofer or main front outputs, depending on the choice made in the "Bass Redirect" menu. Furthermore, there's no noise sequencer for assessing relative channel balance nor any means of adjusting that balance except for the 6-dB subwoofer switch on the back. These omissions greatly limit the usability of the D2000's 5.1-channel AC-3 decoding, but, for the sake of completeness, I felt obliged to document its performance.

And the basic performance was really quite good. The response curves taken on each channel—normalized so that they will overlie each other—are shown in Fig. 7. (For the main and suround channels, only the curves taken on the left side are included in the graph; the respective right-channel data was the same in each case. The response tolerances—and, as applicable, the –3 dB points—are given in "Measured Data.") There's a wee bit of high-end rolloff in the center and surround channels, but it's less than 0.5 dB, which is negligible. The main front channels are flat as a board.

In Dolby Digital mode, channel outputs were reasonably well balanced, although the center channel's output was nearly 0.75 dB below the main pair's and the surrounds were almost 1 dB weaker. The Dolby Digital section's THD + N (measured at 1 kHz and 0 dBFS on all wideband channels and at 30 Hz on the LFE) was quite good, especially in the main and LFE channels.

Channel separation ranged from 57.4 dB to 88.7 dB (worst case, between 100 Hz and 10 kHz), depending on the pair of channels measured; the "best" and "worst" curves are shown in Fig. 8. But the reality is even better than these curves would suggest. The decrease in low-frequency separation seen in the worst-case comparison, between the center and right-front channels, is probably caused more by the relative loss of bass in the center channel (because of the D2000's nondefeatable "Small" speaker setting) than by an increase in crosstalk. When crosstalk is measured at the "2CH" outputs (Fig. 9), the results are much better, because, naturally, no center channel is involved.

On the video front, luminance (brightness) level was close to the mark and chroma (color) level, although high, was within the range that can be handled by most monitors. Gray-scale and color accuracy were perfect, and there was no measurable chroma differential gain or phase (shifts in color saturation or hue as a function of scene brightness). My measurements of luminance-channel resolution disclosed that levels at the higher frequencies of the multiburst test pattern were down a bit more than on other DVD players that I have tested, but not enough that you'd notice anything by eye.

Use and Listening Tests

And, indeed, I could discern no picture degradation in actual use. On movies and test patterns, the JVC XV-D2000BK delivered clean, crisp images that were a delight to behold. However, to get to that point, I had to recalibrate my lab monitor to accommodate the JVC's hot chroma level. As usual, the quality of special effects depended on the disc being played: pause mode and "Step" could vary from jerky to rock-solid, and some discs were more amenable to being "searched" than others. Personally, special effects don't turn me on (though

Continued on page 57

Everyday I have the blues.

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The blues doesn't get any better than this and Rotel brings it to you straight up with easy to operate features and a performance that's genuine.

"Rotel's products, at all prices, are so impressive that it is safe to think of Rotel as a gold standard against which we can confidently measure the industry's performance as a whole."

Tom Miller
Audio Adventure Magazine
Vol. 3 Issue 9

How do we do it? Our fanatical engineers custom build our own transformers, shop the world for parts from premium grade component manufacturers, then assemble our designs in our own ISO9002 certified factory. Finally, we listen. If it's not absolutely right, we go back to work until we can actually *feel* the blues.

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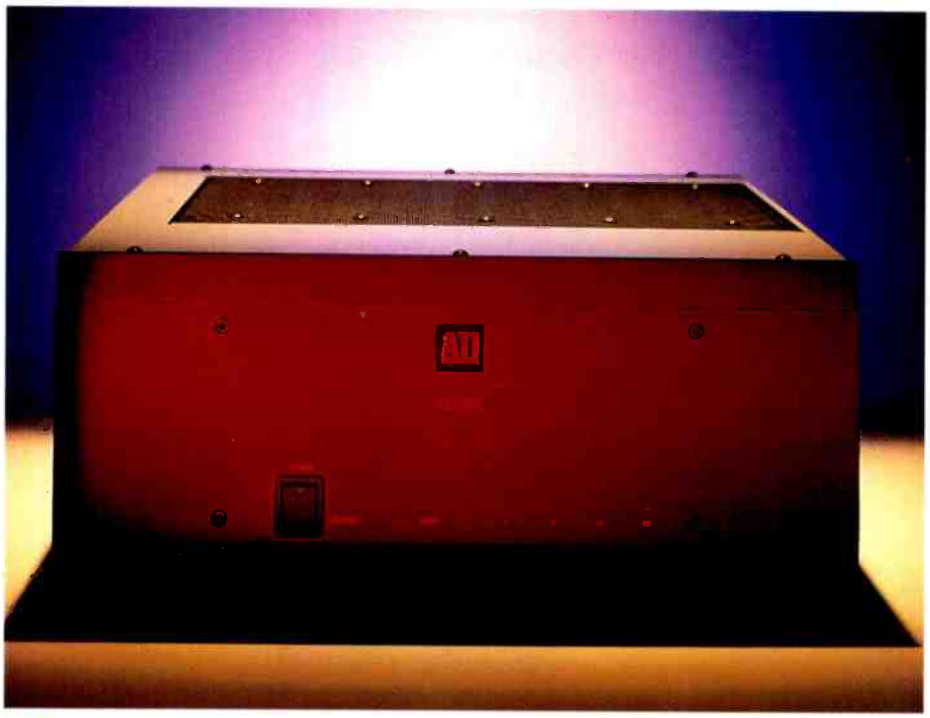
AUDIO ADVENTURE'S MANUFACTURER OF THE YEAR

EQUIPMENT **PROFILE**

BASCOM H. KING

ATI AT1505 FIVE-CHANNEL AMP



Amplifier Technologies, Inc., is well known in the custom-installation market for its two-, four-, and six-channel power amps. But its research showed that the home theater market called for a five-channel model, hence the AT1505. Each channel of this amp is rated at 150 watts into 8 ohms; its rated output into 4-ohm loads, 225 watts per channel, adds up to a very impressive 1,125 watts!

WOW! AND WOW AGAIN! I FOUND MYSELF TOTALLY IMMERSED IN SMOOTH, PLEASANT SOUND.

The AT1505's layout is a function of its modular design. Except for front-panel indicators, the power cord, and the power transformer, each channel is a self-contained unit that can be easily removed should service or replacement ever be needed.

The front panel carries only an on/standby power switch with an LED pilot light and LED clipping indicators for each of the five channels. The 1505 also has an innovative Fuse Fault Indicator (FFI) system on the rear; each channel has FFI LEDs for its positive and negative power-supply rails, which light up when their associated fuses need replacement. Together, the front and rear LEDs give you excellent feedback on the state of amplifier operation.

The rear panel is not as simple as the front, but its layout is logical and easy to understand. A DB-25 connector at the far right provides single-plug access to all five channels' inputs and can carry an on/off trigger signal that actuates a hefty power relay; a growing number of multichannel components have matching DB-25 outputs. A combined IEC fuse holder and cord socket is below the DB-25 connector. Behind the rest of the rear panel are the five amplifier modules. On the rear panel, each module has (from top to bottom) a gold-plated phono input connector, two power-supply rail fuses with associated FFI LEDs, and a pair of five-way binding posts for speaker connections.

The ATI chassis is simple and elegant. A U-shaped piece of 13-gauge steel forms the front subpanel, the bottom, and the rear panel; another forms the enclosure's top

and sides. The gray powder coating of these pieces contrasts with the black front panel to make a very attractive design. Inside, the beefy toroidal power transformer is bolted to the middle of the front subpanel, and the five amplifier modules are bolted to the bottom of the chassis. Slots in the bottom and grillwork above the modules let plenty of air flow through each module's 425-square-inch heat sink. The modules themselves are very nicely laid out; each consists of a p.c. board attached to a large heat-sink extrusion. The parts are of high quality and the wiring neat.

Measurements

The results reported here are for the left front channel, except where noted. That channel's frequency response is shown in Fig. 1; the other four channels' responses matched it very closely. Response with my

Rated Output: 150 watts per channel into 8 ohms or 225 watts per channel into 4 ohms, from 20 Hz to 20 kHz.
Rated Distortion: THD + N, less than 0.03% at rated power; IM, less than 0.03% from 250 mW to full rated power.
Dimensions: 17 in. W x 7 in. H x 16 in. D (43.2 cm x 17.8 cm x 40.6 cm).
Weight: 73 lbs. (33.2 kg).
Price: $1,695.
Company Address: 19528 Ventura Blvd., #318, Tarzana, Cal. 91356; 818/343-4777; amptech@ix.netcom.com; www.ati-amp.com.

Photos: Michael Groen

TECHNICAL HIGHLIGHTS

The AT1505 amplifier modules are fully complementary designs and use bipolar devices. Each channel's input circuit is a complementary dual differential amplifier (CDDA). The CDDA consists of two differential amps, one built from a dual NPN device (two NPN transistors in one housing) and the other from a dual PNP; each dual device is fed from its own two-transistor current source.

Signals fed to the 1505 are capacitor-coupled to the CDDA's noninverting input. The CDDA's NPN and PNP inverting outputs are directly coupled to a complementary voltage-amplifier stage. A bias-spreading regulator is tied between this stage's collector outputs, which are directly coupled to the output stage.

The output stage is configured as a complementary triple emitter follower, using three pairs of output transistors. Overall negative feedback is taken from the output back to the inverting input of the CDDA. To ensure that each channel's DC gain is unity, an electrolytic capacitor bypassed with a film capacitor is connected in series with the shunt feedback resistor.

The clipping indicator circuit is clever. Because the rest of the amplifier gets its signals from the CDDA's inverting outputs, its noninverting outputs are not used. The clipping indicator therefore uses the NPN side's noninverting output, feeding it to the base of an inverting PNP transistor. Under normal signal conditions, the signal at the NPN noninverting output isn't high enough to turn the PNP transistor on. But when the amp clips, the feedback error signal at the CDDA's output is high enough to do so. The PNP's collector is connected to the negative supply rail via two resistors in series. The front-panel clipping LED is connected across the resistor closest to that rail. When the PNP turns on, current flows through the series resistors and the LED illuminates.

The power supply's arrangement is novel. To begin with, the rectifier bridges and filter capacitors are on the amplifier modules. Further, each module has separate rectifier bridges for its positive and negative supply rails. Each bridge is fed by a separate secondary winding on the power transformer, for a total of 10 secondary windings. This is more complex than the usual approach, whereby a center-tapped winding with one rectifier bridge develops the positive and negative supply voltages. ATI's approach yields greater isolation between channels and between supply rails, thus reducing ground currents and their effects. *B.H.K.*

NHT dummy speaker load was essentially the same as for the 8-ohm resistive load up to 30 or 40 kHz; that's a sign of low output impedance, as we'll see when we get to the test of damping factor. Rise and fall times at an output level of ±5 volts into 8 ohms were each 1.4 microseconds.

Square-wave response (Fig. 2) is typical of a good solid-state amplifier. With an 8-ohm resistive load, there's a slight aberration in the 10-kHz trace (top), where the waveform's leading edge merges with the steady-state, horizontal, part of the waveform. The ringing caused by putting a 2-microfarad capacitor across the 8-ohm load (middle trace) is minimal and very well damped. The 40-Hz square wave's moderate tilt (bottom trace) is caused mostly by the RC input coupling network, whose –3 dB point is 1.7 Hz; this is not atypical, but a lower cutoff frequency would have improved square-wave response here.

Measuring the AT1505's relationships between distortion and maximum power with 8-ohm loading was relatively easy, as I had five suitable 8-ohm power resistors. But measuring with 4-ohm loads was trickier, as I did not have five high-power 4-ohm loads or ten 8-ohm loads. To get around this problem, I first put two of my 8-ohm resistors in parallel across one channel, to give it a 4-ohm load. I then connected the remaining four channels as bridged pairs by driving each pair's channels with signals of opposite phase, connecting an 8-ohm load between the hot outputs of each channel

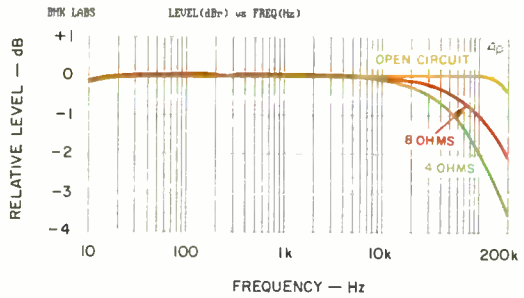


Fig. 1—Frequency response as a function of loading.

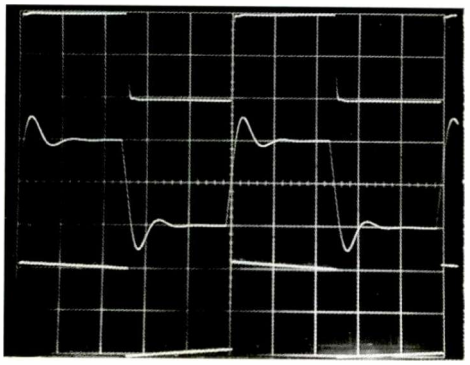


Fig. 2—Square-wave response for 10 kHz into 8 ohms (top), 10 kHz into 8 ohms paralleled by 2 µF (middle), and 40 Hz into 8 ohms (bottom).

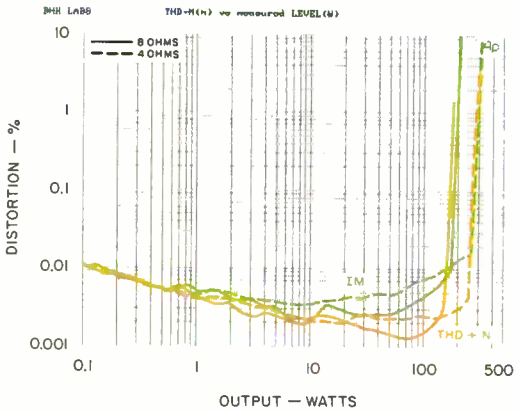


Fig. 3—THD + N at 1 kHz, and SMPTE IM distortion, vs. power output.

pair and tying together the output grounds of each pair (needed because the channels are all isolated from each other). This was equivalent to loading each channel with 4 ohms.

As you can see from Fig. 3's curves of total harmonic distortion plus noise (THD + N) and SMPTE IM distortion versus power output, the AT1505 more than meets its FTC power and distortion specs. My test of THD + N versus frequency (Fig. 4) reveals some increase in distortion at high frequencies, but it's admirably slight. In both graphs, the THD + N at low power levels is dominated by noise induced in my measurement setup, mostly from ground resistances in the Y adaptors and cables I used to feed test signals to all five channels at once. A spectrum of the harmonic distortion residue for a 1-kHz, 10-watt output into 8 ohms is plotted in Fig. 5. This amp's distortion performance is excellent.

The low output impedance mentioned earlier yields a damping factor of about 400 up to 100 Hz (Fig. 6). Damping decreases above this frequency, however, and its rolloff becomes steeper between about 350 Hz and 4 kHz. This rolloff is mainly caused by a buffering inductor following the output stage, which raises the amp's output impedance. The transition frequency (–3 dB point) of this 3-microhenry inductance and the low-frequency output impedance (0.02 ohm) occurs at about 1 kHz.

To assess interchannel crosstalk, I successively drove the left front, right rear, and right front channels and measured the crosstalk in the other four channels for each case. In general, crosstalk was greatest for the channel nearest the driven one and decreased as I measured channels farther and farther away. Crosstalk increased with rising frequency, at about 6 dB per octave. At 1 kHz, the adjacent-channel crosstalk was about –100 dB, increasing to –74 dB at 20 kHz. Crosstalk two channels away was about 20 dB better. These are quite good results. Most of the AT1505's crosstalk occurs at the DB-25 connector, where all five channels' inputs come together. If you're not using the DB-25, you can disconnect the leads between it and each module, which should make crosstalk even lower.

