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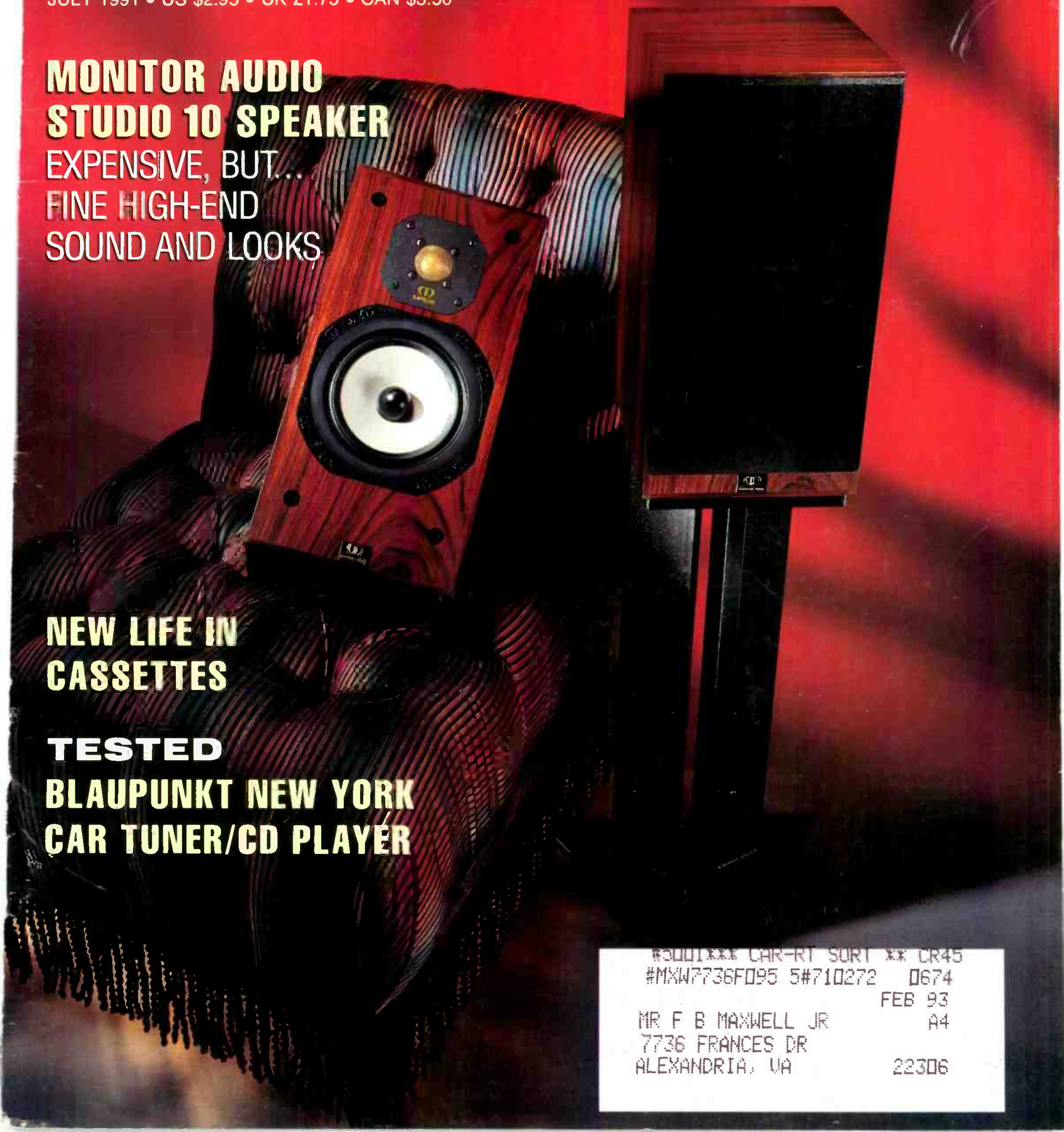

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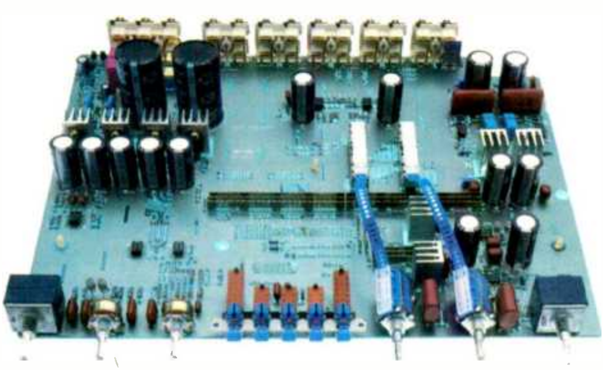

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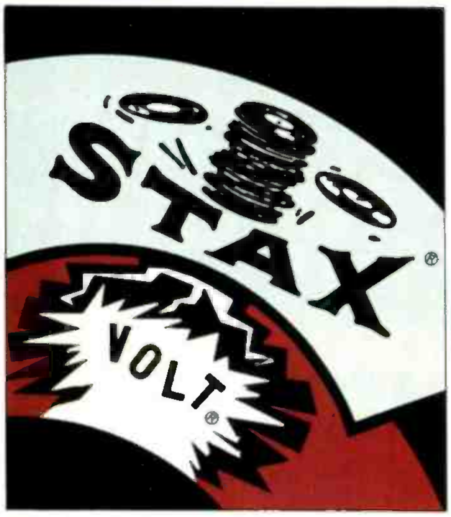

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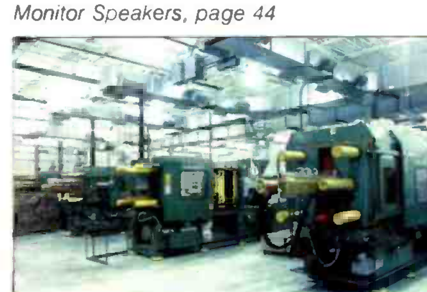

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SIGNALS & NOISE

Reprise of the Bitstream

Dear Editor:

We at Analog Devices—as leading suppliers of audio converter ICs—are pleased to see in-depth articles on converter technology such as "Music of the Bitstream" by Prasanna Shah (January). Because of the debate (and confusion) in the industry between oversampled sigma-delta converters and "classical" current-steering converters, his article was timely and informative.

Unfortunately, Shah's article continues to reinforce widespread confusion about the role of "oversampling" in the digital-to-analog conversion process. The first point to be made is that digital oversampling interpolation filters are required *regardless of the D/A converter technology*. That is, both oversampled and current-steering D/A converters are preceded by interpolation filters in virtually all modern designs. Confusion is natural when trying to understand why a sigma-delta D/A converter that is oversampled by 64 is preceded by an interpolation filter that oversamples by eight. There are two kinds of oversampling going on. The former is accomplishing quantization noise shaping, as is well explained in Shah's article. The latter, interpolation filtering, ". . . allows for simpler and lower order, phase-linear analog post-filtering," as reported. In fact, that's the *only* reason for interpolation filtering; its other consequences are negative.

What oversampling interpolation filtering does is move the Nyquist "images" of the audio signal to higher frequencies. Without an oversampling interpolation filter, the first image at a 44.1-kHz sampling rate will begin to appear around 24 kHz. High-order, "brick-wall" analog filters would be required to eliminate these images—with nasty audio consequences, as the first-generation CD players demonstrated. Both oversampled and current-steering D/A converters will produce these Nyquist images starting around 24 kHz unless preceded by an interpolation filter. If the interpolation filter oversamples by four, the first image will occur near 176.4 kHz; if by eight, near 352.8 kHz.

Shah really muddies the waters by adducing two additional but fallacious "reasons" for oversampling interpolation filtering: (1) "To reduce the quantization noise in the analog audio bandwidth" and (2) "To improve the signal-to-noise ratio (S/N)." The phrase "quantization noise" is ambiguous, and Shah fails to clarify. There are three sources of quantization noise in the conversion chain if a sigma-delta D/A converter is used, two if a current-steering type is used. The first is the quantization noise from the analog-to-digital conversion done in the recording process. *There is nothing playback equipment can do about recording quantization noise once it's on the CD!* No electronic magic can take away noise the studio introduced or improve the ratio of signal to this noise. Shah's argument about smaller step sizes with interpolated data is completely irrelevant to reducing the noise introduced by the original 16-bit quantization process. Even ideally, this noise is ±½ least-significant bit *at the 16-bit level*.

Sigma-delta D/A converters introduce their own quantization noise, but eliminating that noise source is what noise shaping is all about; interpolation filters have no impact on that noise. The third type of quantization noise is ironically introduced *by the interpolation filter itself*. Shah is correct that oversampling reduces this noise, but it's noise that wouldn't even be there without (oversampling) interpolation.

Interpolation filters perform multiplication/accumulation operations on 16-bit input data. To retain "perfect" accuracy using 16-bit coefficients requires internal accumulators that are at least 32 bits wide. Ultimately, the filter outputs a 16-, 18-, or 20-bit word that represents a signal "interpolated" between the original signal values. In any event, accuracy is lost when the filter's internal values are truncated to one of these smaller word widths. This quantization noise is probably best called "requantization" noise because truncation effectively accomplishes a second quantization of the music signal. (The finite word length of the coefficients, non-ideality of the digital filter, and other factors also contribute digital noise to the interpolation process, but in a well-designed interpolator, truncation noise will dominate.)

Now, it's easy to explain the benefits of 18- and 20-bit D/A converters. Requantization noise will be spread out

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Introducing the new Adcom GTP-500 II Tuner/Preamplifier.

Only a few years ago, Adcom announced the dawn of a new era by introducing its GTP-500 tuner/preamplifier. Together with any of Adcom's critically acclaimed power amplifiers, this unique audio product has given thousands of cost-minded, serious music lovers a quality alternative far superior to the common receiver. The new, evolutionary GTP-500 II offers a meaningful expansion of convenient features and sonic performance.

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For total music system integration, the GTP-500 II remote sensors will also receive and retransmit commands to a majority of remotely controlled components, regardless of brand. This remarkable design gives you full command of your entire music system throughout your home and offers the ultimate flexibility of integrating the remote features of components manufactured by others.

Value Measured By Performance

The overall performance of the new GTP-500 II is demonstrably superior through its evolutionary design and the use of state-of-the-art component parts.

Adcom's unique, low-impedance RIAA compensation provides lower noise and distortion in the phono input stage. To further reduce noise and distortion in all stages, all switching devices are buffered.

Long term adherence to circuit design objectives is accomplished by utilizing 1% Roederstein resistors in all critical applications as well as a new low-loss, printed circuit board.

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Part of what makes this hobby so exciting is that every year something new and different is introduced.

over the wider frequency range of the interpolation filter's oversampling rate. If the interpolation filter's results (at eight-times oversampling) were truncated to 16 bits, the requantization noise would add about 1.5 dB to the noise floor. If instead we truncate at 18 bits, then the requantization noise is lowered by about 12 dB. Truncation at 20 bits reduces requantization noise yet another 12 dB. Thus, the advantage of 18- and 20-bit converters is that they can reduce the deleterious effects of interpolation filters to a fraction of a dB above the theoretically ideal. Whether this noise difference is audible above all the other noise sources in the playback chain is a question I'll leave to the "golden ears."

David Fair
ASIC Marketing Manager
Analog Devices
Wilmington, Mass.

Author's Reply: I don't think there is any confusion about the role of oversampling in the digital-to-analog conversion process. Neither does the article associate oversampling and interpolation filters only to a specific D/A converter technology. It is common knowledge that oversampling and interpolation filters have been utilized since 1982, when the 14-bit D/A converters were used. It seems to me that Mr. Fair is mixing up the roles played by the oversampling process and interpolation in the reconstruction of the audio signal. It can be easily found in almost all elementary textbooks on digital signal processing that the quantization noise is proportional to the step size. If Δ is the step size, then the quantization noise will be $(1/12)\,\Delta^2$.

Also, the article never claims to reduce the quantization noise introduced by the original digital master recording in 16 bits, through either D/A converter technology. In fact, the article tries to dispel the myth about 18- or 20-bit accuracy being achieved in sound reproductions of 16-bit-mastered Compact Discs using the 18- and 20-bit D/A converters, which is perpetuated by the manufacturers of these converters and the CD players that employ them.

Lastly, Mr. Fair is trying to explain the benefits of 18- and 20-bit D/A converters. He is unfair in associating the extra bits in the 18- and 20-bit converters with the spreading of requantization noise over a wider frequency range. The smaller step size in voltage levels does not spread the noise in frequency. But a noise shaper with oversampling and interpolation will shift the quantization noise from the audio spectrum to higher frequencies. I recommend the fourth reference listed at the end of the article for further information on this topic.

In order to have any kind of benefit from 18- or 20-bit D/A converters, they need to maintain less than ½ LSB differential linearity, ½ LSB integral linearity, minimal gain and offset errors, minimal glitch energy, and minimal zero-crossing distortion—and to keep these parameters constant—over the entire operating temperature range. I am sure that even Mr. Fair will agree that such an 18- or 20-bit D/A converter is not commercially available, and even if it were, it would not be viable for consumer CD players.—*Prasanna Shah*

An Alternative Bandwagon

Dear Editor:

I was highly delighted and a little surprised to see reviews of Mano Negra's *Puta's Fever* and Tackhead's *Friendly As a Hand Grenade* in your November 1990 issue. I've always enjoyed the reviews in the Rock/Pop Recordings column, but seeing these "alternative" bands was great! I hope this turns into a trend. There's quite a bit of alternative music out there, and a lot of it is very good. There just doesn't seem to be enough exposure, but if a few more avenues of exposure open up, we'll be hearing more of this music on the mainstream stations and more will be available in mainstream stores. And this would suit me just fine.

Marty P. Hoar
Longmont, Colo.

Shining Sunier

Dear Editor:

John Sunier's interview with the rather incredible Robert Parker and his infernal machines (February 1991) was absolutely first-rate. Best piece you guys have run in months. Three cheers for all concerned from sun-drenched La Jolla.

J. Lee Anderson
La Jolla, Cal.

More Like Oil and Vinegar

Dear Editor:

In response to a letter in your January 1991 issue from Leland A. Beaman:

YES, *Audio* is an *outstanding* magazine.

NO! *Audio* should *not* eliminate the wonderful world of video from this outstanding publication.

While I agree the field of audio deserves its own literature, video products are taking a great part in the audio systems of many of the readers of *Audio* magazine.

The two are *not* oil and water.

Part of what makes this hobby so exciting is that every year, if not every day, something new and different is introduced to us. From the movie theater we now have surround sound in our homes that works in harmony with our audio media *and* our video media. We no longer live in an age where a television is for seeing and not hearing. In my system, the two work quite well together.

Also, I feel a bit sorry for Mr. Beaman, as it seems he must not have yet experienced the joy of recording audio onto Hi-Fi videotape. It would probably blow his current "audio" cassette deck out of the water.

Grant M. Billings
Milwaukee, Wisc.

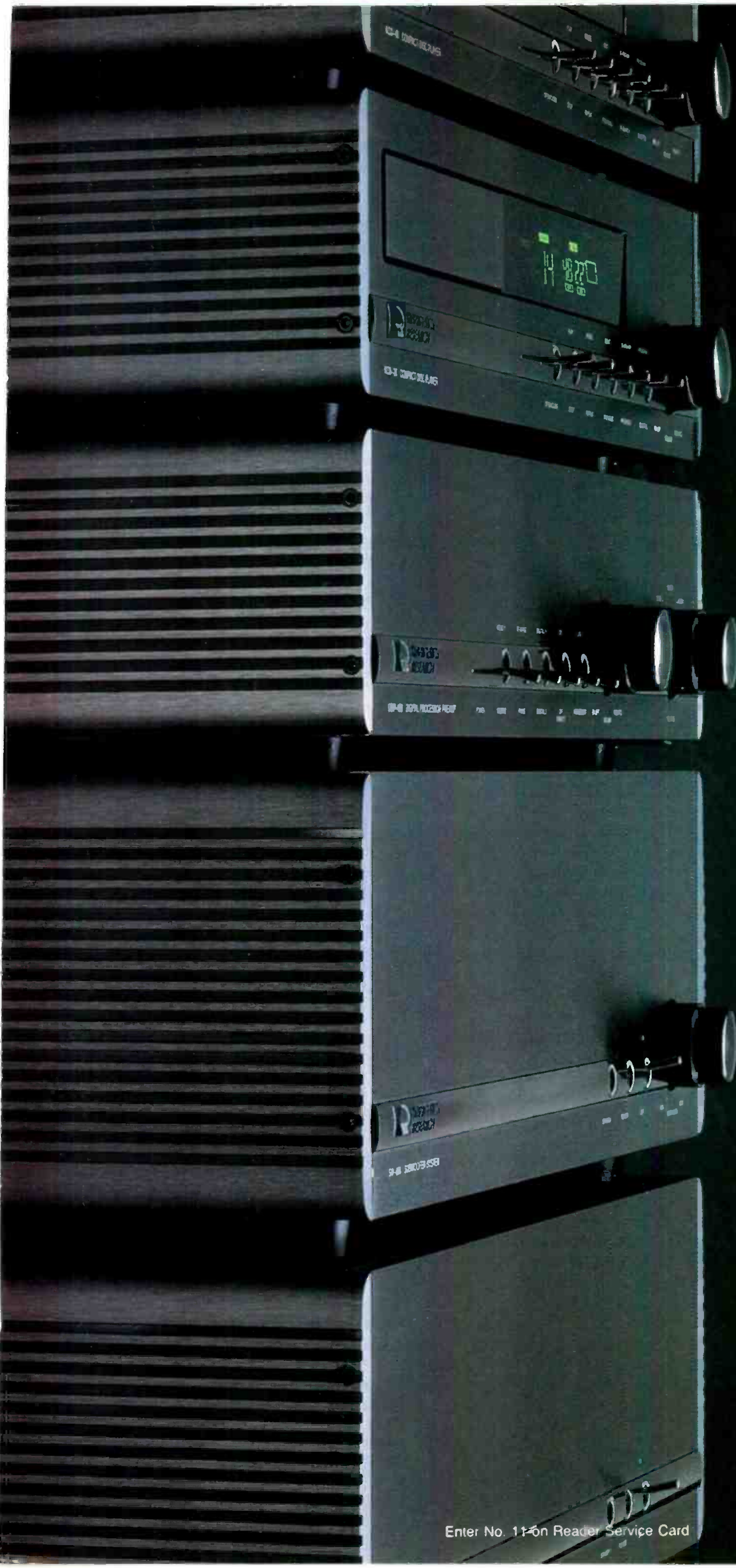
Referral of Fortune

Dear Editor:

I would like to tell you about a remarkable experience with one of your advertisers, Advanced Audio in Leechburg, Pa. I had written to them looking for a couple of cheap woofers for my workshop and mentioned that I intended to use the woofers with small speakers I had on hand from a junked car stereo.

Advanced Audio wrote back, explaining that none of their speakers were exactly what I needed. Instead, they provided the name of a *different* company, a list of exactly what to order, and precise diagrams for building the enclosures and hooking up the crossover. If they did all this for somebody who wasn't buying anything, their paying customers must really be treated like royalty.

Jon Vilhauer
Placerville, Cal.



TAPE GUIDE

HERMAN BURSTEIN

Why Adjust Bias at −20 dB?

Q. I adjust my deck's fine bias knob, using white noise from a test CD, to match the source with the tape playback at a level of −20 dB. But when I increase the record level to 0 dB, the source and tape don't match anymore; the tape is duller. Which procedure is correct, bias adjustment at −20 or at 0 dB, and why?—Anthony Hudaverdi, Santa Monica, Cal.

A. You should adjust at −20 dB, for the following reasons: Assuming all frequencies have the same amplitude, as is essentially true of white noise, in a cassette system the tape saturates more easily at high frequencies than at others. This is largely due to the great amount of treble boost employed in recording. Such boost is needed to compensate for magnetic and electrical losses encountered in recording, and it may reach something like 15 dB at 15 kHz. Therefore, using white noise, high frequencies are presented to the tape (and tape head) at much greater amplitude than are the middle and low frequencies.

To avoid tape saturation and consequent loss of highs when adjusting bias with a white-noise test signal, it is necessary to keep the signal level distinctly below DIN or Dolby level. (One or the other of these two levels, which are about 2 dB apart, is usually the 0-dB reference.) The usually recommended level is −20 dB.

Fortunately, in most program material the amplitude of the highs is substantially lower than that of the rest of the audio range. This natural fall-off of highs tends to compensate largely or completely for the treble boost employed in recording. Accordingly, if we adjust bias at the −20 dB level when using white noise, we avoid tape saturation at high frequencies when recording so that peaks reach 0 dB or even about 3 to 5 dB higher.

Some program material does contain unusually strong highs, and the recordist may then have to reduce recording level by several dB to avoid saturation. One can't simply "set and forget" when it comes to recording level; judgment must be employed.

Type and brand of tape also enter the picture. Type IV (metal-particle) tape is more immune to saturation than the other types. Within a given type, susceptibility to saturation tends to vary somewhat from one brand to another. In the case of Type IV tape, one could adjust bias at around −10 dB, if one wished, when using white noise.

Finally, there is the matter of what type of noise reduction is employed. Because of special equalization in the high treble range (spectral skewing and anti-saturation curves) employed by Dolby C and Dolby S, these noise-reduction systems help guard against tape saturation more effectively than Dolby B NR. The dbx system guards still more effectively. Accordingly, the need for going below 0 dB when adjusting bias with white noise will vary.

Tape recordists frequently employ FM interstation noise to adjust bias. Above about 2 kHz, this noise drops steadily in level, owing to the tuner's standard FM de-emphasis of 75 µS; the drop eventually reaches a rate of 6 dB per octave. To illustrate, the interstation noise at 10 kHz is nearly 13 dB lower than at 1 kHz. Accordingly, the need for going below 0 dB when setting bias is reduced.

Safe Head-Cleaning

Q. I have just purchased a dual-well cassette deck and would like to know what the best products are to clean it with and how often to demagnetize it. I am a little wary of using anything right now because I have heard that alcohol-based products can damage the heads and that abrasive tape cleaners do the same.—Donna Farley, San Marcos, Tex.

A. You should first consult the owner's manual of the deck to discover what, if anything, the manufacturer recommends for cleaning the heads and other parts (capstan, pressure roller, guides) contacted by the tape. If nothing is suggested, it is generally safe to use 91% isopropyl alcohol, which many drug stores carry. Audio stores usually carry special cleaning fluids intended for tape decks; often they contain trichlorofluoroethane. Apply the alcohol or other substance with a cotton swab to all deck components contacted by the tape. Let things dry at least five minutes before using the deck. Avoid 70% isopropyl alcohol, rubbing alcohol, and similar alcohol compounds because they usually contain contaminants that may leave undesirable residues, such as gums and oils. It is generally considered that direct cleaning, as described here, is preferable to use of a cleaning cassette, which may be abrasive.

Demagnetization is preferably performed with a wand-type demagnetizer rather than a demagnetizing cassette; wand demagnetizers are apt to be more effective. When you use any type of demagnetizer, be sure that the rest of your audio system is *off*. If your deck is feeding into your audio system, and if the system is accidentally left on when you are demagnetizing, the resulting loud hum can damage your speakers.

Cleaning and demagnetization should take place after about every eight hours of use, to be on the safe side. Some advocate less frequent demagnetization—say, every 16 hours. If you notice substantial accumulations of tape oxide on the heads and other components, cleaning more frequently than every eight hours may be advisable. Excessive deposits on the heads, etc., may indicate the need to change your brand and/or grade of tape.

"Improved" Type II Tapes

Q. I have recently come upon some tape brands that combine metal particles with ferric oxide and take Type II bias. It is claimed that these tapes approach the extended frequency response of Type IV tapes for less cost. Are these tapes really better than ordinary Type II?—Rhet Diaz, Playa Del Rey, Cal.

A. The very extensive review of cassette tapes by Howard A. Roberson in the March 1990 issue does show that a few Type II tapes are nearly as good as the best Type IV tapes in this respect. A 10-kHz tone recorded at Dolby level will typically drop about 4 or 5 dB in level, and occasionally much more, when recorded on Type II tapes. On Type IV tapes, this tone would typically be about 1 dB down. Roberson's article enables you to identify which Type II tapes have the best treble response at high recording level.

If you have a problem or question on tape recording, write to Mr. Herman Burstein at AUDIO, 1633 Broadway, New York, N.Y. 10019. All letters are answered. Please enclose a stamped, self-addressed envelope.

JOSEPH GIOVANELLI

Insufficient Phono Output

Q. The output from my phono cartridge is low compared to that of other program sources in my system. The rated output of my cartridge is 0.25 mV. Even with the extra gain provided by the low moving-coil input on my preamplifer, the output from the speakers is still too low.

During some soft musical passages, the volume needs to be turned up to a point where I hear noticeable hiss. What can be done?—Name withheld

A. When you say your cartridge's level is too low, do you simply mean you need to turn the volume up when listening to records? Or do you mean you cannot get enough volume even when you turn your control up all the way? If you can get satisfactory listening levels from the system, it could be that you are served well enough despite the nuisance of having to readjust the level control when changing sources. Just remember to turn the volume up a notch or so when playing phonograph records, and then to turn it down again before switching to other program sources. In any event, a good habit to get into is to turn the volume down completely while switching from one input to another. You'll never "blast" your system or damage your speakers or amplifier by following this rule. This is true even if and when you do match phono level with that of other music sources.

The hiss you hear when you turn the volume up to listen to soft passages might perhaps be on the LPs themselves. When this is the case, the hiss will remain as a constant background—even when you have adjusted the phonograph output to match that of other program sources.

If the background noise you hear in soft passages is electronics noise generated within the preamplifier, you should use a transformer between the phonograph and the preamplifier inputs. The transformer will boost the voltage sufficiently to overcome the background noise. Manufacturers of moving-coil cartridges usually offer transformers designed for use with their units.

There are some "preamplifiers" which are designed to boost the output voltage from a moving-coil cartridge in exactly the same way that the transformer does. Such units serve no other function.

Although using such transformers or preamplifiers will increase the loudness of your phonograph playback, this does not guarantee that phono output wil match all other sources. Keep in mind that some phonograph records are "louder" than others, and the output from some CD players tends to be higher than other input sources. Recording levels can vary from one CD to the next and from one cassette to the next.

I can recall one correspondent who was sufficiently bothered by this problem that he incorporated a limiter into his system. Every source sounded as loud as any other. Soft musical passages were as loud as loud ones. He was happy! I heard a sample of this "beautifully balanced" system; I was definitely unhappy.

No Bass Punch

Q. My problem: The sound from my system is bland, lifeless—very little stereo separation and very little bass. When I use headphones, everything seems to jump out and sound great.

My loudspeakers are located about 5 feet apart on either side of my entertainment center—about a foot away from the back wall and about 3 feet from the side walls. There is a rug on the floor. It's a long room, about 12 × 20 feet. My equipment consists of a preamplifier, surround decoder, power amplifier, and four speakers—two mains and two for the surround effect. What's wrong with my system?—John B. Smyth, Clinton, Md.

A. If you like the sound from your headphones, it could be that you just don't like your loudspeakers I say this because your system is the same in all respects when you listen through headphones and when you listen via your loudspeakers.

Before making any impulsive moves, however, first check to determine if the phase between your two main loudspeakers is correct; if it is not, the sound may well be lifeless and lack bass. Before making this check, kill the surround speakers so that all you hear are the main units. Once you have gotten the phase correct, there should be an improvement. If you do have such an improvement, turn on the surround speakers. If the audio quality again deteriorates, maybe your surround speakers are set at too high a volume.

The 5-foot separation between your speakers is a bit small. Move them apart till each one is against both the side and back walls. The increased physical separation should increase the amount of stereo. The corner location should add considerable bass. This may solve your problems.

I hasten to point out, however, that, in most instances, stereo stands out more when listening with headphones than it does when listening via loudspeakers. The problem is that headphone listening tends to exaggerate the stereo effect beyond what is heard in the real world.

Unusual Phonograph Hum

Q. I have an annoying phono hum which has me perplexed. The hum is present only when in the phono mode; it is low in level and only occurs in the right channel. The ground wire from the turntable is correctly connected to the phono ground on the rear panel of the amplifier. I have noticed that, when I disconnect the ground wire, the hum disappears completely. What could be causing this hum, and why does it go away when the ground wire is disconnected?—Richard Dunn, Hampton, Va.

A. I have no idea why the hum is heard in only one channel. It certainly suggests poor connections to the ground side of the cartridge's right channel or to the grounds where the tonearm and the main phono cables meet. It could also indicate a loose skirt on the phono plug.

Why the hum disappears when the ground wire is removed is another matter. My best guess is that your turntable has a three-prong NEMA plug attached to its power cord. If so, the turntable will automatically be grounded to the system via the ground pin on the plug (assuming that your amp also has an NEMA plug). Adding the ground wire would produce a ground loop, causing the hum. The cure is to remove the ground wire.

If you have a problem or question about audio, write to Mr. Joseph Giovanelli at AUDIO Magazine, 1633 Broadway, New York, N.Y. 10019. All letters are answered. Please enclose a stamped, self-addressed envelope.

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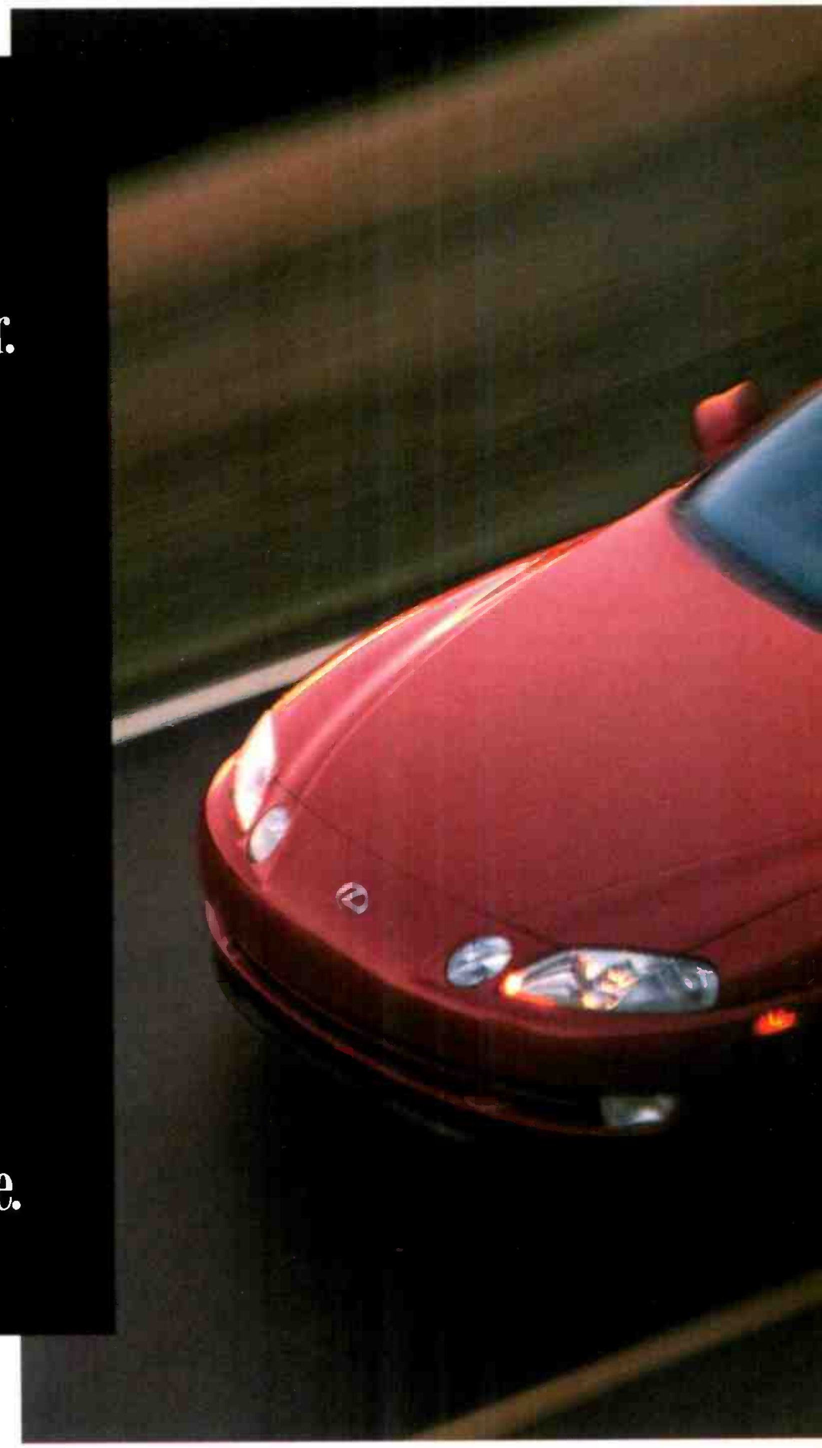

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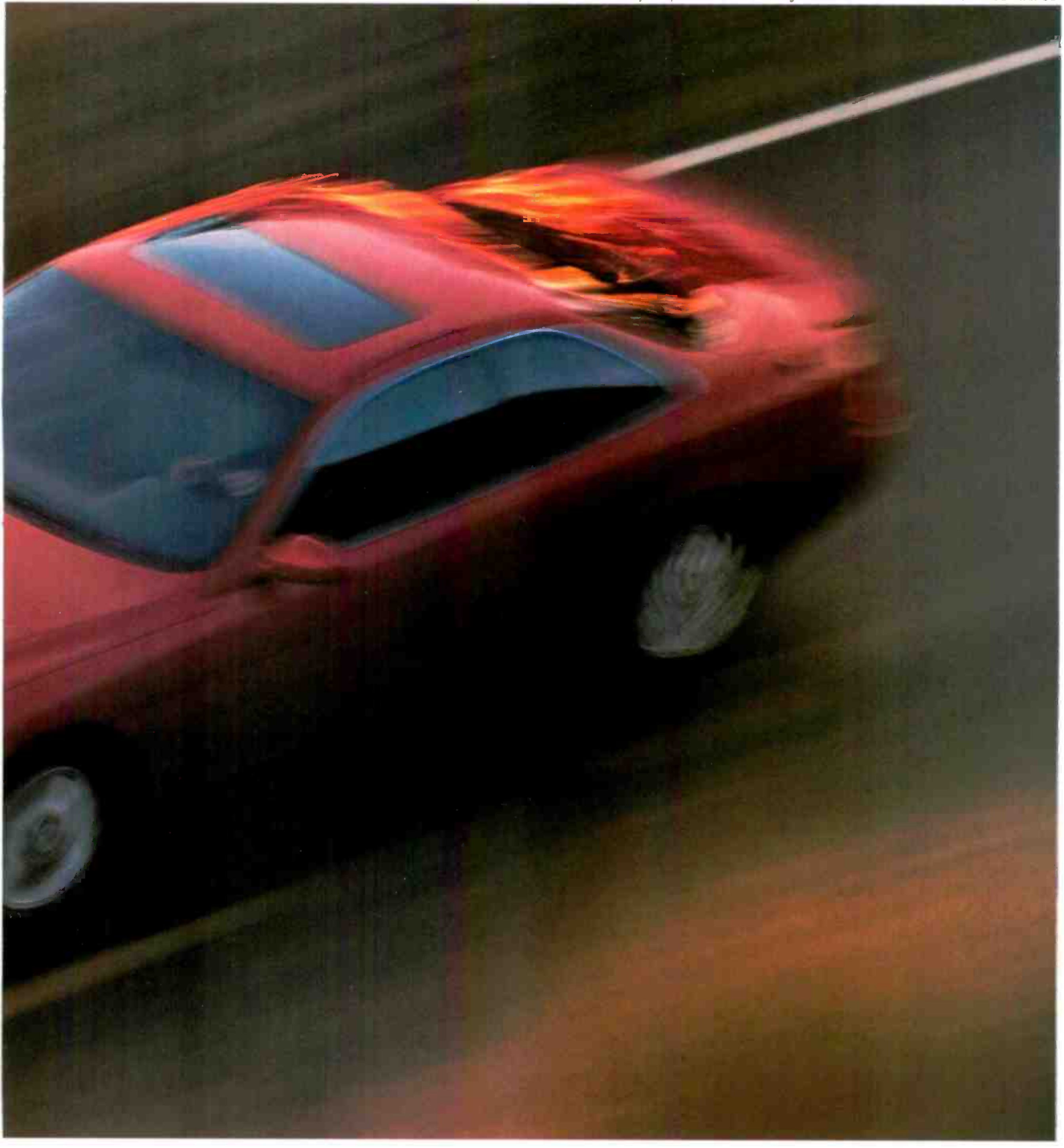

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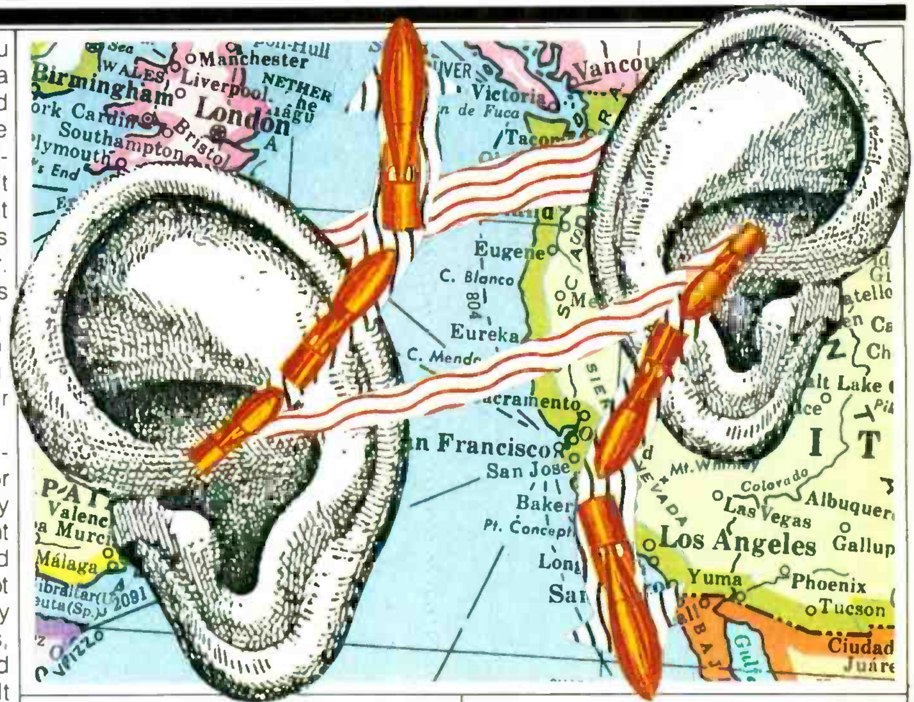

Illustration: Valerie Pizzo

My April installment left you hanging with Dr. Diana Deutsch and my soap-based friend Jim, who had sent me a *Science News* report on Deutsch's latest musical research into hearing. He couldn't understand the musical details but hoped I might. I could indeed and was fascinated. So I continue, working Dr. Deutsch in with some previous ideas on music that I had already planned to explore. In this I am fortified by our own earlier *Audio* Deutsch article which you may have read—and heard—in our March 1987 issue.