Output noise was reasonably similar for each channel. Wideband output noise ranged from 125.4 to 134.6 microvolts, averaging 129.8 microvolts; the A-weighted measurements ranged from 25.2 to 28.4 microvolts and averaged 26.3 microvolts.

Associated Equipment Used

Equipment used in the listening tests for this review consisted of:

CD Playback Equipment: PS Audio Lambda Two Special CD transport, Classé Audio DAC-1 D/A converter, and Genesis Technologies Digital Lens anti-jitter device

Surround Processor: Millennium Technologies 2.4.6

Phono Equipment: Kenwood KD-500 turntable, Infinity Black Widow arm, and Audio-Technica ML150 moving-magnet cartridge

Additional Signal Sources: Nakamichi ST-7 FM tuner, Nakamichi DR-3 cassette deck, Technics 1500 open-reel recorder, and Denon DMD1300 MiniDisc recorder

Preamplifiers: DXG Audio DDP-1 (for speaker-specific equalization and temporal alignment), Sonic Frontiers Line-3, and Ayre Acoustics K-1

Loudspeakers: B&W 801 Matrix Series 3s, Samadhi Natalias, and Infinity prototype

Cables: Digital interconnects, Illuminati DX-50 (AES/EBU balanced); analog interconnects, Transparent Cable MusicLink Reference (balanced) and Tara Labs Master and Music and Sound (unbalanced); speaker cables, Transparent Cable MusicWave Reference and Tara Labs RSC Master Generation 2

Averaging the A-weighted noise levels yields an IHF signal-to-noise ratio of 100.6 dB re 1 watt and an impressive 122.4 dB re continuous rated power.

The dynamic power that the AT1505 could attain into 8-ohm loads was 248 watts at the beginning of the 20-millisecond tone-burst signal and 218 watts at its end. Dynamic headroom, based on dynamic power at the beginning of the burst, was 2.2 dB. For 4-ohm loads, the results were 450 watts at the beginning of the test signal and 351 watts at its end, for a dynamic headroom figure of 3 dB. Steady-state power into 8-ohm loads at the visual onset of clipping (about 0.7% THD) was 180 watts, equivalent to 0.8 dB of clipping headroom;

for 4-ohm loads, the figures were 280 watts and 0.95 dB.

The voltage gains of the five channels matched quite closely and averaged 28.9 dB. Corresponding sensitivity for a 1-watt output into 8 ohms was 101.3 millivolts. The ATI amp's DC offset for the five channels ranged from –0.7 to –1.7 millivolts, with an average of –1.38 millivolts.

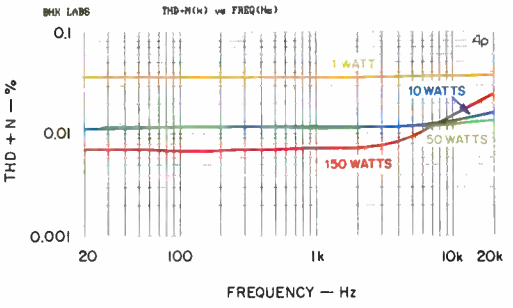


Fig. 4—THD + N vs. frequency, 8-ohm loads.

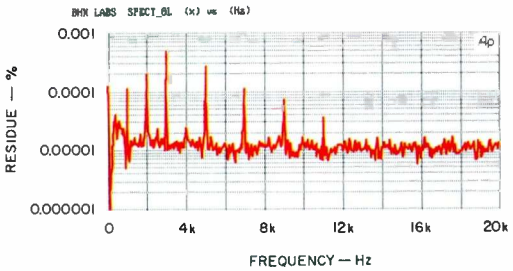


Fig. 5—Spectrum of harmonic distortion residue for a 1-kHz signal at 10 watts out into 8 ohms.

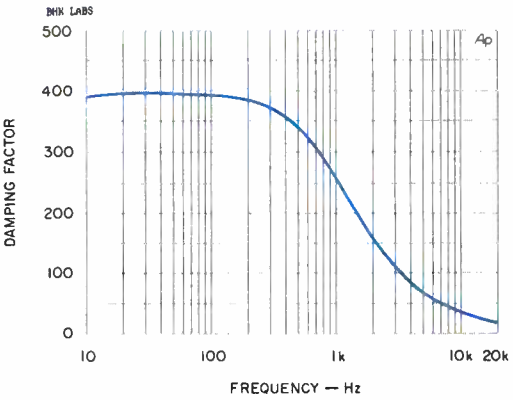


Fig. 6—Damping factor.

Use and Listening Tests

I first used the AT1505 in a stereo music system, with two pairs of its channels bridged together. This amplifier has no bridging switches, so I made XLR-to-phono adaptors, one for each signal phase from my preamp's balanced output (which automatically provided oppositely phased signals to each channel pair I bridged). I wired each bridged pair's negative speaker terminals together and connected a B&W speaker between each bridged pair's positive terminals.

This gave me a stereo amplifier with more than 550 watts per channel into 8-ohm loads. Well! I quickly reacquainted myself with the power and whack the B&W 801s can deliver with this many watts on tap. The AT1505's bass was tight, powerful, and tuneful. The rest of the range was nicely detailed and quite listenable. Edginess was relatively low, and tonal balance, imaging, and sense of space were quite good.

Because the AT1505 is designed for multichannel systems, I hooked it up to a Millennium Technologies 5.1-channel DTS surround processor. I played a number of DTS-encoded music CDs on a PS Audio transport, feeding the digital signal through a Genesis Digital Lens to the Millennium. Since the B&Ws have plenty of bass, I did not use the Millennium's subwoofer output but did connect its other five outputs to the inputs of the ATI amp, controlling level with the processor's main volume control. For the surround channels, I used a pair of Samadhi Natalias, relatively high-efficiency (93-dB) speakers that I keep on hand for listening to low-power single-ended amplifiers. For the center channel, I used an Infinity prototype speaker that's normally part of my modest video setup.

Wow again! This was a completely different ball game! I could see how five-channel surround can make music more realistic and involving than two-channel stereo, and I found some of the DTS-encoded CDs downright captivating. I was totally immersed in sound, and that sound was, again, mostly smooth and free of edginess. The ATI amp really pumped it out, playing at quite insane levels without its clipping lights turning on. In view of its price and performance, the AT1505 should find its way into many home theaters. A

JVC, *continued from page 52*

searching is sometimes useful); I'm more interested in performance during normal play, which happened to be quite good here. And I really liked JVC's on-screen menus.

On the other hand, the transport in my sample was rather noisy when it was in operation; even when no disc was loaded, it emitted a high-pitched whir that could be heard up close. Of course, I couldn't hear this from across the room during a live movie with a soundtrack, but still...

I must admit I gave up trying to use the internal 5.1-channel decoding in my home theater. I guess I could have used it, had I been willing to use a test DVD with a cycling tone to calibrate the system and had I been able to find either a six-channel integrated amplifier with individual level adjustments on each channel (in addition to its unified volume control) or a six-channel control preamp that I could use with my power amp (using the amp's gain controls for calibration). Maybe those products exist, but they're hardly mainstream.

It was much simpler to couple the JVC XV-D2000BK to my reference Sony SDP-EP9ES AC-3 decoder via the digital link and be done with it. Fortunately, JVC provides both optical and coaxial jacks, so you're not limited in your choice of downstream equipment at all. And going that way compensates for the limited bass management, the absence of setup controls in the JVC's built-in decoder, and the rather tizzy sound of the PEM converters on high strings and brass. (Cymbals struck me as sounding surreal, but many people may like that.)

THE JVC XV-D2000BK DELIVERED CLEAN, CRISP VIDEO IMAGES THAT WERE A DELIGHT TO BEHOLD.

Used with a good external decoder, the JVC XV-D2000BK shows its mettle: good video, nice menuing, and versatile audio and video outputs. But, since you probably will not want to use the internal 5.1-channel decoding, why not look into JVC's XV-1000BK ($899.95), with only two-channel analog output, and save a few bucks? A

EQUIPMENT PROFILE

EDWARD J. FOSTER

BRYSTON B-60 INTEGRATED AMP

With the advent of DVD, a lot of attention has been focused on video and multichannel sound. I am a hearty advocate of multichannel sound—for video. But it will be years before multichannel release formats for music arrive and recording engineers learn how to take advantage of them. (Remember how long it took engineers to progress beyond playing ping-pong with stereo?) For now, I prefer my music in plain-vanilla stereo, so I was pleased by the opportunity to review the Bryston B-60, a 60-watt/channel stereo integrated amplifier designed and constructed in the traditional manner.

"Tradition," a word that's bandied about rather lightly, has meaning when applied to Bryston. This Canadian company has one foot in the professional audio market and the other in consumer audio and manages to serve both markets very well. The products that Bryston makes for the two markets don't differ radically, the main distinctions being a rearrangement of the relative voltage gains of the preamps and power amps and, for the pro market, a bit more emphasis on balanced connections. You can easily use Bryston professional products at home, and more than one pro studio has used Bryston consumer products. Both lines emphasize "traditional" circuit topologies, exceedingly well executed and employing the finest-quality components.

You will not find frills on a Bryston product. There's no cutesy circuitry that is there merely to justify advertising some new "class" of output operation; Bryston power amps are "old-fashioned" Class AB, thank you. You won't find much in the way of remote control either, although the B-60 is available with an optional wireless remote that operates its motor-driven volume control and lets you mute the sound completely. Why is there no remote source selection? Because it almost invariably involves using relays or solid-state switches, neither of which square with Bryston's purist views. And why is there no balance control on the remote? Because that would require a solid-state attenuator or, worse, a voltage-controlled amplifier; the former can (and the latter almost certainly would) be noisier and more distortion-prone than the potentiometer Bryston uses.

BRYSTON'S HOME AND PRO GEAR EMPHASIZES TRADITIONAL CIRCUITS, EXCEEDINGLY WELL EXECUTED.

That pot signifies Bryston's preference for traditional over trendy in another way. While it's now common practice to adjust level in the digital domain, there are no real advantages to doing so, other than simplicity if the signal is already digital, and there are definite drawbacks. If not done with extreme care, digital level adjustment raises quantization noise as the signal level is reduced. And if the signal isn't already digital, what's the point of converting from analog to digital and back again just for volume control? The conversion process invariably caps the dynamic range and limits the treble response to half the sampling rate,

Rated Power: 8 ohms, 60 watts/channel; 4 ohms, 100 watts/channel.
Rated THD + N: 0.01%.
Dimensions: 1¾ in. H x 17 in. W x 10½ in. D (4.5 cm x 43.2 cm x 26.7 cm).
Weight: 20 lbs. (9.1 kg).
Price: $1,495; remote control, $300.
Company Address: Box 2170, Peterborough, Ont. K9J 7Y4, Canada; 705/742-5325.

Photos: Michael Groen

MEASURED DATA

Output Power at Clipping (1% THD at 1 kHz): 8-ohm loads, 80 watts/channel (19 dBW); 4-ohm loads, 113 watts/channel (20.5 dBW).

Dynamic Output Power: 8-ohm loads, 100 watts/channel (20 dBW); 4-ohm loads, 195 watts/channel (22.9 dBW); 2-ohm loads, 205 watts/ channel (23.1 dBW).

Dynamic Headroom Referred to Rated Power: 8-ohm loads, +2.2 dB; 4-ohm loads, +2.9 dB.

THD + N, 20 Hz to 20 kHz: 8-ohm loads, less than 0.024% at rated power and less than 0.023% at 10 watts/channel; 4-ohm loads, less than 0.552% at rated power and less than 0.043% at 10 watts/channel.

Damping Factor Referred to 8-Ohm Loads: 535.

Output Impedance: 20.2 milliohms at 1 kHz, 67.1 milliohms at 5 kHz, 128 milliohms at 10 kHz, and 200 milliohms at 20 kHz.

Frequency Response: 20 Hz to 20 kHz, +0, –0.1 dB (–3 dB below 10 Hz and at 96 kHz).

Sensitivity for 0 dBW (1 Watt): 54.6 mV.

A-Weighted Noise: –89.6 dBW.

Input Impedance: 49 kilohms.

Input Overload (1% THD at 1 kHz): Greater than 10 V.

Channel Separation, 100 Hz to 10 kHz: Greater than 61.8 dB.

Channel Balance: ±0.25 dB.

Recording Output Level: 490 mV for 500-mV signal at CD input.

Recording Output Impedance: 50 ohms.

which usually holds the top end to about 20 kHz.

The potentiometers Bryston uses for volume and balance control feel remarkably good under the hand, despite the motor clutched to the shaft of volume pot. Motor-driven controls tend to feel sloppy because of backlash in their gear trains, but that's not the case with the one Bryston uses; you wouldn't know the motor were there if you didn't see the knob turn when you operated it from the remote control. The B-60's balance control has the usual center detent but has an unusually gradual taper around the central inflection point, which enables you to make exquisitely fine adjustments—so fine that, on the bench, I was able to repeat balance settings within a few hundredths of a decibel. Try doing that with a digital attenuator!

The only other controls on the B-60's front panel are a four-position rotary input selector and miniature toggle switches for the tape monitor and AC power. An LED near the power switch glows green in normal operation and red when muting is on or the amp is muted during power-up. Next to the LED is the remote-control sensor.

The headphone jack, near the tape monitor switch, is driven by the B-60's preamp section. Inserting a plug into the jack disconnects the preamp from the amp section. Bryston recommends headphones with impedances of 50 to 600 ohms, which covers most models, consumer and pro.

THE BRYSTON B-60'S BALANCE CONTROL LETS YOU MAKE EXQUISITELY FINE ADJUSTMENTS.

The gold-plated RCA input jacks on the rear panel are labeled "Tuner," "AUX," "CD," and "Video" to correspond with the "Selector" markings, but, as all these inputs are identical, the labels are really arbitrary. Also on the rear panel are the tape monitor loop's input and output jacks and pairs of "Pre Out" and "PWR In" jacks linked by gold-plated jumpers. This enables you to patch in an external component, such as a surround processor, either before the volume and balance controls (via the "Tape Loop" jacks) or after them (via the preamp-out and amp-in jacks).

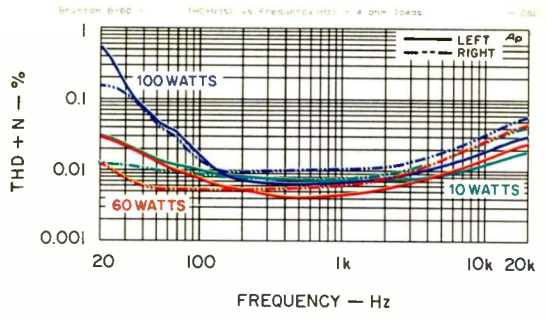
Despite the Bryston B-60's relatively modest power rating (60 watts per channel into 8-ohm loads, 100 watts per channel into 4-ohm loads), the manufacturer has outfitted this amplifier with gold-plated multiway binding posts that would do a blockbuster amp proud. The hole in each post is large enough to accommodate heavy-gauge wire, and the posts are spaced ¾ inch apart to handle both single and dual banana plugs. (Hear! Hear!) Completing the back panel is a socket for the removable three-wire IEC line cord.

I've often twitted manufacturers about using gold-flashed headphone jacks on the front (where the gold is readily seen by the customer but provides little technical advantage) while using base-metal input connectors on the back (where the gold is less visible but more likely to do some good). It's nice to see Bryston use the shiny stuff where it counts! But this is typical of a company that seems to pay uncommon attention to component quality and circuit layout. The latter is especially important in a product as compact as the B-60, which is only one "rack unit" (1¾ inches) high (if you rest the B-60 on a shelf, add a quarter inch for its feet); a rack-mounting kit is available.

The B-60's shallow chassis makes things fairly tight inside. In addition to preamp circuitry and two power amps, the B-60 carries independent power supplies for each channel. Although this qualifies the product as "dual mono" in my book, Bryston makes no such claim. Nonetheless, the independence of the power supplies extends even to the use of separate toroidal transformers for each channel, whereas many so-called dual mono amps simply use separate windings on a common core!

Each output stage has its own heat sink, designed more to conduct heat from the output devices to the chassis' top and bottom plates than to radiate it into the surrounding air. The heat sinks are screwed to the top and bottom plates, which then become part of the radiating surface itself. There are no vents or louvers on the B-60; the entire chassis, which is made of heavy-gauge metal, dissipates the heat.

The signal circuitry is designed with discrete components, a philosophy that Bryston claims avoids "the compromises, phase shift and nonlinearities inherent in ICs." Extensive use of 1% metal-film resistors,



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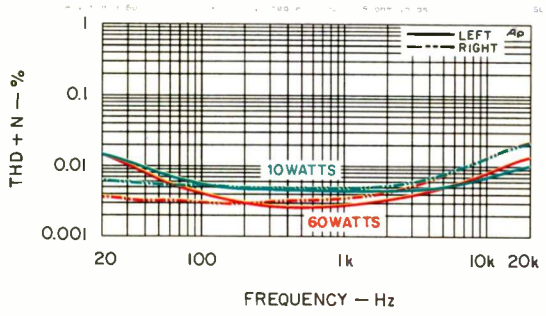
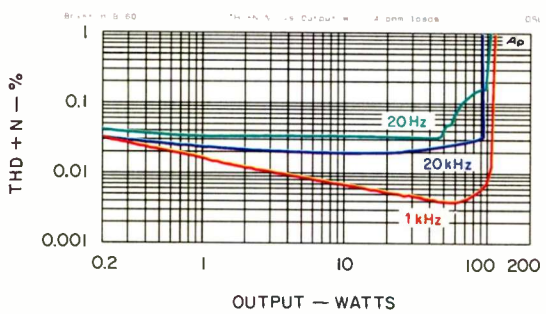


B

Fig. 1—THD + N vs. frequency into 4-ohm loads (A) and 8-ohm loads (B).

The B-60's optional remote adjusts volume.



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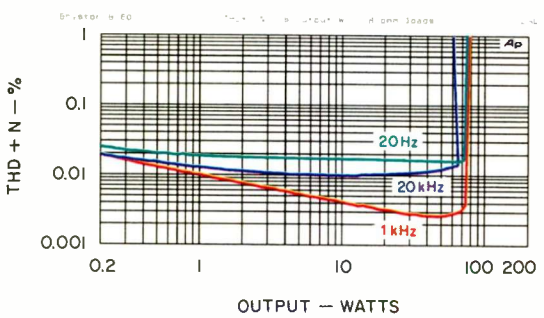


B

Fig. 2—THD + N vs. output into 4-ohm loads (A) and 8-ohm loads (B).

polystyrene capacitors, and hand-selected, matched transistors is said to reduce noise and distortion to the absolute minimum. Bryston assembles and tests each product and covers it with an unlimited, transferrable 20-year warranty.

Measurements

Fitting not one but two traditional power supplies into the B-60 couldn't have been easy. Professional amps that are just one (or even two) rack spaces high usually have switching power supplies. These supplies convert the 120-volt, 60-Hz power from the AC line directly to DC, without an intervening transformer, and then convert the DC to a high-frequency (30 to 60 kHz) square wave by a switching oscillator. The high-frequency power is then transformed to the desired voltage, rectified, and filtered. For a given power rating, high-frequency transformers are much smaller than 60-Hz power transformers, and, since the filter capacitors are recharged much more frequently, smaller capacitor values can be used.

But there is no free lunch: While switching supplies are far more compact, their powerful square waves generate tremendous quantities of high-frequency energy that extends well into the RF region. I've had FM tuners block completely because of this RF trash—which can also contaminate audio signals, closer in frequency to the square wave. Thus, power amps with switching supplies usually have low-pass input filters to limit amplifier bandwidth to 30 kHz or so. Source components, not knowing that there's a switching supply in the system, have to fend for themselves.

I mention this because Bryston has chosen the safer approach of using a traditional 60-Hz power supply, which allows wide bandwidth. No free lunch here, either; the problem is getting adequate filter capacitance into a 1¾-inch-high package. On the whole, Bryston has succeeded reasonably well, but the penalty for its choice is apparent: The B-60's power supply runs out of filtering when asked to deliver large currents at low frequencies. This may or may not have a major effect in the listening room (depending on your speakers, program choice, and listening level), but it does rear its head on the test bench.

As you can see in Fig. 1A, total harmonic distortion plus noise (THD + N) turns up sharply in the low-frequency region when the B-60 is driving 4-ohm loads at a continuous 100 watts per channel. On my sample,

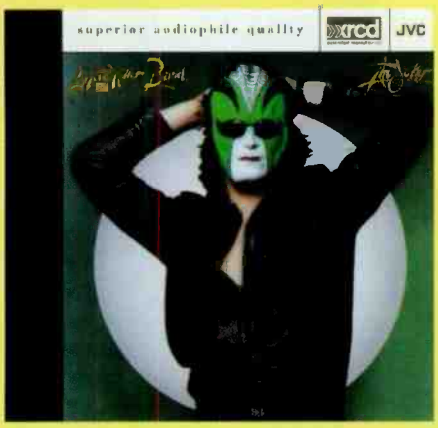
DYNAMIC HEADROOM WAS A GENEROUS +2.2 dB INTO 8 OHMS AND A WHOPPING +2.9 dB INTO 4 OHMS.

the left channel's distortion was higher than the right's, which probably means the right channel's power supply had greater filter capacitance. (Electrolytic filter capacitors typically exceed their nominal values quite a bit, so it's not surprising to be blessed with more capacitance in one channel than the other.) However, this low-frequency THD + N is not harmonic distortion; it's power-supply ripple that gets through because the filter capacitors can't supply all the current that's being demanded of them. That much was clear from a frequency analysis of the "distortion." It's also clear that dropping the output level from 100 watts to 60 watts yields a huge decrease in ripple, from 0.552% to 0.028% at 20 Hz. And that's still using 4-ohm loads, the minimum recommended by Bryston. With 8-ohm loads (Fig. 1B), bass THD + N at rated output (60 watts per channel) barely exceeds 0.015% in the left channel and is less than 0.004% in the right!

This effect was also apparent in my measurements of THD + N versus output (Fig. 2), which were taken on the left channel (the more problematic channel in the bass region). As you can see in Fig. 2A, THD + N at 20 Hz, after coasting along at around 0.03% out to almost 50 watts with 4-ohm loading, suddenly jumps up as the filter capacitors run out of steam and can no longer

JVC is proud to introduce the first two pop titles available on **xrcd**. Listen and compare.

the steve miller band the joker JVCXR-0043-2



When you hear the name Steve Miller, the first thing that comes to mind is *The Joker*. Miller's classic 1973 album features the title track, which was his first huge #1 single, as well as "Sugar Babe" and "Something to Believe In." During rehabilitation following a car accident that put the artist out of commission for a year and a half, Miller began to reinvent his style. Leaving behind a more blues based rock style to compose compact, catchy and melodic pop songs, Miller created *The Joker*. It was this turning point recording that set the stage for Miller's exquisitely crafted material that would follow in the mid and late seventies. This historical rock recording is available for the first time as an audiophile disc. The critically acclaimed XRCD technology reveals nuances previously unheard and presents this platinum-selling disc the way it was originally intended.

tina turner private dancer JVCXR-0044-2

It has been said that Tina Turner is "the woman who taught the world to dance in heels." From the early days to the present, the fabulous Tina has managed to captivate listeners with her electrifying vocals and mesmerizing presence. Perhaps nowhere is her unique musical personality more completely captured than on her solo breakthrough *Private Dancer*. Few artists can claim to have had two distinct careers, however, Tina Turner can claim just that as *Private Dancer* exposed this compelling artist to an entirely new generation. Containing the title track as well as "What's Love Got to Do With It," "Better Be Good to Me" and "Let's Stay Together," *Private Dancer* is practically a greatest hits collection itself. Recorded with a variety of producers, this disc also features a blistering Jeff Beck solo on the track "Steel Claw." Now this multi-award winning disc is brought to new life utilizing the critically-acclaimed XRCD technology...listen and compare.

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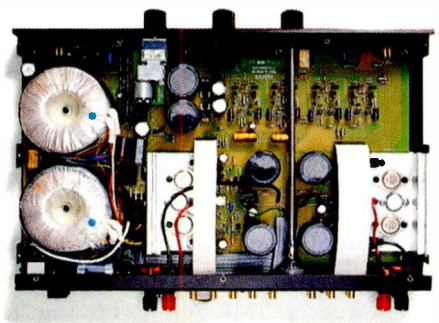
supply the required current. With 8-ohm loads (Fig. 2B), everything is ducky out to 80 watts. At that point (which is well above the B-60's rated 60 watts), the power supply abruptly runs out of voltage, but not current.

There's evidence that Bryston protects the output stage with high-frequency current limiting (although I have no schematic from which to verify this). If you look carefully, just beyond the clipping point you may be able to see the 20-kHz curves in Figs. 2A and 2B fold back slightly. Protection circuitry may also explain the gradual increase in treble THD + N seen in Fig. 1. (Although distortion in that region is mainly second- and third-order and not of sufficient magnitude to be worrisome.)

The B-60 may run out of steam driving low-impedance loads with continuous low-frequency sine waves, but it sure had no trouble with the IHF dynamic-headroom tone burst. I concocted this test years ago, while chairing the IHF Amplifier Standards Committee, because we listen to music, which has a high peak-to-average power ratio, not to high-power, continuous, 20-Hz sine waves. Therefore, a reviewer should establish what an amplifier and its power supply can do under music-like conditions, not just what it does with sine waves.



THE B-60'S FREQUENCY RESPONSE IS BEAUTIFULLY FLAT AND QUITE BROAD, ITS NOISE ADMIRABLY LOW.

In this regard, the Bryston B-60 acquits itself very well indeed. With 8-ohm loads, the amplifier delivered dynamic power of 100 watts per channel, for a generous dynamic headroom of +2.2 dB! Even more significant is the dynamic output power available from the Bryston into 4-ohm loads, since this was the sore point on the continuous-output tests. Here, the B-60 delivered a whopping 195 watts per channel, almost double its 4-ohm rating. Clearly, the output stage has no problem pushing current into the load; only when the power supply is taxed beyond its ability to deliver current on a continuous basis does any weakness show up.

Damping factor at 50 Hz was greater than 500 (which is excellent), but its inverse, output impedance, increased in the treble somewhat more than I'd like to see. At 20 kHz it was 200 milliohms, equivalent to a damping factor of 40. Could be better, but it sure could have been a lot worse! Channel separation (Fig. 3) is greater than 55 dB. That's perfectly adequate, but, given the B-60's dual-mono design, it would probably be greater still if the circuits weren't cheek by jowl in this small package.

Now let's turn to the benefits of Bryston's design choices. Frequency response (Fig. 4) is exquisitely flat and quite broad; each channel's –3 dB point is near 100 kHz. At the IHF standard volume setting, the channels' gains differed by 0.5 dB, which is easily corrected with the balance control. (Remember this control's gradual taper near the inflection point; it takes a rotation of perhaps 5° or 10° to correct a mismatch even this small.) After I adjusted gain, the two response curves overlay each other perfectly.

The third-octave noise spectrum (Fig. 5) is even more impressive. There's just a slight trace of power-line-related hum at 60 and 120 Hz, but those components are around –110 to –115 dBW and thus inaudible. Thanks to Bryston's pure analog design, the ultrasonic noise spikes usually apparent with digital products and switching supplies are simply not there. In fact, output noise was an admirably low –89.6 dBW, A-weighted, and –87.1 dBW, unweighted. These figures calculate to full-power S/N ratios of 107.4 dB, A-weighted, and 104.9 dB, unweighted. I'm all the more impressed with the noise data, given the B-60's high input impedance (49 kilohms) and higher than usual voltage gain (34.3 dB); usually there's a trade-off between these factors.

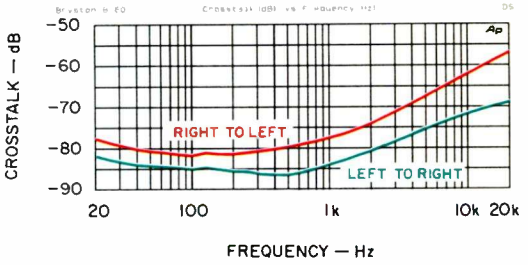


Fig. 3—Crosstalk.

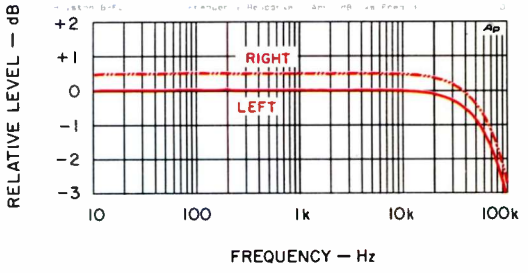


Fig. 4—Frequency response.

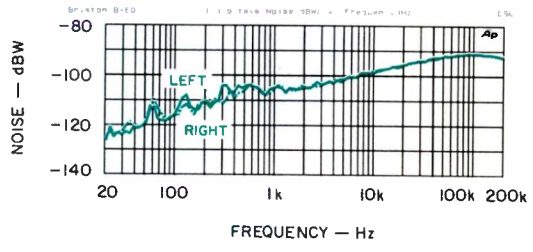


Fig. 5—Noise analysis.

A final word on noise. The grounding of my basic test setup is theoretically ideal. Nevertheless, some components I test require that I try various grounding schemes between the component and the analyzer to eliminate (or at least minimize) ground loops and put the product in its best light. The Bryston B-60, however, thumbed its nose at my gyrations and tested the same under virtually all conditions. That's the way it should be with products whose internal grounding arrangements have been carefully thought out and executed. Such products are likely to work well and be

Continued on page 69

EQUIPMENT **PROFILE**

EDWARD J. FOSTER

MARANTZ MA-700 MONO AMPLIFIER

Once the playthings of esoteric audiophiles, single-channel (monoblock) power amplifiers today are finding wider application in home theaters. I suspect that's partially because the number of amplifier channels needed for home theater is so variable. Depending on your setup, you could need four, five, or six amp channels, and you might already own an amp you can use for some of them. With single-channel power amps, you can buy as few or as many as you need and change your mind tomorrow without losing today's investment in hardware.

MARANTZ PROVES ONCE AGAIN THAT MONO AMPS CAN BE AS COST-EFFECTIVE AS STEREO AMPS.

There are technical advantages to the monoblock, too: cooler operation, better channel separation (though that shouldn't be a problem in home theater), and the potential for powering up a complex system's components sequentially. But monoblocks are theoretically less cost-effective than multichannel amps: It's cheaper to make one large chassis than several smaller ones and cheaper to use one power supply than many. The MA-700 is the second Marantz amp to show that this theory needn't hold. The earlier MA-500, a 125-watt mono amp priced at $300, was cost-competitive with multichannel models, and so is the more powerful MA-700. Both amps carry Home THX certification, which, among other things, means minimum output of 28.3 volts into impedances from 8 to 2 ohms, equivalent to 100 watts into 8 ohms. But whereas the MA-500 cleared Lucasfilm's power requirement by just 1 dB, the MA-700 clears that hurdle by a full 3 dB; it is rated at 200 watts, continuous, into 8 ohms and 300 watts, continuous, into 4 ohms. Pairs of MA-700s can be connected and operated in bridged configuration (which Marantz calls "BTL," for balanced transformerless) to deliver 600 watts into 8 ohms.