I missed that issue due to eye troubles, now cleared away, but the Editor rushed me a black-and-white copy from the office machine so I might catch up. The bound-in plastic record reproduced very nicely but would not play, being on paper. So I went to my big bound volumes of back *Audio*s, and there was the article in splendid red, white, and blue. But no record. It was removed before binding.

The newer Deutsch study, again, concerns our curious perceptions of up and down in musical pitch—the very foundation of musical notation and hence of live performance and, consequently, our audio that converts it to signal and back again. Practically everything, you see, goes up and down in music. And here is Deutsch, always ready to drop significant bombshells, telling us according to her tests that, lacking certain clues, we can seriously disagree among ourselves as to what goes UP and what goes DOWN! That's like disputing the law of gravity. Well, I could have told her the same long ago out of my own experience. But never in the disciplined detail that comes from her kind of research.

Dr. Deutsch doesn't use music. She devises test tones, you might say test tunes, of utter and calculated minimality, patterned and grouped for (mostly) headphone listening, each ear receiving its own channel. Binaural. In this new study, an extension of a 1986 report, she uses no more than two tones at a time. (Two successive tones make a minimum tune, don't they, like the cuckoo's song?) Moreover, these tones are as pure as the driven snow, i.e., sine waves. The most basic frequency shape, minus all distracting harmonics that might confuse the results.

To a musician, these tones are dismally vacuous. No personality compared, say, to the richness of an oboe's sound. But they have the immense advantage of being elemental, the better to aid in pinning down the enormously subtle workings of our sound perception.

Dr. Deutsch offers new bombshells each time she comes out with a study. And then goes on often to further implications and new testings. We can confuse our musical ups and downs? That was 1986. The new tests, those I referred to in the April issue, find that our perceptions of up and down are strictly related to our *spoken language*, our local dialect. Where her English testees heard the mini-tune go UP, her American (Southern Californian) listeners said it went DOWN. An unsettling thought—does our music listening vary in any such way? Could be. Here, Deutsch converts what must have rated as an informed hunch into a disciplined proof. She is good at informed hunches. I might add that music and language have been subtly related since the time of the ancient Greeks, whose poets "sang," and probably long before. I expect Neanderthal man did the same, so Deutsch is well within a long tradition.

In her up-down studies she has made use of what she calls the *paradoxical tritone*. (I assume that this is where my friend Jim admitted defeat.) This is a musical interval—the proportion in frequency between tones—that is well known for its strange, featureless, ambiguous sound, its near-irrational ratio. (You won't find it approximated until the 11th harmonic.) In notation the tritone encompasses three whole steps (tones) in the modern music pitch system, hence the name. It may be heard as an augmented (stretched) *fourth*, as F to B, or as a diminished (shrunken) *fifth*, as in B to F. Our musical alphabet is repetitive, so this covers the five piano white notes BCDEF, hence a diminished fifth. But if you continue, FGAB, you have still another tritone, this one an augmented fourth. Highly ambiguous, even polyguous.

The tritone was shunned in early music. It was the "wolf" in the musical henhouse—the devil in music. But well before the 15th century, a way was found, just one, which surprisingly removed both the wolf-like fierceness and the musical ambiguity. If you put another note 1½ tones lower (i.e., down a minor third), the tritone vanished! You can easily hear this on the piano. Play F and B (a tritone), then add a D below it. The tritone is softened. In its place is a gentle chord which moves easily on to a C or C chord, forming a *cadence*. In music, a cadence (a falling, from the Latin—not to be confused with a march) says mildly, THE END, or the end of something, a place to take a breath. And so it was long used. The effect is much like the stronger (and later) cadence from the *dominant* to the *tonic*. We in the audio/music world would understand this as the third harmonic to the second harmonic and its fundamental an octave lower. Play the note G and then a C, and you'll get the idea. Better, play a G chord and a C chord. The older tritone cadence has no third harmonic at all. It is purely melodic. No simple harmonic relationship.

Please take a small breath! Like all professional terminology, music's is hopelessly polysyllabic and sounds much worse than it is. All of this is ever so simple for the ear. You have heard at least five billion cadences in the music that surrounds us even without going to a concert.

Mathematically, the tritone rates as an interval—relation between two pitches—of a half octave. Play C, F sharp, and the C above, and you will hear that there is indeed a tritone in each direction from the F sharp. But what is the tritone in numeric terms? A bit like the square root of 2. And that is how it sounds. The octave is simple, even basic, 2:1. Not the tritone, 11:8.

Why *octave*, for tones in the 2:1 relationship? Because if you play eight tones of a scale, eight white notes on the piano, you cover the span of an octave. Likewise, if you play five or three notes, you have fifths or thirds and so on, even when they are small or large—as in major and minor.

Hi-fi makes use of octave relationships to compensate for loudspeakers that cannot reproduce the fundamental. The second and third harmonics are usually present, so thus the ear "manufactures" a facsimile of the fundamental as a difference tone to those harmonics. For example, say a speaker cannot reproduce a 30-Hz tone, but the 60- and 90-Hz tones are present. The difference between these tones is 30 Hz, and the ear hears this as a *resultant tone*. Organ-builders have used this trick to produce fundamentals without full-length pipes.

To polish off the idea of a cadence, note that around the year 1600, as musical language widened, composers came to the logical thought that they might combine the old, gentle tritone cadence with the newer, stronger dominant-to-tonic cadence, written in harmonic language as V I (five moving to one). (Naming chords, harmonies, we convert to Latin.) The combination of these two cadences was stronger, juicier, more expressive—the *dominant seventh*, V^7! It still has the tritone in it, also the extra covering tone (the D—see above) *and* the dominant-chord harmonies. Very familiar, very convincing. I recently found an early one in a madrigal by the young Girolamo Frescobaldi, later a famous organist and keyboard composer. The music was published in Holland in 1608. A newly discovered sound effect.

In musical literature (Western) these tritone ambiguities are wondrously exploited by clever composers from Bach to Debussy, Stravinsky and onward. For this tritone is a kind of musical pun word, which may jump from one meaning to another, startlingly different. Often this is via the augmented-sixth chord and its relatives, including a tritone as the unstable element. Here, a minor (small) seventh, e.g., C to B flat, converts to an augmented, stretched, sixth, C to A sharp, the same tones. The other note in such a chord, an E (the chord's third) is a tritone away from that A sharp. See Haydn, Mozart, Beethoven, Schubert, Brahms, et al. for thousands of easily listenable examples.

In addition, the tritone is used melodically to give a somehow exotic, mysterious, or bizarre effect since it does not advertise itself as to what part of an ordinary familiar scale it might belong. The "Prelude to the Afternoon of a Faun" (Debussy), flute solo, faunlike. It plays up and down a tritone. The trained bear in *Petrouchka* (Stravinsky) does a lumbering dance to a tritone-clumsy tune.

Dr. Deutsch works in two musical dimensions. Her new study, like that of 1986, is vertical, concerning ups and downs. In our 1987 Deutsch article, the thrust was sidewise, rights and lefts. Here, too, her test tones, quite different, were devilishly ingenious, aimed at sorting out and pinning down what a single ear, unaided by its teammate on the other side, could do on its own. In nature, in musical listening, our pairs of

In our musical listening, as in nature, our pairs of ears grab at a subtle complex of different clues for direction.

ears grab at an immensely subtle complex of different clues for direction, as we know when we try to reproduce musical sound. There'll never be an end to our own arguments over sonic directionality or of our intense interest in the practical side, for broadcast and recording. What Deutsch does is to narrow down these multiplicities to clear specifics, once again. Listen to her tests on *Audio*'s bound-in record. It's all explained in the article. No tri-tones here, and the "tunes" are much longer, pitch patterns, changing alternations right and left, lots of octaves (jumping up and down contrarily in each ear), chromatic half-step lines, wide jumps up and down, and so on. Always a different signal to each ear. Ups and downs but oppositely.

The two ears cannot relate and join these sounds—too different. So they are strictly on their own. What can an isolated ear do for apparent directionality when its partner can't work with it?

Very strange, as you might guess. Sometimes, *tones fed to the right ear are heard to be on the left*, though the left ear receives no such signal. It's another Deutsch bombshell.

No, you won't set up your coincident stereo mike array and find the violins on the wrong side even though your connections are not crossed. This is music, not testing. In stereo, both ears working on both loudspeakers, there are enough richly assorted directional cues to keep things in place unless you get into flighty changes in phase somewhere along the lines, or faulty volume balances. Deutsch tells us only, as I get it, that the single ear is not merely mono but has a positively unstable directionality when its partner ear is sending noncompatible info to the common brain. Sometimes right is right (in the right 'phone), sometimes it's on the other side of the head.

There are those secondary bombshells that Deutsch sends our way, so intriguingly. One in the *Audio* article has really raised my consciousness. It says that the way the single ear perceives lefts and rights, right or wrong, has to do with *handedness*. In the tests, lefties reacted distinctly differently from righties. Now I am a lefty, even a mini-Leonardo. My directional wires are hopelessly crossed at the gut level. Say "QUICK, TURN RIGHT!" and I instantly turn left, traffic allowing. But not if I have time to think. I tread on square-dance toes, creating dance gridlock, because I invariably put the wrong foot forward. And I can write backwards. When I learned longhand with my right, the left hand learned it in reverse automatically. I still can write backwards, but I can't read what I write. Unless in a mirror. The eyes, you see, are on a different circuit.

So go find Diana Deutsch's articles, and listen to her tones too. As for me, I'd better get out to California and have myself checked. I think maybe my left hand is attached to my right arm. ▲

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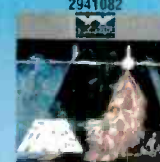

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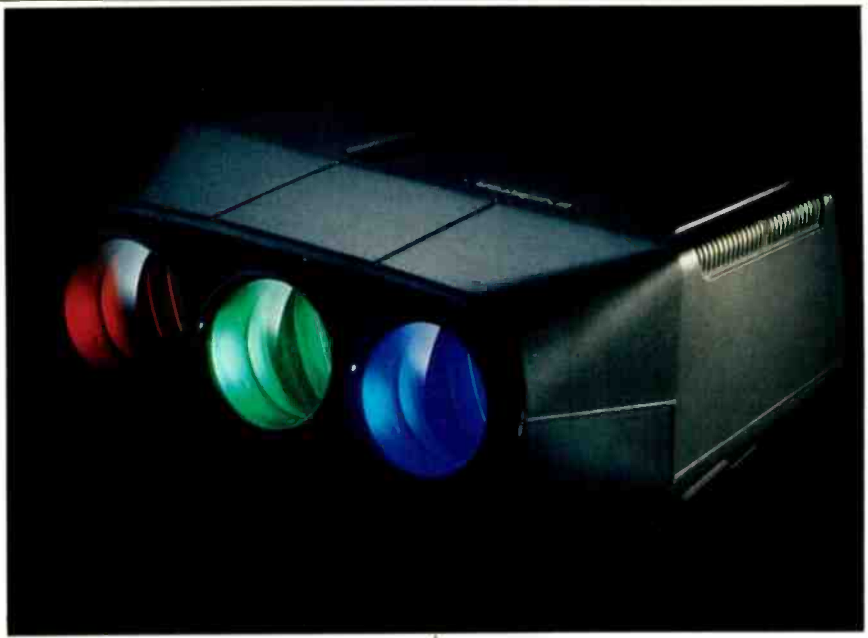

It has been over three years since I described my surround sound home theater system in the February 1988 issue. Since then the concept of home theater has gained astonishing popularity; currently, surround sound is the hottest buzzword.

As might be expected, the Japanese entertainment electronics companies have really jumped on the surround sound bandwagon, producing a flood of audio/video equipment. Many of the better quality units employ Dolby Pro-Logic circuitry for enhanced surround sound processing. The dramatic resurgence of the LaserDisc and the availability of relatively inexpensive units that can play both CDs and videodiscs is quite remarkable. People like the superior resolution of the LaserDisc and that it can provide digital sound.

For those who want to come as close as they can to emulating the Dolby movie theater experience, the dedicated home theater with a large-screen front-projection system is the optimum configuration. There have been many advances in the technology of the audio and video components of surround sound home theater systems since my first setup in 1988. Recently, I decided to update my surround sound home theater. After lengthy investigation and evaluation of many new audio and video components, I found that I would have to make major changes in order to take advantage of new technology and to maximize the audio and visual performance in my home theater.

My room was the simplest part, being nearly the same as I described in my earlier column. The 14 × 30-foot room still has drapes behind the projection screen and is treated with 4-inch-thick Discrete Technology Soundsorber acoustic foam wedges which cover each side wall out to 10 feet in front of the screen. The concrete floor is still thickly carpeted. The difference in my room is the addition of two side-by-side RPG diffusor panels that cover nearly all of the rear wall behind the viewing position. The Infinity projector I used in my original home theater was a very satisfactory unit providing very good image quality. However, advances in projection TV technology have considerably improved all aspects of video image quality. After due consideration of such factors as price, performance, flexibility, reliability, size, and ease of installation, I decided the $5,995 Vidikron TGS 200 TV projector, made by Boffi of Italy, was the best choice.

The Vidikron TGS 200 is surprisingly compact, with a sleek-looking charcoal gray or white composite enclosure. The unit is only 9⅛ inches high, 21¾ inches wide, and 24½ inches deep and weighs only 59 pounds. It can be mounted in an optional coffee table, Model CT One, which has an extra shelf for a VCR or videodisc player. The Vidikron ceiling mount is designed so that the projector is only 11 inches from the ceiling, but an optional CPL-100 projector lift can store the unit inside the ceiling! I decided to use the CT One table to mount the projector.

The TGS 200 uses the Vidikron FP chassis, which was developed for professional video applications and data display. The Vidikron is equipped with 7-inch large-aperture red, green, and blue picture tubes which are liquid cooled. These optical-electronic assemblies have extremely small spot size and dual focusing capabilities for center and edges, thus improving sharpness of small details in the picture. The tubes also have new phosphors that improve chromaticity of the color gamut and provide a wider range of subtle color hues. Thus, crimson, scarlet, and ruby reds can be readily differentiated. The TGS 200 also features a very sophisticated color decoding circuit with perfect linearity for reduced chroma noise, separate horizontal and vertical processing circuitry for superior sync processing, and 50-50 interlace—which makes video scanning lines virtually invisible. (Some high-brightness/high-resolution projectors have clearly visible and annoying scanning lines.) I could not detect scanning lines in the image even when I was as close as 2 feet from the screen! Special video processing maintains a neutral gray scale over the entire contrast range from dark shadows to peak whites. A peak white limiter circuit prevents "blooming" of the phosphors under high brightness conditions, thus providing a very bright, high-contrast picture with no loss of detail in the brightest sections.

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Solti: Tchaikovsky, 1812 Overture (London) 25179 *
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En Vogue: Born To Sing (Atlantic) 14187
Paula Abdul: Shut Up And Dance (The Dance Mixes) (Virgin) 80326
Sinéad O'Connor: I Do Not Want What I Haven't Got (Chrysalis) 33512
Talking Heads: Stop Making Sense (Sire) 24580
The Police: Every Breath You Take—The Singles (A&M) 73924
Lisa Stansfield: Affection (Arista) 34198
The Robert Cray Band: Midnight Stroll (Mercury) 73659
America: History (Greatest Hits) (Warner Bros.) 23757

Peter Gabriel: Shaking The Tree-16 Golden Greats (Geffen) 11089
M.C. Hammer: Please Hammer, Don't Hurt 'Em (Capitol) 34791
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Scorpions: Crazy World (Mercury) 14795
Paul Simon: Graceland (Warner Bros.) 72315
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Patsy Cline: 12 Greatest Hits (MCA) 53849
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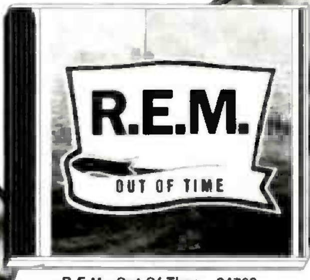

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To match the visual thrills provided by big-screen projection, the surround sound system must have special qualities.

TGS 200 is cooled by a d.c. muffin fan, which is quiet and quite unobtrusive.

Interfacing includes two composite video inputs, one S-VHS (Y and C) input and one RGB-TTL input, and an RGB analog input on a SCART connector. Stereo audio inputs for the two composite and the S-video inputs are also present, and a variable stereo line-level audio output is provided. A variable stereo speaker output is available from built-in 10-watt amplifiers.

The Vidikron TGS 200's 14-function, infrared remote control provides variable adjustment of brightness, color, contrast, tint, and sharpness as well as video input selection and RGB-TTL or analog selection.

The projector has more than 500 lines of horizontal resolution, and over 900 lines at the RGB input with its standard lenses. This permits picture size up to 15 feet (diagonally). Optional HD6 glass lenses ($1,700) afford 1,500 lines of resolution at the RGB input and picture size up to 20 feet! Brightness is rated at 600 lumens, almost 2½ times brighter than the Infinity projector. To take advantage of the high brightness/high resolution of the TGS 200, I used a National Viewtech 100-inch diagonal, curved, high-gain screen.

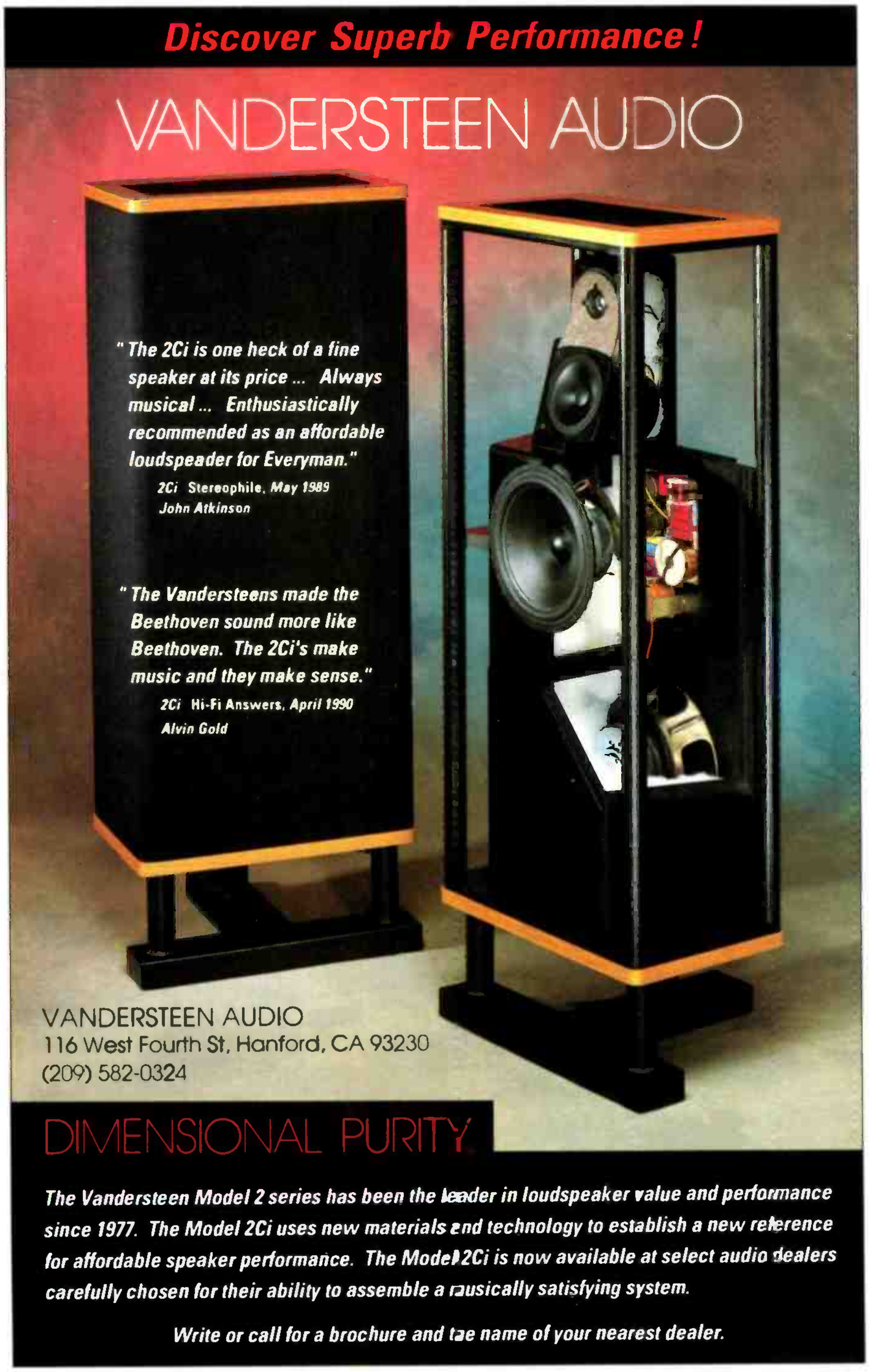
Like most semi-professional and professional video projectors, this Vidikron does not have a built-in video tuner. The tuner of a VCR can be used, but a second VCR is necessary if you want to record one program while watching another. To obviate this, I acquired the JBL TC-1 video tuner/controller. This $995 unit is widely used with professional projectors.

The JBL TC-1 offers extreme flexibility in interconnecting audio and video sources and the projector. It has three 75-ohm r.f. inputs, two auxiliary video inputs, two S-VHS inputs, and S-VHS, RGB, and sync outputs—not to mention the associated audio input and output jacks. I use the RGB output of the TC-1 connected to the RGB input on the Vidikron TGS 200, not only because of the superior resolution but because the RGB output also provides on-screen graphic displays. The tuner/controller has on-screen menus that permit audio adjustments, color and picture adjustments, and clock and channel adjustments; within these menus are sub-groups. For example, pressing button six (input) on the audio adjustment shows another on-screen menu that provides six input choices. In the color-adjust menu, bar graphs for brightness, contrast, color, and tint are displayed, and the plus or minus adjustments can be seen on screen. If you call up an external standard color bar pattern, you can similarly watch the effects of your color adjustments. The TC-1 has a 125-channel capability and is an extremely quiet and clean-sounding component.

The combination of the Vidikron TGS 200 projector, the JBL TC-1 tuner/controller, and the National Viewtech

If one were willing to buy a large speaker for use as a center speaker, there would be a major problem of placement.

screen provides a really stunning image quality. With the best LaserDiscs the resolution is right out to the limits of the NTSC format. The picture is crisp and clean, with outstanding brightness. Colors are vibrant, fully saturated, and accurate in balance. Whites and blacks are clean, and the punchy picture contrast does not obscure details in shadows or bright areas. Truly, the image quality is limited only by the video source. On the *Fire Birds* LaserDisc, the sharpness and detail are as close to high-definition TV as we are likely to see before we actually switch to the HDTV format!



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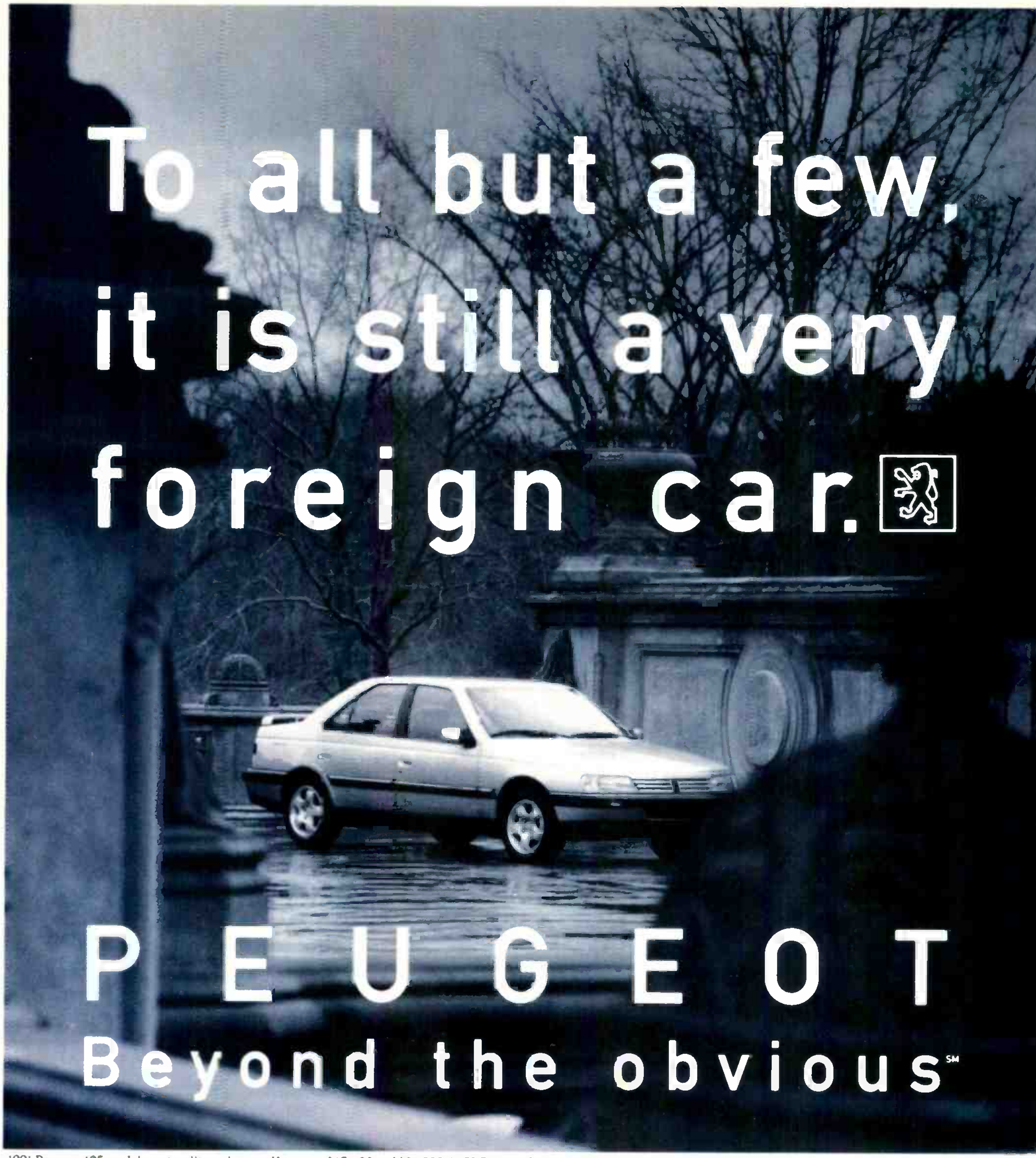
Obviously, to match the visual thrills provided by the best big-screen projection, the surround sound system must have special qualities to help simulate the Dolby movie theater experience in the home. The surround sound system I described in my 1988 column did not utilize matched loudspeakers, but the speakers did have similar tonal characteristics, and had the same efficiency (90 dB SPL). The case for matched loudspeakers in Dolby surround sound is solidly grounded in the requirements for maintaining a smooth, spacious stereo sound field with seamless sonic transitions among the three front speakers. It is especially important to remember that the center front loudspeaker is pivotal—a sort of "sonic anchor" in Dolby Surround, particularly if Dolby Pro-Logic decoders are used. The center front speaker not only is the dialog channel, but many high-level, often violent special effects sounds are reproduced through this speaker.

Big-screen projection TV literally demands big, high-level sound if one is to simulate the emotional intensity and involvement of the Dolby movie theater experience. Big sound is usually equated with big loudspeakers and big amplifiers. If you wanted to incorporate large stereo system speakers into a surround sound home theater, you would most likely use them as the left and right front channels. Even if you were willing to buy another, identical speaker to use for the center channel, there is the major problem of placement. In its normal upright position, the speaker would block the lower portion of the projection screen. Even if placed in a horizontal position, the speaker still may intrude on the screen. The recourse is to use a smaller loudspeaker for the center channel, which, of course, poses problems of tonal balance and efficiency—and generally, small speakers are not equated with big sound. Dolby Surround movies by their nature impose some formidable challenges if you want to optimize their sonic presentation.

In my next column, the second part of this surround sound saga, I'll discuss the remarkable Shure HTS surround home theater system, which, in essence, allows you to have your cake and eat it too!



1991 Peugeot 405 models are intelligently priced between $15,490 and $21,990. MSRP. Excludes tax, title, options, registration and destination charges. In Canada call 1-416-566-1900.

Europeans have long appreciated the remarkable engineering and world-class styling of a Peugeot.

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Years ago Polk Audio recognized the importance of more absolute separation of information reaching each ear. Of course, the fundamental concept of stereo reproduction is that there are two separate channels of information, each intended for one ear only (i.e. "true stereo").

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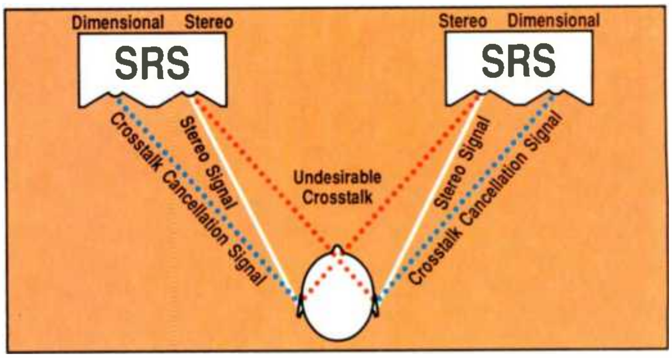
Polk's "True Stereo" SDA technology delivers left signal information to your left ear and right signal information to your right ear. Each ear only hears its proper signal, thereby maintaining full stereo separation. The resulting soundstage is dramatic.