The MA-700 is so narrow that three will fit, cheek by jowl, in the same 17¼-inch shelf width as most single components. The shelf will have to be sturdy and deep, however, because each amp weighs almost 20 pounds and is nearly 19 inches from front to back. But a weight of 60 pounds for three channels of 200-watt power isn't all that excessive, and 20-inch shelf depths (including room for connections) are not unknown. Plus, it's certainly easier to lift 20 pounds three times than 60 pounds all at once, another advantage.

The color-coded multiway binding posts on the back of the MA-700 will accept single (but not dual) banana plugs if you pry out their plastic safety inserts (which are now required by Underwriters Labs for high-powered amps). Two gold-plated and four base-metal RCA jacks are strung out along the top of the back panel. One of the gold-plated jacks is the input connector. The other gold jack ("Invert Output") carries a reversed-polarity signal at the same level as the input; you couple it to the input jack of a second MA-700 if you want to bridge the pair. You use a small slide switch

Rated Output, 20 Hz to 20 kHz: Mono, 200 watts rms into 8 ohms at 0.05% THD or 300 watts rms into 4 ohms at 0.09% THD; bridged pair, 600 watts into 8 ohms at 0.09% THD.
Dimensions: 5¾ in. W x 5¾ in. H x 18¾ in. D (14.5 cm x 14.6 cm x 47.4 cm).
Weight: 17.6 lbs. (8 kg).
Price: $500 each.
Company Address: 440 Medinah Rd., Roselle, Ill. 60172; 630/307-3100; www.marantzamerica.com.

MEASURED DATA

Output Power at Clipping (1% THD at 1 kHz): 8-ohm load, 250 watts (24 dBW); 4-ohm load, 390 watts (25.9 dBW); bridged pair into 8-ohm load, 780 watts (28.9 dBW).

Dynamic Output Power: 8-ohm load, 275 watts (24.4 dBW); 4-ohm load, 470 watts (26.7 dBW); 2-ohm load, 740 watts (28.7 dBW); bridged pair into 8-ohm load, 1,025 watts (30.1 dBW).

Dynamic Headroom: Re 8-ohm rating, +1.4 dB; re 4-ohm rating, +1.9 dB.

THD + N, 20 Hz to 20 kHz: 8-ohm load, less than 0.0033% at rated output and less than 0.004% at 10 watts; 4-ohm load, less than 0.0057% at rated output and less than 0.0091% at 10 watts; bridged pair into 8-ohm load, less than 0.0067% at rated output and less than 0.0225% at 10 watts.

Damping Factor re 8-Ohm Load: 202 at 50 Hz.

Output Impedance: 40.4 milliohms at 1 kHz, 51 milliohms at 5 kHz, 72.4 milliohms at 10 kHz, and 101 milliohms at 20 kHz.

Frequency Response: 20 Hz to 20 kHz, +0, –0.04 dB (–3 dB below 10 Hz and above 200 kHz); bridged pair, 20 Hz to 20 kHz, +0.22, –0.1 dB (–3 dB below 10 Hz and at 130 kHz).

Sensitivity: At 0 dBW, 74 mV; at rated output, 1.05 V.

Voltage Gain: 31.6 dB; bridged pair, 37.7 dB.

A-Weighted Noise: –91.7 dBW; bridged pair, –72.9 dBW.

Input Impedance: 22.6 kilohms.

("BTL") to select whether the amplifier is the "Master" or the "Slave" of the pair. Between the slider and the input jack is a tiny input level control, which is bypassed on the slave amplifier in bridged operation; the "Invert Output" signal is taken from a point following the level control on the "Master" amplifier. For bridged operation, the speaker is connected to each amp's positive (red) output terminal and the two neg-

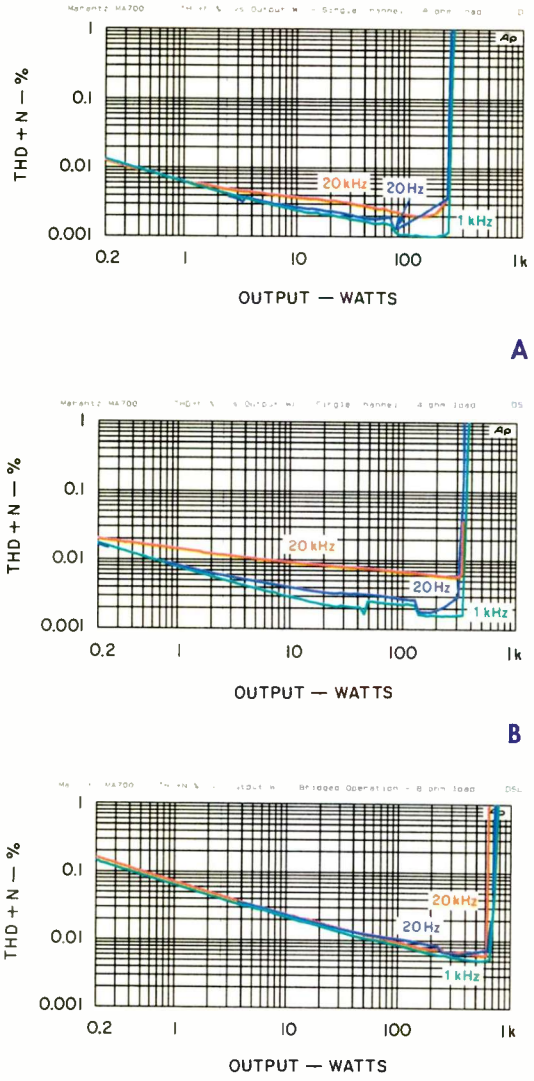


Fig. 1—THD + N vs. output for single amp with 8-ohm load (A), single amp with 4-ohm load (B), and bridged pair with 8-ohm load (C).

ative (black) terminals are tied together by a supplied heavy-gauge jumper.

The four base-metal RCA jacks are for remote control. Two of them, "In" and "Out," enable the MA-700 to be daisy-chained with other components that are compatible with Marantz's RC-5 control system. A third jack, "System Out," sends a power-on signal to the next MA-700 amp in the system after a 0.1-second delay, for sequential turn-on. This helps prevent a pile-up of simultaneous inrush currents that could trip your power line's circuit breaker. The last jack, "EXT. CONT. In," enables the amp to be switched on by a video signal from any television having a spare video output or by a triggering voltage of +5 to +13 volts DC.

The unswitched convenience outlet on the back of each amp is rated at 250 watts. The owner's manual says you can use it to operate another Marantz MA-700 but not more than one. The front panel has a master power button and two LEDs. "Power On" blinks for 4 seconds when power is first applied (and whenever the amp's protection circuitry has been triggered) and then glows steadily; the other LED glows when the amp is in standby mode. The 700 comes with one audio cable, one cable for remote-control interconnections, and the wire to jumper the two negative output terminals together when you're bridging two amps.

Measurements

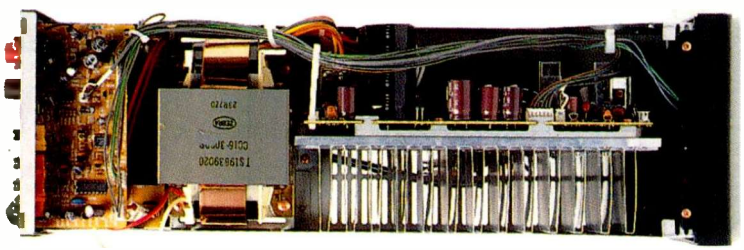
I received a pair of Marantz MA-700s for review. I tested the amps individually with 8- and 4-ohm loads and then operated the pair bridged into a load of 8 ohms. Except where noted, measurements are for an unbridged amplifier, which is the way I think most people will use the MA-700. All of the tests were conducted with the input level controls fully advanced.

Marantz uses eight 200-volt, 15-ampere bipolar transistors in each amp's output stage and powers them from supply rails of two different voltages, using relays to switch rails. I discovered this when I observed discontinuities in total harmonic distortion plus noise (THD + N) versus output (Fig. 1) and simultaneously heard a relay clicking within the amp. Upon checking with the company, I learned that the MA-700 uses ±44-volt supply rails up to the point where its output reaches 23 volts rms (equivalent to 66 watts into 8 ohms or 132 watts into 4 ohms, the points of the discontinuities in the curves) and switches to ±80-volt rails at higher signal levels.

Marantz has listed the MA-700 as a Class-AB amplifier, but it's not your garden-variety AB, as its use of dual supply rails is more characteristic of so-called Class-H operation. However, it's not garden-variety Class H, either, as it's the first amplifier I've seen that uses relays rather than transistors to switch rails. I'm not sure exactly how Marantz accomplishes that, but the test results are most impressive. As is apparent from Fig. 1, the MA-700's THD is negligible by any standard you'd care to apply, both before and after the supply-rail transition occurs. Furthermore, the 20-kHz curves in Figs. 1A, 1B, and 1C are nearly as good as those taken at 1 kHz and 20 Hz. Often, neither of these situations obtains in Class-H operation, and you pay a price in distortion for getting Class-H efficiency. Not so with the Marantz MA-700. It runs cool as the proverbial cucumber and is practically distortion-free in the bargain.

You can also see this in the curves for THD + N versus frequency (Fig. 2). With a single amplifier driving 8 ohms (Fig. 2A), the curves taken at 100 and 200 watts are so low that they almost fall off the bottom of the graph! The 10-watt curve is higher, but that's because of noise, not distortion. With single-channel operation into 4 ohms (Fig. 2B) the curves lie a bit higher, but in the 200- and 300-watt curves, which virtually overlie each other, distortion never exceeds 0.0057% anywhere in the audible frequency range. The 100-watt curve, for which the MA-700 was using the lower supply-rail voltages, lies slightly above the curves taken

THE MARANTZ MA-700 RUNS COOL AS A CUCUMBER AND IS PRACTICALLY DISTORTION-FREE.



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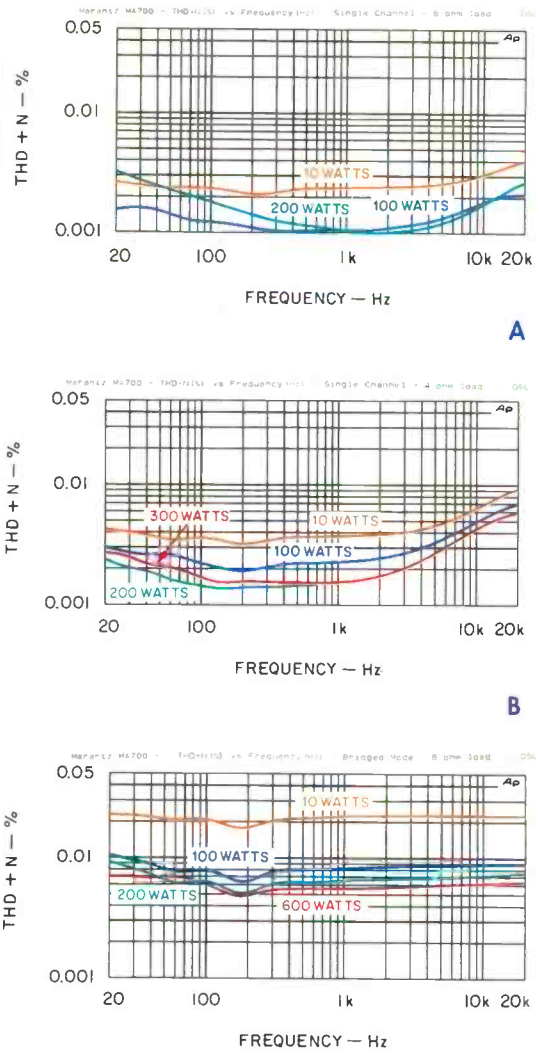


Fig. 2—THD + N vs. frequency for single amp with 8-ohm load (A), single amp with 4-ohm load (B), and bridged pair with 8-ohm load (C).

at higher power, but even there THD + N remains below 0.007% across the board. Again, the 10-watt curve lies above the others mainly because of noise.

The bridged-operation curves (Fig. 2C) tell a somewhat different story. Noise dominates in every curve, even the one taken at 600 watts! If you look at "Measured Data," you'll see why: The A-weighted noise for a bridged pair is nearly 20 dB higher than for a single amp. Some increase in noise with bridged operation is normal, because sensitivity typically increases by 6 dB in that mode. But this big a jump is most unusual.

The third-octave noise spectra (Fig. 3) bear out the A-weighted results in "Measured Data." Over most of the spectrum, the single-amplifier and bridged curves differ by about 15 dB, and the difference often exceeds 20 dB between 100 and 500 Hz. What's more, there are prominent power-line-related hum components.

I suspect that much of the noise arising from bridged operation of a pair of MA-700s comes from trying to get two amplifiers to function as one when they are not on the same chassis, have separate input stages whose gains don't necessarily match, and use separate power supplies. This arrangement can't help but encourage the introduction of noise into the ground lines. For example, the voltage gain of the MA-700s I tested was 6.1 dB greater in bridged operation than the gain of the master amplifier; it should have been precisely 6.0 dB greater. Although a 0.1-dB difference certainly doesn't sound like much, it indicates a gain imbalance that may have caused bridging problems.

This brings up another point: The noise in bridged operation might have been lower had Marantz designed the MA-700 for lower gain. Lucasfilm specifies that the voltage gain of a THX power amplifier should be 29 dB, making the 0-dBW sensitivity 100 millivolts. Unbridged (the only way it is THX certified), the MA-700 has a 0-dBW sensitivity of 74 millivolts and a voltage gain of 31.6 dB, 2.6 dB greater than Lucasfilm's spec. (If you want to restore gain to THX level, the amp's rear-panel "Input Level" control has only a mark, no detent, to indicate the proper setting. I found the control to be reasonably accurate although off by about 0.5 dB nonetheless.) When a pair of MA-700s is bridged, the voltage gain gets another 6-dB

I REALLY LOVED THE MA-700'S SOUND; IT WAS UTTERLY CLEAN AND HAD A SMOOTH, EXTENDED HIGH END.

shot in the arm, and it takes less than 37 millivolts to deliver 1 watt into 8 ohms. That much gain is just asking for noise problems.

One glance at the MA-700's frequency response (Fig. 4), and you can see that this is a pretty wideband amp. The –3 dB points for a single amplifier are below 10 Hz and above 200 kHz (the limits of my test gear), and response between 20 Hz and 20 kHz is essentially ruler flat. When a pair is bridged, a 0.22-dB bump appears at the top of the audio band (another possible indicator of grounding problems) and the –3 dB point moves down to 130 kHz (still pretty broadband in my book).

Clearly, the MA-700 does not lack for power, whether used alone or bridged. On a single amplifier, I measured output at clipping as 250 watts into 8 ohms and 390 watts into 4 ohms. Bridged, a pair cranked out 780 watts, continuously. With the IHF tone burst, the 8-ohm single-amplifier clipping point rose by 0.4 dB to 275 watts; the 4-ohm clipping point was at 470 watts, and the 2-ohm point was at 740 watts. Bridged, the pair delivered a dynamic power of more than a kilowatt into 8 ohms! Damping factor for a single MA-700 was high and quite uniform. At 50 Hz, it just topped 200; at 20 kHz, it was about 80. That's twice as good as Lucasfilm requires for THX certification.

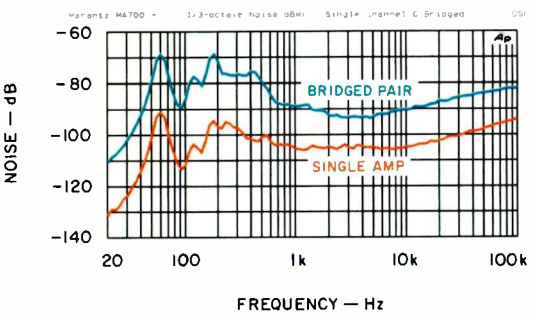


Fig. 3—Noise spectra.

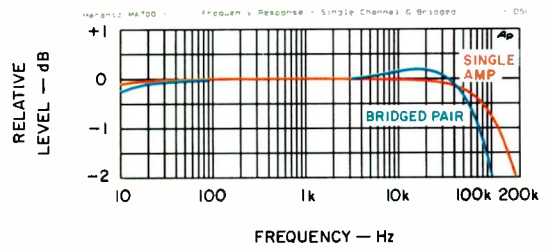


Fig. 4—Frequency response.

The MA-700 has more jacks than most mono amps, including an output for bridging and four jacks for remote control.

CLEARLY, THE MA-700 DOES NOT LACK POWER, WHETHER USED ALONE OR IN A BRIDGED PAIR.

Use and Listening Tests

With only two Marantz MA-700s at my disposal, I couldn't power my home theater with them. Then again, I would rather review a power amp by reproducing music in my listening room anyway, so that's what I did. When I used them as single-channel monoblocks, with each MA-700 driving its own speaker, I really loved the sound! These amps are absolutely and utterly clean and have the smooth, extended high end that I associate with uniformly low output impedance. I expect that they'll elicit the best from just about any speaker, which is high praise indeed for a power amp.

Bridged? Well, what can I say? Not recommended. The MA-700s become hummy and a little noisy when they're bridged—but there's really no need to bridge them, because they've got plenty of oomph by themselves. Marantz shouldn't encourage people to sacrifice day-in, day-out performance for the few milliseconds a year they might actually need more than a quarter kilowatt per channel. After all, as single-channel monoblocks the MA-700s are absolutely wonderful. A

BRYSTON, *continued from page 63*

hum-free in almost any system. Too often, that's not the case. Hats off to Bryston!

Use and Listening Tests

I confess to being a Bryston fan; a Bryston BP-20 preamp is in my reference system, and I've often used the company's 4B-ST, a 250-watt/channel power amp, as a reference. The B-60, which is as small as the BP-20 alone, can't hold up against that combo in a no-holds-barred comparison—but, given reasonably favorable circumstances, it does quite well, thank you.

I used it with Mirage OM-6 speakers and my old Allison Ones. The OM-6 woofers are self-powered, which relieves the strain on the B-60's bottom end, and the Bryston amp did fine with this speaker. However, it also had little problem driving the Allisons, which are totally passive. Admittedly, the Ones are not a terribly taxing load, but neither are many other speakers. Based on my lab tests, I'd say that the trick is to avoid speakers whose impedance drops unduly low in the deep bass. But with the speakers I had available when I tested the B-60 (I also used some Paradigms briefly), I heard nothing untoward. Oh, perhaps I could have done with a trifle more transparency in the high treble, but overall, I heard some remarkably fine sound: clean, clear, and utterly free of hum and noise.

I HEARD REMARKABLY FINE SOUND WITH THIS AMP: CLEAN, CLEAR, AND UTTERLY FREE OF HUM AND NOISE.

The B-60 delivers "only" 60 watts per channel, so it can be pushed beyond its limits. But thanks to its generous dynamic headroom, it's not easily overdriven by normal music, at normal levels, using speakers of normal efficiency and impedance. If in doubt, try it out. It's worth the experience. Yes, it's just a 60-watt/channel amplifier with only four line-level inputs (and a tape loop) and a rudimentary remote control. Looked at that way, it's pricey. But it's a Bryston. So I repeat: Try it out. It's definitely worth the experience. A

AURICLE

ANTHONY H. CORDESMAN

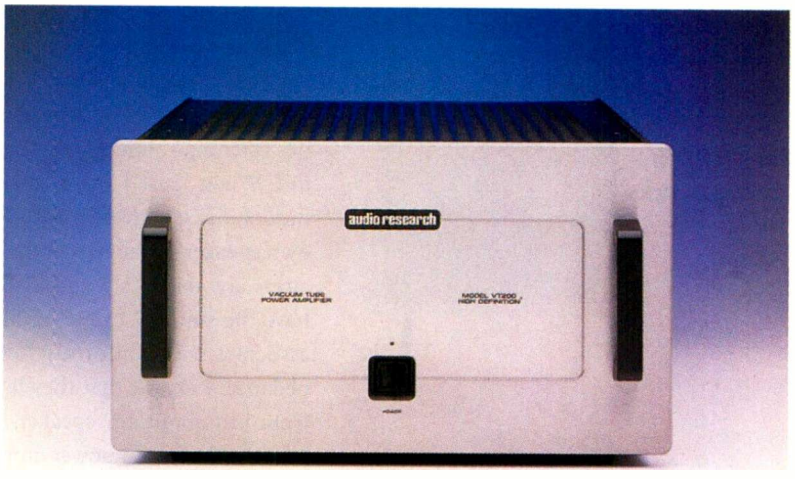
AUDIO RESEARCH VT-200 AMP AND REF 1 PREAMP

Audio Research is one of the handful of high-end manufacturers so consistently good that you can count on state-of-the art sound from their products. So it's hardly news that the company has produced another great amp and preamp. The issue is what's new and different about the VT-200 and REF 1, in style, technology, and sound.

The REF 1 preamp ($8,495), the more strikingly styled of the two components, carries forward Audio Research's beautiful craftsmanship and distinctive design. Although it adds green LED indicators that enable you to see each control's setting from across the room, these indicators don't turn the front panel into a gaudy light show. The restrained elegance of the VT-200 amp ($8,995) is more austerely functional.

Company Address: 5740 Green Circle Dr., Minnetonka, Minn. 55343; 612/939-0600; www.audioresearch.com.

The REF 1 is a line-stage preamp with remote control. Its audio circuitry is all tube, using eight Russian-made 6922/E88C dual triodes, but a microprocessor controls volume and balance adjustment and input and record-output selection. The tube heaters, high-voltage rails, and microprocessor control circuits each have toroid power transformers and isolated, highly regulated power supplies. A turn-on delay mutes the output temporarily, to prevent thumps and extend the life of the tubes.



The REF 1's circuit consists of two gain blocks connected by an overall feedback loop. Constant-current sources in each block's cathode circuit stabilize the current flow through that block's tubes. They also guarantee precise phase inversion, by ensuring that the signals on each side of the stage's two dual triodes are mirror images, even if the signal is imbalanced, so that the input stage responds to the differential in single-ended or balanced inputs. Audio Research feels this improves the circuit's push-pull balance under actual operating conditions.

Specifications are excellent for a tube preamp. Rated distortion is less than 0.015% at 4 volts balanced output and is only 0.5% if you drive the preamp to its maximum output of 30 volts. The signal-to-noise ratio is rated at 110 dB below a 4-volt balanced output and 93 dB below a 2-volt unbalanced output. The overall gain of the REF 1 is 18 dB, although this can be set at the factory to 12 dB. Frequency response is said to be within 1 dB from 1 Hz to 200 kHz, and the claimed –3 dB points are below 0.3 Hz and above 400 kHz.

The REF 1's front panel is uncluttered, and its ergonomics are excellent. Audio Research omitted useless features and circuit complications but not such useful ones as a balance control for locking in the soundstage, a polarity switch for experiments with absolute phase, and a muting control. On the rear panel are eight inputs and a tape/processor loop, all with balanced XLR and unbalanced RCA connections. Two pairs of main output jacks enable biamping; a tape output is also provided.

The VT-200 power amp is a dual-mono circuit except for its use of a single power transformer; Audio Re-

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ch uses a similar topology in its less erful VT-50 and VT-100 amps. The VT-200 s transformer, however, has dual-mono high-voltage windings that share current only under high-demand conditions.

Audio Research believes that amplifiers need large, stable, electronically regulated power supplies to handle dynamic music signals properly and sound as good as they measure on the test bench. But instead of the usual massive capacitors, the VT-200 has multiple smaller capacitors, distributed on the two channels' output boards. Small capacitors are said to have better transient response and distortion characteristics, and their distributed placement minimizes the length of the signal path.

The VT-200's input stage is a "long-tailed pair" balanced differential circuit, directly coupled to a driver stage of similar topology. This configuration is said to provide an accurately balanced push-pull signal to the driver stage from either single-ended or balanced inputs. The input and driver stages use seven constant-current sources, which Audio Research feels provides a highly linear drive and maintains exceptional stability, balance, and input headroom under dynamic conditions.

I HAVE ONLY PRAISE FOR THE SOUND OF AUDIO RESEARCH'S VT-200 AMP AND REF 1 PREAMP.

The output stages combine Ultra-Linear operation with partial cathode coupling. Ultra-Linear operation is a cross between triode and pentode operation; Audio Research says it yields much of the sonic benefit of triodes with much of the efficiency of pentodes. It also makes the amp a very stiff drive source. The partial cathode coupling adds less than 12 dB of local current feedback within the output stage. This further reduces output impedance and adds a measure of cross-coupling between the two halves of the push-pull output circuit, lowering crossover distortion. Together, these topologies provide a lower and stiffer output impedance into speaker loads, helping to keep the amp's sonic character unchanged under different dynamic conditions and into varying loads. Because the output stage is highly linear on its own, less overall loop feedback is required, which can result in cleaner, more dynamic sound.

The two main problems of push-pull design cited by proponents of single-ended amps are phase-inverter distortion in the input stage and crossover distortion in the output. The VT-200's circuitry deals effectively with these challenges.

The VT-200 has a damped chassis, a three-speed fan (dead quiet in normal operation), balanced and unbalanced inputs, and five-way gold-plated posts for the 4- and 8-ohm taps' positive and negative poles and the center tap of the output transformer. (The center tap allows unbalanced operation at 4 ohms and below, required for some older biamplified speakers.) Timed restart circuitry and delayed turn-on with a slow ramp-up to full operation help lengthen the life of the amp's tubes. The output tubes are 6550Cs; Audio Research believes more exotic tube designs offer no real advantages. It also believes exotic tubes may become obsolete, a potential problem for a company that takes pride in the fact that it can still service every product it has ever made.

I have only praise for the sound of this amp and preamp. In my listening sessions, frequency response, soundstage, dynamics, and transparency were all excellent. There was no euphonic fall-off in the treble, yet the highs were exceptionally musical and sweet. The REF 1's deep bass response was equal to that of the finest transistor preamps, and the VT-200 avoided the interaction problems in the middle and deep bass that can occur when a speaker needs lots of control from a tube amp. The REF 1 and VT-200 sounded virtually as quiet as the most silent solid-state equipment.

Top high-end amps and preamps have evolved to the point where their sound differs only in nuance and the degree of system synergy they provide; rarely will you hear significant weaknesses. But one audiophile's "nuance" can be another audiophile's "vital, massive difference in sound quality." As a result, your buying choices must depend largely on the particular illusion you want your system to create and on the ways your amp and preamp interact with your other equipment and your room.

I stress illusion because no combination of source material, electronics, and speaker, even in a purpose-built listening room, can provide real sonic truth. So your choice among top amps and preamps will depend on the subtle ways in which they enhance the illusion you want to create in your listening room.

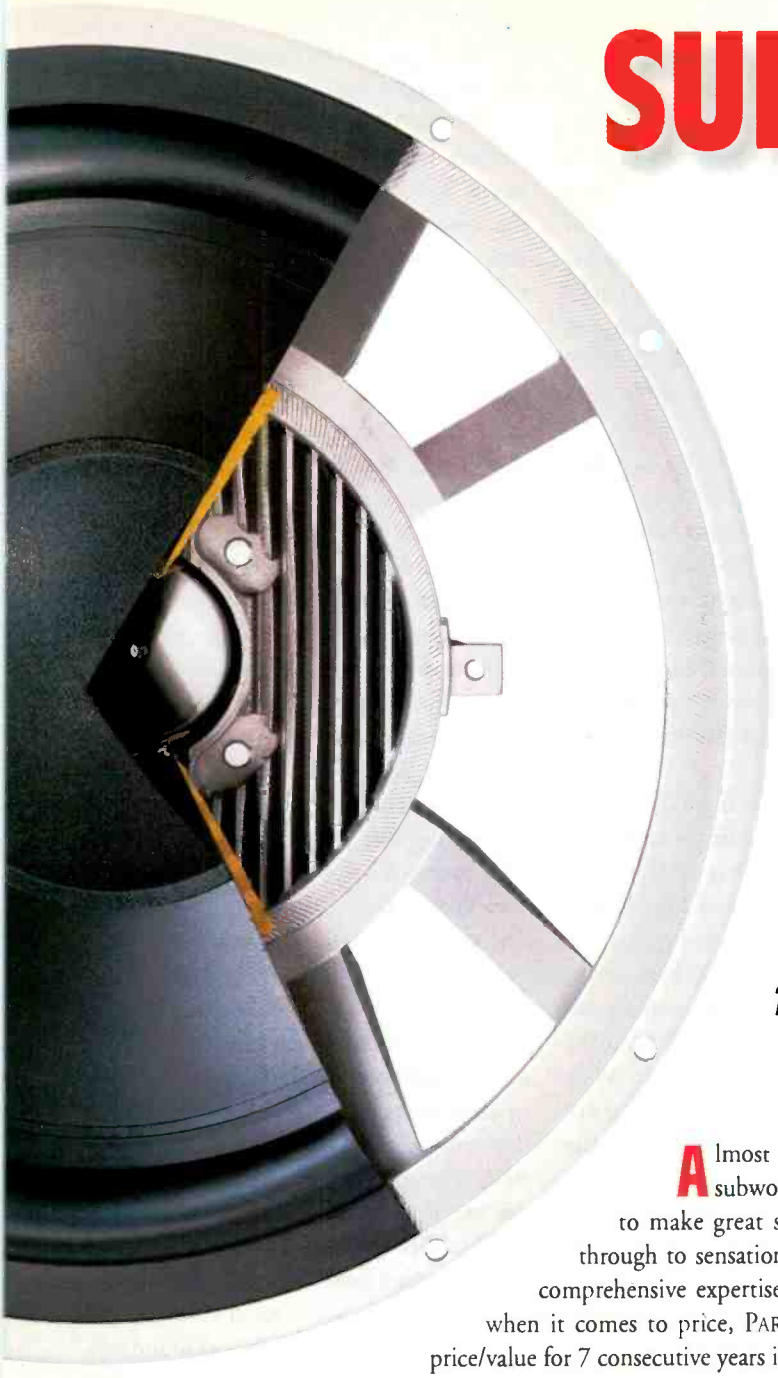
Synergy is important because many of the most important nuances in amps and preamps come from their interactions with the rest of your system. Even if all other interactions are minimal (which is often not the case), the interactions between your amplifier and speaker audibly affect the midbass and deep bass, which can change the apparent timbre, transient behavior, and dynamics of your entire system.

Although I can screen equipment well enough to tell you that certain components are exceptionally good, I cannot know what illusion you prefer or how important particular nuances will be to you. Nor can I predict the interactions and synergy that will result in your system. I can, however, describe some of the most important nuances I heard in *my* system when I compared the Audio Research REF 1 and VT-200 to my reference Krell and Pass Labs electronics.

The Audio Research REF 1 sounded slightly more live and dynamic than the Krell KRC-HR or Pass Aleph P preamp. The REF 1's midbass and deep bass were slightly warmer but not quite as tight or controlled as the KRC's. The differences in bass between the REF 1 and the Aleph were less striking, but the REF 1 had slightly more apparent transient or dynamic energy.

All three preamps were slightly sweeter and softer in the midrange and treble than most bipolar transistor preamps, but they were not rolled off or lacking in detail. They were highly transparent, with very low apparent noise, an exceptional ability to reproduce low-level detail, excellent transient response, and near-effortless handling of complex musical material and dynamic peaks. The REF 1, however, sounded slightly more dynamic and "live," while the KRC provided more apparent deep bass and high treble detail and a bit less dynamic energy; the Aleph sounded slightly sweeter than the KRC.