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Yes, Everything You Hear is True

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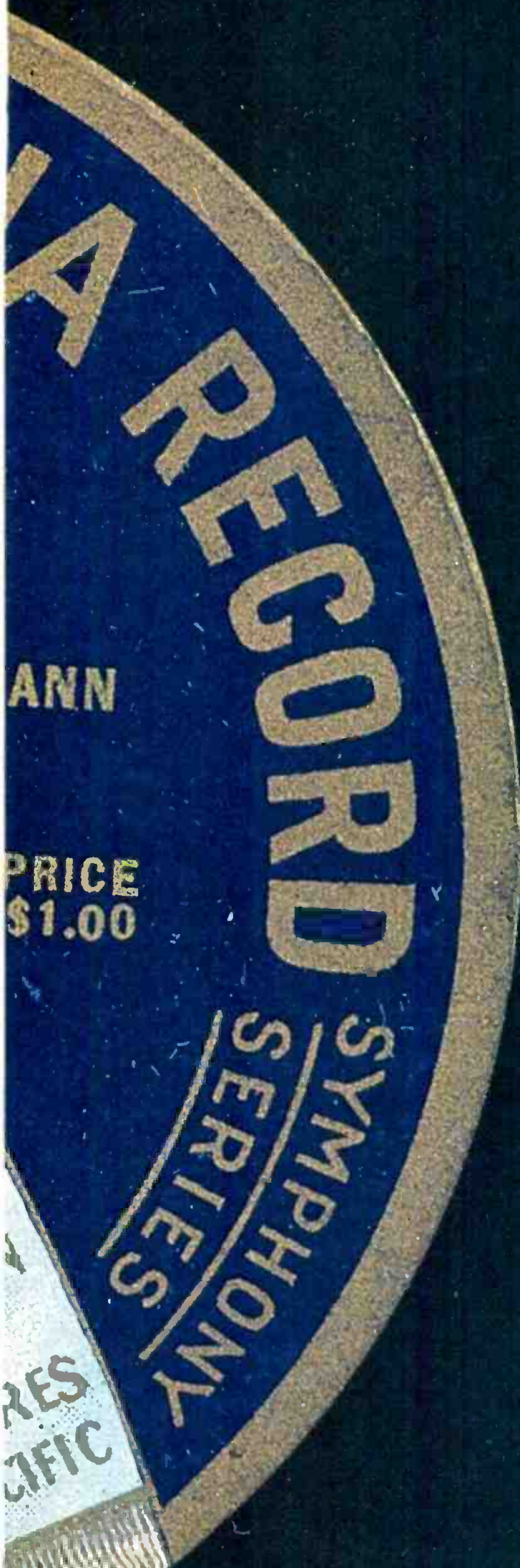


Part 2

SONIC RESTORATION *of* HISTORICAL RECORDINGS

Unnatural resonances are found on many early electric 78s, but they are especially bad on acoustics, where the conical recording horns (true exponential horns were seldom used) not only resonated on the harmonics of the basic frequency but also generated subharmonics. Occurring only under certain, very specific conditions, subharmonics are not a part of what we consider "natural sound" and are usually perceived as distortion. A half- or third-octave graphic equalizer can reduce the grosser effects, but only the parametric—with control over gain, frequency, and bandwidth—can eliminate the subtler distortions of unnatural horn resonance without damaging the natural sound. With early electric recordings, two or three bands of parametric equalization usually suffice, but with acoustics, seven, eight, or even more bands may be needed. Again, if the user is not prepared to work for weeks, even months, to develop skills he will do much better to stay with a straight third-octave, multi-graphic equalizer.

Michael R. Lane

We'll give just one example of the possibilities with parametric equalization. A typical Victor acoustic record generally has one of its strongest resonant peaks in the area of 3,100 Hz; the precise frequency will vary from one record to another (Fig. 5A). By adjusting a parametric band for a narrow positive spike and sweeping the frequency back and forth while listening for the worst sound, you can easily find the exact center frequency of the resonant peak (Fig. 5B). It is always easier to find a resonant peak by exaggerating it rather than notching it out. Having found the exact center of the resonant peak, lower the gain of the parametric band to create a deep notch. The result will sound much better and be something similar to Fig. 5C. Next, reduce the notch (increase the gain), which will bring back some of the ugly sound; then adjust the bandwidth wider or narrower for best sound. Work back and forth between the notch depth and the bandwidth until no further improvement is possible (Fig. 5D). If you are good at it, you will produce an exact but opposite EQ curve to the original resonance, and the resulting signal will be a smooth response without any loss of natural sound qualities. This technique takes practice, but the results are well worth the work and much better than just making the notch deeper and deeper until the offending resonance is gone *along with some of the music*. In the cited example you may need to repeat the process on a lesser scale at the second harmonic, 6,200 Hz, and even at the subharmonic, 1,550 Hz. If an electric 78 had this 3,100-Hz resonance, it might also require additional work at the third harmonic, 9,300 Hz. In addition to eliminating unnatural resonances, parametric equalizers like the Orban 642B can serve as excellent notch filters and are very important as phase-modifying devices. Also, they can help reduce surface noise in conjunction with the Packburn 323A noise suppressor. Anything that other equalizers can do, parametrics can do as well or better, but the amount of work is formidable.

NONLINEARITY AND GAIN RIDING

Another serious problem on acoustics, but almost never encountered on electrics, is that of nonlinearity in the treble frequencies. The acoustic recording process suffered from mechanical hysteresis (slop or play) in the linkage between the horn and the cutting stylus. Hence, the higher frequencies, insofar as they could be recorded, reproduce well on loud passages but poorly on soft ones. Among collectors of acoustic records, this is thought of as a "blasting" effect; that is, if the treble sound is relatively bright on normal passages, then the loud peaks usually come blasting through in an irritating way. The sound is similar to overmodulation on electric recordings. This nonlinear or blasting phenomenon on acoustics is aggravated by unnatural resonances and internal phase-shift problems, but even when these are removed with parametrics, the original problem remains.

The best way of handling nonlinearity or blasting, at present, is downward gain riding of selected treble EQ on the loud passages while keeping the full treble EQ for normal and softer passages. Sometimes it's helpful to use upward gain riding of treble EQ in exceptionally quiet passages. After selecting the appropriate EQ, the procedure is to play the record a number of times, practicing the EQ gain riding until it can be done smoothly and imperceptibly, before making a final tape. Records with a relatively narrow dynamic range are not likely to have the nonlinearity problem. It is most noticeable with singers, particularly singers with a powerful, dramatic voice, such as Marcella Sembrich or Ernestine Schumann-Heink. Most recordings of such singers can't be successfully restored without this frequency-selective gain-riding technique.

In a similar way, although not for the same reasons, selected bass EQ gain riding can be of great help on many acoustics and some electric recordings. Sometimes, rumble filters, even when combined with low-frequency gating, as with the old Phase Linear 1000, can't totally eliminate rumble without cutting into the sound. In these cases, the bass should be set for the best sound at loud and medium levels and downward gain riding used on the softer passages where the masking effect of the music is absent. Again, careful discrimination is needed so that the results are inaudible to the listener. The most difficult of all are those recordings where selective gain riding is necessary on both high and low frequencies. You may have to practice extensively and then tape the record a number of times before the results are just right.

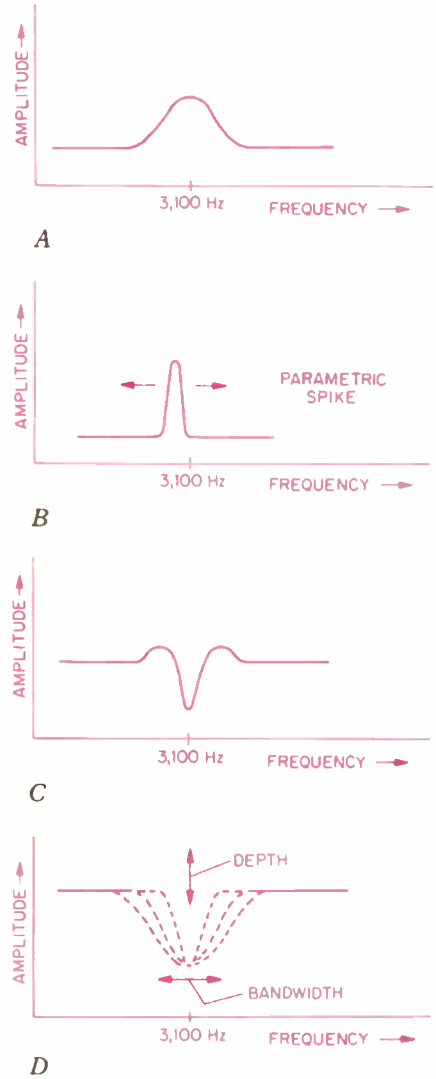


Fig. 5—*A record resonance (A) and steps in its correction; see text. Sweeping with a narrow parametric spike (B) locates the resonance, which can then be notched out (C). Notch depth and bandwidth are then readjusted alternately (D) for smoothest and most natural results.*

DYNAMIC EXPANSION

Among many listeners to old recordings, the processing methods of dynamic expansion, reverberation, synthetic stereo, compression, limiting, and others have very bad names and often deservedly so. It is not because these things are inherently bad but rather because of their excessive use or, in some cases, because the equipment used is improper for the specific job. We cannot stress too strongly that processing must not be heard when it is applied. One should only notice when it is turned off; its absence should be noticeable, but never its presence.

On most electric 78s, dynamic expansion can greatly aid the sense of life and realism. Even acoustic records may need some expansion, as the recording horn and system of mechanical recording compressed the sound in unnatural ways. If the nonlinearity problems are corrected, then 3 to 6 dB of expansion will be of great help. Noise pumping must be avoided at all costs, but proper noise-reduction techniques usually reduce noise pumping to inaudible levels except on records in really bad condition. Downward expansion of quiet passages may also improve realism and additionally can further reduce noise. Again, subtlety is the watchword. For normal dynamic expansion we favor our old, modified Phase Linear 1000, but for subtle downward expansion the Dynafex DX-1 is the unit of choice.

PHASE EFFECTS?

We have observed that, with some acoustic records undergoing restoration, the normal bass and treble controls (or the gain of adjacent parametric bands) seem to operate in reverse. Increasing the bass level seems to produce less bass; decreasing the treble level seems to increase treble, etc. We have observed this strange phenomena in varying degrees quite a number of times, always on acoustics and never on electrics. Assuming proper operation and use of the electronic equipment, there seems to be some form of phase cancellation or augmentation between the effect of the equalizer control and acoustic recording-horn resonances. There may also be interaction between the phase shifts inherent in analog equalizers and the resonances that are unique to acoustic records.

Digital equalizers, without the inherent analog phase shifts, may solve this problem. While some are available now, their sound quality does not yet seem comparable to that of the analog units. The physics of the complex phase and resonance relationships on acoustic records seems to defy analysis. For now, the problems can only be treated empirically—by trial and error. Without doubt this is the most complex area in sonic restoration. It is the reason that work on acoustics is so much more difficult than on electrics. If you can do a good job on acoustics, then electrics will be relatively easy.

SPECTRUM ANALYZERS AND HIGH-FREQUENCY ENHANCEMENT

A third-octave (or narrower), real-time spectrum analyzer can be a very useful tool. It should have storage capability, a fast sampling rate, and peak and averaging display modes covering up to 4 or 5 seconds—perhaps longer. It's useful in locating resonant peaks, checking inherent record EQ, rebalancing weak treble or bass, and many other applications. We use the Gold Line 30, which, among its many other features, can store the waveform of the sound at any six moments in time, as selected by the user. These can then be recalled from memory at a later time and compared with each other as desired. For example, if you are working on the 1928 recording of Richard Strauss conducting the Berlin Philharmonic in Beethoven's Fifth Symphony, you may wish to store in memory the spectral pattern of the very first opening chord. Then by similarly storing that same chord from a modern recording or a number of modern recordings, you can leisurely compare

the 1928 spectral pattern with modern ones having much better sound, and thereby get an idea of where the sonic problems lie and what to do about them. This type of comparative technique is useful and a time saver, provided you don't become so enamored with the technology that you forget to listen. More expensive and elaborate spectrum analyzers can show all kinds of helpful comparisons and information, but at times the spectrum analyzer can appear to give misleading information, so always use your ears.

There are several devices on the market that can be used to enhance the weak higher frequencies on old records. The BBE Sound Model 422A Sonic Maximizer (Fig. 6) is an extraordinary device. It breaks the sound into three frequency bands divided at 150 Hz and 1.2 kHz, introduces small time delays to the lower bands, and uses a voltage-controlled amplifier to alter the apparent level of the highest band based on the content of the middle band. It is effective and unobtrusive on any sound source, giving better apparent highs and improved clarity. Its low-band level control enables the user to correspondingly increase the bass frequencies. We use this device in all our restorations, and its outstanding characteristic is naturalness of sound. The Sonic Maximizer is very easy to operate and has superb sound qualities, but it can be overused.

REVERBERATION, TIME DELAY, AND AMBIENCE

Even when all the techniques discussed so far are employed, there is still something missing from the sound of early electric 78s and even more so with acoustics. Sound exists in some kind of environment—an acoustic space. The sonic reflections of the recording hall or acoustic recording studio are weak or missing on old records. A quality reverb, time-delay, and ambience system can be of great aid in restoring the sense of acoustic space. Acoustic records were very close-miked, or perhaps we should say "close-horned." It was the only way to get enough energy to drive the mechanical cutters. The medium and long room reflections associated with a good music environment are almost entirely missing, with only a few of the shorter room reflections being present. This results in an extremely dead sound. What is needed is to introduce a fair amount of the longer reflections and an even larger amount of the medium delays. We use the a/d/s/ Model 10 Acoustic Dimension Synthesizer. No longer available, it was a home entertainment system, not terribly flexible in its use with tape recording, so a few interface modifications were needed. However, it was more natural sounding than some professional units costing three or four times as much. There are also some currently available reverb, time-delay, and ambience systems by Yamaha, Lexicon, JVC, and other manufacturers which are well worth investigating.

Remember, with any audio equipment, judge primarily by using your ears, not necessarily the published specifications, which don't always reflect what the sound is like. Reverberation, time delay, and ambience can be very useful in reducing the dry, dead sound of many historical recordings, but the result should never sound like some of the overreverberant modern recordings.

COMPRESSION, LIMITING, AND DE-ESSING

The more these three processes can be avoided, the better, but sometimes they are necessary. In the acoustic era a form of mechanical compression was sometimes used with singers who had very powerful voices. It was really quite simple: The singer moved up close to the recording horn before singing very soft passages and backed away rapidly before singing very loud ones. It worked to some extent but could be pretty hard on the singers! Compression is the reduction in the level of loud passages in a graduated manner, and it is the opposite of dynamic expansion. With recordings having wide dynamic range, a small amount of compression may be needed, especially if the results are going onto cassettes.

Limiting, the abrupt stop of level increases beyond a preset point, should generally be avoided in restoration work. In a few cases, limiting helps to minimize the nonlinearity problem with acoustics, discussed in the earlier section. It should be used in addition to, but not to replace, selective-EQ gain riding.

De-essing, which minimizes the sibilants associated with the "S" sound on vocals, isn't needed on 78s because of their limited frequency range, but there is one exception. Worn records that

Fig. 6—*The BBE Model 422A Sonic Maximizer.*

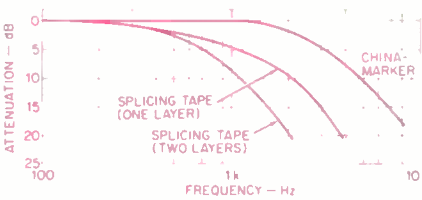


Fig. 7—*Playback attenuation of high frequencies in 15-ips tape recordings by application of yellow china-marker or short lengths of 0.001-inch-thick splicing tape to the oxide side of the recording tape.*

sound "edgy" on highs may be helped by this, since distortion, barring actual sound breakup, is worse on the transient or attack where de-essers function. We have Orban's Model 424A Gated Compressor Limiter/De-esser and find it to be a useful, subtle, and natural-sounding device when applied with discretion.

EDITING

The standard method most of us have to rely on is the old mechanical method of tape cutting and splicing. Most 78s are less than four minutes per side, and with long musical works, the unavoidable interruptions to change record sides are awkward and disconcerting. Where direct splicing, instead of cross-fading, is used to join sides, it is best done on the start of a note or possibly on the end of a note from the previous side; it should never be done in the middle of a pause as the shift in background hiss would be very disconcerting. A splicing block with a very gradual 2-inch cutting groove can be helpful in making splices less noticeable. When editing sides together, a gradual decrease in treble at the end of a record is sometimes audible on early records. This is inherent in the nature of disc recording; it was compensated for, in later recordings, by diameter equalization (a gradual increase in treble added on the inner grooves). When this treble-loss problem is encountered, the restorer can add diameter equalization with a gradual increase of 3 to 5 dB of treble on the inner grooves, followed by a return to normal before the start of the next side.

An interesting editing approach to clicks, pops, and swish has been developed by Richard C. Burns. It involves using tiny bits of splicing tape on the *oxide surface* of the tape to create artificial dropouts! The advantages of this approach are that there is no alteration of the timing and the degree of dropout can be controlled by using one or more layers of splicing tape. Of course, exact location of the click, pop, thump, or swish is necessary, but this is no more difficult than with the traditional tape cutting and splicing method. A further advantage is that, if you make a mistake, correction only involves careful removal of the splicing tape, rather than splicing back in the portion of tape removed, as is the case in the cut-and-splice method. Swish is usually too lengthy to be removed by tape cutting and splicing, but can be handled by this technique, using a compromise between degree of dropout and loss of high frequency. In some cases of swish, where even a single layer of splicing tape causes too great a dropout, Burns recommends using a china-marker on the oxide surface and lightly coating this with baby powder to prevent the tape sticking to the recorder heads. (See Fig. 7 for the dropout characteristics.)

The new digital, stereo-editing work stations offer greater flexibility, accuracy, and speed. They enable the restorer to try the blending of 78 sides by direct connections or cross-fades in any place and with any blending slope. The work can be tried time after time until the results are perfect, and all this can be done without any mechanical tape cutting. Digital editing of any residual clicks or pops, which the Packburn might leave, becomes relatively simple. In mechanical editing, there are many occasions where audible clicks and pops are masked by the sound which is heard at the very low tape speeds encountered while "rocking reels" on a recorder. It can be a maddening experience to try to locate a defect's precise location on the tape. With digital editing it becomes relatively easy. There is only one problem—the expense of such equipment is far too high for most of us who live in the real world.

STEREO

Artificially synthesized stereo from a mono source doesn't work out very well. The Orban 245F creates quasi-stereo by the use of phase filters and shifters, but even when the control settings are very low, the results are audible and do not sound very natural. Their broadcast version with more bands is a bit more subtle, but it still sounds artificial. We have never heard any synthesized stereo that didn't sound better when the channels were paralleled to produce mono.

A very subtle and natural stereo spread can be produced by using slightly different settings on parametrics to create two channels. A somewhat fuller and richer sound can be achieved this way without any artificial quality. Mixing in some of the stereo output of a reverberation, time-delay,

and ambience system can also be useful in helping produce a subtle and natural stereo effect. Perhaps better stereo synthesizers will appear in the future.

PROCESSING SEQUENCE

We have found that our best results are obtained when the restoration sequence is as follows:

Clean the record and make repairs.

Play the record, adjusting for optimum stylus size, geometry, tracking force, and turntable speed to ensure correct pitch.

Adjust inherent EQ for best sound, using our record EQ chart (Table II, June issue) as a starting point.

Adjust for best noise reduction.

Do preliminary sound rebalancing with a graphic equalizer.

Carefully study the results for unnatural resonances, blasting, and other problems.

Work with parametrics for best sound.

Work with high-frequency enhancement and selective EQ gain riding as needed.

Work with dynamic expansion and/or compression if needed.

Work with reverb, time delay, and ambience as needed.

Work with quasi-stereo if deemed appropriate.

Carefully listen to how all the processing interrelates, and adjust to eliminate poor interactions. Also check to see if it is possible to eliminate the use of any processors! Theoretically, the fewer the better.

Repeat the second through twelfth steps until no further improvement is obtainable.

Document the audio chain sequence and all control settings.

Put the resulting work aside for a day or two, then come back and listen again to see if it still sounds the same; if not, adjust as needed. In some tough cases, it may be necessary to start over again.

When you are satisfied, tape the results at 15 ips to create a working or edit master tape. It may be necessary to make this tape several times until any selective EQ gain riding is imperceptible.

Edit the edit master tape carefully as needed.

Using the edit master tape as a source, repeat any of the preceding steps that yield further improvement.

Check and adjust for best absolute polarity.

Tape the final result, which becomes the copy master tape and is the source of all user records, cassettes, CDs, etc.

OTHER CONSIDERATIONS

For restoration work we use and recommend Otari reel-to-reel and Nakamichi cassette tape recorders. They are of superb sonic quality, but as with all analog recorders, there are problems with noise and high-frequency losses that increase with each generation. Tape print-through can also be a problem. Digital recording, which has overcome its own early problems, solves the difficulties inherent in analog tape recorders and is now the medium of choice. Unfortunately, as is the case with digital editing, the expense is still prohibitive for most of us. Digital audio tape recorders are beginning to make their appearance and offer the possibility of digital recording at a more affordable price.

Reliable long-term storage of recorded information is vital in the field of sonic preservation. It involves not only the stability of the media on which the information is stored but, equally important, the ability to play back that information without damaging either the storage medium or the information itself. Analog tape recording, barring catastrophic tape failure, is proven by over 30 years of experience to work well, but there are some losses. Digital recording, on the other hand, potentially offers permanent storage with near 100% accuracy for an indefinite time, and with no increase in hiss when a tape is copied from one machine to another.

Digital recordings using Reed-Solomon codes can be largely self-correcting in playback from information errors. It is theoretically possible to lose a high percentage of digital information and still obtain 100% recovery if high-order Reed-Solomon codes are employed in the recording and playback process. (*Editor's Note:* Dr. Toshi T. Doi's April 1984 article, "Error Correction in the Compact Disc System," went into this in great detail.—*E.P.*)

Physical deterioration of the storage medium—be it wax, shellac, wire, magnetic tape, vinyl records, or even optical discs—will eventually occur from time alone if nothing else. This may be rapid, as in the case of wax or acetate recordings, or very slow, as with the newly developing optical storage disk. But even if the physical storage medium deteriorates very slowly, information loss can be rapid in the recovery or playback process. Tin-foil recordings deformed disastrously with two or three plays, acetate and wax recordings deform seriously with a few dozen plays. Shellac and vinyl records suffer some wear with each playing. The same is true of magnetic tape but to a much lesser degree. Only electronically or optically read information results in no wear on the storage media, but even here reading and tracking errors are common and appear to increase with the passage of time. Digital storage using high-order Reed-Solomon codes can potentially solve many reading and tracking problems. Likewise, it can potentially solve the long-term storage-medium problem by re-recording every 50 years or so, before medium deterioration has progressed to the point where high-order Reed-Solomon codes can no longer correct errors. Of course, this storage technology hasn't yet been proven by experience, but archival storage for hundreds or even thousands of years is more than just a dream.

INTERCONNECTIONS

In professional audio systems, interconnection of equipment is made with balanced connections to keep hum and noise to a minimum. With our sonic restoration audio system, some of the most useful equipment is designed for home music systems and has only unbalanced (i.e., RCA) inputs and outputs. Coaxial-type interconnect cable, where the shield carries one side of the signal, is satisfactory in small systems, since interconnects are relatively few and short. On the other hand, very high-quality and complex audio systems, such as used in sonic restoration, can involve many electronic units and long lengths of interconnecting cable with resulting hum caused by r.f.i. and e.m.i. One good solution is to use quad mike cable for interconnections. We like Mogami Neglex 2534; the two twisted white wires are soldered together at both ends, as are the two twisted blue wires, with the shield grounded at one end only. This method of interconnection (bifilar configuration) eliminates electromagnetic hum induction almost completely.

One of the most frustrating problems for those working with complex audio systems is to have a patch panel, jack, or plug become intermittent during an important tape recording. Intermittent patch panels, jacks, plugs, switches, and connectors, along with noisy pots, are basically due to dirt or oxidation. There are many products for this, but the outstanding one is Cramolin, which comes in either spray or liquid. It effectively cleans, preserves, and lubricates. It reduces contact resistance and prevents contact intermittents.

DISTORTION AND SAMPLERS

We have previously mentioned a number of things that may help reduce distortion including stylus size selection to track above or below the dam-

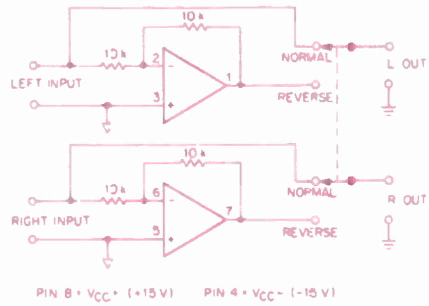


Fig. 8—*A polarity-inversion circuit for line-level use. The IC is a TL072, and the switch is a two-pole, two-position make-before-break type.*

aged area in a record groove, and de-essing to reduce distortion on transients, along with parametric settings. In the usual situation where the noisier side of a mono groove wall is also the more distorted, the Packburn's Switcher can be a big help, but occasionally the noisier groove wall is less distorted than the quieter groove wall. If this is encountered, the Switcher shouldn't be used. A two-track recording should be made in which the treble (with bass filtered out) is recorded from the wall with noisiest but cleanest treble, and the bass (with treble filtered out) from its cleanest wall. The two tracks are then mixed together, yielding an overall reduction in distortion even though the noise will be increased. Where distortion is severe, with actual sound breakup or shatter, downward gain riding on the treble during the bad passages is about the only even partial remedy. Perhaps in the future the rapid explosion in computer and digital technology may offer some help.

In a few cases, electronic samplers may be of use. For example, there are cases of groove damage where a sizable portion of a musical note is missing. The sampler can take what remains, even if only a few milliseconds, and "loop it" to the degree necessary to extend the note to its original length. It is possible to do this by the old method of repeated recording and splicing, but the results are usually not satisfactory. Every note consists of three parts—attack, sustain, and decay. With a good sampler, coupled to other equalizers if needed, it is possible to mimic all three note parts based on any fragment of the note that remains. Good samplers are expensive, but if you're doing a lot of work with badly damaged records, the cost is justified. Additionally, there is sometimes no choice but to copy a note or even a musical phrase from an undamaged portion of a record to fill in a totally destroyed area. The sampler is a great advantage in doing this, and it is possible to alter the intensity or timing of the note or phrase where the reinsertion occurs, to be more consistent with the artist's interpretation at that point in the performance. Whenever this type of alteration is employed, we believe that it is mandatory, in the interest of authenticity, to clearly state what was done in the documentation that accompanies the restoration.

ABSOLUTE POLARITY AND POWER-LINE CONDITIONING

Some maintain that the absolute polarity between musical source and listener should be maintained for best sound. With live musical performance this is automatic, but with electronic processing of any type, 180° polarity reversal may occur. There is no industry-wide standard in this matter. Our own simple tests convince us that this effect is real and *probably* inherent in the recordings. On many recordings, reversing the polarity of the audio system output makes a definite change in clarity, especially in the lower frequencies. Therefore we suggest that restoration systems—and all quality listening systems, for that matter—employ a circuit like that shown in Fig. 8. Restoration systems should be checked to maintain consistent polarity after the polarity switch so that the final restoration tapes will have the optimum polarity.

Many in the restoration field are unaware of the importance of having

quality a.c. power, stable in voltage and free from spikes and garbage. Standard power-line conditioners are inadequate for high-quality audio work. The Tice Power Block is expensive, but it solves most a.c. power-line problems, other than outright loss of power, and we find a definite audible improvement in sound quality. Historical records have enough problems without further degradation from poor power.

ARTISTIC ELEMENTS

Except for live performan ces, records lack the interplay between performer and audience. Those who knew the great actress Sarah Bernhardt said that her recordings do not give the slightest idea of the impact she made live on the theater stage. All great artists of the past had that elusive quality called projection; without microphones, they could be heard clearly in the back row. But projection isn't so important now that small voices can be electronically amplified and enhanced to have tremendous impact. The charisma of many artists can't be expressed by sound alone—and in this regard, motion pictures, and now video recordings, have expanded the possibilities. Some artists, like Glenn Gould, preferred recordings and didn't concertize very much. With others, as diverse as Ignace Jan Paderewski and Elvis Presley, audience interaction and the visual impact of the artist were a vital aspect of their art.

Attempts to fully re-create the artistry of performers are problematical and incomplete at best. Our standard for sonic restoration is limited to what is possible. What we can say, and this is important, is that a given sound recording represents the sonic portion of a performance under one set of conditions, at one specific time and place. Sonic restoration means to re-create as fully as we can the specific interpretation of the artist when the record was made. We cannot know the impact Sarah Bernhardt made when acting on the stage. The most we can hope to know is what she sounded like and looked like when she made her acoustic records and silent films.

ENGINEERING ALTERATIONS

Historical recordings made before 1960 have relatively few intentional alterations by recording engineers. There are a few gross ones such as level shifts or changes in mike position, but these are very obvious and relatively easy to undo in our restoration work, although in the case of drastic level shifts the required corrective gain riding may be a bit tricky. For a shift in mike position, a gradual or abrupt, as may be required, change in compensating EQ will usually do the job. With modern recordings the situation is entirely different. Many of today's recordings are an artist and engineering blend not entirely authentic to the artists, being an intentional alteration of performance for effect. The current standard, especially in the pop field, is 24- or 36-track recording with innumerable alterations and mixings. This is not an appropriate model for historical recordings. The earlier recording engineers did not have the means to make such modifications, and this is fortunate for the restorer. Had historical recordings been able to employ a lot of artistic and engineering synthesis, we could never recover the artist's interpretation, as it would be impossible to distinguish between artist and engineer.

The sonic restorer must compare the past with the present to become aware of stylistic changes. Attempts in movies, TV, or new recordings to re-create the style of the past are frequently unsuccessful. For example, modern performances of Glenn Miller's arrangements are mostly syncopated dance music; they don't have Miller's quality of *swing*. With current technology it is quite possible to remove the voice from an historical vocal recording and add a new accompaniment. It is true that many of the earliest vocal acoustics had mediocre piano or poor in-house orchestras for accompaniment, but that's the way it was! While 78s of electric orchestras dubbed over the acoustic Caruso voice sounded fuller, the effect was grossly out of character. It is dishonest to represent such inferior results as accurate. They can't be an integrated performance, and they lack the true style of the time. In the sonic restoration of historical recordings, the key word is historical, and discrimination is the essence of the art. Gross tinkering is easily spotted, but the line between restoration and enhancement may be very, very thin.

COMPARATIVE TECHNIQUES

Through comparative techniques, we can infer, with considerable accuracy, what an historical recording sounded like at the original performance. The basic reference must be live sound heard with no electronic intervention. Next best is "flat" recorded sound such as can be heard on the old Mercury Living Presence and Westminster Lab LPs, Sheffield Direct Discs, most Telarc CDs, and some others. Timbre (sound quality) is all-important. If, through the use of filters, all overtones are eliminated, then different instruments or voices all sound alike except for pitch. It is the overtones, their presence or absence and their relative intensities, that produce timbre and the articulation of transients.

From personal experience and good recordings, we know what a symphony orchestra sounds like. Of course, there are subtleties of timbre distinguishing, for example, an English horn in one orchestra from another English horn in a second orchestra, but all these timbre differences tend to cancel out when you are dealing with many instruments. The main differences from orchestra to orchestra are created by the conductor. Tempo, accenting, liberties with the printed score, and emphasis of one instrument or group of instruments over another are inherent in the recording and depend very little on the quality of the sound. The sonic restorer will have to make allowances for some possible differences, such as lower pitch and smaller or different orchestral forces. Sometimes conductors in the acoustic record era used special musical arrangements and/or special seating arrangements for the members of the orchestra, to accommodate the acoustic recording process. A special violin, known as a Stroh violin, with a horn attached to direct weak violin sound at the acoustic recording horn, was used by some conductors. Bass string instruments were sometimes replaced with wind instruments. But keeping these differences in mind, if the restorer modifies the overall sound qualities of a primitive orchestral recording to sound much more like a modern one, he has done a good job.

INSTRUMENTAL

With instrumental soloists, the problems are more complex, because with very small groups or soloists, timbre differences are more obvious. While all violins have a similar overtone structure, the unique overtone structure of, say, Mischa Elman's Guarneri sets it apart from all other violins and is an important element in his art. A comparative approach is the way to solve the problem of inaccurately recorded overtone structure. The sound on Elman's acoustic records is compared with that on his later electric recordings, which have much better sound; then we can get a good idea of what modifications are necessary to make Elman's acoustic records sound more authentic. While Elman undoubtedly always used his Guarneri violin, other artists using physically large instruments, such as a piano, could not be so selective and had to perform on the instruments that were available at their recording sessions. Nevertheless, it is reasonable to suppose that they would choose instruments of similar sonic qualities to the instrument they normally used. It is unreasonable to suppose that a pianist of the stature of Alfred Cortot, if he could not have his own magnificent Pleyel piano with him when he made acoustic recordings for Victor at Camden, would consent to play on any piano that was incompatible with the tone of his own. Unfortunately, available discographical information has little to say on what artist used what instrument for what recording. Still, much of instrumental performance was, as in the case of the orchestra, conveyed by acoustic records. If, at the end of our work, a piano sounds like a piano and a cello sounds like a cello, we won't have gone far wrong.

With vocalists, especially acoustically recorded vocalists, the difficulties are much greater. While tempo, inflection, intensity, phrasing, and other characteristics are well conveyed even by acoustic records, the overtone structure is not. This overtone structure contains the qualities of tone and resonance that make each singer unique. But what did the tone qualities of acoustic vocalists really sound like? We believe that the majority of vocal electric recordings made between 1925 and 1960, when played back properly, do a fairly good job of capturing the qualities of the artists they represent. Of course, the highest overtones are missing or weak, especially on the earliest electrics. In addition, the early electrics were sometimes still made in poor-sounding acoustic recording studios. Yet by 1930 or 1935 the worst problems were overcome, and the lower harmonics, which are most important, were being recorded

in their correct proportions. Hence we can, with some obvious exceptions, employ many of the recordings made from 1925 to 1960 for comparison standards.

CROSSOVER TECHNIQUE

The great coloratura soprano, Amelita Galli-Curci, spanned the 1925 crossover from acoustic to electric recordings. If we play a number of her early electrics, we can get her unique sound quality firmly in mind. Then in restoring her acoustics, we use our equipment to increase the natural resonances and overtone structure which the electrics reveal should be present in her voice. Additionally, we decrease or eliminate the unnatural resonances of the recording horn. The procedure isn't perfect, since voices age and change with time, but such changes are usually a darkening of the voice and perhaps a lack of steadiness, not a basic change in tonal quality. There are hundreds of such comparisons that can give us a true picture of what the timbre of these 1925 crossover artists actually sounded like when they made their acoustics.

COMPANION VOICE

With Enrico Caruso the problem is more complicated, for he didn't live long enough to make any electric recordings. However, he did make many records with what we call companion voices—duets, trios, quartets, etc. So we adjust a Caruso and Galli-Curci collaboration for what we know is the Galli-Curci electric sound quality and obtain a "set" on Caruso's sound quality. We do the same with the Caruso and Emilio de Gogorza duet and obtain another set on Caruso. We can also obtain sets on Caruso via his acoustic recordings with Frances Alda, Giuseppe De Luca, Ernestine Schumann-Heink, and others whose careers and recordings extended into the electric era. Always, we adjust the companion voice for those qualities present on its electric recordings. Soon we have many sets on Caruso, and if he sounds the same on all these sets, then we have with considerable accuracy the true voice quality of Caruso as he sounded at the recording horn. We may speculate that he sounded the same on the stage of the Metropolitan Opera House, but we can't know for certain because there are too many variables between studio recordings and live performance. The memories of those still living, who heard him live, are colored by many years of nostalgia and diminished hearing, and the written commentaries of his contemporaries give only a word picture. We must settle for what Caruso and his fellow artists sounded like when they stood before the recording horn.