These nuances interacted with the three preamps' soundstaging abilities to create



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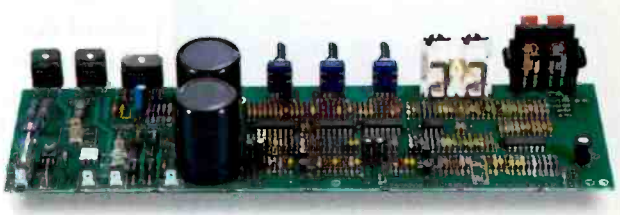

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§ *Inside Track Annual Dealer Survey*

three disparate, yet very convincing, musical illusions. The Audio Research REF 1's soundstage was wide and deep, with excellently detailed center fill; it seemed to place me close to the stage in rows D to H of a concert hall. The Krell KRC, while equally convincing, placed me a few rows farther back in the hall. Its soundstage wasn't quite as wide but did have a bit more sense of depth. The Pass Aleph P sounded much like the Krell but made the illusion of the hall's sound seem slightly warmer.

When I compared the Audio Research VT-200 amp to the Krell KSA-300S and Pass Aleph 1.2, I heard the same kind of differences. But, except in the bass, changing preamplifiers had more impact on the overall sound than changing amplifiers did. I found this surprising, since I'd initially assumed that a line-stage preamp would have less sound character than the output stage of a power amp.

In the bass, however, the three amps made a bigger difference than the preamps did. The Krell amp, for example, provided more apparent deep bass energy and a tighter and more defined bass than the Audio Research or Pass Labs amp. The VT-200's bass, on the other hand, was generally a bit warmer and more dynamic than that of the KSA-300S. The Aleph 1.2 split the difference. With bass-heavy material, these low-frequency differences seemed to slightly alter the whole system's timbre.

Interactions between amplifier and speaker or between speaker and listening room were very important. For example, the Audio Research VT-200's warmth and dynamic energy worked exceptionally well with Thiel CS6 speakers in my upstairs listening room but slightly less so when I moved the amp and speaker down to my first-floor listening room. With B&W 801 Matrix Series 3 speakers, the VT-200's warmth was less desirable although its dynamics worked; this combination sounded more consistent from room to room. The KSA-300S worked better with Vienna Acoustics Beethoven speakers in both listening rooms, but the Aleph 1.2 worked better with Vienna Acoustics' smaller Mozart speakers. All three amps worked very well with Martin-Logan CLS IIz electrostatics in both listening rooms, but the Audio Research did the best job of compensating for this speaker's lack of lower-midrange warmth, the Krell extended its bass the farthest, and the Pass, again, split the difference.

With the VMPS Super Tower III, an extremely large speaker that produces immense bass energy even well below 25 Hz, the amplifiers' bass differences became more obvious. Once again, the Krell offered the best deep bass extension, power, and control. The Audio Research, however, often made the midbass seem slightly more natural and alive, and the Pass added a bit more warmth than the Krell. These shifts in bass energy were particularly striking with organ and bass drum.

The realism of the resulting illusion sometimes depended as much on the synergy between the recording and the system as on the system itself. For example, the sound of the bass drum on Lorin Maazel's version of *The Rite of Spring* (Telarc CD-80054) is strikingly different from that on the recording under Eiji Oue (Reference Recordings RR 70CD). The VT-200 sounded more natural on the Oue recording, while the KSA-300S sounded more natural on the Maazel. This demonstrates the risk of using a narrow range of recordings when auditioning equipment.

Interconnects and speaker cables did not affect the sound as much the other components. I did, however, find that all three sets of electronics performed best with cables that sound flat and open and that do not restrict dynamics. I would be careful about the use of terminating networks. The new Kimber BiFocal XL and Kimber 3033 speaker cables proved exceptional with all three amplifiers, giving me the best overall resolution I have heard to date. (I found myself going back again and again to Kimber Kable's 3033, an almost affordable version of the company's Black Pearl. I would advise any serious high-end audiophile to audition it.)

What nuances and synergy will the Audio Research REF 1 and VT-200 produce in your hands? Short of having you send me your system, listening room, and ears (and a very large, self-addressed envelope), I have no way to tell you. I can say that this Audio Research amp and preamp are so good that they will never provide performance of less than reference quality. But if you are seeking the ultimate personal illusion, you will have to go and hear them for yourself. A

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AURICLE

JOHN SUNIER

MUSICAL FIDELITY X-TONE TONE CONTROL

The X-TONE shares its case design with seven other Musical Fidelity components.

For decades I've been grousing about the "hair-shirt" approach that most high-end component makers have taken in eliminating from their preamps and integrated amps such useful features as tone controls and headphone jacks. Audio designers have told me that consumers don't want them, that they are too expensive to execute really well, or that even defeatable tone controls will subtly degrade the sound. But I say "up your fidelity" to that. To be barred from controlling the high and low frequencies in an audio or home theater system is absurd. Tone controls give us a way of coping with the massive variations among recordings in timbre, noise, ambience, and the like.

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Now a small British audio company has done something to remedy the situation. The $250 X-TONE is part of Musical Fidelity's line of eight look-alike cylindrical components (which include the X-CANS headphone amp, the X-PRE preamp, the X-DAC D/A converter, and the X-LP phono stage). Each one's case is a ribbed black cylinder, about 8⅝ inches long and about 4⅜ inches in diameter, with aluminum end caps.

Most people would insert the X-TONE between their preamp and amp(s); putting it into a tape loop is an alternative. The controls are four small, yet easily grasped, knobs. The two on the left control the treble end of the spectrum, and the two on the right govern the bass end. (The sensitive midrange is left alone, because the most subtle degradations resulting from a tone control would be most audible there.) The first knob's settings are "Off" and a selection of treble turnover frequencies: 5, 10, or 15 kHz. The second increases or decreases response above the selected frequency by up to 9 dB. With the third knob, you select a bass turnover frequency of 30, 60, or 120 Hz or turn the effect off; with the fourth control, you can boost or cut the bass a maximum of 9 dB.

With the controls defeated, the X-TONE has a rated frequency response of 20 Hz to 20 kHz, ±0.2 dB, a rated S/N of 112 dB ("A"-weighted), and rated channel separation of 85 dB. The X-TONE's six bass and treble filters were carefully chosen to avoid phase anomalies that might compromise the midrange.

I found the X-TONE to be a wonderfully welcome and thoroughly functional addition to my system. (You'd think a $3,500 hybrid preamp would offer something as basic as a high-frequency rolloff for cleaning up the sound of a scratchy old LP, wouldn't

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—D.B. Keele, Jr. on the new Celestion A3, *Audio* August 1997

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"WILL THE A3 PLAY LOUD AND CLEAN? IN SPADES! ITS BASS OUTPUT SURPASSES EVEN THAT OF SOME SUBWOOFERS."

No matter what source materials he selected, from Mozart symphonies to movie soundtracks, Keele was amazed by the A3's performance. He wrote that **"their dynamic range and effortlessness border on the best I have ever heard"** and that **"their imaging and localization could not be faulted."**

There is so much advanced technology in our new A Series loudspeakers it fills a White Paper. Call us and we'll send you a free copy as well as full literature on the speakers and copies of the *Audio* review.

Once you've read the Celestion story and heard the Celestion sound, you'll see why D.B. Keele, Jr. and *Audio* gave us an A. And why it's time for other speaker companies to go back to school.

CELESTION

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you? But noooo.) I heard no degradation of my system's sound with the Musical Fidelity device in the tape loop other than a very subtle loss caused by the tape loop itself.

The first recordings I tried the X-TONE on were recent LP and CD reissues of Leopold Stokowski's *Rhapsodies* album, originally an RCA Living Stereo LP. The CD version in *The Stokowski Stereo Collection* (RCA 09026-68443) sounded almost identical to Classic Records' LP reissue (LSC-2471). The difference was a 60-Hz hum, almost inaudible on the LP reissue but extremely prominent on the CD. Setting bass rolloff on the X-TONE to 60 Hz and turning the bass knob down to about its 8 o'clock position cut the hum from the CD to the same easily ignored level as that from the LP, and there was no noticeable loss of the music's bass content.

Next I sampled some of the CDs from a boxed set of *Sergei Rachmaninoff: The Complete Recordings* (RCA Gold Seal 0926-61265) that I reviewed in *Audio* five years ago (March 1993). At the time, I complained that RCA seemed to have added some noise to these recordings rather than using the latest restoration technology to diminish it. Although my hearing no longer extends out to 17 kHz, as it did in my younger days, I could still hear most of this noise and therefore brought the X-TONE's 10-kHz filter into play. Turning the treble knob fully counterclockwise reduced the irksome "egg-frying" noises, and since the original 78-rpm apparently had no musical content above 10 kHz, nothing was lost in the process. If you have any noisy 78s, hissy LPs, open-reel tapes, or cassettes and you don't have DNR (or similar) after-the-fact noise reduction, the X-TONE can reclaim a more enjoyable listening experience from them.

In contrast to the RCA box, some reissues of a few years ago from Philips and EMI suffer from excessive noise reduction. The Philips engineers who remastered a CD series of great composers conducting their own works were evidently so enamored of the early NoNoise digital noise-reduction gear that they overused it to a horrifying degree. All the "air" and musical qualities were scrubbed clean out of the original 78s or mono tapes, and what remained was dull and colorless. This is a more difficult condition to attempt to correct, replacing something that isn't there anymore. (RCA's over-inclusive approach on the Rachmaninoff recordings was preferable.) However, a boost of 5 or 6 dB at either 10 or 15 kHz can make these CDs listenable. I didn't find many recordings where the X-TONE's 5-kHz or 30-Hz filter was needed, but the other four settings proved invaluable.

The X-TONE also proved useful in radio listening. Many announcers try to deepen their vocal timbre by speaking close to a cardioid mike so that the proximity effect will boost the bass somewhat. That may sound good on simple radios, but on a wide-range audio system it can be annoying. Using the X-TONE's 120-Hz filter to remove this boost can do wonders for boomy radio voices. It can also improve the balance between announcer and music levels, especially when you're listening to classical and jazz programs.

Musical Fidelity's X-TONE is the sort of component you may not realize you need until you have it in your system. I've wanted something like this for years and am glad it's finally available. A

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CLASSICAL

RECORDINGS

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Liberty! Original Soundtrack
Mark O'Connor
SONY CLASSICAL SK 63216; 63:10
Sound: A, Performance: A

Liberty! is a PBS miniseries about the American Revolutionary War, and Mark O'Connor was an inspired choice to compose the music for it. As an award-winning bluegrass and country fiddler, he has played a variety of traditional American music. As a composer, he has used an ever-widening palette, extending from country and traditional to jazz and classical pieces. Thus, he is perfectly cast in the role of composer.

O'Connor has chosen melodies from the Revolutionary period to carry the weight of the score. His own piece, "Song of the Liberty Bell," frames the album and recurs throughout. Besides himself on fiddle, O'Connor's core band of Nashville aces includes the incomparable Jerry Douglas on Dobro, John Jarvis on harpsichord and piano, Russ Barenberg on guitar, John Mock on penny whistle and recorder, and Mark Schatz and Glenn Worf dividing the bass chores. This group appears on seven of the 12 selections, while three tracks feature the Nashville Symphony. The two others are gorgeous duets: O'Connor and cellist Yo-Yo Ma perform "When Bidden to the Wake or Fair," a popular song of the era, and he collaborates with Wynton Marsalis for a rare pairing of violin and trumpet on "Brave Wolfe," a traditional ballad that tells of British General James Wolfe's death at the Battle of Quebec in 1759.

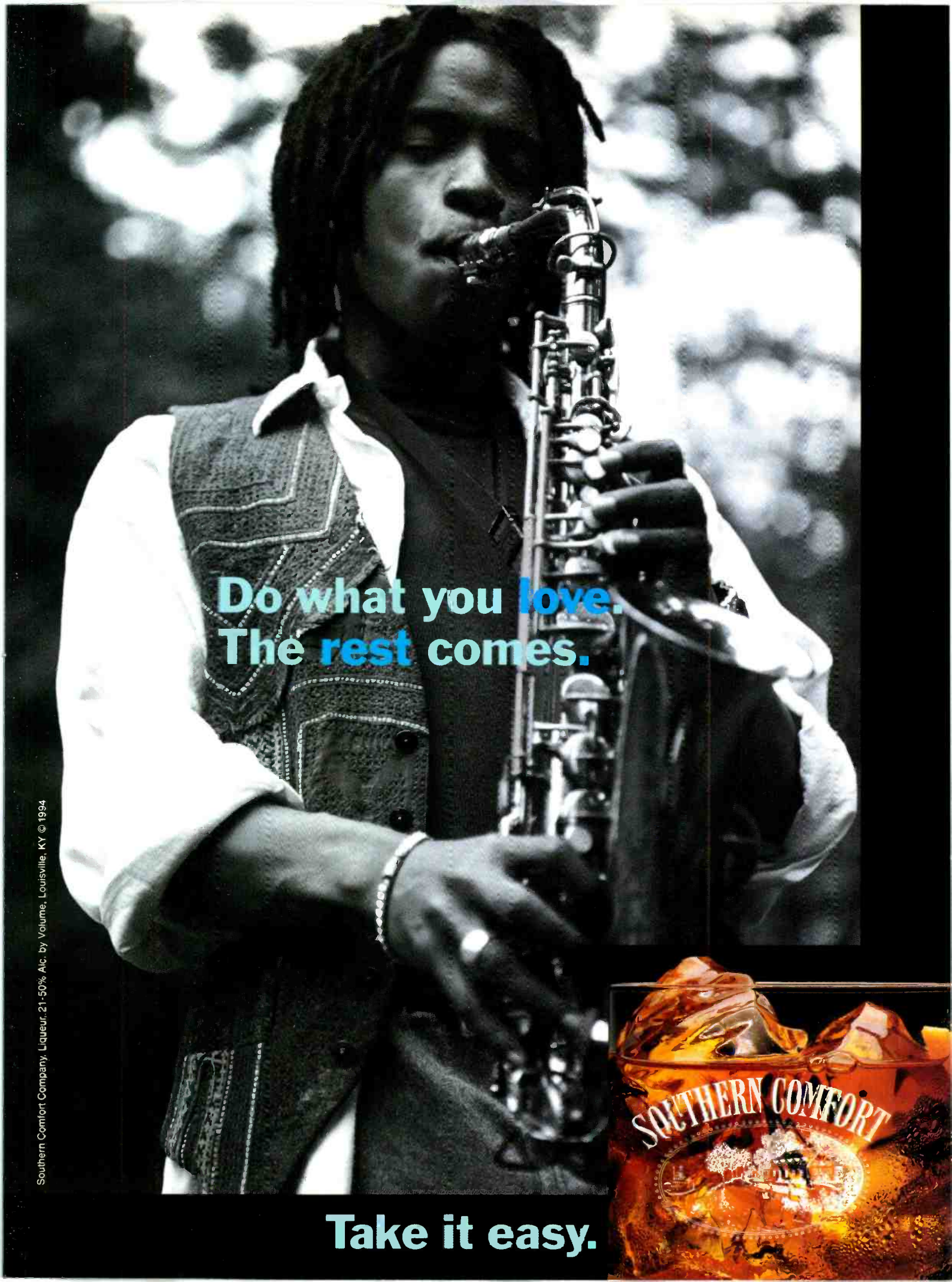
Most of the score is somber in tone—stately, lovely, reverent, and contained. Still, "Devil's Dream" and "Soldier's Joy" stand out as spirited, upbeat pieces, each with 18th-century roots. (Incidentally, Soldier's Joy was a period term for morphine, a soldier's only relief from pain.) "The Flowers of Edinburgh," another period favorite, is also a bright spot.