The companion-voice technique is a bit less reliable than that for singers who spanned the 1925 acoustic-to-electric crossover where direct comparisons between acoustics and electrics can be made of the same artist. When Caruso and Galli-Curci recorded together, he may not have stood the same distance from the recording horn as she did (he probably didn't), and the horn resonance characteristics for the two voices would be different. Companion voices may have been considerably older when they made their electrics. Further, early electrics have their own host of resonance problems and defects even though they are vastly superior to the even earlier acoustics. However, as the number of companion-voice sets increases, so can the accuracy and authenticity of our results. To help establish the validity of using early electric recordings as sound references for acoustic recordings, we can make comparisons with artists who lived to make acoustics, electrics, *and* early LPs. By comparing their LPs with their late electrics, early electrics, and finally their acoustics, we can gather useful information as to the reliability of using later records as references for work on earlier records. While, for example, Beniamino Gigli's voice changed in quality between his acoustics and his LPs, the change between his early and late electric 78s is not so great that useful comparisons can't be made.

Once we have established Caruso's true tone qualities, we can then use him in turn as a companion voice to obtain sets on earlier singers he recorded with where acoustic/electric crossover recordings don't exist. There are many singers that can be referred backward from more recent and, in some cases, relatively modern recordings. Certainly as we go backward in time, the comparative process to determine vocal quality becomes less reliable, but it does offer a technique based on the evidence in the records themselves.

COMPANY-AGE TECHNIQUE

The singers most difficult to pin down in timbre or vocal quality are those for whom there are few or, in some cases, no companion voices that can be traced into the electric era. Even here, the situation isn't hopeless. From our experience with thousands of records going back to the late 1890s, we have found that acoustic recordings of a given company and date tend to have very similar resonance and sound characteristics. The great Italian tenor Eduardo Garbin didn't make a great number of records, and his Fonotipia discs were very early, around 1905. We found only one companion voice, giving a single set on his voice quality, and that isn't enough. However, it is extremely likely that his Fonotipias have resonance characteristics similar to other Fonotipias of the same era that we can trace up to the electric era via the companion-voice comparison technique. It is reasonable to suppose that the corrective parametric settings that apply to these other Fonotipias should also apply to Garbin's recordings. It is never certain, but it seems the only approach, and it offers much more than just guesswork. Garbin represents a style of singing not heard today, and it is important that restorations of his recordings and those of his contemporaries have some degree of authenticity.

THE ART

Sonic preservation must be preservation of whatever sound is on the recorded source and of that physical source itself. It's an *objective* process with little or no room for opinion. Sonic enhancement is primarily *subjective*—it can include altering sound quality, pitch, and reverbation, as well as adding quasi-stereo and substituting modern performances—and is done for "effect." Sonic restoration attempts to walk the very thin line between preservation and enhancement. It attempts to be authentic to the original performance. Acoustic recordings and, to a lesser extent, early electrical recordings cast veils of haze between the artists and the listener. The sonic preserver leaves these veils as they are; the sonic enhancer adds and subtracts veils of change for effect. The sonic restorer tries to remove all the veils between artist and listener. Whether the restorer is successful will be determined by the results, which must speak for themselves.

The current trend in musical culture, especially in the popular field, seems to be for ever more and greater sensory impact. To us this seems to be a substitute of quantity for quality. The new buzzwords are computer, synthesizer, and digital. Just as the piano and violin are the instruments through which the pianist and violinist create music, so too can the computer be the instrument through which the musician programmer creates music. But music is a human experience, and if with technology the human element should disappear, whatever sound remains won't be music as we know it. While new technologies are important in the sonic restoration of historical recordings, the new *technological art forms* should not be imitated.

Work in the restoration field does not always move forward. The Nimbus Prima Voce CDs are a case in point. Nimbus plays both acoustic and electric historical recordings on an antique acoustic phonograph and records the resulting sound using the latest technology. This 60-year-old re-recording technique lacks transients, has many unnatural resonances, and eliminates the lower frequency characteristics of the voice. On acoustic records it is poor; on electrics it is a disaster. The glorious lower tones of Rosa Ponselle are gutted, and the already reverberant Eva Turner record sounds like it was recorded in a rain barrel! Nimbus does a disservice to the artists.

It is essential not to confuse today's extraordinary technology with its applications. The technology is neutral; the applications rarely are. Modern technology, having overcome many early problems, can produce unequalled realism and naturalness of sound. However, the "a little is good, therefore a lot more is a lot better" approach can easily abuse the sound. Those who argue against use of today's sophisticated processors in sonic restoration confuse the technology with the application. One of the hardest lessons we have learned and are still learning is that if use of a processor produces a good result, then *try a wee bit less*. It may be even better.

The would-be sonic restorer needs some detachment from the current musical culture plus some historical perspective. He also needs flexibility in looking at both old and new music and technology. Attitude is fundamental and basic to everything else. The art of sonic restoration cannot be taught; it is a perception of, and respect for, the older artists and their achievements. It is the patience to do the job over and over until it is right. Above all, the art is that subjective discrimination, in using all the electronic tools now at our command, to attempt as objective and authentic a restoration as possible. The sonic restoration of historical recordings is both art and science. The science is the knowledge of music—its history and psychology. It is acquiring and maintaining the restoration equipment. It is developing the skills to use that equipment. It is staying abreast of new and rapidly changing technical developments. The art is undefinable. While patience, discrimination, attitude, cultural outlook, ethics, and love of the work are some of its aspects, it remains an elusive quantity.

When the best of the science is combined with the best of the art, then a clear window of great pleasure and insight opens for us, and blues singer Ma Rainey, King Oliver's Creole Jazz Band, cornetist Bix Beiderbecke, soprano Nellie Melba, conductor Richard Strauss, pianist Josef Hofmann, and a host of other artists and performers all come alive for us. ◢

Without the help of my associate, Mr. Donald H. Holmes, this article would have been impossible. His years of experience with parametrics and many useful suggestions on restoration are a vital part of Lane Audio and this article. Also, I am greatly indebted to Richard C. Burns of Packburn Electronics and Carl J. Malone of Specialty Audio for their review and suggestions.

The records shown are from the collection of Michael R. Lane and Donald H. Holmes, who run a restoration service, put out auction lists of historical records, and offer specialty equipment for historical record reproduction. Lane Audio & Records is located at 1782 Manor Dr., Vista, Cal. 92084.

N E W L I F E I N

DIGITAL DU

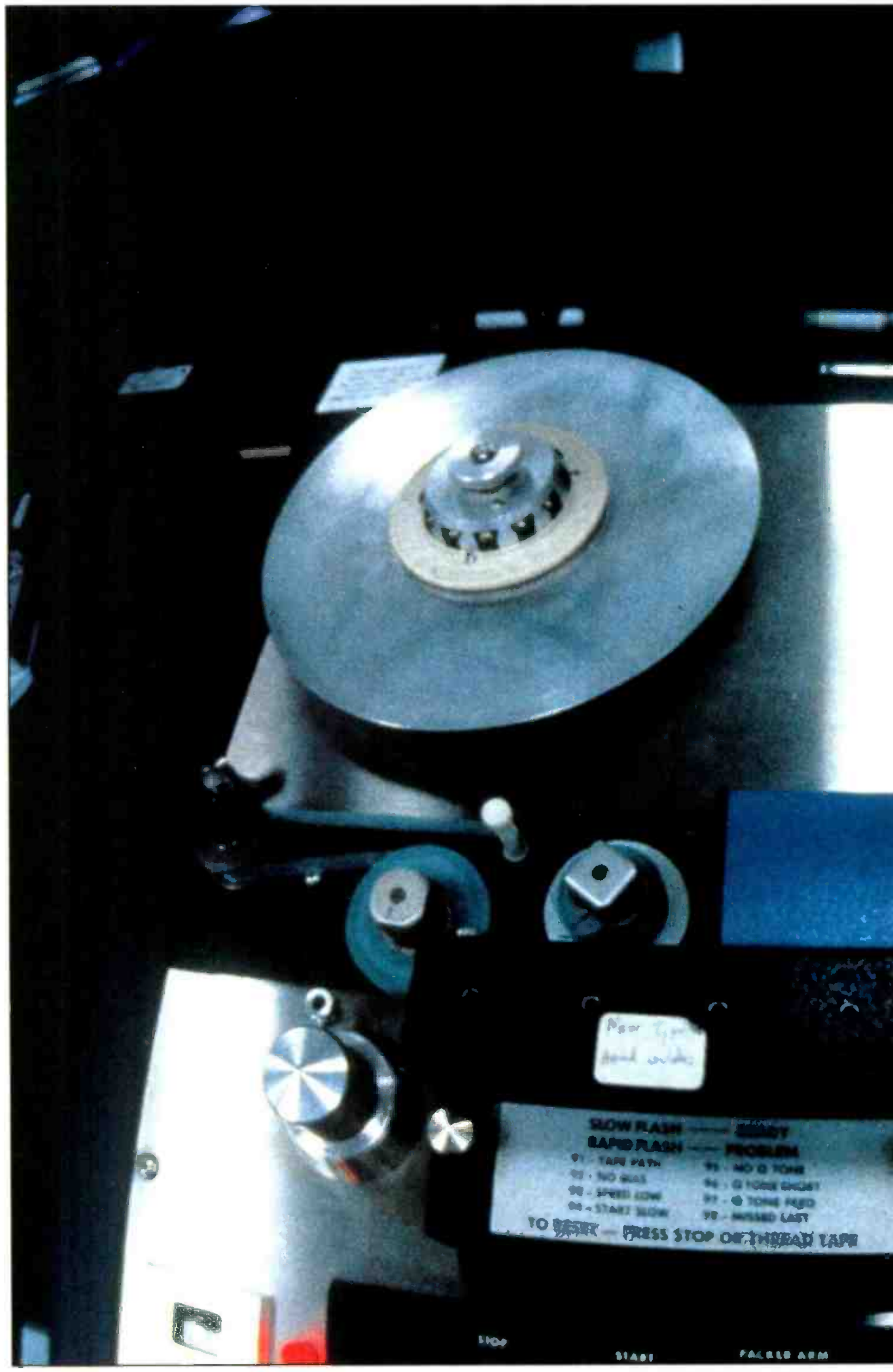
JOHN EARGLE

The Philips Compact Cassette is very likely the most universal carrier of recorded music the world has ever known. It is estimated that there are three cassette players per household in the United States; considering the popularity of auto stereo and various forms of personal stereo, this seems reasonable. Overall, the world's population of players is estimated to be greater than one billion.

The cassette was introduced into the United States in the mid-1960s, and its basic technical performance went little beyond the requirements of an office dictating machine. At the time, RCA, Ford Motor Company, and Learjet were promoting the Stereo-8 endless loop cartridge for stereo-on-the-go applications. With a tape speed of 1⅞ ips, the cassette suffered by comparison with the 3¾-ips Stereo-8 format. But in just a few years, the cassette won out, primarily because it allowed the consumer the flexibility of conveniently recording material at home for later replay in the automobile—something that Stereo-8 could not do.

In terms of basic quality objectives for home recording, the cassette was up against reel-to-reel stereo tape. In time, the improvements in tape, shell design, and recorder performance, and above all the addition of Dolby B noise reduction, helped the cassette mount a formidable assault on reel-to-reel; by the mid-1970s the cassette again became the clear winner. Record companies had seen all of this coming and

Group of Gauss 2400 high-speed recorders.



C A S S E T T E S

PLICATIONS

Electro Sound 8000-series high-speed master recorder.

had geared up to produce prerecorded cassettes on a large scale.

In 1983 the unit sales of cassettes in the United States exceeded those of the LP, and the later onslaught of the CD put the LP into further eclipse. Now, even as the CD gains in momentum, the cassette holds strong and promises to do so for many years to come.

The cassette is mass-duplicated in a manner which is physically identical to the consumer's in-home recording procedure. There are, of course, economies of scale, but essentially the tape to be copied is run on a master transport, and a number of "slaves" are fed directly from it. On a modest scale there may be no more than four slaves, and the duplicating speed ratio may be no more than 4:1. The slaves themselves may be standard cassette transports which have been modified for the increased speed of operation, and the "master" may simply be a cassette itself. This method is shown in Fig. 1 and would be applicable for very short runs of speech-quality program.

A substantial step forward in quality is shown in Fig. 2. Here, the master is a digital source, a DAT or possibly a Sony PCM-F1. During the mid-1980s, Nakamichi duplicated short runs of very high-quality cassettes using a method similar to this. The source was a digital F1 tape whose transfer quality was carefully monitored by noting the digital block-error rate as the tape was repeatedly played back. The slaves themselves were top-of-the-line Nakamichi recorders which were self-aligning before each run. The duplicating ratio was, of course, 1:1, or so-called *real time*. Tapes were duplicated with Dolby B or Dolby C noise reduction, and HX Pro headroom extension was routinely used. Each side had to be duplicated separately.

Nakamichi provided this service for owners of their machines who wanted, and were willing to pay for, audiophile-quality cassettes from such labels as Delos and Sheffield. Nakamichi could honestly say that these tapes "were first-generation copies of the original digital master" if all steps in the preparation of the running master had been carried out in the digital domain.

These duplicating methods are quite "labor intensive" in that the yield of product per man-hour is limited. However, they remain just about the only way for producing short runs.

For larger scale duplication, however, some fundamental changes must be made and other considerations enter into the picture. Many slaves may be used, and the duplicating ratio may be as high as 96:1 for music and 128:1 for speech quality. (See Fig. 3.) The production time required for each copy is essentially reduced and can be determined by dividing the playing time in one direction by the duplicating ratio multiplied by the number of slaves. The master itself is run as an endless loop with all four tracks copied at the same time. Figure 3 shows a modern duplicating system with four slaves and an endless-loop tape bin for the master. The cassettes are duplicated end-to-end on large "pancakes" of tape which are subsequently broken down and loaded into the cassette shells.

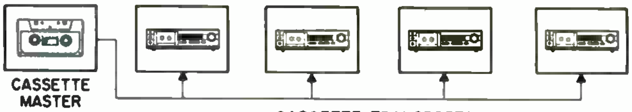


Fig. 1
Modest duplicating setup for limited runs of speech-quality cassettes. No more than four slaves are used, and speed ratio is 4:1 or less.

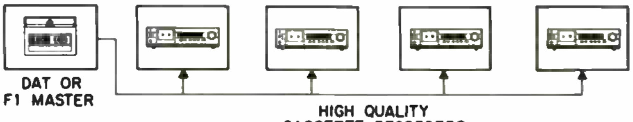


Fig. 2
Real-time (1:1) duplication from digital copy master, for high quality.

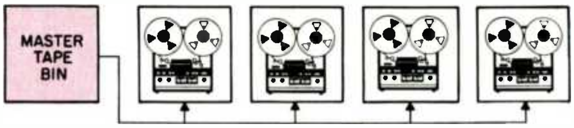


Fig. 3
Large-scale duplication, using endless-loop master and slave recording tape "pancakes." Setup shown here is for music, using 7½-ips master running at 240 ips and tape pancakes running at 60 ips, a 32:1 duplicating speed ratio. For speech-quality tapes, 3¾-ips masters and still higher speeds would be used, for ratios of 128:1 or more.

Many of the larger duplicators injection-mold their own cassette shells and operate large printing shops for paper inserts and labels. Their basic purchased operating materials are commodities, such as plastic, paper and tape—for which prices are relatively negotiable. Such "vertical integration" reduces operating costs considerably in a highly competitive marketplace. Attention to line scheduling and quality assurance maintains good "loading" of the plant, again in the interests of controlling operating costs and minimizing downtime.

Even though the CD has gained in sales momentum, the cassette holds strong and promises to do so for many years.

The duplicating ratios used today are a far cry from the 8:1 methods of the 1960s. The electronic challenges were relatively easy to meet; bias frequency has been raised to the range of 8 to 10 MHz, and equalization requirements have been simply transposed upward as required. The major problems to overcome were in the physical handling of the tape. Tape skew and air filming have been the major problems in ensuring positive tape-to-head contact at high speeds. The design of the endless-loop tape bin for the master was a considerable challenge, in that the requirements were to move the tape at a speed as high as 480 ips while handling it gently to minimize wear and damage.

At this point, we will follow a master tape through the entire duplicating cycle, noting the many procedures which ensure quality and process control.

Duplicating plants prefer to receive a master in the form of a digital clone of the final edited master, with A and B sides clearly indicated. The digital tapes are then carefully checked to determine if there are any potentially troublesome high frequencies present in the program. If not, then the digital masters are transferred to ½-inch tape running at 7½ ips. If the cassettes are to be in Dolby B (most of them are), then the 7½-ips tapes will be made as a Dolby B copy. In a single pass, side A is copied in one direction, while side

B is copied in the other. The tape made at this point is referred to as the *running master*.

Should there have been any problems with the source tapes, these would be discussed with the client and adjustments made either at the client's studio or at the duplicating plant.

Before the actual production run, the master will be copied onto a cassette on a master-slave setup, which, in effect, duplicates all production conditions. It is transferred at the intended production level and on the intended tape stock. It is then sent to the client as a reference of what the finished product will sound like. The client usually has a technician check the tape and judge the quality of the transfer. Then, if all has gone well, the client will send an approval to the duplicating plant and production can then get underway.

The production control department takes over at this point and ensures that all paper components (labels, inserts) are on hand. Even though the entire order for cassettes may be quite large, the client may not want more than, say, 5,000 or 10,000 units at any one time. The run is scheduled accordingly, and the master tape is loaded into the endless-loop bin. For high-quality music duplication, a ratio of 96:1 would probably not be exceeded. At this duplication ratio, and assuming a total program length of about 40 minutes, a single slave can produce about 1,800 copies per eight-hour shift. Thus, a master transport with four or five slaves might easily handle the production run in about half a shift.

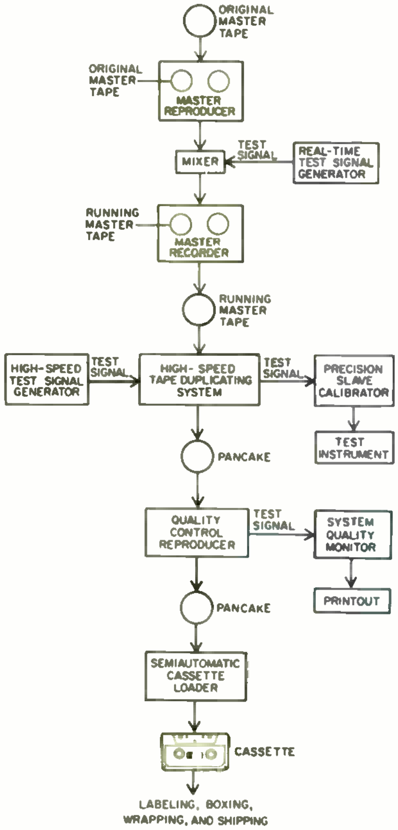


Fig. 4
Tape duplicating chain, with electronic quality-control stages.

Obviously, one cannot play every cassette to ensure that everything has gone properly. Cassettes are spot-checked according to established sampling procedures, but more to the point, all of the process and the incoming materials are carefully monitored. The duplicating chain itself is subject to several levels of maintenance, including those which are performed daily, such as cleaning, and those that are done at much wider intervals, such as replacement of heads and bearings. Between these extremes is routine electrical checkout of the systems.

While the incoming raw tape stock is sampled to make sure it meets magnetic requirements, each duplicated 8,400-foot pancake of tape is recorded with a diagnostic sequence of signals. This serves as a running check on outgoing quality, since no pancake will be loaded into cassette shells unless the pancake passes the test.

A pancake contains many passes of the master, and between each pass is a low-frequency cue tone which is used during the breakdown process. At this stage, the pancake is loaded onto the cassette winder, and individual cassettes are loaded at speeds up to 360 ips. The cue tone stops the winding process when each cassette is fully loaded. The operator then removes the loaded cassette and replaces it with a new shell.

The loaded cassettes then find their way to the labeling machine, which affixes the appropriate label to each side of the shell. Then, they move on to final packing and shrink-wrapping.

With recent developments in random access memory (RAM) capability and high-speed digital-to-analog (D/A) conversion, it is now possible to operate duplicating slaves directly from a digital source, thus bypassing the analog running master completely. The technology for this was developed by Concept Design, and one of the major installations of this is at the Sonopress manufacturing facility in Asheville, N.C.

Master tapes are received from clients, preferably in the Sony 1630 format, which stores the program on ¾-inch videocassettes. From this source,

Injection-molding department, Sonopress, Weaverville, N.C.

the plant's mastering department makes a pair of R-DAT clones, one for side A and one for side B. When a program is to be duplicated, the two R-DATs are loaded into RAM simultaneously, but on a real-time basis. Thus, it takes about 20 minutes to "load in" each new program. When duplication gets underway, the RAM and high-speed D/A converter function just like the running master and master transport in the typical duplicating setup. The duplicating ratio is 80:1, so this helps offset some of the rather long load-in time for new programs. In all other regards, the plant works very much like a traditional duplicator.

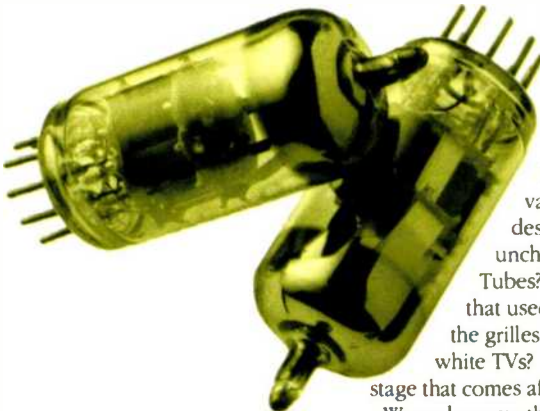
Sonopress is owned by BMG, which is the parent company of RCA Records, and the technology can be heard on RCA cassettes as well as A & M, Delos, and Telarc product. Sonopress places great emphasis on quality-control procedures to ensure that the benefits of the new technology will clearly find their way into the consumer's home.

The process gets us one step nearer to the digital master, in that each cassette is a first-generation copy of the digital master, but the next major technical leap forward for the cassette will be the DCC, or Digital Compact Cassette. The DCC is designed to complement the standard cassette and not necessarily make it obsolete. Since all DCC players will also play standard cassettes, there will be no need for wholesale adoption of the new medium. In fact, it may be quite reasonable to make the conjecture that speech-only cassettes, a very large market indeed, may remain analog based for the foreseeable future.

Tape duplicators and manufacturers of duplicating equipment are overwhelmingly in favor of DCC because it reinforces their fundamental investment in technology. DCC is designed to be duplicated at a 64:1 ratio on traditional slaves which have been outfitted with new heads. A number of details have yet to be worked out in DCC but it appears poised for introduction in 1992.

CAN TUBES WARM UP CD SOUND?

How a very old technology can make a brand new compact disc player sound extraordinarily good.



Our new SD/A-490t has a clock that "ticks" 33 million times a second, multi-stage noise shaping, pulse width modulators and enough other edge-of-the-art circuitry to finally qualify us for entry into the hallowed Compact Disc Techno-Jargon Hall of Fame.

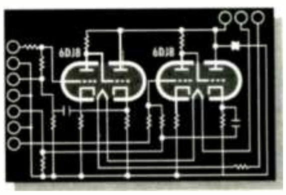
But it also includes two vacuum tubes whose classic design has remained unchanged for over 35 years.

Tubes? Those warm glass things that used to glow cheerily through the grilles of old radios and black & white TVs? Yes. In an important circuit stage that comes after all the digital wizardry.

We and many other critical listeners believe that this anacronistic addition to an already excellent CD player design significantly enhances its sound. Read on and decide for yourself.

THE AMPLIFIER THAT DOESN'T AMPLIFY.

Between a CD player's D/A converter and external outputs is circuitry called a buffer amplifier stage. When you hear the word amplifier, you think of something which makes a signal louder. But that's not a buffer amp's purpose. In fact, contrary to popular lore, a CD player's buffer amplifier doesn't boost the signal strength at all — the final output of a CD player's D/A converter already has sufficient voltage to directly drive a power amplifier!



Instead, the buffer amp is a *unity gain* device which *1) increases output current, and 2) in the process, acts as a sort of electronic shock absorber.

A signal emerging from a CD player's digital-to-analog conversion process has sufficient voltage but insufficient current for proper interaction with a preamplifier or power amp. By acting as a current amplifier, the buffer stage helps lower impedance to a level that's compatible with modern components — about 50 ohms in the case of the SD/A-490t.

At the same time, the buffer stage helps isolate the relatively fragile D/A chip set from the nasty outside world of demanding analog components.

TUBES VERSUS SOLID STATE.

All compact disc players have buffer amplifiers. But more than 98% of them use solid state devices for this stage: either integrated op-amp circuits or discrete transistors.

A handful of hard-to-find, esoteric designs in the $1200 to $2500 range employ one or more tubes instead. As does our readily-available $699 SD/A-490t. For fundamental physical reasons, tubes have different transfer function characteristics than transistors. When used in ultra-expensive, audiophile preamplifiers and power amplifiers, their sound is variously described as "mellower", "warmer", "more open and natural" or simply "less harsh than solid state".

At the heart of these perceived differences are three basic facts:

1. Tubes produce *even*-order distortion (i.e. 2nd, 4th, 6th harmonics, etc.) while transistors create *odd*-order distortion, particularly 3rd harmonics which are less psychoacoustically pleasant.
2. In a buffer stage, a tube acts as a pure Class A device, which is considered the optimal amplifier configuration. Op-amps function as Class A in and Class B out, with potential crossover distortion as voltage swings from positive to negative.
3. Tubes "round off" the waveform when they clip. When over-driven, solid state devices cut off sharply, causing audible distortion.

THE SD/A-490t'S OUTPUT SECTION

Our new CD player uses two 6DJ8 dual triodes (each literally two separate tubes in a single glass envelope) placed between the digital-to-analog converter and a motorized volume control.**

Operated at less than 30% of their maximum capacity, these tubes achieve a highly linear output voltage with very low static and transient distortion while providing very high dynamic headroom.

And because they're "loafing" at 1/3 their rated current capability, the SD/A-490t's tubes are designed to last the life of the CD player without replacement or need for adjustment.

A "LESS IS MORE" DIGITAL APPROACH FOR CLEANER ANALOG SOUND.

It would be pointlesss to have a tube output stage if the digital circuitry which precedes it

wasn't
first rate. The SD/A-490t uses Single-Bit D/A circuitry to eliminate a form of exceedingly audible distortion inherent in most current CD player designs, and to provide better signal linearity than ever before.

If you've read current CD player brochures, you've probably stumbled across descriptions of de-glitcher circuits, laser trimming and even 22-bit converters. All these are merely fixes, applied to the same basic kind of D/A converter in an attempt to overcome built-in shortcomings.

In contrast, the SD/A-490t uses a completely new technology which avoids many of the problems that older approaches have struggled to surmount. We'd have to buy a whole section in this magazine to fully explain the differences (if you're interested, call 1-800-443-CAVR for an appropriately long and detailed brochure), but here's a short synopsis.

Traditional converters require 16 separate reference circuits, each of which must be accurate to one part in 65,536 — but, due to the realities of mass production, rarely are. If they're not "dead-on", an unpleasant form of noise called *zero-cross distortion* is produced. Because Carver's Single Bit D/A Converter transforms a 16-bit signal into a 1-bit pulse signal array, the "ladder" of 16 ultra-high-precision reference devices is not required. In effect, the SD/A-490t need only manipulate a stream of varying-width on/off pulses instead of having to accurately create 65,536 different amplitude levels at all times.

Zero-cross distortion is non-existent, and the SD/A-490t's Single Bit converter is able to decode linearity in excess of 115 dB below peak level with exceptionally low noise. You'll particularly notice the difference in the heightened purity and clarity of music during very quiet passages. Every nuance, intonation and harmonic of the original recording is there. Yet

The Carver SD/A-490t.
*At $699, its suggested retail is $500 less than the nearest competitor with tube output****

"digital" harshness is noticeably absent even before it enters the SD/A-490t's mink-lined tube stage.

AN ARRAY OF FEATURES AS RICH AS ITS SOUND.

We've designed the SD/A-490t to be both useful and easy-to-use. 21-key front panel or remote programming. Fixed and variable output. Programming grid display. Random "shuffle" play. Variable length fade. Automatic song selection to fit any length of tape. Even index programming for classical CD's.

Plus our proprietary Soft EQ circuitry which compensates for variables in spacial (L-R) information and midrange equalization found in many CD's mastered from analog tapes.

BRING YOUR TWO BEST CRITICS TO A CARVER DEALER.

It's tempting to further regale you with how well we think the SD/A-490t's tubes and Single Bit circuitry improve the sound of a compact disc. But your own ears should be the final arbiter of quality.

Thus you are invited to bring a few familiar compact discs down to your local Carver dealer and compare for yourself, hopefully creating your own superlatives in the process.

Suffice it to say that almost all critical listeners not only are able to hear a difference, but prefer the sound of the remarkably affordable SD/A-490t's dual triode transfer function.

THE SD/A-490t

- Dual 6DJ8 Vacuum Tube Output Stage
- Over-sized Disc Stabilizer Transport
- 24-Track Programming with 21-key front panel & remote input
- Music Calendar Display
- Indexing
- Random Play
- Motorized Volume Control
- Time Edit/Fade Taping Feature with user-variable time parameters
- 2 to 10 Second Variable Length Fade
- Exclusive Carver Soft EQ (Digital Time Lens) circuitry
- Optical and Coaxial
- Digital Outputs
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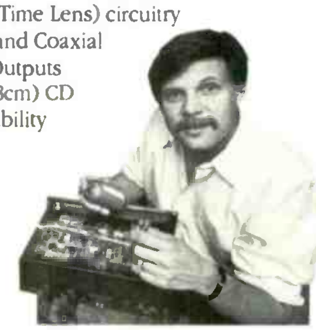

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***Source: 1990 Audio Magazine Annual Equipment Directory.

MONITOR AUDIO STUDIO 10 SPEAKER

Manufacturer's Specifications

System Type: Two-way, vented, stand-mounted system.

Drivers: 6½-in. (16.5-cm) metal-cone woofer and 1-in. (2.54-cm) metal-dome tweeter.

Frequency Response: 40 Hz to 20 kHz, ±3 dB.

Sensitivity: 88.5 dB SPL for 1 watt input at 1 meter.

Maximum Output: 120 dB SPL.

Crossover Frequency: 3.4 kHz, 6-dB/octave slope.

Impedance: 8 ohms nominal.

Recommended Amplifier Power: 20 to 200 watts per channel.

Dimensions: 15¾ in. H × 7⅞ in. W × 9⅞ in. D (40 cm × 20 cm × 25 cm).

Weight: 17 lbs. (7.7 kg) for single speaker.

Price: $3,000 per pair, not including stands. Available in Santos rosewood, California oak, black ash, and American walnut. ST-10 lead-filled metal stands, weight: 66 lbs. (30 kg) each, $850 per pair.

Company Address: P.O. Box 1355, Buffalo, N.Y. 14205.

For literature, circle No. 90

The Studio 10 is Monitor Audio's entry in the field of expensive two-way monitors. The system embodies the results of some of the latest materials and manufacturing research, as evidenced by its use of not only a metal-dome tweeter but also a one-piece metal-cone woofer. All Monitor Audio systems are supplied with premium real-wood veneered cabinets, manufactured by Monitor Audio itself. The review samples were supplied with a pair of massive metal stands that are almost four times heavier than the speakers themselves.

Monitor Audio was the first British speaker company to offer metal-dome tweeters, in 1984. The Studio 10's tweeter is unique in that its dome is made of an aluminum/magnesium (88%/12%) alloy with a gold-colored anodized finish. The anodizing greatly increases stiffness, which raises the first breakup mode above the audible range. The tweeter's voice-coil former is vented and cooled with Ferrofluid to minimize temperature increases.

The 6½-inch woofer uses an aluminum-alloy cone, which is drawn in three stress-relieved steps into a complete one-piece cone and voice-coil former assembly. The heat generated by the voice-coil is conducted through the coil former to the metal cone itself, for improved dissipation. The cone is 100 μm (0.004 inch) thick and is sandwiched between two anodized ceramic damping coatings, 50 μm thick, making a total cone thickness of 200 μm. The cone is also crimped over along its circumference for increased stiffness. The woofer's unique cone materials and construction raise the cone's first breakup mode above 6 kHz, above its operating band. The woofer, which has a vented-pole magnet, is also built with a heavy, 10-mm thick die-cast frame which strengthens the assembly and helps to maintain close production tolerances.

Monitor Audio was founded in 1972 by Mo Iqbal, a Kenyan of Indian descent who studied electrical engineering at Cambridge University. The company is now one of the most vertically integrated speaker companies in the U.K., manufacturing its own drivers, crossovers, and cabinets, and producing cabinets for other British speaker manufacturers. Instead of following standard production-line methods, Monitor lets each worker build a complete product from start to finish. With only one worker per assembled product, there is no one else to blame if something is incorrect or goes wrong!

Monitor Audio's philosophy is that simpler is better when it comes to system and crossover design; their whole line contains only two-way systems. The company feels that this configuration allows more money to be put into developing and manufacturing each driver and the crossover, and that less complex systems allow greater fidelity to be achieved.

The crossover, a relatively simple design, has only six components, equally distributed among resistors, capacitors, and inductors. The slope of the crossover is stated to be 6 dB per octave. The system has two pairs of five-way binding posts on the rear, connected with short lengths of bus wire which may be removed for bi-wiring. Monitor Audio states that the unique design of their drivers allows a simpler crossover because their responses are much smoother and better controlled, both within and outside of their operating bands.

The enclosures are very well built of ¾-inch Medite medium-density fiberboard. They are finished on the front and four sides, while the backs are black. The four sides of each cabinet are produced from one veneered plank of fiberboard so that all the sides match perfectly. The evaluation systems were supplied in a gorgeous, very well matched rosewood. Both outside and *inside* surfaces of the cabinet are veneered with real wood. (Now if I only could figure out how to turn the cabinet inside out because of a scratch on the outside!) The enclosure, which Monitor Audio calls a Single Flow Reflex, is a vented box (bass reflex), tuned by a tube 3½ inches long with a 2-inch inner diameter, at the top rear of the cabinet.

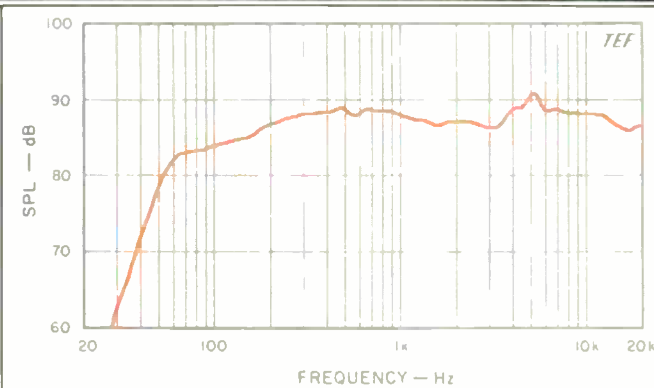

Fig. 1—One meter, on-axis anechoic frequency response, measured with grille off, for an input of 1 watt into 8 ohms (2.83 V rms).

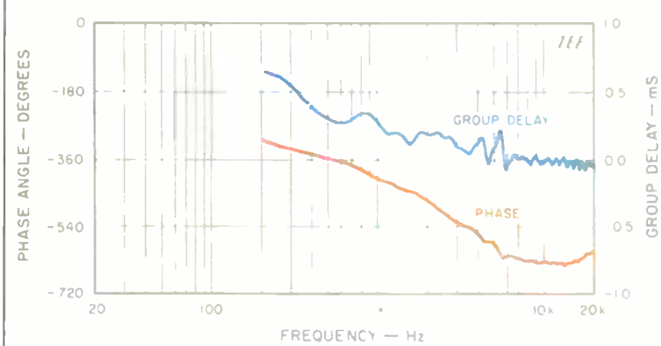

Fig. 2—On-axis phase response and group delay, corrected for tweeter arrival time.

Measurements

The on-axis frequency response curve, for a 2.83-V rms input, is shown in Fig. 1. A tenth-octave smoothing filter was used. The curve was actually taken at a distance of 2 meters, 12 inches up from the bottom of the box, normal to the enclosure's front surface but is referenced to a 1-meter distance. With the grille on, the response was minimally affected, less than ±1.5 dB or so. All the following measurements were taken with the grille off.

Excluding the slight peak at 5.1 kHz, the curve fits within a ±3.0 dB window from 60 Hz to 20 kHz. Even with the peak, the curve fits within a much tighter ±2 dB envelope from 180 Hz to 20 kHz. The response droops below 300 Hz and then falls quite rapidly (at 24 dB/octave, typical of vented boxes) below 60 Hz. Averaging the axial response over the range of 250 Hz to 4 kHz yielded a sensitivity of 87.7 dB,

The woofer's metal cone not only raises its breakup frequency but conducts heat away from the voice-coil.

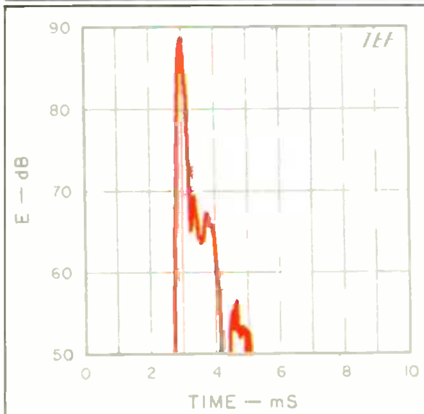

Fig. 3—One-meter on-axis energy/time curve, measured with grille off. The main peak is well behaved, but some broadening is evident at lower levels.

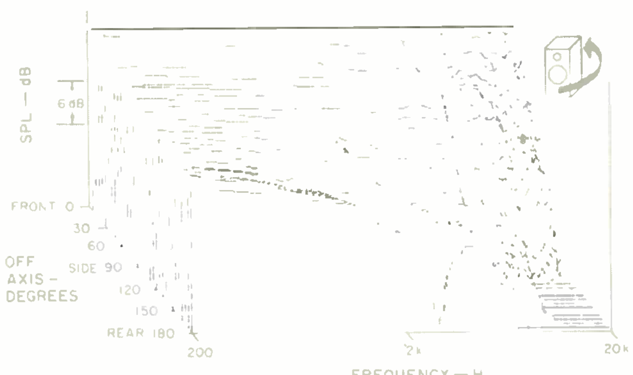

Fig. 4—Horizontal off-axis frequency responses, taken from the front, around the side, to the rear of the speaker and normalized to the on-axis response.

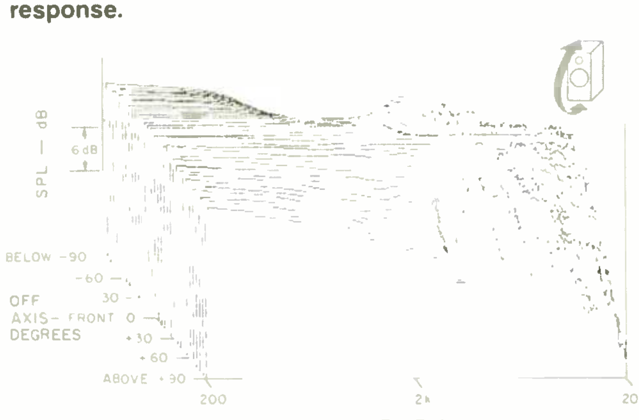

Fig. 5—Vertical off-axis responses taken from below, up the front, and to the top of the speaker and normalized to the on-axis response.

only slightly lower than the manufacturer's rating of 88.5 dB. The systems were matched quite closely, within ±1 dB above 100 Hz. A higher 30-kHz measurement revealed a high-Q dome breakup resonance at 25.8 kHz, which stuck up about 15 dB above the average level of the system. Most metal-dome tweeters exhibit such resonances, but fortunately the Studio 10's tweeter resonance has been raised way above the audible range and should not be a performance detriment.

The axial phase and group-delay measurements of the system, corrected for the tweeter's time arrival, are shown in Fig. 2. The phase response exhibits a total phase rotation of only about 220° between 1 and 20 kHz. The group-delay curve is fairly well behaved above 1 kHz, and shows that the midrange lags the tweeter. A separate measurement of offset indicated that the midrange does indeed trail the tweeter by about 0.11 mS (110 µS), which corresponds to a distance of 1½ inches (38 mm). This is about one-third wavelength, about 120°, at the measured 3.0-kHz crossover.

The energy-time curve (ETC) is shown in Fig. 3. For it, a test signal is swept from 200 Hz to 10 kHz at an equivalent of 2.83 V rms at 1 meter on axis. The main arrival, at 3 mS, is quite compact and well behaved, but the overall response exhibits some broadening at lower levels. (Under these test conditions, a perfect energy-time curve would appear as a single sharp spike centered at 3 mS, with a width of about 1 mS at the base, the 50-dB line, and tapering to a rounded point at the top.)

All the inside surfaces of the cabinet are covered with inch-thick foam to damp internal standing waves and reflections. The sides also have an inert black damping pad, ¼ inch thick, attached to their surfaces to reduce wall resonances. In addition, as the company literature stated, all the inside surfaces are veneered, but not finished, and the veneer is not rosewood.

A high-level low-frequency sine-wave sweep revealed that the cabinet sides and back resonated slightly at about 445 Hz but were otherwise quite rigid. Fairly significant wind noise was generated from the port (from the inside opening, not its tapered outside edge) at levels above 5 V rms (3 watts) at frequencies from 45 to 85 Hz. The woofer's excursion reached a strong minimum at the 60-Hz box tuning, which indicated that the vented enclosure was working very well. Below 60 Hz, where the vented box unloads, the woofer's excursion increased very significantly, accompanied by high distortion. The woofer exhibited some dynamic offset when the impedance fell as frequency increased.

The horizontal off-axis curves of the Studio 10 are shown in Fig. 4. These normalized curves are quite well behaved within ±20° of the axis and exhibit some roughness above 3 kHz at angles beyond 20°. The vertical off-axis curves, shown in Fig. 5, are also quite well behaved except for off-axis peaks and dips in the crossover region. The curves indicate reasonably symmetrical up/down behavior, showing that the driver's acoustic responses are mostly in phase with each other through the crossover region, thus minimizing lobing error.

The six crossover parts are wired point to point and attached by hot-melt glue to the input-terminal panel, which is a piece of ½-inch particleboard. Notwithstanding the 6

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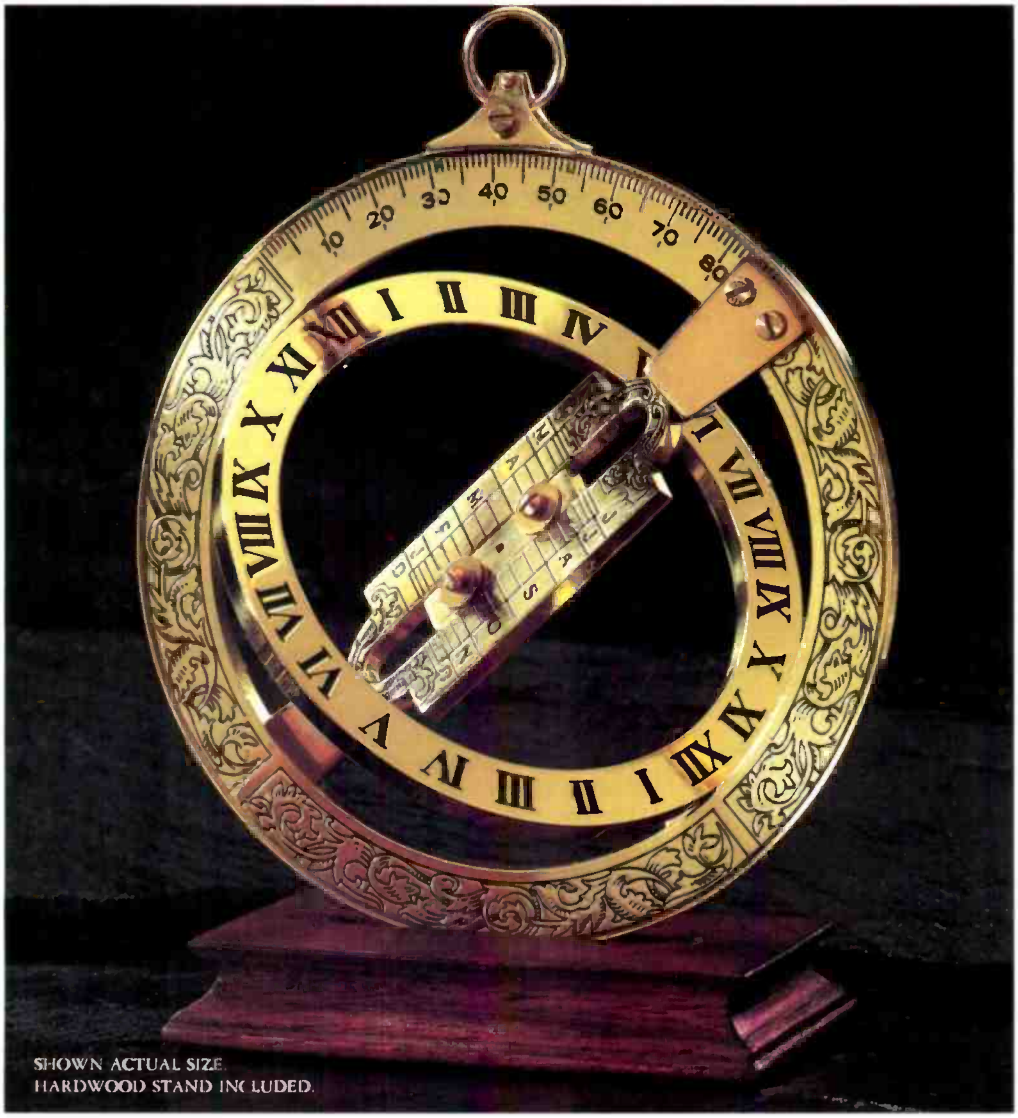

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Except for one slight peak, the frequency response is flat within ±3 dB from 60 Hz to 20 kHz.

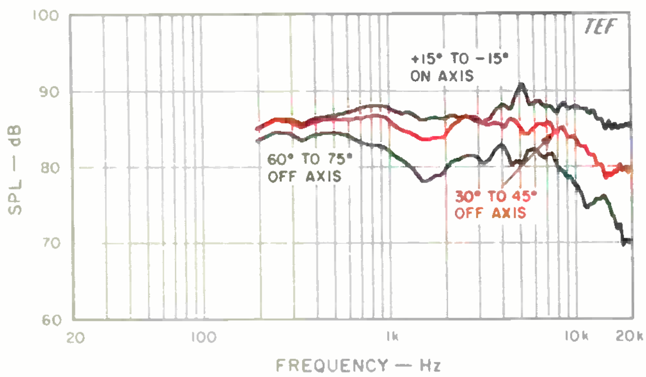

Fig. 6—Mean horizontal response, derived from data of Fig. 4.

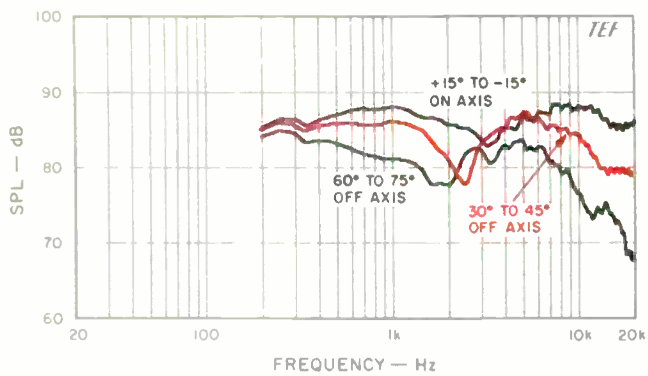

Fig. 7—Mean vertical response, derived from data of Fig. 5.

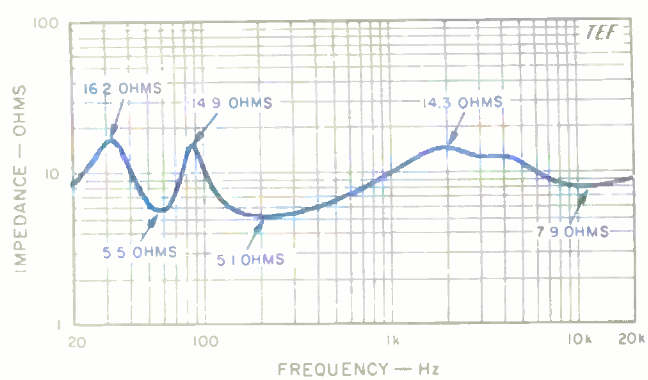

Fig. 8—Impedance; note the logarithmic impedance scale.

dB/octave claimed, both high- and low-pass portions of the crossover are of second-order, 12-dB/octave electrical design. The specific configuration of the low-pass network for the woofer side can be considered either a second-order low-pass or a first-order low-pass with an impedance-compensating "Zobel" network. Response measurements of driver voltage confirmed that the network indeed provides 12-dB/octave roll-offs, at least at points beyond the crossover range. However, this is not the whole story; the actual crossover response consists of the cascaded combination of both the network's *and* the drivers' responses. Measurements of each driver's acoustical response when connected to the crossover revealed that the response within ±½ octave of the crossover frequency is about 6 dB/octave, becoming 12 dB/octave thereafter. Nonetheless, the drivers actually measured somewhat in phase with each other through the crossover region, rather than 90° out of phase, as expected from the 6-dB/octave slope. This explains the minimal lobing error.

The NRC-style mean horizontal and vertical on- and off-axis response curves of the Studio 10 are shown in Figs. 6 and 7, respectively. The horizontal curve in Fig. 6 is quite smooth and extended except for the narrow peak at 5.1 kHz. The 30° to 45° response is fairly well behaved and extended but exhibits high-frequency roll-off above 10 kHz. The 60° to 75° off-axis averaged response exhibits a plateau of sorts above 1.5 kHz, and its roll-off, which begans at 6 kHz, becomes steeper above 10 kHz.

The vertical response of the Studio 10s is shown in Fig. 7. The axial curve exhibits a shallow dip in the crossover region at 3 kHz, which also shows up to a greater degree in the two remaining off-axis mean curves. The off-axis curves both roll off above 5 or 6 kHz.

Figure 8 shows the Studio 10's impedance from 20 Hz to 20 kHz. The system has a low of 5.1 ohms at 200 Hz and a high of 16.2 ohms at 31 Hz, which makes it a fairly easy load for most amplifiers. The characteristic double-humped impedance response of vented enclosures is evident between 20 and 150 Hz. The dip at 60 Hz indicates strong loading at the Helmholtz box resonance. At this frequency, most of the sound is radiated by the port, with minimal output from the woofer. The system's minimum impedance of 5.1 ohms, coupled with its variation of only 3.2× from minimum to maximum, makes the Studio 10 somewhat sensitive to cable resistance. To keep cable-drop effects from causing peaks and dips in response of more than 0.1 dB, cable series resistance must be limited to a maximum of 0.087 ohm (87 milliohms). Figure 9 shows the well-behaved complex impedance (Nyquist) plot from 5 Hz to 24 kHz. The phase angle reached a maximum of +40° at 20 Hz and a minimum of −39° at 105 Hz.

Figure 10 shows the 3-meter room curve of the system, with both raw and sixth-octave smoothed responses. The Studio 10 was in the right-hand stereo position, mounted on its stand, and aimed at the listening location, and the test microphone was placed at ear height (36 inches) at the listener's position on the sofa. The system was swept from 100 Hz to 20 kHz with a 2.83-V rms sine-wave signal (corresponding to 1 watt into the rated 8-ohm load). The parameters of the TDS sweep were chosen so that the

Metal-dome tweeters have resonances, but here it has been raised way above the audible range.

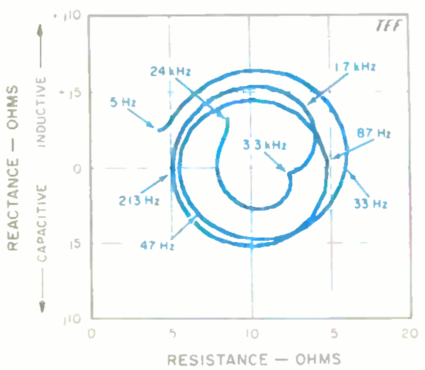

Fig. 9—Complex impedance, showing reactance and resistance vs. frequency.

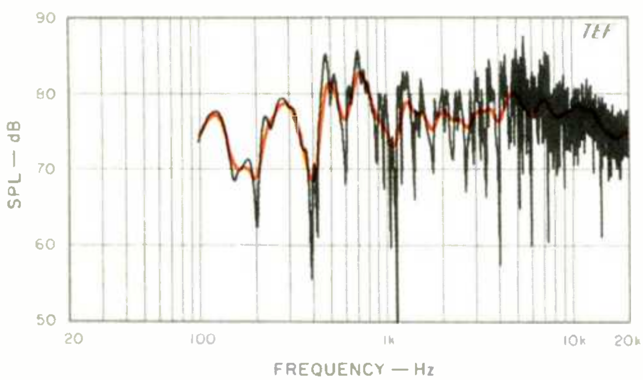

Fig. 10—Three-meter room response, showing both raw and smoothed data; see text.

direct sound plus 13 mS of room reverberation were included. The curve is reasonably well behaved and extended except for response roughness below 1 kHz, and most of this was caused by room effects. Above 1.5 kHz, the curve is satisfactorily smooth, with just a small amount of roll-off above 10 kHz.

Figures 11, 12, and 13 show harmonic distortion versus power at the musical notes B_1 (61.7 Hz), A_2 (110 Hz), and A_4 (440 Hz). These measurements indicate the level of harmonic distortion generated with the application of a single-frequency sine wave at power levels from 0.05 to 50 watts (−13 to 17 dBW, a 30-dB dynamic range) in steps of 1 dB. The power levels were computed using the rated system impedance of 8 ohms (20 V rms = 50 watts, etc.). Actual power levels are somewhat higher because the impedances at each tested frequency are somewhat lower than the rated impedance.

Figure 11 shows the B_1 (61.7-Hz) harmonic distortion data. The higher tone B_1 was used, rather than the customary lower E_1 (41.2 Hz), because E_1 is below the passband of the system and essentially provides no woofer loading because the frequency is about ⅔ of an octave below the 60-Hz box tuning. In a preliminary 41.2-Hz test, 100% second-harmonic distortion was reached at a level of only 15 watts! Inasmuch as B_1 is close to the Studio 10's box tuning frequency, the distortion at 50 watts is a relatively low 12% second and 5% third, with the higher harmonics significantly below 1% (the test's frequency scale only goes up to the fourth harmonic). At 50 watts, the system generated a fairly loud 99 dB SPL at 1 meter at 61.7 Hz.

The A_2 (110-Hz) harmonic data in Fig. 12 show that only the second and third harmonics are significant over the tested range, with the second harmonic predominating. The second harmonic reaches a moderately high level of about 10% at full power, where the third harmonic reaches 6%. Levels of higher harmonics are very low. At 110 Hz, the system generated about 101 dB SPL at 1 meter for 50 watts. The A_4 (440-Hz) harmonic measurements, shown in Fig. 13, are quite low except for some unexplained third harmonic (reaching about 1.5%) at lower power levels.

The IM on a 440-Hz (A_4) tone created by lower frequency tones of equal input power level is shown in Fig. 14. Note that when 41.2 Hz (E_1) is used as the modulating tone, IM distortion reaches 75% at full power! Clearly, E_1 is below the passband of the system. In contrast, with the higher B_1 tone, the distortion is more reasonable, about 15%, at full power. The high IM distortion at low frequencies indicates the system is quite susceptible to being overdriven by high-level program material.

Figure 15 shows the short-term, peak-power input and output capabilities of the system, versus frequency, measured with a third-octave bandwidth tone burst. The peak input power was calculated by assuming that the measured peak voltage was applied across the rated 8-ohm impedance. The maximum input power is shown in the lower curve. At 30 Hz and below, peak power must be limited to only about 2 watts to prevent excessive distortion and intermodulation. Above 30 Hz, the input power rises rapidly up to about 400 watts at the 60-Hz box resonance. A plateau is maintained until about 160 Hz, after which the power rises gradually until it reaches the amplifier's clipping point, about 5 kW at frequencies above 1.5 kHz!

The upper curve in Fig. 15 shows the maximum peak sound pressure levels the system generates at a distance of 1 meter on axis for the levels shown in the lower curve. Also shown in the upper curve is the "room gain" of a typical listening room at low frequencies. This adds about 3 dB to the response at 80 Hz and 9 dB at 20 Hz. The peak acoustic output rises very rapidly with frequency up to 60 Hz, where a plateau of about 110 dB is reached. Above 160 Hz, the maximum output rises to above 120 dB at frequencies above 300 Hz. With room gain, a single Studio 10 can generate peaks in excess of 110 dB SPL above 60 Hz and greater than 120 dB above 250 Hz. Below 60 Hz, the low-frequency output rolls off very rapidly at a rate approaching 48 dB/octave, thus making the low-bass output essentially unusable. A pair of these systems operating with mono bass

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Even with equipment that's not high end, the Studio 10s managed to elicit all that was good in the signal and expose some of the bad.

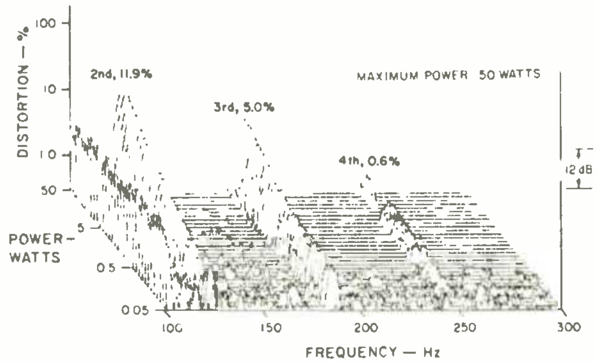

Fig. 11—Harmonic distortion products for the musical tone B_1 (61.7 Hz). Note the change from our customary E_1 (41.2-Hz) tone, which is below the system's passband; see text.

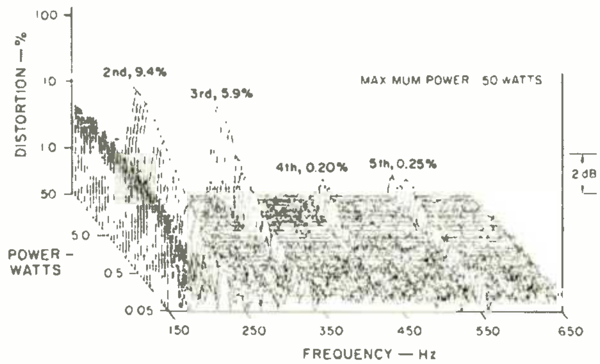

Fig. 12—Harmonic distortion products for the musical tone A_2 (110 Hz).

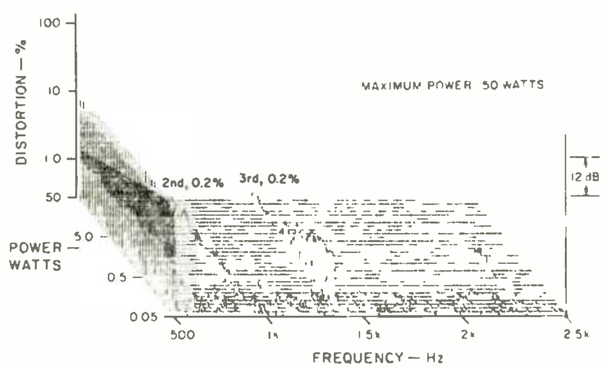

Fig. 13—Harmonic distortion products for the musical tone A_4 (440 Hz). Some third-harmonic distortion is evident at lower power levels; see text.

will be able to generate bass levels 3 to 6 dB higher, particularly if set up near wall boundaries.

Use and Listening Tests

The Studio 10s spent some informal listening time in my office before being moved into the larger listening room. Here they were hooked up to a Vector Research VRX-3600R receiver and a mid-1980s Kenwood DP-1100B CD player. Even with this equipment, decidedly not high end, they made a very good account of themselves, wringing out all the good that existed in the supplied signal along with exposing some of the bad. The Studio 10s are suited to smaller listening environments because of their small size and limited low-bass capability.

After setting up the 10s in my larger listening room and driving them with my standard equipment, they really took on a life of their own. Driving equipment included the usual Onkyo Grand Integra DX-G10 and Rotel RCD-855 CD players, along with some new amplification gear: The Jeff Rowland Consummate preamplifier (a bona fide high-end preamp with full remote-control capabilities) and two Jeff Rowland Model 7 monoblock power amplifiers. Also used was the new Crown Macro Reference power amplifier (I must point out up front that I am a paid consultant to Crown). The Krell KSP-7B preamp and Krell KSA-200B power amplifier performed flawlessly and with much distinction during the period I had them. Hookup was with Straight Wire Maestro interconnects and speaker cables. As usual, I did most of the listening before the measurements.

Most of my serious listening was done with the Studio 10s placed on their stands in my accustomed evaluation position, about 6 feet away from the short rear wall, separated by 8 feet, and about 4 feet from each side wall. Most listening was done with the systems canted in and aimed at my head. I listened sitting on the sofa about 10 feet away, which placed my ears about 36 inches above the floor.

The systems were hooked up in a normal single-cable, rather than bi-wired, configuration. The input terminals of the Studio 10 are on the bottom rear of the cabinet and are composed of two sets of five-way binding posts on ¾-inch centers separated by about 2 inches. (We're not talking about the heavy-duty posts you tighten with a nut driver, but the hand-tightened kind with a small hole for the wire.) You can't plug your standard ¾-inch-spaced double-banana plugs into these terminals because the posts spaced ¾ inch apart are actually for the same polarity. Their small holes are mostly filled with the 22-gauge jumper wires connecting the high- and low-pass sections, leaving essentially no room for the cables from the amp. Spade lugs can be used, but they still have to share space with the bus wires. These are definitely not the well-thought-out connectors you should find on a $3,000 pair of speakers.

The Studio 10s sounded very similar to my B & W 801 Matrix Series 2 systems, except that the low bass was missing and some high-frequency emphasis was evident. In addition, the sensitivities of the different systems were essentially the same. Their soundstaging and imaging were first-rate, and they exhibited a very revealing character.

On the analog-recorded CD *The Choir of Grace Cathedral, San Francisco* (Wilson Audiophile WCD-794/805), an-

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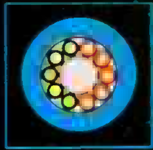

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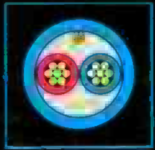

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The Studio 10s were very revealing, and they showed first-rate soundstaging and imaging.

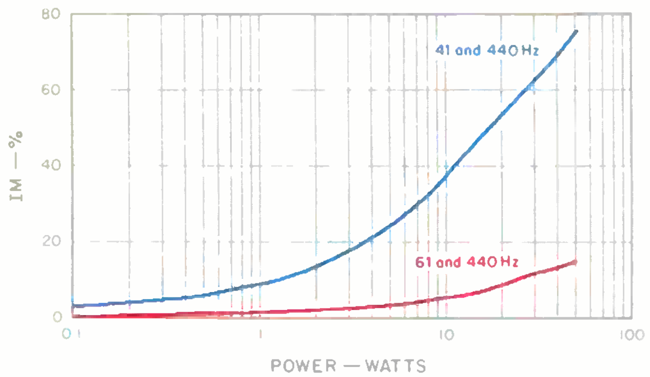


Fig. 14—IM distortion on 440 Hz (A_4) produced by 41.2 Hz (E_1, upper curve) and 61.7 Hz (B_1, lower curve), when mixed in one-to-one proportion. The distortion is excessive with the customary lower frequency modulating tone, but it reaches a more reasonable 15% or so IM at 50 watts with the higher B_1 tone; see text.

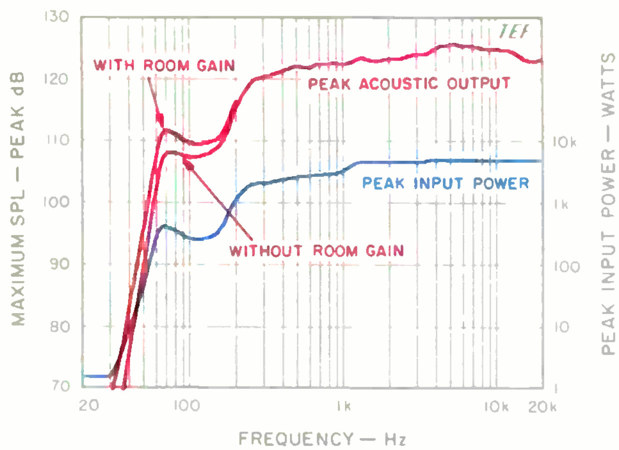


Fig. 15—Maximum peak input power and maximum peak sound output vs. frequency at 1 meter on axis. Above 250 Hz, the system can generate substantial peaks in excess of 120 dB SPL; see text.

other great CD for organ buffs who also happen to like religious music, the Monitor Audios exhibited a slightly more open and forward sound than the B & Ws on the choral tracks, but with diminished low bass. The high-frequency emphasis of the Studio 10s was evident on the tape hiss between tracks. On track 11, between 6:46 and 6:50, there was severe intermodulation of the choir voices by the organ pedal notes at moderate to loud levels. It is clear that not only is the system's low-bass output reduced, but its low-frequency power handling is low as well. A very steep, 50-Hz high-pass filter would be very beneficial to a system that includes Studio 10s. This would greatly reduce IM distortion and dramatically increase the levels at which the 10s can play material with appreciable bass below 50 Hz. A good subwoofer and associated crossover would also be very appropriate for use with the Studio 10s.

The Studio 10s rendering of the lute solos on *O Mistress Mine, A Collection of English Lute Songs* (Dorian CD DOR-90136) was done with much detail and expressiveness. The crisp plucked-string sound and the reverberant decay of the room were delivered very smoothly, with much realism. I actually preferred the Studio 10s' reproduction of the tenor voice on this CD :o my reference systems'. The jazz string-bass line on track 1 of the *Denon High End Hi-Fi Recordings* CD (Denon GES-9515) was re-created very evenly, with none of the upper bass emphasis that is common with some systems.

A great sense of presence and space was generated on the Schubert Trios for Piano, Violin, and Cello on the three-CD set of *The Isaac Stern Collection, The Trio Recordings, Vol. 1* (Sony Classical SM3K 46425). My notes say, "Very musical! Good delineation of instruments." The 10s exhibited a moderate amount of upper-mid tonality changes on the pink-noise stand-up/sit-down test; the reference B & W systems exhibited essentially no change. At 40 Hz and below, on third-octave band-limited pink noise, the speakers' output was unusable and they just generated distortion.

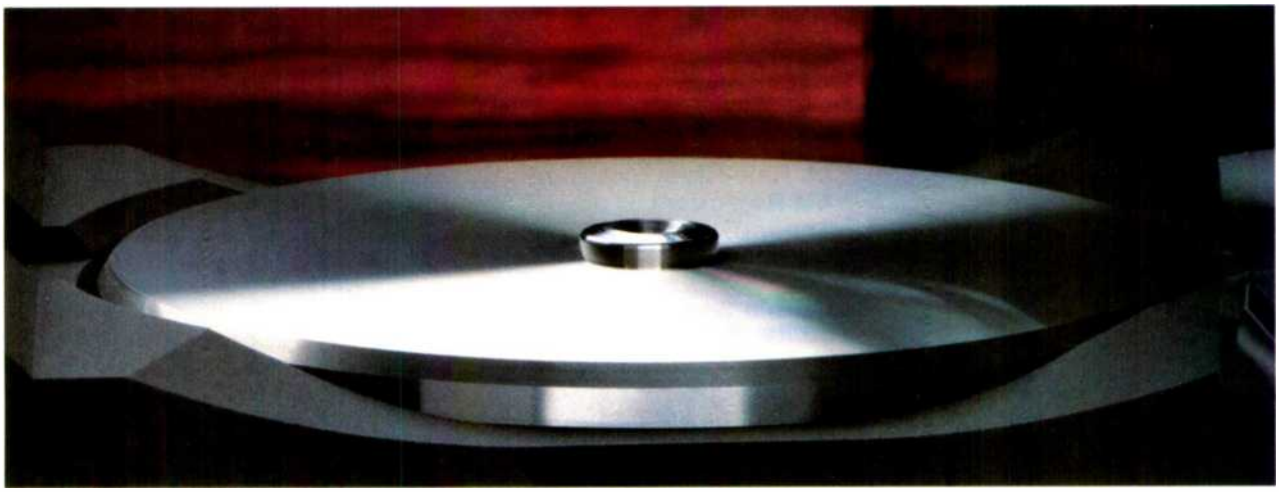
On the *Girl You Know It's True* CD by Milli Vanilli, or whoever the heck sang on that album (Arista ARCD-8592), the Studio 10s just did not have the bass excitement at high levels that the B & W systems had. However, when I listened to the Studio 10s playing the same album in my office, the low end was quite adequate. That room is much smaller, the speakers were positioned close to the walls, and I was much closer to them. This just emphasizes the fact that the Studio 10s do better in smaller rooms—which, of course, is where small monitors are often used.