The album's one vocal is the ballad "Johnny Has Gone for a Soldier,"

PEPLOWSKI

The Other Portrait
Ken Peplowski, clarinet and saxophone; the Ken Peplowski Quartet; the Bulgarian National Symphony, Ljubomir Denev
CONCORD CONCERTO
CCD-42043; DDD; 62:54
Sound: A–, Performance: A

Known as a jazz clarinet virtuoso, Ken Peplowski follows in the footsteps of Benny Goodman and Woody Herman by making a crossover album. *The Other Portrait* runs the gamut, from the swing of Mark Lopeman's arrangement of Billy Strayhorn's "Duet" to a jazz-tinged neoclassical concerto written by Darius Milhaud in 1941. Tunes by Miles Davis, Ornette Coleman, and Duke Ellington represent the jazz side, while Witold Lutoslawski's Dance Preludes covers the contemporary classical side. Throughout the program, Peplowski demonstrates that he has the technique to pull everything off. He also has an uncanny feeling for the lyric line and a lovely, unforced tone with which to convey that feeling. The sound is clean and neat, with the clarinet front and center, as it should be in a virtuoso program like this. *Rad Bennett*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elegantly performed by James Taylor. This melody, too, recurs throughout.

Liberty! is moving music, beautifully executed and recorded. It is a rewarding listening experience that works excellently on its own, completely apart from the television series. It effectively evokes the Revolutionary era's music and moods and is a work Mark O'Connor can justly be proud of. *Michael Tearson*

Luminaries: Music of Shostakovich, Whitacre, Ito, and Hindemith

James Riggs, saxophone; Pavel Wlosok, piano; Jerry Bierschenk, baritone; the North Texas Wind Symphony, Eugene Corporon
KLAVIER KCD 11077; DDD; 70:51
Sound: A+, Performance: A

There's not a bad disc in the entire Klavier Wind Recording Project series, but even in a collection of such excellence, this one stands out. Its repertory is fascinating. The informative notes tell us that Paul Hindemith actually wanted to do his own band arrangement of the well-known Symphonic Metamorphosis on a Theme by Carl Maria von Weber, but his publisher didn't want it, telling the composer it wouldn't sell. The "Ghost Train Triptych," by 27-year-old Eric Whitacre, is the best new work I've heard in a long time. Its outer movements thrillingly describe a mighty steam locomotive as it races across America, while the blue-jazz interlude conjures up a lonely stop along the way. The Triptych's sound is of demonstration caliber, successfully capturing timbral combinations that range from full band to lonely soprano saxophone.

Eugene Corporon once again proves himself a conductor who should be ranked among the best, and the soloists all turn in outstanding performances. This is really a disc with something for everyone. It's a must-have for every audiophile as well as those who love great music. *Rad Bennett*

Bach: Concerto in D Minor for Two Violins (BWV 1043), Concerto in A Minor for Violin (BWV 1041), Concerto in E Major for Violin (BWV 1042), and Concerto in D Minor for Two Violins (BWV 1060)

Andrew Manze and Rachel Podger, violinists; the Academy of Ancient Music, Andrew Manze
HARMONIA MUNDI 907155; 56:41
Sound: A, Performance: A+

Johann Sebastian Bach was not only a master composer but a prolific arranger of his and other composers' music. This talent has often given modern editors and musicologists riddles to solve, since Bach would rewrite the same music for a number of different ensembles. For instance, the second of the double violin concertos on this recording is usually performed as the Concerto for Violin and Oboe in the key of C minor. The reconstruction of various Bach arrangements and rearrangements can result in a variety of possibilities, depending on which musicologist you believe.

The musical decisions by the Academy of Ancient Music reveal a judicious blend of scholarship and exquisite taste. Director and violinist Andrew Manze has a well-deserved reputation for baroque interpretation, and his colleague Rachel Podger, also on violin, performs with equal authority. The slow movements of the two solo concertos are particularly striking for their beauty and style. Recorded in London's Blackheath Concert Hall, the sound is vibrant but without so much reverberation that the inner parts of the faster movements might have been obscured.

When the original Academy of Ancient Music was founded in the 18th century, its purpose was to perform music ". . .composed more than 20 years earlier." The Academy's current incarnation has expanded that scope

GIAN CARLO MENOTTI

The Medium
Joyce Castle, mezzo-soprano; Patrice Michaels Bedi, soprano; Ensemble of Chicago Opera Theater, Lawrence Rapchak
CEDILLE CDR 90000 034
DDD; 62:05
Sound: A–, Performance: A

Gian Carlo Menotti's tragic two-act opera, *The Medium*, is about a woman who suddenly experiences fear and doubt when she notices a ghostly hand on her neck as she conducts one of her fake seances. Chicago-based Cedille's recording brings a compelling performance right into the listening room. The lead vocalists are ideally cast and, from beginning to end, the supporting singers and players right on the mark. Good notes and a full libretto are included. *Rad Bennett*

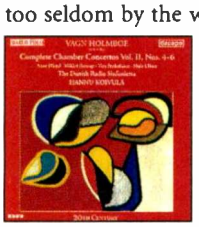
considerably, and this CD demonstrates that its interpretations of Bach are among the finest presented today. *Patrick Kavanaugh*

Holmboe: Chamber Concertos, Vol. II

Various soloists; Danish Radio Sinfonietta, Hannu Koivula
DACAPO/MARCO POLO 8.224063
DDD; 62:00
Sound: B+, Performance: A

Perhaps it is fanciful to think of Vagn Holmboe as the Mozart of modern Danish music. Perhaps not. The sense of joy in composing that comes through in much of his work—these concertos certainly included—is similar to the feeling you often get when listening to Mozart. And like Mozart, Holmboe was a practitioner who accepted music as he found it and sought new ways of making it work without reinvention. When his younger compatriots were turning to serialism, for example, Holmboe remained true to his roots, more or less in the tradition of Carl Nielsen.

The present volume has Nos. 4, 5, and 6 of the 13 chamber concertos Holmboe penned. The Fourth substitutes a piano trio (piano, violin, and cello) for the usual single soloist. It therefore begs comparison to Beethoven's Triple Concerto. The latter tosses good tunes about in pleasant fashion but never seems to go anywhere; the Holmboe, without real tunes, is more interesting for my money. The solo part in the Fifth is for viola—a wonderful, earthy instrument that is given its due far too seldom by the world's composers. Holmboe wrings both drama and lyricism—and even an almost violin-like brilliance—from it. The showiest of the three is No. 6, with violin solo. The swagger of the violin part is, in fact, rather atypical for Holmboe, who often focuses on the interactive textures of his instruments and leaves relatively little room for headstrong individualism.



The name of the orchestra, Danish Radio Sinfonietta, correctly suggests the sonics: those of a radio studio. The recording is clean and attractive, with reasonable depth and space in the soundstage, but it might have been something more had it been made in a fine hall. *Robert Long*

Proclamation

Douglas Yeo, bass trombone; the Black Dyke Mills Band, James Watson
DOYEN DOY CD 055; DDD; 80:17
Sound: A, Performance: A+

Few of us think of the bass trombone as a solo instrument, but this extraordinary disc could convert many to that view. Indeed, its very title, *Proclamation*, could be viewed as an assertion that the bass trombone's value as a solo instrument is the same as that of any other orchestral instrument.

Douglas Yeo, bass trombonist of the Boston Symphony Orchestra, displays dazzling tone quality. He plays with a flowing lyricism that is usually associated with woodwinds, not brass instruments. Yeo's impeccable solos are beautifully complemented by one of England's finest brass ensembles, the Black Dyke Mills Band, whose beginnings go back several centuries. Most of the selections were recorded in Peel Hall at the University of Salford, Manchester. The sound is rich and organ-like, with an expansive dynamic range. Striking brass and percussive effects abound.

Perhaps brass recordings aren't for everyone, but this one—with its variety of compositions ranging from Palestrina to jazz, from 19th-century hymns to contemporary arrangements—should go far in winning many new fans. *Patrick Kavanaugh*

Haydn: Orfeo ed Euridice

Cecilia Bartoli, mezzo-soprano; Uwe Heilmann, tenor; Ildebrando D'Arcangelo, bass-baritone; the Academy of Ancient Music Chorus and Orchestra, Christopher Hogwood
L'OISEAU-LYRE 452 668
Two CDs; DDD; 2:04:26
Sound: B+, Performance: A

Though not as intensely lyrical or dramatic as Gluck's *Orfeo ed Euridice*, Haydn's musical setting of the story of Orpheus and Eurydice does have some beautiful arias and exuberant choruses that make for good operatic listening.

In dual roles, the appropriately limpid Euridice and the fiery, tempestuous Sibyl (the latter originally written for a castrato voice), Cecilia Bartoli is beyond reproach. Were this a house performance, her virtuoso singing of Sibyl's lone aria, "Al tuo seno fortunato"—a tour de force with full orchestra accompaniment, including trumpets and timpani—would be accorded 20 or more minutes of standing ovation. Uwe Heilmann's supreme artistry and fine lyric tenor voice bring Orpheus to life. Christopher Hogwood's leadership of the Academy of Ancient Music is solid, if someimes bordering on pedantic.

The recording of the voices is quite good, but the orchestra and chorus sound, although impeccably clean and refined, might prove a tad dry for some tastes. *Rad Bennett*

ROCK~POP RECORDINGS

Photo: Nick Knight

Static & Silence
The Sundays
DGC/GEFFEN DGCD-25131, 42:16
Sound: B, Performance: B

In 1992, dreamy British pop quartet The Sundays released the melancholy, atmospheric *Blind*, which was a piercing scream compared to the deafening silence that followed. Over the next five years, the group's mentors, The Cocteau Twins, returned in peak form; their apprentices, The Cranberries, ascended to pleasant pop stardom; and The Sundays packed up their gear to pursue other interests. Guitarist David Gavurin and vocalist Harriet Wheeler had a baby and constructed their own recording studio. Finally, they decided they'd better do something with all the new gear, so they set about working on *Static & Silence*.

Many bands who disappear for a long time need to refit the training wheels, but time off served The Sundays well. Whereas their first two records were somewhat dull, relying on heavy-hearted repetitions of the same old themes, the new one unravels like an onion, each layer revealing a different shade of emotion. "Summertime" is sprightly and optimistic, offsetting buoyant guitar jangle with lively horn bursts, while "Folk Song" is more introspective, conveying its message with sparse guitar plucks, lush strings, and Wheeler's bittersweet vocals. Then there's "I Can't Wait," a peaceful, splendorous track augmented with the sounds of chirping birds.

In the past, The Sundays' songs frequently revolved around broken hearts and unrequited love; the subject matter on *Static & Silence* is as varied as the music. "When I'm Thinking About You" is a "Calgon-take-me-away" song about daydream romance, "Cry" is about the death of a loved one, and "Monochrome" recalls the first lunar landing from the perspective of a young child.

On the cover of *Static & Silence* is a close-up of the moon, bringing to mind the strong human desire to expand and explore. On this new album, The Sundays finally break their silence and reach their gangly arms skyward. *Jon Wiederhorn*

POISON LOVE

Buddy Miller
HIGHTONE HCD8084, 43:07
Sound: B+, Performance: A

At a time when country music is battling for its soul, singer, songwriter, and guitarist Buddy Miller is all but defining country soul. His 1996 solo debut, *Your Love and Other Lies*, was the best country album of the year that most people never heard. And *Poison Love* is another masterpiece that the country music establishment will no doubt ignore in its desperate quest to cash in on pablum.

In contrast to what's on the country charts, Miller creates mature, intelligent, and heartfelt songs that celebrate the grand ole C&W heritage while pushing the envelope. Those poles of tradition and innovation are best exemplified by two tracks: a fiddle-laced cover of the 1950s chestnut "Poison Love," where Miller sings with Steve Earle and is backed by Emmylou Harris and her touring band Spyboy (of which Miller is a member), and his achingly bittersweet, countrified reading of the Otis Redding soul hit "That's How Strong My Love Is." These classics are matched by material Miller has written with his wife Julie Miller, his longtime cohort Jim Lauderdale, and the one and only George Jones (whose singing Miller emulates in a deeper, rawer voice). The songs include infectious toe-tappers ("Nothing Can Stop Me," "Help Wanted," "Lonesome for You," and "Love Snuck Up") and touching weepers ("Don't Tell Me," "Baby Don't Let Me Down," "Draggin' the River," and "I Can't Help It"). The capstone is "100 Million Little Bombs," which laments the countless land mines strewn across the world.

With his global concerns and a distinctly American musical vision as strong as John Fogerty's, Buddy Miller could be just the man to rescue contemporary country from its creative doldrums, if only the powers that be would open their ears. *Rob Paterson*

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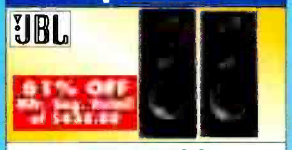

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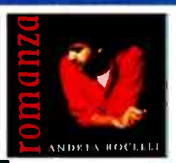

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LED ZEPPELIN

BBC Sessions
Led Zeppelin
ATLANTIC 83061, two CDs; 2:34:13
Sound: A, Performance: B+

In the early days of Led Zeppelin, Jimmy Page either understood aspects of the music business better than anyone else or was very, very lucky. By refusing to release singles and controlling the band's image, he created the illusion that Led Zeppelin was a band of mythic proportions. This collection of "live" recordings captures two nights in the life of Led Zeppelin and strips the band of its Page-manipulated studio finesse (although disc one does have a few overdubs). One night is a grimy blues workout from several BBC sources in 1969; the other is an electric/acoustic performance at the Paris Theatre in London on April 1, 1971.

The discs differ slightly. On the first, Zep creates its predictable hybrid of electrified blues and spaced-out, guitar-rock self-indulgence. Portions of the improvisatory jams are little more than time-wasting exercises, but the band charges back with an unusual sense of brilliant bombast. A stab at Eddie Cochran's "Something Else" is forgettable, but the three versions of "Communication Breakdown" all shake as if the goal were to topple the theater.

The second disc expands a bit. It begins in hyperdrive with the seismic "Immigrant Song," lapses into jam central for "Heartbreaker" and an 18-minute "Dazed and Confused," and revives with "Going to California" and a medley of tunes wrapped in "Whole Lotta Love."

Some may never wish to hear these songs in any version again, thanks to the oversaturation of classic rock radio. But for those who can never get enough, these restored recordings capture Led Zeppelin at a vital time: when the band was learning the ropes others would soon fail to climb. *Rob O'Connor*

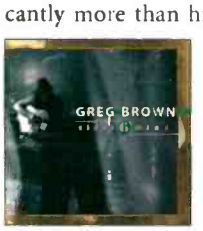
Ladies and Gentlemen, We Are Floating in Space
Spiritualized
DEDICATED/ARISTA DED 34P, 69:14
Sound: A, Performance: C–

As with many previous megalomaniac studio freaks, studio seclusion and tyrannical single-mindedness have shut off Spiritualized leader Jason Pierce to the point that he's far too busy knob-turning to realize that he doesn't have many good ideas left. Thus, *Ladies and Gentlemen, We Are Floating in Space* grasps for too many disparate things at the same time.