The Studio 10s have turned out to be very revealing and articulate systems which can be played quite loudly without compromising their fine high-end sonic qualities. However, they have been optimized for usage above 50 Hz, and cannot do justice to program material that has a high content of low frequencies. If you have a large room, and your tastes tend toward music with only a moderate amount of low bass, such as much baroque or chamber music, these systems will do an extremely good job for you. In smaller rooms that prov.de more bass reinforcement, they may satisfy all your needs. However, at a pricey $3,000/pair ($3,850 with stands), they deserve close scrutiny to see if they match your needs. *D. B. Keele, Jr.*

Professional type, balanced output jacks are grounded, and shield the signal against noise

In airline pilots, brain surgeons, and CD players, steadiness is a pretty fundamental requirement.

In the case of our newest CD player, the Elite® PD-75, its rock-solid stability has rocked the world of music lovers and audio critics. As the reviews have rolled in and the



[How A Concept Called The Stable Platter Turned The CD Upside Down.]

awards have been bestowed, it is apparent that the standard for CD players has been advanced dramatically. Behind this success lies a principle that Elite has brilliantly exploited: The mechanical elements of a CD player are just as critical to its quality as its electronic components.

The first significant innovation to come out of this insight is at the heart of the PD-75. The stable platter.

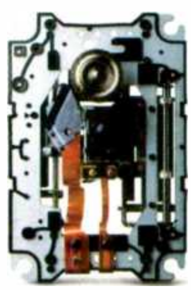
Two basics of physics — mass and inertia — combine to make the stable platter an obviously superior platform to support a disc spinning at high velocity.

The Elite PD-75 Compact Disc Player
Its elegant urushi finish reflects technical elegance within

Next, the stable platter, by supporting the entire area of the CD disc, minimizes wobble and chatter.

A wobbling disc presents a difficult target for the laser, while a chattering disc creates resonance, distorting the signal, which distorts the sound.

Another problem for CDs is gravity. Spinning above the laser pickup and supported only in the center, the disc sags microscopically. Which to a laser beam is significant degradation.



An advanced linear drive motor moves the laser pickup with smooth speed and precision

But on the Elite CD platter, the disc is turned upside down — that is, label down, information side up. The disc lies firmly clamped to a solid surface.

Meanwhile, the laser pickup reads the disc's digital code from above, where it is immune to dust settling on the laser optics.

We invite you to bring your favorite CD to an Elite dealer and demonstrate the advantages for yourself. Give that disc an audience on the PD-75 for what one critic called "a dimension of sound that you have never heard before."

And usher in a new era of stability.

ELITE
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For the name of the select dealers in your area carrying the full line of Elite Stable Platter CD Players, please call 800-421-1606, ext 602 © 1991 Pioneer Electronics USA Inc., Long Beach, CA

Enter No 17 on Reader Service Card

BLAUPUNKT NEW YORK CAR TUNER/ CD PLAYER

Manufacturer's Specifications

FM Tuner Section

Usable Sensitivity: 13 dBf.
Mono 50-dB Quieting Sensitivity: 15 dBf.
S/N: 75 dB.
Frequency Response: 20 Hz to 18 kHz, ±3 dB.
Capture Ratio: 1.0 dB.
Alternate-Channel Selectivity: 85 dB.
Image Rejection: Greater than 80 dB.
I.f. Rejection: Greater than 100 dB.
AM Rejection: 65 dB.
Separation: 50 dB at 1 kHz.

AM Tuner Section

Usable Sensitivity: 20 µV.
50-dB Quieting Sensitivity: 60 µV.

CD Player Section

D/A Conversion: 16-bit linear with two-times oversampling; separate converters for each channel.
Frequency Response: 5 Hz to 20 kHz, ±1.0 dB.
THD: Less than 0.005% at 1 kHz.
S/N: Greater than 90 dB.
Dynamic Range: 90 dB.
Separation: 85 dB.
Track Program Memory Capacity: 18 discs, 16 tracks per disc.

General Specifications

Loudness Control: +8 dB at 60 Hz.
Bass Control: ±14 dB at 60 Hz.
Treble Control: ±10 dB at 10 kHz.
Dimensions: Head unit, 7.1 in. W × 2 in. H × 6.3 in. D (18 cm × 5.2 cm × 16 cm); tuner module, 7 in. W × 1.7 in. H × 3.35 in. D (17.9 cm × 4.3 cm × 8.5 cm).
Prices: $799.95 with one CD cartridge and one open CD cartridge adaptor; pull-out shuttle mount kit, $31.95; additional CD cartridges, $4.95 each.
Company Address: 2800 South 25th Ave., Broadview, Ill. 60153.
For literature, circle No. 91

If you are looking for sophisticated and useful car audio features, Blaupunkt's top-of-the-line New York might turn out to be the Big Apple of your eye. Blaupunkt has always been an innovator in mobile electronic products, and this time they have truly outdone themselves with unusual features. Despite the multitude of features, the FM and CD performance was not among the best I have measured lately. But let's talk about those wonderful features first.

The FM tuner section has two reception modes, toggled by a "HiFi" button. In the "HiFi" mode, frequency response extends all the way out past 15 kHz, while switching "HiFi" off improves reception in weak-signal areas. Among the circuits that switch in and out when going from one mode to the other are two ceramic filters that increase selectivity, an ignition-noise suppressor, and Dynamic Noise Reduction. The DNR circuit improves overall FM S/N ratio during weak-signal reception at the expense of treble response. A great deal of emphasis has been placed on the design of the i.f. section, which has no fewer than 12 poles of filtering, with inductors rather than ceramic filters.

The FM tuner's "HiFi" mode extends the treble response by switching out filters and noise reducers needed only in weak-signal areas.

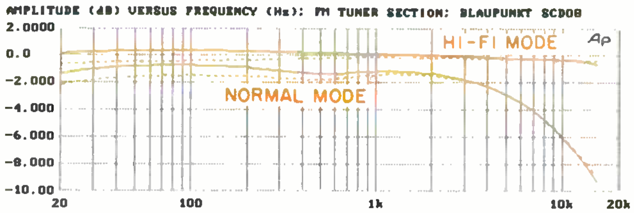
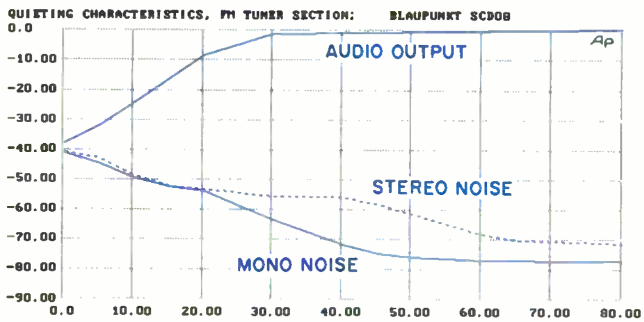


Fig. 1—Frequency response, FM tuner section, for left channel (solid curves) and right channel (dashed curves).



A

B

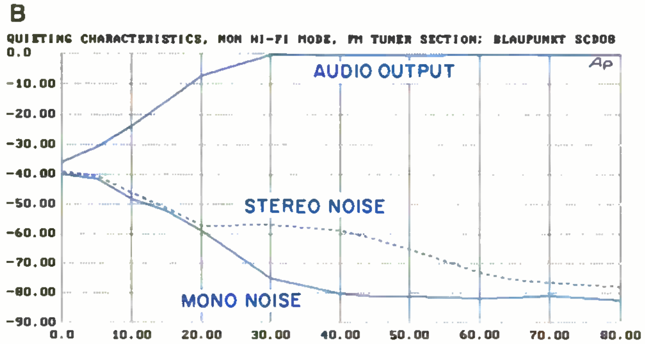


Fig. 2—FM quieting characteristics for "HiFi" mode (A) and normal mode (B).

The tuner can handle a total of 36 presets, 24 for FM and 12 for AM. This includes the contribution of Travel Store, a feature that automatically memorizes the first six strong stations it finds in your area. The tuner also has manual tuning, seek, scan, and preset scan. Seek and scan sensitivity can be adjusted to stop at virtually all stations or just the strong ones. Both local/distant reception sensitivity and mono/stereo blend are switched automatically.

Among the features in the CD player section is a Track Program Memory that "recognizes" up to 18 of your favorite CDs and plays only those selections that you have previously programmed into the New York's memory bank. The player employs a CD cartridge loading system. One cartridge is supplied with the unit, and of course more can be purchased separately. Two types of cartridges were included with the sample I tested. One type seals in the CD, keeping out dirt, dust, and fingerprints that I find invariably end up on the playing surface of CDs whenever I try to load "loose" ones into ordinary car CD players. The other type included with my sample is effectively a cartridge with one end and the top open. You slip this cartridge into the slot and are then able to load loose CDs. I prefer the first type, since that loading method really gets around my chief objection to the whole concept of CD players in cars—the damage to loose CDs that ultimately results from handling them while driving.

The CD player also features track scanning, automatic disc repeat, fast forward and reverse, and pause/play. Disc program search skips forward or backward; which track is accessed depends on how many times you've pushed the appropriate button. The CD playback circuitry employs two-times oversampling plus dual 16-bit D/A converters. Although the New York does not have provisions for an extra input (such as a portable cassette player), you can purchase an interface accessory for connecting a Blaupunkt cassette or DAT deck to the system.

The New York has full-range bass and treble controls and a properly designed loudness-compensation circuit. Perhaps most important of all in these perilous times, a four-digit code system renders the unit useless once it has been removed from its power source, unless the secret code is punched in when reconnecting power. My only problem with such a theft-prevention scheme is the fear that any thieves who steal this lovely head unit, or those who buy from them, won't *know* that it won't work for anyone else unless they know the code, even though the word "Code" is discreetly lettered on the panel. However, a slide-out shuttle bracket is available so you can take the unit with you. The New York, by the way, can be adjusted to mount at angles up to 45° in cars that don't allow mounting it horizontally.

The tuner module accompanying the main chassis has no controls, and only your car antenna needs to be connected to it. It can therefore be mounted out of sight, under the dash, but its final location is limited by the rather short cable provided for connecting it to the unit's main chassis. I was particularly pleased to notice that, at last, Blaupunkt has seen fit to provide an adaptor cable to go from their DIN output connector to four standard phono jacks (two for the front amplifier and two for a rear amplifier). The adaptor also has a separate wire that will serve as a "trigger" for turning on most car amplifiers. There was also a DIN-to-DIN cable that could be used to hook directly to any one of Blaupunkt's four-channel amplifiers or to one of their equalizers.

Control Layout

One of the most welcome features of the front panel is its chameleon-like control markings. When a CD cartridge is inserted, the green illumination of the numbered station

XF 230
XR 240

Blaupunkt's CD cartridge loading system prevents the damage that loose discs undergo in cars.

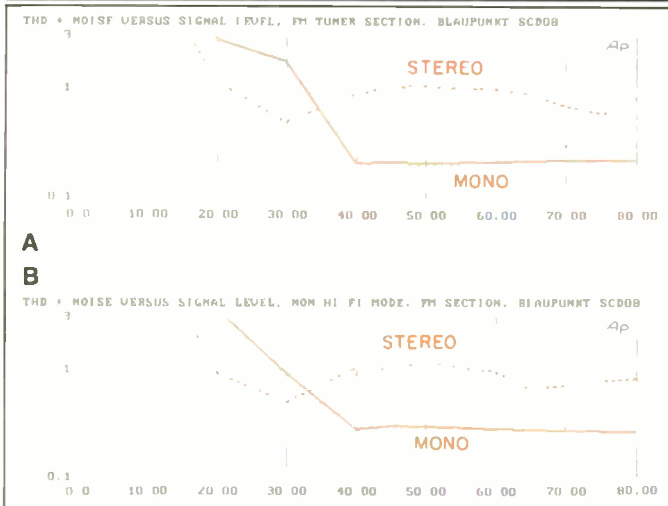


Fig. 3—THD + N vs. FM signal level in "HiFi" mode (A) and normal mode (B); see text.

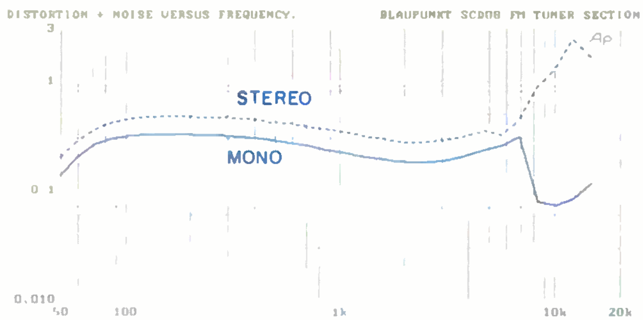


Fig. 4—THD + N vs. frequency, FM tuner section.

preset buttons turns off, and illuminated words appear in red to indicate the CD functions that these buttons now control. That's sure a lot clearer than trying to cram indecipherable double abbreviations onto each button and leaving it up to the user to figure out what they stand for and which are for CD and which for radio.

The "HiFi" on/off button is at the upper left. In early production units, including the samples I and Ivan Berger tested, this button had to be switched on whenever the "HiFi" operating mode was desired, as the set defaulted to the normal mode when it was turned on. Units now in production allow the user to select either mode as the default. A light below the button indicates when the "HiFi" mode is in use. At the lower left is the volume knob, with concentric "Fader" ring and loudness switch. The volume knob also turns the set on and off and, if pulled, becomes the balance control. To the right are recessed bass and treble tone controls (which can be popped up for adjustment) and buttons that select any one of four preset "bands" for FM (counting Travel Store) and two for AM. The six preset buttons to the right of the display therefore command as many as 24 FM and 12 AM stations. Buttons to the right of the presets handle all other tuner functions. A button labelled "PS-TS," if pressed briefly, causes the tuner to scan in succession all stations stored in the AM or FM "bands." Holding this button down for more than 2 S activates Travel Store, automatically memorizing the first six strong stations it finds in the area. The next button, labelled ". . m," cycles the unit through automatic search (seek) tuning with either low (".") or high ("..") sensitivity, then switches it to manual tuning ("m"). The "CD TU" button changes operation between tuner functions and CD playing (if a disc has been loaded into the unit). In both seek and manual tuning modes, a rocker switch in the lower right corner of the panel tunes up and down the frequency band. The "Scan" button just to its left plays every station in the currently selected broadcast band for a few seconds.

When playing CDs, the "PS-TS" and "Scan" buttons become inactive. The rocker switch is now used for track selection. The six buttons previously used for station presets take on new identities and, as mentioned, have red labels instead of their previous green illumination. Button "1" now becomes "TPM" (for Track Program Memory) and is used for choosing and storing the track-playing sequence of up to 18 of your favorite CDs. The second preset button is now used to "Clear" previously stored track sequences. The third button scans all tracks of a CD, playing the first 10 S or so of each track. If this "Scan" button is pressed at the same time as the "TPM" button, only the selections in Track Program Memory will be played, and in whatever order they were programmed. Labels above the "4" and "5" buttons show that they now handle audible fast searching in either direction of play, while button "6" now toggles between pause and play. An eject button at the upper right corner of the panel, next to the CD slot, completes the New York's front-panel layout.

The well-illuminated display area shows station frequency, stereo indication, station preset number, band indication, selected search tuning sensitivity, and memory bank indications when using the tuner functions. When operating the CD player section, the display shows playing time (including total playing time, when a disc is first inserted), Track Program Memory mode, number of the currently playing track, and "Scan" if that function is in use.

Measurements

When I first turned on the New York and began to measure FM frequency response, I didn't believe the results I obtained. After all, the published specification claims a flat response (within ±3 dB) from 20 Hz to 18 kHz, and I seemed to be getting a roll-off amounting to more than 9 dB at 15 kHz. It was then I determined that, on my sample, it was necessary to push the "HiFi" button after turning on the set. Once I did so, response was down no more than

The AM section impressed me with its bass response and its excellent sensitivity, achieving 20 dB S/N with only 20 μV of signal.

about 0.7 dB at 15 kHz. Results of both these tests are shown in Fig. 1.

Since I wanted to see just how much improvement in signal-to-noise ratio I would get by disabling the "HiFi" mode, I ran two tests of the quieting characteristics of the FM tuner section. In "HiFi" mode (Fig. 2A), 50-dB quieting in mono required about 23 dBf of input signal. With "HiFi" defeated (Fig. 2B), 50-dB quieting required about 20 dBf. Furthermore, even at strong signal levels, ultimate S/N was somewhat better with the "HiFi" mode inoperative—better than 80 dB in mono and about 78 dB (at 80 dBf) in stereo, as against 78 dB in mono and 72 dB (at 80 dBf) in stereo. So, as suggested by Blaupunkt, the "HiFi" mode represents a trade-off of signal-to-noise for better frequency response. Of course, at strong signal levels, the difference in S/N is minimal, so I would use the "HiFi" mode whenever possible to obtain flat response.

Figures 3A and 3B show how THD + N varied with signal strength. There was virtually no difference between results obtained with the "HiFi" setting or without it. The results are very strange, however, in another respect. Rarely have I ever seen a situation where distortion at low signal levels is actually lower in stereo than in mono. The curves indicate that this is so, but I think I know what the reason may be. When I plot these curves, I adjust for 100% FM modulation, which, in the U.S., corresponds to ±75 kHz deviation. That's considerably more than the maximum deviation used by European FM stations. Blaupunkt uses superb i.f. filtering to obtain extremely high alternate-channel selectivity, and I suspect that the higher than usual levels of mono THD are the result of this restricted i.f. bandwidth. It is responsible for an apparent "mono usable sensitivity" of 20 dBf. Remember, though, that usable sensitivity is determined by a combination of noise and distortion. As I saw earlier, 20 dBf was enough to produce an S/N of more than 50 dB without "HiFi" turned on. The failure to meet the published usable sensitivity spec must have been due entirely to distortion caused by my high levels of modulation during testing.

So, how come the apparent usable sensitivity (the point at which THD + N reaches 3%) is so much better in stereo? Well, to tell the truth, below about 20 dBf, the set is not actually operating in stereo any longer but has reverted to mono. Nevertheless, my modulation now consists of only 90% left-channel-only, not 100%. This corresponds to a deviation of ±67.5 kHz instead of ±75 kHz, just enough of a decrease to reduce the distortion caused by the set's i.f. bandwidth limitations. The 19-kHz pilot signal, which remains on throughout the stereo plot, produces the additional 10% of FM modulation.

Figure 4 is a plot of THD + N versus modulating frequency, for mono and stereo, in the "HiFi" mode. Mono THD + N was a bit more than 0.3% at 100 Hz, slightly more than 0.2% at 1 kHz, and 0.26% at 6 kHz. In stereo, results were somewhat higher: 0.46% at 100 Hz, 0.35% at 1 kHz, and 0.33% at 6 kHz.

Figure 5 shows how FM separation varied with frequency. At strong signal levels (represented by the difference between the upper solid curve and the lower dashed curve), separation measured 50 dB at 1 kHz, exactly as claimed. Separation was still a very high 45 dB at 100 Hz and 37 dB

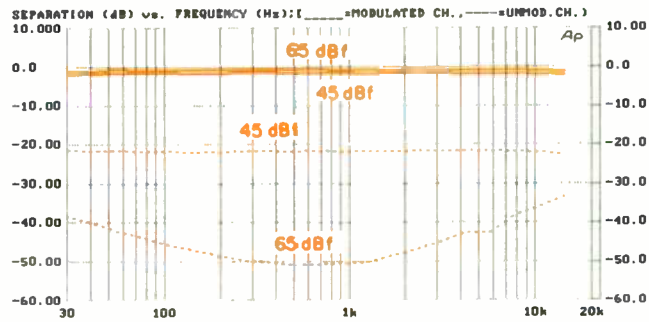


Fig. 5—FM frequency response and separation at two signal levels. Modulated channel shown by solid curves, unmodulated channel by dashed curves.

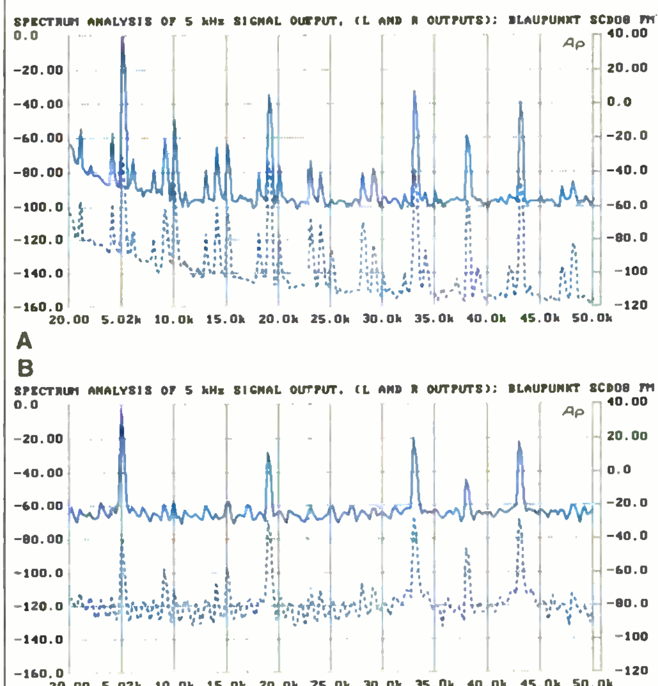


Fig. 6—Spectrum analysis of crosstalk and subcarrier products for FM stereo signal with one channel modulated by 5 kHz (solid curve) and the other channel unmodulated (dashed curve) for "HiFi" mode (A) and normal mode (B).

Deviation from linearity for dithered signals from −70 to −100 dB ranks with the best I've yet measured for a car CD player.

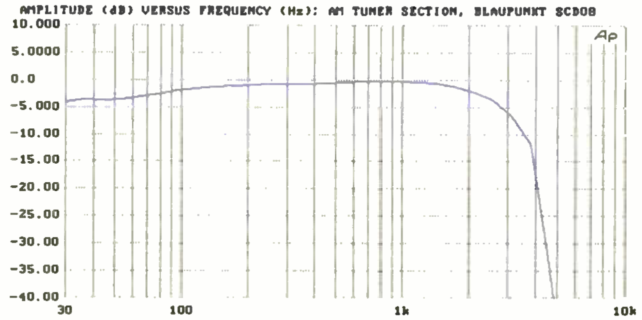


Fig. 7—Frequency response, AM section, for signal with new standard 75-µS pre-emphasis.

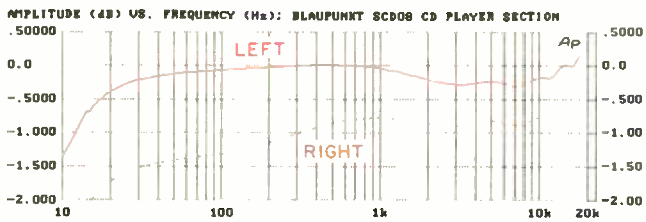


Fig. 8—Frequency response, CD player section, from 10 Hz to 20 kHz; see text.

at 10 kHz. The effect of blending is evident when signal strength is reduced to 45 dBf. Yet even at that low signal level, separation remained more than 20 dB across the entire frequency spectrum—enough to yield a perfectly satisfactory stereo soundstage, particularly in an automobile.

I suspected that there would be a difference in FM stereo crosstalk and distortion products with and without the "HiFi" mode engaged. Accordingly, I ran my spectrum analysis test twice, using a 5-kHz signal to modulate only one channel to 100%. Results are shown with "HiFi" on (Fig. 6A) and off (Fig. 6B). While the 5-kHz separation seems to be a bit greater with "HiFi" turned off, notice how much more prominent the residual 19- and 38-kHz subcarrier signals are in this mode. Additional tests made for the FM tuner in "HiFi" mode confirmed the very high rated alternate-channel selectivity of 85 dB and the superb i.f. rejection of greater than 100 dB. Capture ratio was 1.3 dB, and image rejection measured close to 90 dB.

I was impressed with the low-frequency response of the AM tuner section (Fig. 7). However, even though treble response extended beyond 3.0 kHz, that's a long way from meeting the goal of the National Radio Systems Committee (NRSC) of having AM tuners exhibit essentially flat response to at least 7.5 kHz. Sensitivity of the AM tuner, meanwhile, was excellent, with a 20-dB S/N ratio achieved with only 20 µV applied to the antenna input.

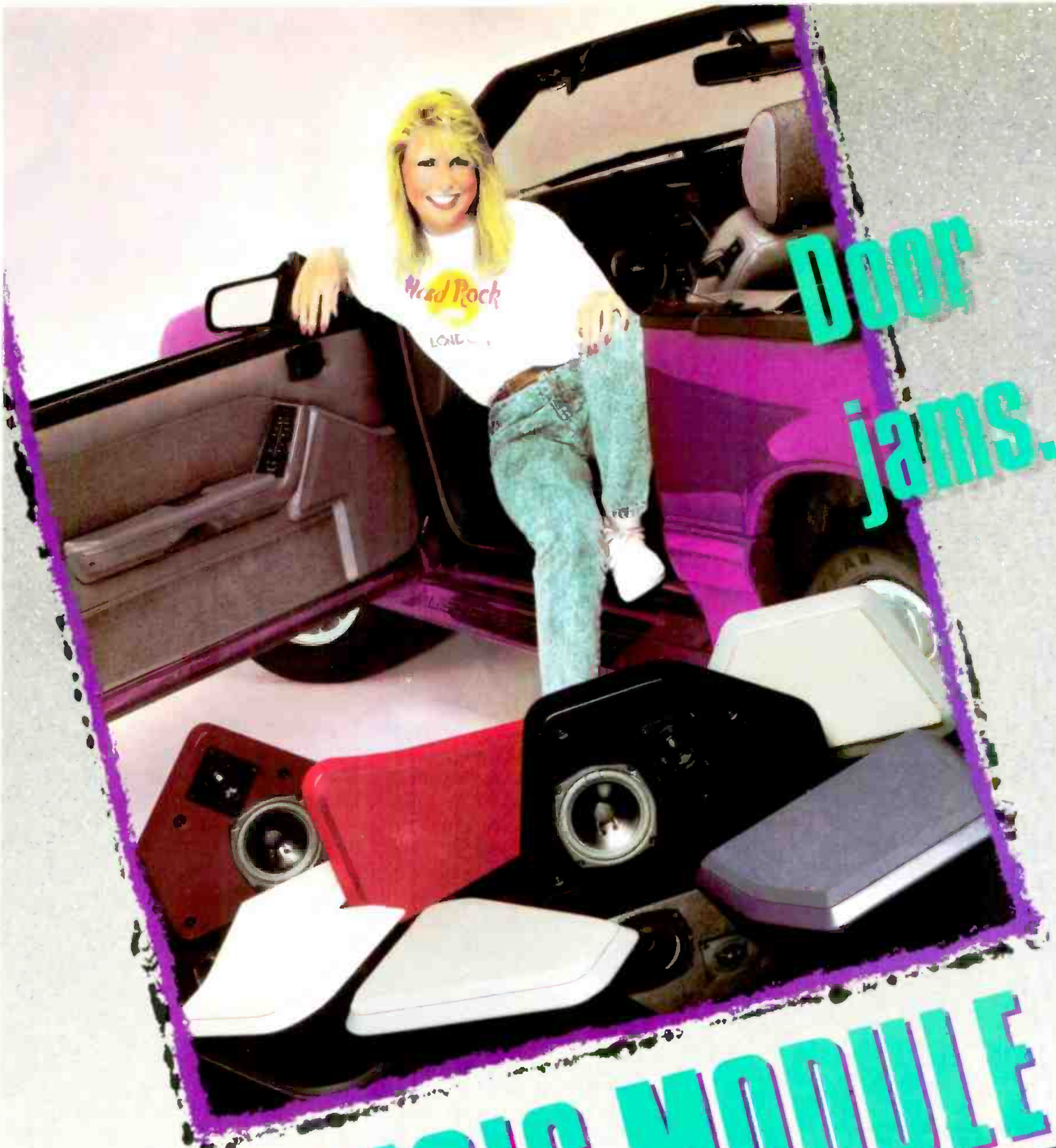
In checking frequency response of the CD player section, I was somewhat shocked to find a channel imbalance greater than 0.7 dB at mid-frequencies and even greater at lower frequencies. Results of the simultaneous response plots for both channels are shown in Fig. 8. Certainly, a half dB or so of channel imbalance is nothing to get too upset about, but in view of the fact that output levels from left and right channels were virtually identical for the FM tuner, I can't imagine why this difference in output should have occurred when the New York operated in the CD player mode. Of course, it can be argued that the expanded vertical scale I use in making the CD player measurements tends to exaggerate the difference. I would point out, on the other hand, that it's the same scale I use for testing all CD players, and I can't remember seeing such a significant difference in output level between left and right channels. In any case, it would be an easy enough matter to correct this with the balance control, and chances are that another sample would not even exhibit this condition.

Figure 9 shows how THD + N varied with frequency for the CD player. At 1 kHz, THD + N was less than 0.005%, as claimed. At higher frequencies, the rise in the curve was caused largely by out-of-band, inaudible beats. Figure 10 shows how THD + N varied with recorded signal level. It is obvious from this plot that Blaupunkt designed an excellent analog audio section, for even at maximum recorded level (0 dB), there was practically no rise in distortion relative to maximum level. At lower levels (below −20 dB), THD + N hovered around the −90 dB point, which corresponds to a percentage of 0.0032% below maximum recorded level. The −87.5 dB reading at 0 dB corresponds to 0.0042%, providing close correlation with the result for 1-kHz maximum recorded level shown in Fig. 9.

From a spectrum analysis of a 0-dB, 1-kHz signal played back through the CD section of the New York, I determined that the actual distortion components were primarily the seventh and ninth harmonics at levels of around −88 and −90 dB. Calculating the effective THD from those figures, I came up with a value of 0.00506% for harmonic distortion, close enough to the previous results.

The A-weighted S/N for the CD player section was 95.5 dB for the left channel and 95.4 dB for the right channel. A spectrum analysis of the residual noise at the output of the New York while playing the "silent" track of my CBS CD-1 test disc showed that residual noise was at or below −110 dB from about 30 Hz to 4 kHz, rose to about −102 dB at 30 Hz and 20 kHz, and reached a low of −120 dB at 200 Hz. Figure 11 shows how separation varied with frequency, measuring 75.5 dB from left to right and 81.6 dB from right to left at mid-frequencies. Even at 10 kHz, worst-case separation was still in excess of 70 dB.

Figure 12 is a plot of deviation from perfect linearity. With undithered signals, linearity at −90 dB was off by between 2.2 dB and 3.0 dB (depending on the channel measured). For low-level dithered signals ranging from −70 to −100



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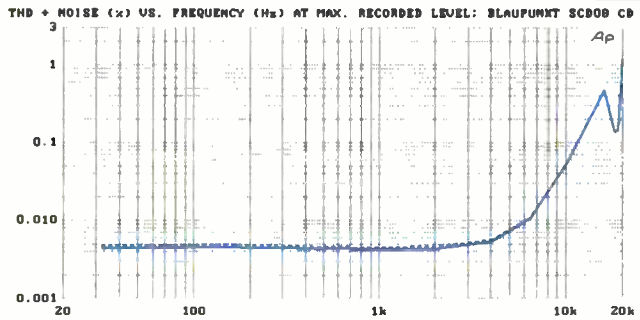


Fig. 9—THD + N vs. frequency, CD player section, in percent relative to 0-dB level.

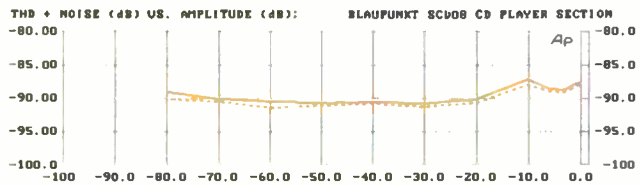


Fig. 10—THD + N vs. signal amplitude, CD player section, relative to 0-dB level.

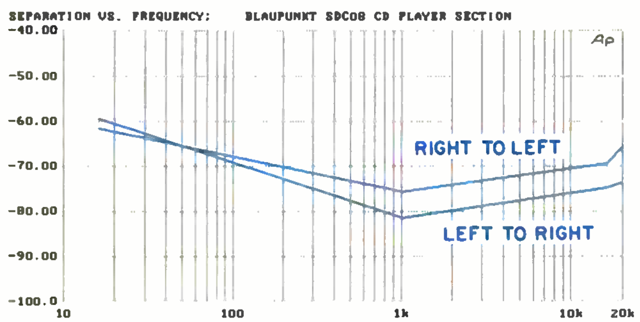


Fig. 11—Separation vs. frequency, CD player section.

dB, deviation, while not the lowest I have measured for all types of CD players, was still among the best I have seen for a car CD player. These results were further confirmed when I ran the fade-to-noise test shown in Fig. 13. This test, employing dithered signals, plots deviation from linearity and increase in noise for a signal varying linearly from −60 to −120 dB. From the results in Fig. 13, I was able to ascertain the player's figure for EIA dynamic range, which amounted to just over 100 dB. With the EIAJ method, dynamic range measured 92 dB for the left channel and 92.4 dB for the right.

The real-time plot of a unit pulse reproduced by the New York revealed that this player does not invert polarity of recorded signals. Other tests made for the CD player section included a spot test of SMPTE-IM distortion at maximum recorded level, which turned out to be 0.0109% for the left channel and 0.0128% for the right. Internal clock accuracy was such that reproduced tones were within 0.0107% of absolute accuracy.

Finally, I measured the range of the bass and treble tone controls; the results (Fig. 14) come close to the rated values. In my opinion, Blaupunkt offers a bit too much bass boost for a car unit, though I know full well that they are probably responding to demands of the marketplace which dictate that thundering (if exaggerated) bass is what "good" car audio is all about. We purists, who don't go along with this, have the option of keeping the control flat, of course, while bass-hungry car audio buffs can drive their power amplifiers as far into overload distortion as they please!

I was very pleased to note that Blaupunkt is one of the few companies that understands what a loudness compensation circuit is supposed to do. Reduced setting of the New York's volume control resulted in *only* gradually increasing amounts of bass boost, with no alteration of the treble response.