In the rare moments this album succeeds, it shines like a beacon from beyond. The glistening, Elvis-copping title track and the sparse ambience of "Broken Heart" are excellent. When the album fails, which is far too often, things get kinda hairy. "No God Only Religion" is sloppy, prog-rock mimicry, while "Come Together" is a blatant Primal Scream knockoff in more than title alone. Yet "Cop Shoot Cop..." (drugs, man!) is by far the worst. Enlisting legendary producer Jim Dickinson and Dr. John would seem like a sure bet to save any song from failure, but even they can't rescue the loping, redundant, and too-long album closer that Pierce surely sees as a *pièce de résistance*. Sadly, it's just another obstacle in your quest to get to the end of this frustratingly overwrought record. *Jason Ferguson*

Slant 6 Mind
Greg Brown
RED HOUSE RECORDS RHR CD 98, 54:10
Sound: B+, Performance: A

Greg Brown, the ornery but often brilliant folksinger and songwriter, has produced significantly more than his share of dazzling moments, including the recent masterpieces *Further In* and *The Poet Game*. This time out, his lucky-13th recording for Red House, Brown eschews his bookish, introspective side by bringing to his compositions a more colorful spectrum of mood and tone. On *Slant 6 Mind*, he is flanked by two excellent guitar players, longtime collaborator Bo Ramsey on elec-



tric and slide and Kelly Joe Phelps on acoustic lap and lap steel. This album's instrumentally sophisticated blues, gospel, country, and swamp folk turn the experience into a late-period Dylanesque romp, complete with politics, humor, and gritty imagery.

Brown's rich growl remains a stirring constant; it's nasty on the bluesy "Enough" and "Hurt So Nice" and imbued with twang on the compelling "Wild Like a Sonny Boy" and "Why Don't You Just Go Home." Through it all, too, is his Bukowski-meets-Faulkner lyricism—witty, angst-ridden, and rife with devilry. "She says 'Come hither,' but when I get hither, she is yon," he sings drolly on the album's opener, "Whatever It Was." And Brown's eye for quirky characterizations is utterly impeccable.

After hitting his stride on *Further In, Slant 6 Mind* finds Greg Brown looking out over new musical vistas, and his view from the top is splendid indeed. *Bob Gulla*

Pre-Set

Liminal Lounge
KNITTING FACTORY WORKS
KFW 202, 44:03
Sound: B, Performance: B+

Barely out of the chute, "illbient" music was declared "tired" by *Wired* magazine. It did seem to be misbegotten nomenclature from the start, a sub-genre of a sub-genre. Nevertheless,

Liminal Lounge makes a good case for it with a soundtrack where body and mind, hallucination and dance, collide.

The New York trio creates a mind-spinning interface between DJ Olive's turntable talking, Lloop's sample systems, and Danny Blume's basses and programmed rhythms (it's Blume's rhythm programs that give the album its title, *Pre-Set*).

Liminal Lounge creates the kind of technologically driven music that would probably fascinate someone like film director David Cronenberg. In fact, "Pre-Set #1 (Night Drive)" could be an homage to his film *Crash*, with vocalist Jana Martin asking, "Will you drive for me?" as her voice spins into hypnotic, erotic loops.

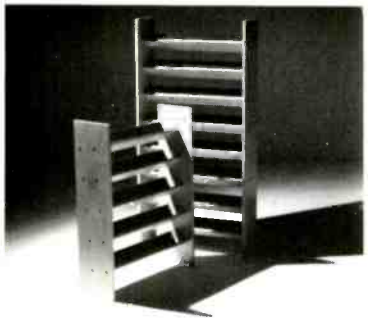
Most of the album, however, is instrumental. With guests Marc Ribot adding funky scratch guitar lines on a couple of tracks and John Medeski laying down synthesizer bleeps and squiggles on "Hush," Liminal Lounge brings an improvisational spontaneity and vitality to an often distant, prefabricated sound. *Pre-Set* isn't tired, it's totally wired. *John Diliberto*

Vanishing Point

Primal Scream
REPRISE 9 46559, 39:22
Sound: A, Performance: A

Primal Scream gets away with embracing a different genre on each album. After a late-'80s debut that was virtually an homage to The Byrds, the band morphed into hard rock, then got on the Manchester groove train with its 1991 hit machine *Screamadelica*. Then there was 1994's *Give Out but Don't Give Up*, with Rolling Stones producer Jimmy Miller and sounding like. . .The Stones.

Vanishing Point, however, is a giant pot containing all of Primal Scream's previous incarnations—an infectious, sublime brew of danceable beats, pulsing dub rhythms, and meaty melodies spiced with guitars, sitars, tablas, and bassoons. The mix-and-match program is evident in the New-York-Dolls-meets-biker-rock energy of "Motorhead," the psychedelics of "Burning Wheel," and the driving acid-industrial soundscape on "Kowalski." On *Vanishing Point*, Primal Scream powers across an East-meets-West landscape, combining funk, dub, and electronics with rock 'n' roll. And somehow, it works. *Jo-Ann Greene*



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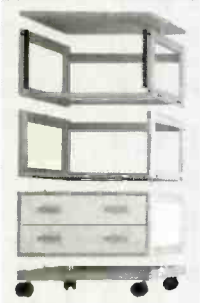

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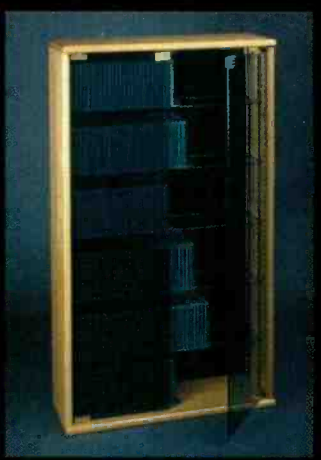

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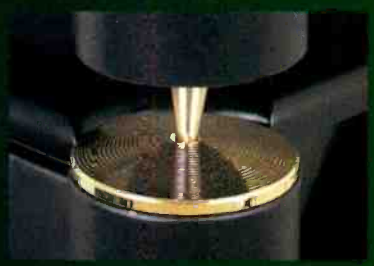

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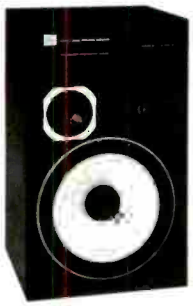

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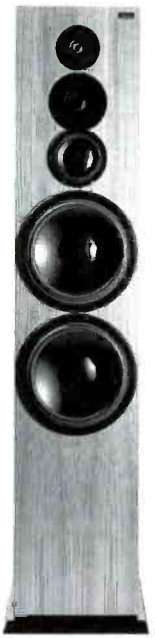

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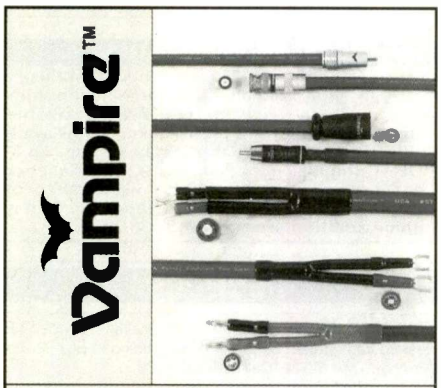

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PlayBack

MB Quart QP 805 Headphones

The QP 805 ($199) is a lightweight, closed-back stereo headphone based on an MB Quart professional model. Frequency range is rated at 20 Hz to 20 kHz, sensitivity at 98 dB. The overall weight is a nonfatiguing 8 ounces, though construction seems quite durable, with a strong metal frame (padded for comfort) and impact-resistant earcups. You position the earcups by pushing or pulling; an accordion-like, flexible plastic cover keeps your hair from getting caught in the adjustable section of the band. MB Quart gets extra points for making the heavy-duty cord a generous 10 feet long; it's terminated with a quarter-inch stereo jack.

I was impressed with the QP 805's sound. After leaving the 'phones plugged into a receiver for a day, to break them in, I hooked them up to an Audio Alchemy Class-A headphone amp and plugged in a CD player and a DAT recorder for some serious listening. I sampled a remastered version of Lynyrd Skynyrd's first album, a direct-to-DAT folk recording, and some classical and jazz recordings. On all of them, the QP 805 sounded balanced, without the excessive bass or sizzly treble I have heard from other headphones. Imaging was very good, placing such fine details as classical-guitar finger squeaks in natural-sounding space.

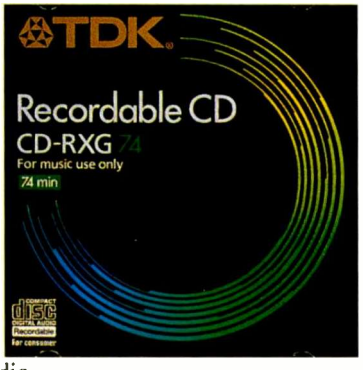
GRADE: A–

The QP 805 felt snug on my ears at first but soon stretched out a bit and became comfortable. The closed-back design attenuated outside noise reasonably well. Overall, the QP 805 is a good-sounding, comfortable, well-made pair of headphones. (MB Quart Electronics: 25 Walpole Park South, Walpole, Mass. 02081; 508/668-8973.) John Gatski

TDK CD-RXG 74-MINUTE RECORDABLE CD

As far as I know, TDK is one of only two companies making "consumer" recordable CDs (Pioneer's the other). The good news and bad news about consumer CD-Rs are inseparable. First, the good news: They will work with consumer CD audio recorders, whereas CD-Rs meant for computer and pro audio use will not. That's because CD-Rs for home audio use are coded to tell the recorder that it's okay to record onto the blank. The CD-R recorders made for computer and pro audio use do not require this code, and discs for those markets don't carry it.

Part of the bad news about CD-Rs—including the pro audio and computer versions—is that they're write-once media: As soon as a track has been recorded, the audio is there permanently—you can *never* erase it. The other part is that home audio discs cost far more than the pro/computer version, to cover a royalty fee that's distributed to performers, composers, lyricists, and music publishers. When I last shopped for home CD-Rs, TDK's CD-RXG had a suggested retail price of $16 each and the cheapest I could find it was $6.99 through a mail-order outfit. The suggested retail price recently dropped to $8.99, so the mail-order price should also drop significantly. However, professional/computer CD-Rs are street priced as low as $1.99 each.



GRADE: B–

The TDK CD-RXG blanks worked perfectly in my Pioneer PDR-04 recorder, with no glitches or dropouts. This green disc can be labeled with a felt-tip pen, and the jewel box contains a blank liner for song titles and other information. The CD-RXGs come in 60- and 74-minute versions, but because the difference in street price is only about 50¢ per disc, you might as well buy the more generous length.

Once a CD-R has been recorded and its table of contents is finalized, any CD player can read it. However, many DVD players can't, even though they can play commercially recorded CDs; my Panasonic DVD-A300, for example, would not recognize the TDK disc.

As with TDK digital and analog tape, I love the quality of the TDK CD-RXG recordable CD disc. I just hate the price; otherwise, the grade would be higher. (TDK: 12 Harbor Park Dr., Port Washington, N.Y. 11050; 800/835-8273.) John Gatski

TERK FM PRO FM-50 FM ANTENNA

Terk built the FM Pro FM-50 ($119.95) to survive outdoors and look fairly inconspicuous indoors. It's designed to mount horizontally against a wall, ceiling, or attic floor. Its shape is clean and simple, and you can paint it to match your walls, but it's a bit large (57 x 2½ x 1¼ inches) and you may find it hard to conceal the RF cable (not supplied) to your tuner.

Mounted about 15 feet lower than the antenna on my chimney, the FM-50 outperformed it slightly on most stations, producing somewhat cleaner—and stronger—signals. (A mast-mounting kit costs $19.95.) The Terk's pickup pattern is a fat figure 8, with its built-in signal amplifier making up for some of the gain lost at the edges of the pickup pattern. Terk says the overall gain is consistent across the FM band, which seemed to be the case; not all companies can make that statement about their antennas. The FM-50's built-in amp did a very nice job at my suburban house, raising output without adding audible noise. It probably helped that the passive part of the antenna is a half-wavelength, not quarter-wave, design, so the amp had a reasonably strong signal to start with. In Manhattan, the FM-50 outperformed a passive whip antenna on most stations and did not overload, which many amplified antennas do in the city. However, one station with heavy multipath did come in better when the Terk was oriented vertically.

Power for the FM-50's amplifier is sent up the RF cable via a supplied junction box, which must be connected at your tuner's input. If the amp is off, the antenna works fine but has less gain. The junction box has an on/off switch for the amp, and an LED on the antenna glows when the amp is on. (Terk Technologies: 63 Mall Dr., Commack, N.Y. 11725; 800/942-8375; www.terk.com.) Ivan Berger

GRADE: A

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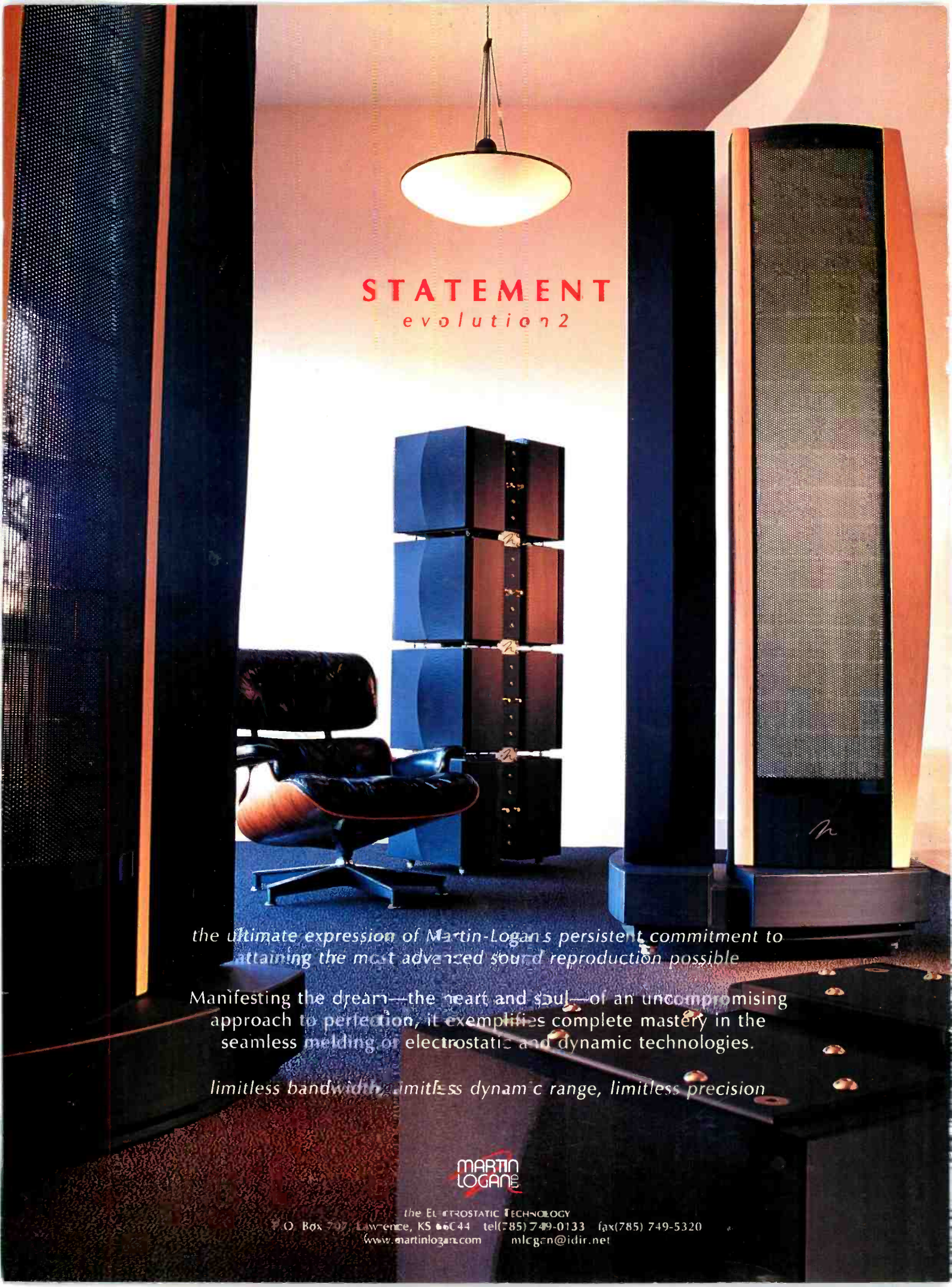
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