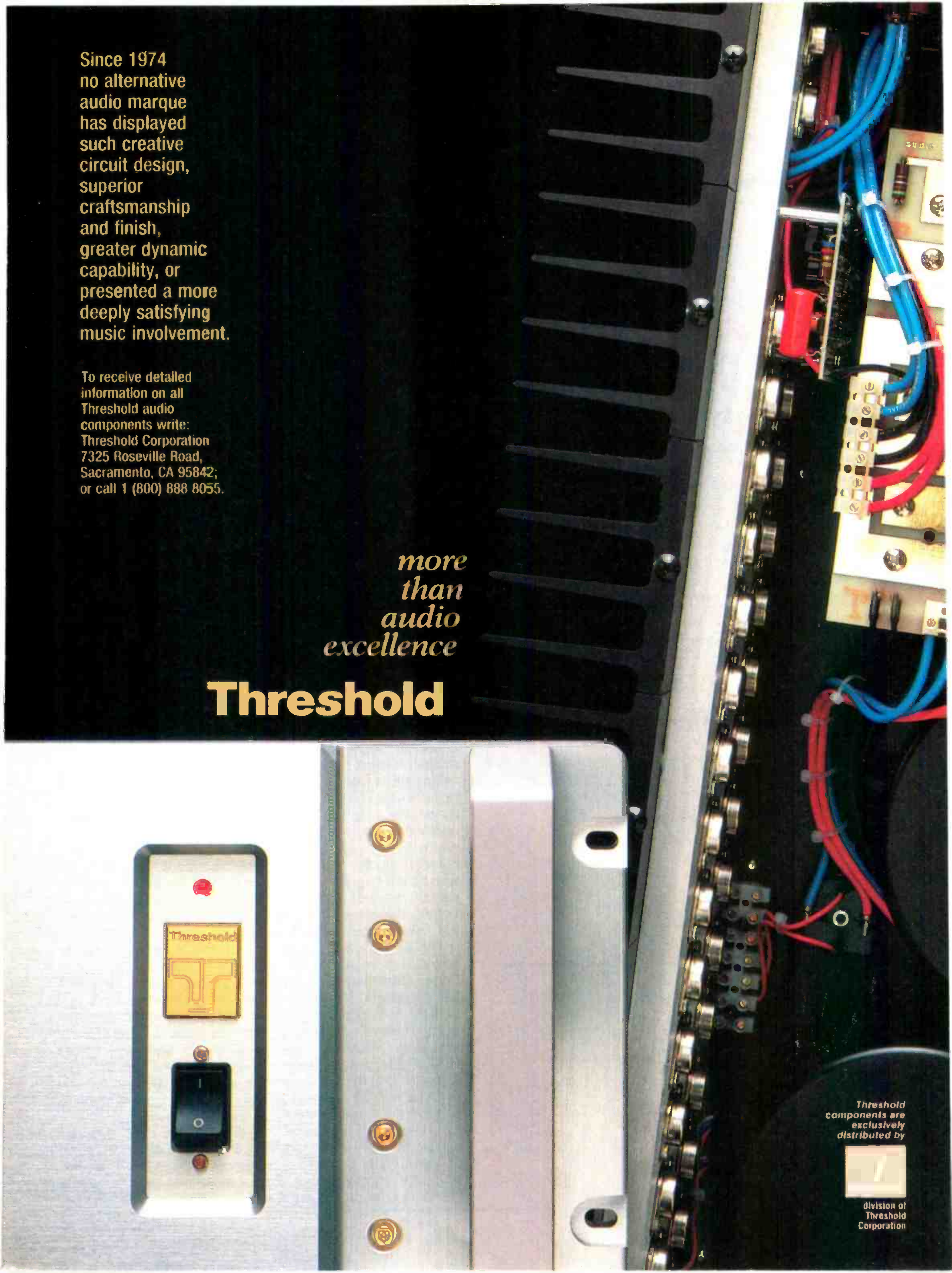
There is so much that's great about this well-designed head unit that I was almost reluctant to point out the minor flaws, such as the slight but surprising channel imbalance of the CD player section (which may well have been peculiar to my sample alone). I thoroughly approved of the convenience features. I liked the cartridge loading system used for CDs, and the easy-to-use Track Program Memory. I do wish the memory could accommodate more than 18 CDs, but I suppose 18 will satisfy most users. FM reception was very good in my lab, and I will be anxious to hear how well the set performs on the highway when Technical Editor Ivan Berger installs it in his car and gives it a "test drive."

Leonard Feldman

Behind the Wheel

Blaupunkt's CD cartridge loading system (which is also used by Clarion and Yamaha) will probably appeal more to those who use the same discs most of the time than those who play a wide variety of discs and constantly try new ones. In the former case, spending $4.95 each for extra CD cartridges beyond the one supplied, and spending time transferring CDs into them, will seem a worthwhile exchange for the resulting disc protection and convenience. Otherwise, the supplied cartridge adaptor that accepts naked CDs will be an utter necessity.

Overall, the New York's ergonomics are straightforward and useful. The layout is good, with audio controls and radio band switches on the left, CD and tuning controls on the right. The preset tuning buttons are in two rows of three instead of one long unbroken row. Having the double-arrow up-and-down buttons for tuning located right next to the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While the New York manages to cram in every feature that I want, you don't need a map and a graduate degree in engineering to use it.

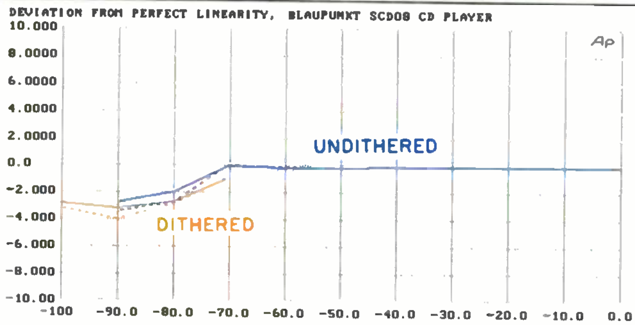

Fig. 12—Deviation from perfect linearity for dithered and undithered signals.

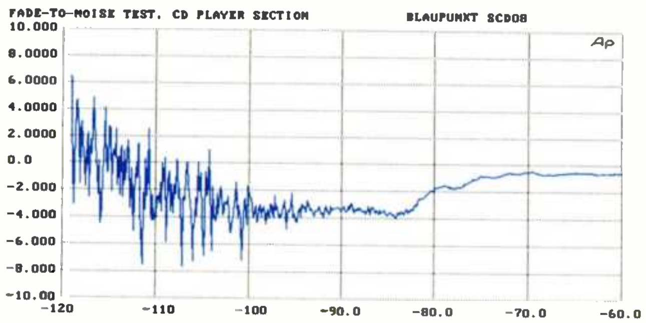

Fig. 13—Fade-to-noise test.

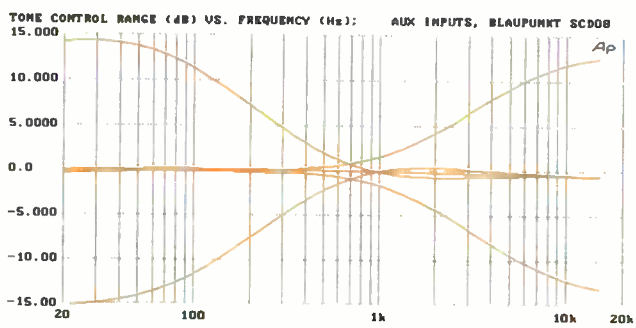

Fig. 14—Bass and treble control range.

"Scan" button lets you move easily back to a station you have passed.

The display was exceptionally informative and very easy to read at night or on overcast days but was washed out by daylight. When the unit is shut off, nothing glows to help you find it in the dark. Yet once it's on, all controls are decently illuminated and the disc loading slot has a faint glow. The change in button illumination as you switch between radio and CD was a big help, especially at night.

The New York has every tuner feature one could ask for—every known tuning mode, automatic local/distance switching, adjustable scan sensitivity, and station memories for every contingency (including travel). Counting Travel Store, which finds six strong stations within seconds and programs them into a separate memory bank, this head unit can memorize 24 FM and 12 AM station frequencies—which is plenty. And the preset scan button runs through *all* the FM or AM presets, not just the currently selected bank.

I couldn't have asked for more CD features, either, though some might want controls for a CD changer. The display shows the time within track as well as the track number; access features include audible fast-forward and rewind, Track Program Memory for your favorite cuts on 18 CDs, and scanning of the first 10 S of every track as well as the usual track search. After such interruptions as a severe bump, switching to the tuner, turning the ignition on and off, or even removing the unit and replacing it in the dash, play resumes from the very place on the disc where it left off.

The New York's FM reception was almost, but not quite, as good as my reference unit's. The difference in sensitivity was very slight, but there were places where my Soundstream could separate two stations on the same or adjacent channels better than the Blaupunkt did. The New York mutes on weak signals, which blocked out some marginally listenable stations but ensured I wouldn't get drowned in noise when I tuned to a station that had long gone out of range. Pressing the "HiFi" button definitely sharpened and clarified the highs, though it also muted the signal for an annoying second. But it only helps on good signals, so I favor having the normal mode as the default. The FM sound was basically good, warm but not unacceptably so. The AM section traded off some high-frequency response to get better interference rejection; that's reasonable, but I wish the "HiFi" button worked on AM too.

The sound on CD was also on the warm side, not as sparkly—or as harsh—as some car CD players I've heard. Oscar Peterson's piano tone on "You Look Good to Me" (*We Get Requests*, Verve 810047-2) lost its percussive edge, and the rosiny bow sounds of the double bass lost their buzz. However, the triangles sounded appropriately silvery and airy. *Elizabeth Schwarzkopf Sings Operetta* (Angel CDC-47284) had a trace of nasality at first, but a slight tweak of the tone controls got rid of that. Bumps did not unsettle the CD player unless they were severe enough to unsettle the passengers as well.

All in all, the Blaupunkt New York provided every feature I could wish for without requiring a map and an engineering degree to use. Its radio reception was excellent, its sound was clear and agreeable, and for those who want it, it offers the extra disc protection of cartridge loading. *Ivan Berger* α

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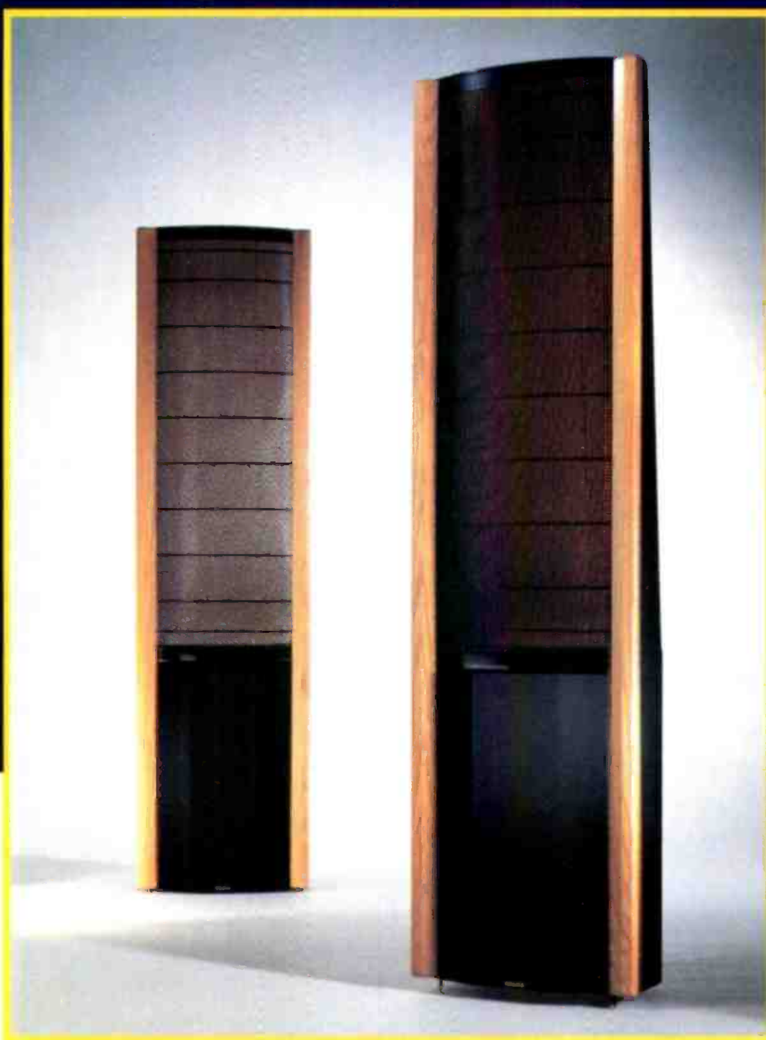

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3

CARY AUDIO CAD-50 and CAD-50SL MONO AMPS

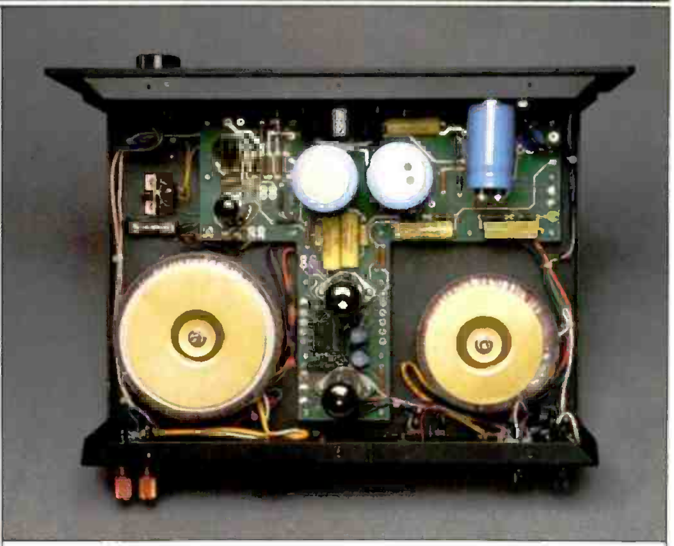
Manufacturer's Specifications
Power Output: 50 watts at 1 kHz.
Frequency Response at 1 Watt Output: 20 Hz to 20 kHz, +0, −0.75 dB; 15 Hz to 20 kHz, ±2 dB.
THD at Rated Power: 2.5%.
Hum and Noise: 80 dB below rated output.
Damping Factor: Greater than 30.
Input Sensitivity: 1.5 V for full output.
Input Impedance: 100 kilohms.
Circuit Type: Push-pull amplification in Class AB1.
Tube Complement: One ECC83/12AX7 pre-driver, one 12BH7 phase inverter, two EL34 output tubes.
Power Requirements: 100 to 125 V a.c., 50/60 Hz; export version, 220 V a.c., 50 Hz.
Dimensions: 17 in. W × 5¾ in. H × 12 in. D (43.2 cm × 14.6 cm × 30.5 cm).
Weight: 35 lbs. (15.9 kg) each.
Prices: CAD-50, $1,295 per pair; CAD-50SL, $1,495 per pair.
Company Address: 101J Woodwinds Industrial Ct., Cary, N.C. 27511.
For literature, circle No. 92

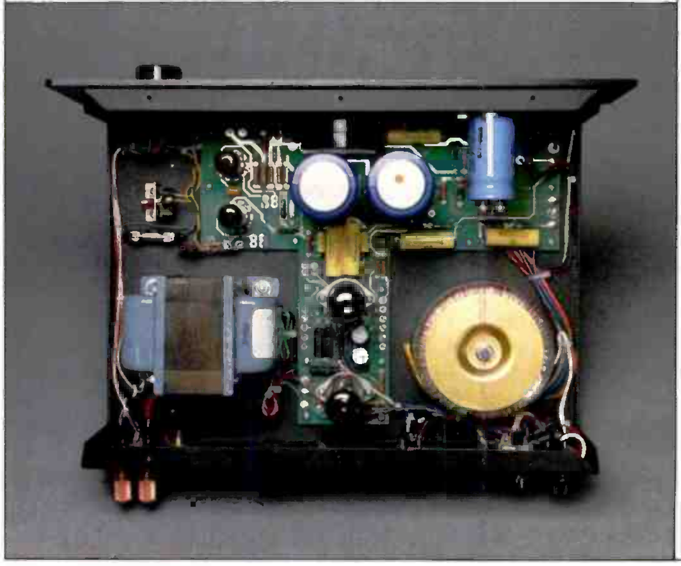
I first learned about Cary Audio Design from an advertisement in an "underground" hi-fi magazine in late 1989 that showed a top view of one of their tube power amplifiers with its cover removed. I was intrigued to see that it used a toroidal output transformer. At the Winter 1990 Consumer Electronics Show, I visited Cary Audio's booth and heard some very nice sound coming out of Dahlquist speakers. I discovered that Cary makes a 100-watt tube power amp with stacked toroidal output transformers, in addition to their 50-watt units. They also make a tube preamp, a CD processor/high-level tube preamp, and a hybrid four-channel power amp using tube front-ends with solid-state output stages.

I then arranged to get some of Cary's amplifiers for review. What they finally sent was two pairs of amps, one the general-purpose CAD-50SL that uses an EI-lamination output transformer, and the other the special-purpose CAD-50, with a toroidal output transformer, whose performance is optimized for bass frequencies. This quartet of amps makes up the Cary Reference System, intended for use as a biamplified system. It just so happens that I have on hand a Martin-Logan Monolith III speaker system that I have been experimenting with and listening to. This system is committed to biamplified use, with a low-level active crossover, and therefore is tailor-made for trying out the Cary Reference System.

I liked the appearance of these units at first sight. They have meters on their front panels, as all God's tube amplifiers should. Other front-panel attributes include a rocker-type on/off switch and a rotary knob for selecting which output tube's plate current will be read on the meter. This control has a third position labelled "Class A" for monitoring the sum of the two plate currents. The use of this term is misleading, in my considered opinion, as it implies the amplifier's mode of operation is Class A when the knob is put in that position.

On the rear panel we find a pair of Edison Price Music Post speaker connectors, outrageously appropriate for large wire and spade lugs; they easily accommodate the thick spade lugs on the Cardas speaker wires that I use.





Also on the rear panel are Tiffany phono connectors for signal "Input" and for "Remote" turn-on and turn-off of the amp, a pair of knobs for adjusting output-tube bias (plate current), two line fuses, a gold-plated ground post, a two-position rotary switch for changing the output tubes' mode of operation from pentode to triode, and the power cord.

Chassis construction is straightforward, consisting of a piece of aluminum bent up to form the rear panel, bottom, and front subpanel. Another piece of aluminum is bent to form the top and side cover. This latter piece is perforated on the top and sides with many small, round holes for ventilation. Inside, the output and power transformers are mounted directly to the bottom of the chassis. A T-shaped p.c. board mounted on stand-offs above the bottom of the chassis carries the amplifier signal circuitry, including the tubes and main power-supply filter capacitors. A 3/16-inch-thick front panel is mounted to the front subpanel to dress up the finished appearance of the unit.

Parts and build quality are excellent in these units. My only complaint is that there are too many screws holding on the top cover!

Circuit Description

The circuit is quite conventional in topology. A number of tube power amplifiers built over the years have used similar circuitry. The first stage (Fig. 1A) is a common-cathode amplifier with paralleled tube elements, direct-coupled to the second stage. This second stage, configured as a split-load phase inverter, again with paralleled tube elements, is capacitor-coupled to the output-tube control grids. High-quality Sidereal brand 0.22-µF, 600-V film capacitors are used here and are bypassed with Sidereal 0.01-µF, 600-V units. The output stage (Fig. 1B) has a switch for operating the tubes as pentodes or triodes. In pentode mode, the screen grids are connected to the B+ supply; in triode mode, the screens are connected to the tube plates. This feature gives the present-day user the ability to experience the old "Pentode/Triode controversy" by listening to these two types of output-tube operation. When the amps are triode-connected, power output is lower (usually somewhat

Just by flipping a switch on the Cary amps, you can relive the controversy over triodes versus pentodes in amplifier output stages.

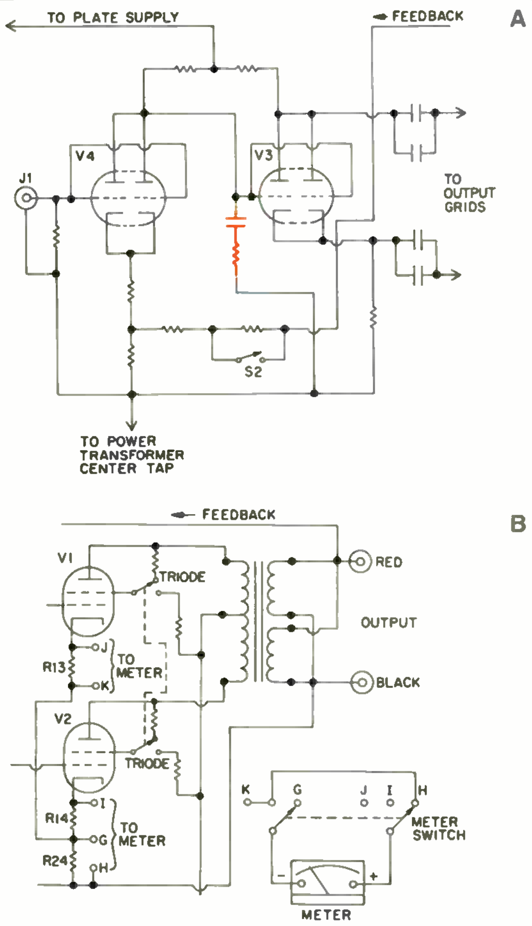


Fig. 1—Initial stages (A) and output stage (B) of CAD-50 and CAD-50SL amps. Note RC circuit used to add mild bass boost to CAD-50, and feedback level switch S2 (A), as well as triode/pentode switch and metering system in output stage (B).

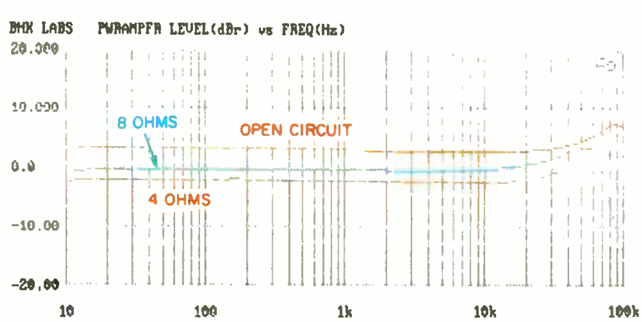


Fig. 2—Frequency response of CAD-50SL vs. load.

less than half that attainable in pentode operation), output impedance is lower, and distortion is less dependent on load conditions. When the tubes operate as pentodes (actually as beam-power tubes, which most of the modern output tubes really are), power output is higher, output impedance is higher, and distortion is more dependent on loading and usually has more higher order odd harmonics. The basic reason for higher power when output tubes are pentode-connected is that saturation voltage, the minimum voltage across the tube when fully turned on, is quite a bit lower in the pentode connection and therefore the voltage swing is larger for the same plate-supply voltage, producing more power output.

A clever arrangement is used in the cathode circuit of the output tubes to measure the plate currents on the front-panel meter. Resistors R13, R14, and R24 are all of the same value. The meter, a milliammeter with a calibrated series resistance which turns it into a voltmeter in actuality, is switched across each of these resistors in turn. When across R13 or R14, the meter will indicate the individual plate currents of each output tube. When switched across R24, the meter will read the sum of the two plate currents because both of these currents flow through R24. It is this latter condition that is termed "Class A" on the front-panel meter switch.

An overall negative feedback loop is connected from the output transformer secondary back to the first-stage cathode. Mounted on the p.c. board is an internal two-position toggle switch (S2 in Fig. 1A) that allows for a change of several dB in the amount of feedback. The units were measured and listened to in the "greater feedback" position. Secondary winding configuration of the output transformer consists of two windings in parallel. Cary's specifications don't indicate what load impedance the transformer secondary loading is optimized for. Dennis Had, designer of the Cary Audio gear, indicated in a conversation that "best match" was set for about 8-ohm loading. We'll find out something about this subject in the measurements section of this profile.

As for the power supply, the high-voltage secondary winding on the power transformer is full-wave rectified with solid-state rectifiers, and loaded with a capacitor input filter consisting of two 320-µF, 450-V electrolytic capacitors. This main filter capacitance is bypassed by one of the Sidereal 0.22-µF, 600-V film capacitors. Interestingly, the rectifier diodes are also bypassed by a pair of these capacitors. This presumably absorbs some of the transient energy when the diodes start and stop conduction, and it may well improve the sonic quality of the amplifier. The tube heaters all operate off a.c. in this design.

Measurements

Voltage gain and sensitivity was measured first for both the CAD-50 and CAD-50SL amplifiers and was found to be 16.6×, or 24.4 dB, for both designs when set for the pentode mode of output-stage operation. The IHF sensitivity, the input voltage for 1 watt into 8 ohms at 1 kHz, was 169 mV for both amps. When set in the triode mode, voltage gain was some 3 dB less, with a commensurate decrease in input sensitivity.

In its triode mode, the CAD-50SL's square-wave response into 4 ohms at 10 kHz is as nice-looking as any solid-state amp's.

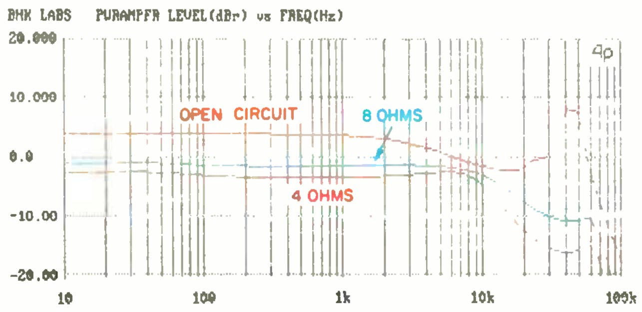


Fig. 3—Frequency response of CAD-50 vs. load.

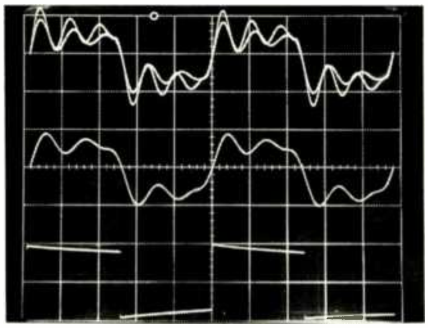


Fig. 4—Square-wave response of CAD-50SL in pentode mode at 10 kHz into 4-ohm and 8-ohm loads (overlaid traces, top), 10 kHz into 8 ohms paralleled by 2 μF (middle), and 40 Hz into 8 ohms (bottom). Scales: Vertical, 5 V/div.; horizontal, 20 μS/div. for 20-kHz traces, 5 mS/div. for 40-Hz trace.

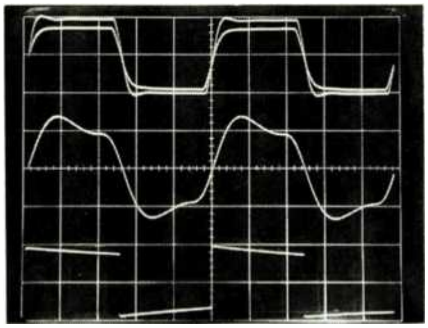


Fig. 5—Same as Fig. 4 but for triode operation.

Frequency responses at the 1-watt level into 8 ohms are shown in Fig. 2 for the CAD-50SL and in Fig. 3 for the CAD-50. Each figure includes curves for open-circuit, 8-ohm, and 4-ohm loading. Doing this gives us a measure of the output impedance's magnitude and its uniformity with frequency, and a good look at the out-of-band behavior of the output transformers. As can be seen, the general-purpose CAD-50SL has the simpler behavior and wider bandwidth. This amp's output impedance is essentially uniform up to beyond 10 kHz and is on the order of 3 to 4 ohms. Of interest, its high-frequency response is more peaked when it is loaded, contrary to the usual behavior of tube output circuits with output transformers. When the CAD-50SL was set to the triode mode, the peaking between 20 and 100 kHz was gone at all loadings from open-circuit down to 4 ohms; output impedance fell to about 2 or 3 ohms.

Looking at the curves for the bass-oriented CAD-50 (Fig. 3), we see just the opposite, the more normal variation of high-frequency peaking or damping with loading. Another attribute of the CAD-50's frequency response is a mild bass boost below a few hundred Hz, about 1 dB at 20 Hz. This was deliberately designed into the amp and is caused by the RC network loading the first tube's plate circuit (Fig. 1A). Needless to say, this network is absent in the CAD-50SL. Note that this boost is virtually absent in the open-circuit load curve, as the greater feedback loop gain under this condition takes out this open-loop frequency response aberration. Output impedance variation is somewhat more complicated in this design, especially in the region above a few kHz. Generally, the output impedance is a little higher in the CAD-50, more on the order of 5 to 6 ohms. Given the measured characteristics discussed, the use of the CAD-50 as a bass amp seems appropriate.

An in-depth look at how the CAD-50SL's behavior changes between triode and pentode operating modes can be seen in its reproduction of square waves (Figs. 4 and 5). In the pentode mode, shown in Fig. 4, the 10-kHz traces (top and middle) show quite a bit of ringing, which relates to the frequency response curves of Fig. 2. The top trace shows response for 8-ohm loading, overlaid on a smaller trace for 4-ohm loading. The amount of high-frequency ringing exhibited by the CAD-50SL in pentode mode is by no means intrinsic to pentode operation of an output stage, but is a consequence of the way this amp's high-frequency compensation was designed. The middle trace shows the effect of adding a 2-μF capacitance across an 8-ohm load. The capacitor actually reduces the amount of ringing and slows down the rise-time. The 40-Hz square wave (bottom trace) indicates relatively good, extended low-frequency response below 10 Hz, the limit of Fig. 2. Figure 5 shows square-wave behavior in the triode mode. High-frequency damping is much better, most likely due to the considerably lower overall circuit-loop gain and lower output impedance of the tubes in the triode mode. The waveshape for 4-ohm loading (smaller of the overlaid top traces) is as nice-looking as that for any solid-state amp. However, putting 2 μF across the 8-ohm load causes more ringing overshoot and slowing of the rise-time than in the pentode mode. The low-frequency droop in the 40-Hz (bottom) trace is also just perceptibly worse than that in the pentode mode.

With the Cary amplifiers and Spica speakers, it was easy to forget amps and stuff and get involved with the music.

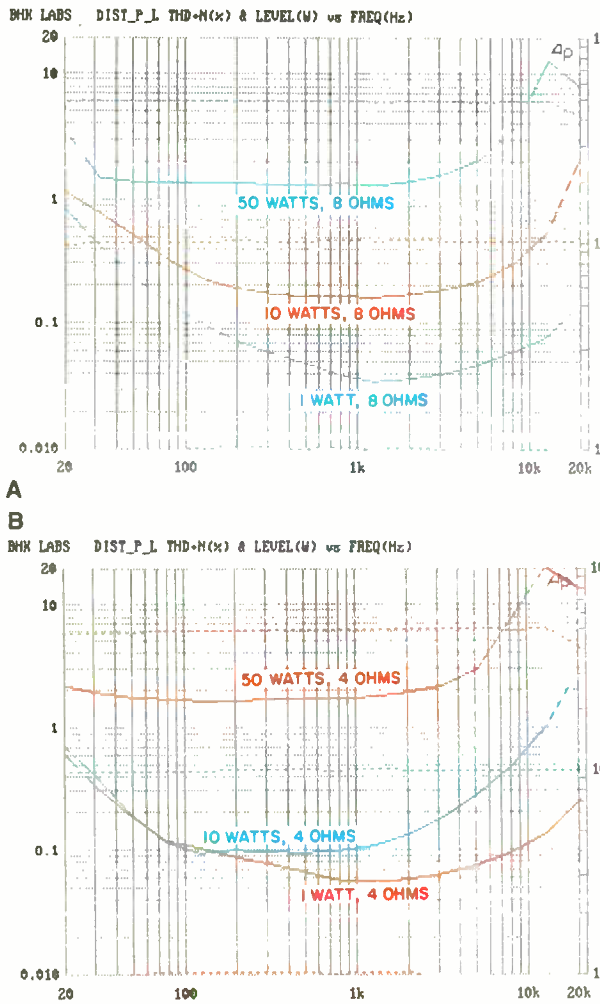


Fig. 6—THD + N vs. power and frequency for 8-ohm load (A) and 4-ohm load (B) for CAD-50SL. Dashed curves are actual power output vs. frequency at the indicated levels (see text); read power from right-hand scale.

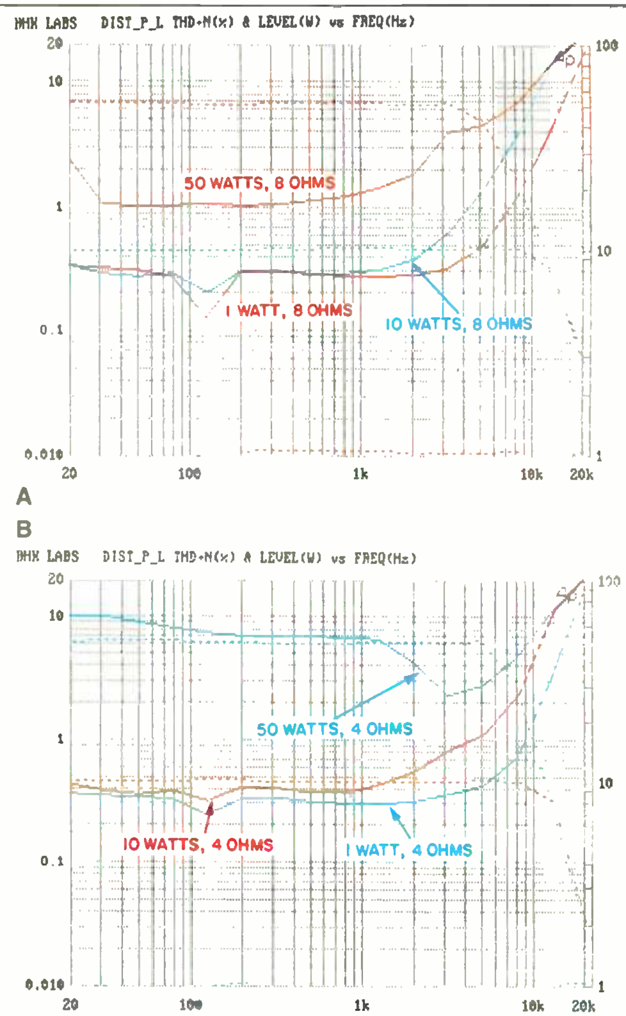


Fig. 7—Same as Fig. 6 but for CAD-50 (see text).

Harmonic distortion plus noise is plotted as a function of frequency, power, and load in Figs. 6A and 6B for the CAD-50SL and in Figs. 7A and 7B for the CAD-50. It's evident from the figures that the CAD-50SL is a somewhat better performer. On these graphs, the solid curves show distortion levels and the dashed curves show power output versus frequency. These tests were done in a regulating mode whereby the generator drive to the amplifier under test is regulated to produce a constant specified power output over the frequency range. In the case of the CAD-50, I let the loop go out of regulation above 4 kHz so the distortion wouldn't get completely out of hand. As a result, the power output dropped below 50 watts above this frequency, as shown by the dashed output curves at the 50-watt level in Figs. 7A and 7B. (For the CAD-50SL, Figs. 6A and 6B, regulation was terminated above about 12 kHz.) Another weirdness in the CAD-50's behavior is the dip in distortion at 120 Hz at lower power levels. This was caused by 120-Hz power-supply ripple in the amplifier output cancelling the distortion residue at this frequency. In Fig. 8, 1-kHz THD + N and SMPTE-IM distortion are plotted against power output and load for the CAD-50SL amp in the pentode mode. The

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The amps sounded more refined and sweet in triode mode, but in pentode mode they were livelier.

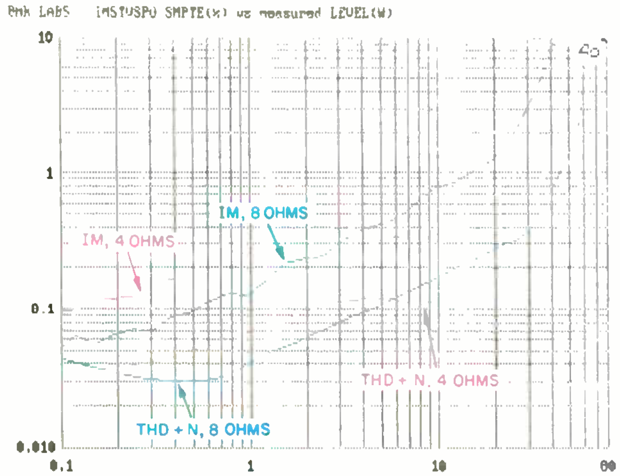

Fig. 8—THD + N and SMPTE-IM distortion for CAD-50SL into 4- and 8-ohm loads.

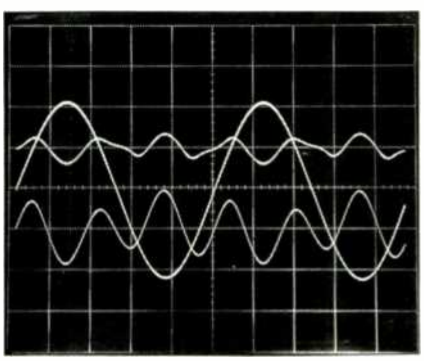

Fig. 9—Output and distortion residue at 10 watts out from CAD-50SL into 4 ohms. Distortion levels were 0.61% in pentode mode (upper residue trace) and 1.6% in triode mode (lower residue trace).

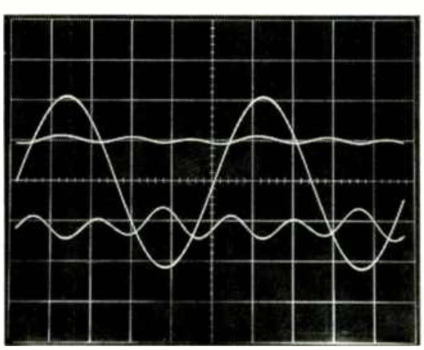

Fig. 10—Same as Fig. 9 but for 8 ohms. Residue was 0.17% in pentode mode (upper trace) and 0.66% in triode mode (lower trace).

wiggles in the 8-ohm IM distortion curve below 1 watt are artifacts of the way my Audio Precision test gear was set and are not really variations in distortion.

The CAD-50SL's distortion residues for a 1-kHz signal at 10 watts output in pentode and triode operation are shown in Fig. 9 for 4-ohm loading and in Fig. 10 for 8 ohms. In each figure, the top distortion-residue trace is for pentode operation and the bottom trace is for the triode mode. The distortion residue for pentode operation into 4 ohms (top trace, Fig. 9) is typical of pentode operation at significant fractions of maximum power and shows an aberration near the signal peaks that produces higher order odd harmonics. When the amp is triode-connected and driving 4 ohms, there is more distortion but it's simpler in nature. The 20-watt level (not shown) was just about at clipping in the triode mode. In Fig. 10, it can be seen that the distortion in both modes is lower in amount when 8-ohm loading is used, and both modes produce dominant third harmonic. Incidentally, these distortion traces show excellent even-harmonic distortion cancellation, a measure of push-pull balance, as all the distortion residues are symmetric about the horizontal zero-distortion time axis.

Output noise measurements for the CAD-50 and CAD-50SL are enumerated in Table I. Some 120-Hz power-supply ripple in the output is the main contributor to the rather high numbers for the CAD-50. This could easily be audible with a high-efficiency woofer system. I don't know why the CAD-50 amps had this 120-Hz ripple in the output, but since the circuits are nominally the same as in the CAD-50SL units, it may be some effect of using a toroidal output transformer. Noise levels for the CAD-50SL are more in line with what they should be.

Data for dynamic and clipping headroom for each unit set in the pentode mode are enumerated in Table II. For some reason, the CAD-50 is a bit weaker than the CAD-50SL, especially when loaded with 4 ohms. All considered, best performance from these amps is likely to come from using speakers with a nominal impedance of 6 to 8 ohms.

Some miscellaneous data and information: Plate current when the meter needle is centered on the red square, indicating correct setting, is about 65 mA. At idle, B+ is about 465 V, and a.c. line draw is about 1 ampere.

To summarize all measurements, good points include excellent push-pull balance, generally low magnitude and low order of distortion products at listening levels with the CAD-50SL, and a relatively constant output impedance over a wide frequency range. Not-so-good points would be the amps' inability to deliver their rated 50 watts at reasonable distortion, excessive ringing and high-frequency peaking in the CAD-50SL, and a very high output impedance that produced damping factors on the order of 1 to 2.

On to what they sound like—which is the real proof of the pudding.

Use and Listening Tests

Signal sources used to evaluate the Cary Audio tube amps were an Oracle turntable fitted with a Well Tempered arm and a Spectral Audio MCR-1 Select cartridge, a Magnavox CDB-560 CD player feeding into a Wadia 2000 decoding computer, a Nakamichi 250 cassette deck, and a

The numbers don't tell you how believable the Cary amplifiers sound, especially when played at full blast.

Technics 1500 open-reel recorder. For LPs, the Vendetta Research SPC-2B phono preamp was used. The outputs from the Vendetta and the other signal sources were connected to my reference selector and switched attenuator unit and thence out to the power amp and speaker location. Other amplifiers on hand were a Berning EA-2101, my own EAR 519s, an Air Tight ATM-1, and a pair of Carver Silver Sevens. Am I a tube freak, or what?

Speakers used were the Siefert Research Magnum III, the Martin-Logan Monolith III, the Spica Angelus, and an experimental model from Genesis Technologies. When I first received the amps, I was using the Siefert speakers, and my listening notes indicated that the CAD-50SL units sounded musical and non-irritating on those speakers. At the time, I thought that the Carys sounded most like the EAR 519s in tonal balance and relative upper midrange softness. After completing the measurements, I got down to some more serious listening with the other speakers.

I first set up the Spica Angelus speakers, and after getting an idea of how these speakers sounded with the various amplifiers on hand, I hooked up the CAD-50SL amps. The overall sound was a little laid-back and smooth in the upper midrange and treble region. Bass quality and extension were good with these speakers. Again, I found the overall tonal balance of the midrange and treble most like that of the EAR 519s. The other three tube designs mentioned are all brighter than these two amps. There are, of course, other very good attributes to the sound of these other amplifiers (covered in my published and forthcoming reviews of them). Since I tend to favor a softer treble presentation, I really liked the combination of the Angelus speakers and the Cary CAD-50SL amps. It was easy to forget amplifiers and stuff and get involved with the music. After all, what are amplifiers for?

I did experiment with the triode/pentode switch quite a bit and generally found the sound in the triode mode to be more refined and sweet. The pentode mode sounds livelier, and I found myself in that mode the most—though at the levels I mostly used, the amplifier was not clipping even in triode mode.

I then set up the Martin-Logan Monolith IIIs, first using a home-built duplicate of the power-amp section of the old Marantz 1120 (which I designed) as a bass amp. I have been using this amp for bass with the Monoliths, and it generally is okay but not great in this application. The Cary CAD-50SL amps were used to drive the electrostatic panels of the speakers. After warming up this arrangement for a while, I put the CAD-50 amps in for the bass and now I had the full boogie going, with all four Cary Audio units being used as Cary intends in their reference setup. I first put on the Telarc recording of Prokofiev's *Alexander Nevsky* (CD-80143) to check bass balance on the bass drums. That was pretty good right off, and I noticed I wasn't getting much, if any, movement of the plate current meters on the bass amps. So I sez, "Let's crank it up a bit and get some MODULATION going here!" I put my switched attenuators all the way up, which simply puts full CD output to the low-level crossover and power amps. Wow! Did that ever sound good! I then proceeded to play a number of things that I like at full blast and found that the Cary amps do play these Martin-Logan speakers quite loudly—and the speakers play quite loudly, too! The believability of the music coming out of the speakers certainly belies some of the less-than-perfect measurements these Cary amps exhibited. Backing down a bit and listening to more favorite music at normal levels, this combination of elements sounded downright outstanding. I noticed that the transition from bass to midrange appeared seamless when I used the same kind of amps for both ranges of the speaker. Boy, if one uses the analogy of good audio gear being like bottles of good wine, and the consideration is which kind of wine do we wish to experience at this moment, I was getting a bit drunk on this great collection of tube amps and speakers.

On a more serious note, the 120-Hz ripple I commented on in the measurements section proved to be easily audible through the woofers in the Martin-Logans. This, I hope, is just a problem of my particular sample pair of CAD-50 amps. Otherwise, they worked without a hitch. These are neat amplifiers and should appeal to those whose musical tastes regarding tonal balance are similar to my own. Do go out and give them a listen. *Bascom H. King*

Table I—Output noise. The IHF S/N was 90.9 dB for the CAD-50SL and 68.1 dB for the CAD-50; see text.

Bandwidth	Output Noise, mV CAD-50SL	Output Noise, mV CAD-50
Wideband	0.95	7.3
20 Hz to 20 kHz	1.01	7.3
400 Hz to 20 kHz	0.055	0.33
A-Weighted	0.081	1.1

Table II—Dynamic and clipping headroom. Clipping level for the CAD-50SL in triode mode was 21 watts into 8 or 4 ohms.

Dynamic Headroom (Pentode Mode)

	CAD-50SL		CAD-50	
Load	Power, Watts	Headroom, dB	Power, Watts	Headroom, dB
8 Ohms	58	0.64	56	0.5
4 Ohms	55	0.41	47	−0.27

Clipping Headroom (Pentode Mode)

	CAD-50SL		CAD-50	
Load	Power, Watts	Headroom, dB	Power, Watts	Headroom, dB
8 Ohms	56	0.5	52	0.17
4 Ohms	47	−0.27	40	−0.97

A STUDY IN SCARLATTI

Domenico Scarlatti: Complete Keyboard Works. Scott Ross, harpsichord and organ.
Erato 45309-2, 34 CDs; DDD; approximately 34 hours.

This project is a true milestone in the history of classical music recording. All 555 keyboard sonatas of Domenico Scarlatti are recorded for the first time and presented in this elegant, nine-volume set of 34 CDs in a special slipcase with a thick booklet that, among other things, features a concise and illustrated analysis of each sonata, with 20 dominant characteristics identified with little icons.

Fernando Valenti began a project back in the mono era to record all the sonatas for the Westminster label. He continued the project, eventually moving into the stereo era but never half completing the Herculean task.

Now harpsichordist Scott Ross has triumphed with this fascinating set that should be a reference for many decades. It shows Scarlatti as perhaps the most innovative composer for the keyboard of the entire 18th century and his sonatas as one of the largest and most impressive collections of works in the history of music.

Scott Ross, originally from Pittsburgh but schooled in Paris, proposed the immense project to Radio France for the 1985 tercentenary of Scarlatti's birth. He was already well known for recitals and recordings of the music of Bach, Handel, Soler, and others, and for being an eccentric regarding attire for public concerts: He wore to the stage whatever informal gear he happened to be wearing—beachwear, hunting outfit, or leather motorcycle garb. Recording of the sonatas took 1½ years. Four different harpsichords were used for variety, plus organ in the few sonatas clearly intended for that instrument. The Guild of French critics designated Ross "Musical Personality of the Year" in 1988 for the project. It was his major life achievement; tragically, Ross died the next year at age 38.

Domenico Scarlatti's music was not widely known until the publication in the early 1950s of his biography written by harpsichordist Ralph Kirkpatrick, who also recorded a special edition of most of the sonatas. One of Kirkpatrick's contributions was to group many sonatas into pairs—usually a slow lyrical one followed by a second one in which Scarlatti's close idiomatic familiarity with the folk music of Spain comes to the fore. Kirkpatrick also recorded some of the sonatas for Columbia, but they are rather joyless and poorly recorded versions. And no matter what skilled pianists, such as Horowitz, brought to the sonatas, if *any* early keyboard music should be heard on the harpsichord instead of the piano, this is surely it!

The Neapolitan composer emigrated to Lisbon as the music master of the young Princess Maria Barbara. When she married the heir to the throne of Spain, Scarlatti followed his royal pupil to the Alcazar of Seville and later to other Spanish royal sites such as the Escorial. The exciting sounds and rhythms of Andalusia and all Spain soon became ingrained in his musical persona and fairly burst out of many of these truly amazing pieces in an almost orchestral fashion. One needn't strain the imagination to clearly discern mandolins, guitars, castanets, the keening lines of *cante hondo* vocalists, and the stamp of the feet in the *zapateado*. Some of the sonatas are punctuated with such sudden and surprisingly percussive fistfuls of notes that it sounds as if the performer's entire forearm were flung unto the keyboard a la Cecil Taylor.

Scarlatti's sonata form is quite different from its successor, the classical sonata. His is usually in binary form, divided into two distinct halves that are complementary but often greatly contrasted. The music is not dependent on theoretical structure. There is not much development of themes, but instead, as Scott Ross put it, "the juxtaposition of swarms of melodic and rhythmic ideas." It is full of joy and vitality. Each sonata bears Scarlatti's unique stamp and requires only a few measures to know it could be by no other composer. The variety encompassed in these 550 short works is astounding; no chance of monotony here.

Ross' approach to performance grew out of his musicological studies, but he admitted he didn't make authenticity a guiding principle. The discipline is there, but so is the freedom and inspiration. His feeling for the rhythmic pulse keeps these pieces interesting and alive.

To appreciate the digital dexterity required by many of the sonatas, one has really to play them oneself. Even a look at the music doesn't always show the wildly abandoned hand-crossings with which Scarlatti teases and tortures the player. When just listening to these sonatas alone, one misses the rapid-fire contortions required to execute important notes.

The miking is just right, not too close and not picking up all the action's mechanical noises as with the Valenti recordings and many other recent harpsichord efforts. (And please don't ruin the realistic effect by playing back these CDs at the same high level you would an orchestral work! Harpsichords are not loud.) The instruments are also well chosen so as to not inundate Scarlatti's sometimes delicate music with clangorous multi-stop registrations that may be more suitable to certain Bach or Handel works. Ross even participated in the editing of the digital tapes because he was able to pick out level variations of less than a decibel!

If you spent a 9-to-5 work week listening only to Scarlatti sonatas, you could get through this set and even have a little time left over to repeat a few of your favorites from the 550. But the captivating world of Scarlatti will enthrall the listener more in smaller doses. Still, the sonatas do make wonderful background music of a sort. (While auditioning these, I was for the first time wishing I had a CD changer!) But don't expect them to stay in the background; they tend to come out and grab your ears in ways that few works of Bach, Rameau, Couperin, and the other keyboard composers do.

By the way, if you fret that "this too too solid acrylic would melt your pocketbook," you will be glad to know that 56 (or about 10%!) of the sonatas have been selected from the complete collection and are available on a three-CD Erato set (45422-2). *John Sunier*

Suppé: Overtures. Academy of St. Martin-in-the-Fields; Neville Marriner, conductor.
EMI CDC 7 54056 2, CD; DDD; 60:53.

The music of von Suppé always seems to harken back to a kinder, gentler time when, on Sunday afternoons in the parks of towns and villages across the land, people listened to band concerts. A pompous bandmaster, usually sporting a cavalry mustache, would lead his woodwinds, brass, and percussion through renditions of Suppé's "Poet and Peasant" and "Light Cavalry" Overtures, which were notable more for their exuberance than for their musicianship.

Cornball connotations notwithstanding, Suppé's tuneful pieces have always been popular. On this EMI CD, Sir Neville Marriner and the splendid Academy of St. Martin-in-the-Fields give Suppé's ingratiating music the full symphonic treatment and play it with great panache.

Marriner has the old warhorses "Light Cavalry," "Poet and Peasant," "Morning, Noon, and Night in Vienna," and "Pique Dame" thundering down a fast track. The polished, spirited performances and playing make them all winners. The less well-known "Viennese Jubilee Overture" and "The Torments of Tantalus," along with the rarely played "The Lady Mistress" and "The Peregrinations After Fortune," fare equally well in Marriner's affectionate readings.

Recorded in the warm acoustics of EMI's Abbey Road Studio One in London, the very clean, well-balanced sound fully delineates the thrusting brasses, highly detailed woodwinds, finely etched strings, and punchy and weighty percussion in this superb recording. If von Suppé's ebullient, effervescent music appeals to you, you will find this disc particularly rewarding.

Bert Whyte

Nielsen: Symphonies No. 2, "The Four Temperaments," and No. 3, "Espansiva." Nancy Wait Kromm, soprano; Kevin McMillan, baritone; San Francisco Symphony, Herbert Blomstedt.
London 4302802, CD; DDD; 67:55.

About 10 or 15 years ago, in the British Army's Berlin equivalent of an American army's post exchange, I found an EMI boxed set (SLS 5027) of eight LPs which changed my life. In 1948 the unique Danish tenor Aksel Schiötz had introduced me to Carl Nielsen's lovely songs; now I discovered his six symphonies (plus his clarinet, flute, and violin concertos), all superbly performed by the Danish Radio Symphony Orchestra under its Massachusetts-born Swedish conductor Herbert Blomstedt. That set appeared in 1975; Nielsen had died in 1931.

Since then, Nielsen's symphonies have attracted powerful latter-day champions, among them Leonard Bernstein, Herbert von Karajan, and Eugene Ormandy. (Sony recently brought out a CD set of the symphonies plus two of the three concertos, reissuing earlier recordings by Ormandy and Bernstein.) Even so, Nielsen's fame and popularity have yet to catch up with those of his Finnish contemporary Jean Sibelius (1865 to 1957).

Geography and linguistics provide the explanation, I believe. Nielsen spent all his 66 years in his native Denmark, and just four million people in the entire world speak Danish. Sibelius

Neville Marriner

Photograph: Steve J. Sherman

Photograph: Steve J. Sherman

Herbert Blomstedt leads The San Francisco Symphony in a recording that reaches the high level expected from London/Decca.

broke out of Finland to Germany, where early acclaim earned him not only powerful advocates but also a leading, influential publisher who propagated his music far more effectively than Nielsen's publisher, in Copenhagen, could his. As a result, only in recent years has the world at large even begun to become aware of Carl Nielsen's true rank as a major composer.

With this third CD of a welcome new series, Blomstedt completes his rerecording of the six Nielsen symphonies, this time with the San Francisco Symphony. This orchestra has noticeably and steadily improved since Blomstedt took it over in 1985. If you haven't yet discovered the pleasures of Nielsen, this disc and its two predecessors offer you the same joy of discovery that old LP set brought me in Berlin. London's sonics, understandably, put that older set into the shade. For these recording sessions, the British engineers carried out what amounted to a partial rebuilding of San Francisco's Symphony Hall, removing many rows of front seats and extending the stage in order to place the orchestra closer to the center of the enclosure. That, plus other pains taken, elevates the recorded sound to the customary brilliant high level that has been maintained by London/Decca over the decades.

The Danes have a reputation as the Pucks of Scandinavia; that certainly holds true for Carl Nielson. At his best, he has composed music here of simple but majestic nobility. (I will never understand why his virtually perfect little song "I Aften" ["At Evening"], to mention only one, hasn't become internationally familiar.) On the other hand, Nielsen, the irrepressible cutup, punctuates many of even his major works by impishly sticking out his tongue or thumbing his nose. For instance, the first movement of his Third Symphony strides along nobly until a point in the development section where, without as much as skipping a beat, it is transformed into a whimsical, airy little waltz.

Certain improbable but undeniable parallels exist between Carl Nielsen and Charles Ives and their respective music. Ives had the benefit of a bandmaster father he adored, who fed little Charlie's musical hunger generously and tirelessly. Nielsen, a farm boy who didn't discover Bach, Mozart, and Bee-

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thoven until he'd turned 14, crossed his own first musical threshold at three, when he discovered that the length of a piece of wood governed its pitch.

In a different, Scandinavian sort of way, the rough-hewn, bardic quality characterizing Ives's music also characterizes Nielsen's. Unlike Ives, Nielsen rarely employs dissonance, but he constantly holds your attention fast, throwing you slightly off balance by introducing the unexpected. For instance, he may sharpen or flatten a crucial melodic note when the ear anticipates the natural. In the second, pastoral movement of the Third Symphony, the unprepared listener gets brought up sharp, in a gentle, Danish sort of way, when two human voices suddenly vocalize fragments of melody for a few enchanting moments.

Generally speaking, Danes have little affection for their Swedish neighbors (Swedish drunks regularly get tossed into the drink in front of Copenhagen's vivacious Nyhavn bars), but Herbert Blomstedt by now must surely have earned something approaching honorary Danish citizenship. He conducts these works with total, passionate conviction, getting the most out of their profundity as well as their comic relief. During a triumphant 1990 tour of Europe (including several major festivals), that continent's most hard-bitten critics ranked the San Francisco Symphony under Blomstedt among America's finest orchestras; certainly these splendid performances reinforce that impression. One hopes they will all carry on now to give us Carl Nielsen's three concertos as well. *Paul Moor*

Shostakovich: Chamber Symphony, Op. 110a; Symphony for Strings, Op. 118a. The Chamber Orchestra of Europe; Rudolf Barshai, conductor. **Deutsche Grammophon 429 229-2.**

These Shostakovich works are given near-definitive performances by conductor Rudolf Barshai, who also did the string orchestra arrangements of the composer's Eighth and Tenth String Quartets from which these works were derived. The playing of the Chamber Orchestra of Europe is breathtaking for its precision of ensemble and its opulent tonality. The richly resonant clean string sound is icing on the cake. *Bert Whyte*

HIGH VOLTAGE

The Complete Stax/Volt Singles: 1959-1968: Various artists
Atlantic 7 82218-2, nine CDs; AAD; 10:52:23.

Sound: A+ Presentation: A+

In the '60s, only Stax/Volt records out of Memphis rivalled the impact of Detroit's Motown machine. Both companies had a seemingly never-ending stream of hits sung by an impressive stable of killer artists and expertly performed by an unbeatable house band with perfect arrangements. Both had begun with strong community roots, too. However, where Motown banked on its Northern city-bred slickness, Stax/Volt's sound was gritty, more Southern, and far, far funkier. And, for my money, a lot more fun.

This nine-disc box set includes every A-side released on the Stax and Volt labels between 1959 and 1968, plus many key B-sides (all of those that charted), the Carla and Rufus Thomas singles that appeared on Atlantic and Atco, and all the R&B A-sides from Stax's predecessor, Satellite. The remastering was done from the original Stax/Volt mono master tapes (stereo versions appeared on albums, but they were never as exciting; these are the original singles as released). In some cases (not specified), the masters had been lost and "original disc sources" were used. Quoting the notes, "Analog to digital mastering was done with a specially modified and restored Ampex 350 full-track mono machine with original tube electronics. All equipment in the transfer process was chosen specifically to re-create the Stax sound on today's stereo systems without compromise." The effort is an absolute success. The music packs a mighty punch, with definition, clarity, and warmth notably superior to the original releases but totally faithful to them. The "dry" sound that was the Stax hallmark has *never* sounded so wonderful. Top commendation must go to the digital remastering team of Bill Inglot (well known for his fabulous work on Rhino's reissues) and Dan Hersch.

The 64-page booklet that accompanies the box features a lengthy appreciative essay by Rob Bowman. It is profusely illustrated with terrific photos of the artists and examples of the looks of the labels. Bowman traces the history of Stax from its founding by Jim Stewart and Estelle Axton (from their two surnames comes the derivation of "Stax") to the end of their distribution relationship with Atlantic in '68, not too long after the death of flagship artist Otis Redding in a tragic plane crash. The booklet appropriately lists each selection with original label, serial number, release date, highest chart position achieved on *Billboard*'s pop and R&B charts, songwriters, publishers, and running time. The book is a superb piece that aids a lot in appreciating the music. And what music it is! The 244 selections include some of the best soul music ever, most of it recorded at Stax's Memphis headquarters with its house players as the band. And what a band!

The core was Booker T. & the MG's, which included Booker T. Jones on piano and organ, Steve Cropper on guitar, the late Al Jackson on drums, and Donald "Duck" Dunn on bass, who took the place of Lewis Steinberg early on. Add to them the great Mar-Keys horn section of Joe Arnold, Wayne Jackson, and Andrew Love. The most remarkable aspect of this wonderful outfit is how they would tailor their work to fit a plethora of styles. They would always adapt to the artist to showcase him/her/them best, whether it might be the gospel-inspired soul shouting of Sam & Dave, the raunch of DJ-turned-singer Rufus Thomas, the growing sophistication of Rufus' daughter Carla Thomas, the Philly-inspired doo-wop stylings of the Mad Lads, the sweet soul crooning of the underappreciated Wendy Rene and later William Bell, the marvelous Mabel John (sister of Little Willie John of "Fever" fame), the gritty but good-natured blues of Albert King, or those great signature instrumentals the MG's and the Mar-Keys released on their own.

And in a class all his own was Otis Redding.

Somehow, everything went to a higher level yet when Otis was the man at the mike. Begin with his quirky but brilliant horn parts, which were of his own invention. They were punctuating and contrapuntal, often downright odd, but ever downright right, an integral part of his instantly identifiable sound and a big part of the incredible energy of his records. (For an excellent overview of Otis, check out Atlantic's three-disc set, *The Otis Redding Story*, 81762-2.)

Otis was a great songwriter (especially when collaborating with Steve Cropper), but others richly deserve mention for writing contributions to the Stax canon. Chief among these are the immortal team of David Porter and Isaac Hayes, who, among their many credits, wrote most of Sam & Dave's hits. Rufus and Carla Thomas both wrote, as did Eddie Floyd (best known

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The "dry" sound that was the Stax hallmark has *never* sounded so wonderful as it does on *The Complete Stax/Volt Singles.*

for "Knock on Wood") and William Bell. However, Bowman's notes make it clear that this was a real community effort in which everyone would pitch in and help, not necessarily getting credit at all times, but there was plenty of opportunity for everyone to get his or her due.

The chronological sequencing works beautifully. It emphasizes the diversity and variety of the Stax catalog and artists. It enhances the fun of listening to these great sides too.

The Complete Stax/Volt Singles really is definitive on all levels: Completeness, production, annotation, presentation. The price tag of about $100 may be hefty, but it is well worth it. As Rob Bowman says, "Soul music never got any better."

A final note from the Caveat Emptor Department: In doing this review, it was my miserable luck to encounter probably the only two defective sets in the run. One had a defective disc that looked like someone tried to shoot a small bullet through the playing area, and the other had an empty jewel box for Volume 8 through a regrettable packing error. Life goes on. . . .

Michael Tearson

Strange Cargo 2: William Orbit. **I.R.S. X2-13055.**

Playing guitars, keyboards, and assorted other instruments, William Orbit creates laid-back, cerebral electronic rock full of airy atmospheres and mind games. (Use headphones.) The music is enjoyable without pyrotechnic display, approaching "experimental" without becoming annoying.

Michael Wright

Tumbleweed Connection: Elton John. **Mobile Fidelity UDCD 01-00543.**

Tumbleweed Connection was the last album Elton John recorded before he broke big, and it is one of his very best, with great songs from start to finish tied together by western cowboy motifs in several of them. Mobile Fidelity's remastering for their 24-karat gold Ultradisc series is superb: Clarity, punch, and definition are leagues superior to the MCA release. They have also included a CD version of the original lyric booklet, a welcome and necessary addition.

Michael Tearson

Fresh Evidence: Rory Gallagher. **I.R.S. X2-13070.**

Popular '70s Irish blues-rock guitarist Rory Gallagher returns with *Fresh Evidence*, a blistering set of blues-based songs that proves he's not lost the touch in the years away from the limelight. His guitar snarls all over aggressive rockers like "'Kid' Gloves," "Empire State Express," and "Ghost Blues" as well as a zydeco-flavored tribute to Clifton Chenier called "The King of Zydeco." A must for old fans and a great introduction for anyone liking blues translated to U.K. style.

Michael Wright

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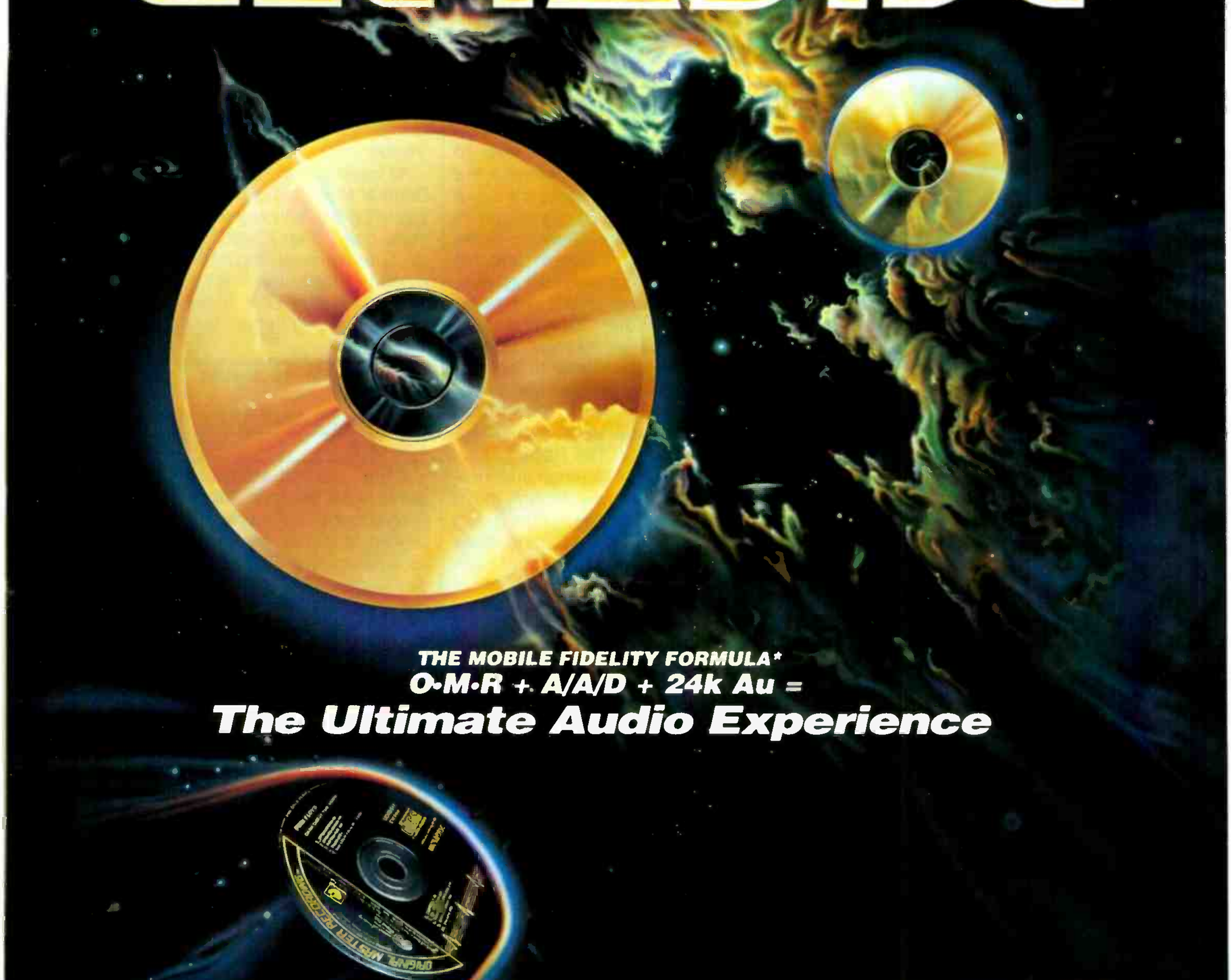

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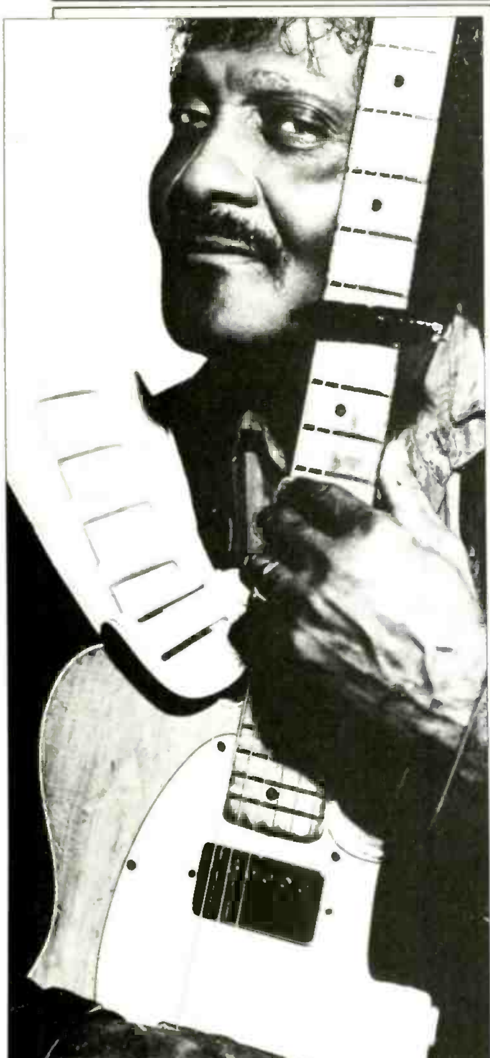
FENDER OVER ICE



Iceman: Albert Collins
Point Blank/Charisma 2-91583, CD; 43:21.

Sound: A– Performance: A

Finally, the Iceman cometh, and the result is a dandy. Albert Collins' *Iceman* stands as the Master of the Telecaster's first release in nearly four years, and his first non-Alligator entry.

This is vintage Collins. The explosive guitarist surrounds himself with an extended backing ensemble which includes the four Uptown Horns and, for good measure, two female backup vocalists who inject just the proper dosage of soul. Collins, virtually flawlessly, leads these 13 musicians through another set of atypical, fresh-sounding tunes, each an original and most of them collaborative efforts among various bandmembers.

Collins is, unquestionably, the most important contemporary blues player. He's an orchestrator, arranger, conductor, and a musician who understands patience and knows how to make this idiom not only breathe but sing. The title track, centered on a classic half-time, I/IV/V progression, is all the vehicle Collins needs to showcase his electrifying sustain and his ability to accomplish more using less.

Amidst such uncluttered matter as the slow, infectious "Don't Mistake Kindness for Weakness" is Collins' ever-present humor, similar to the sentiment he projected on "Too Many Dirty Dishes" from his 1987 date, *Cold Snap*. The same can be said about the brief sarcastic ditty "The Hawk."

Taken as a whole, *Iceman* successfully moves and grooves through mood and situational changes, offering fast pieces, mid-tempo shuffles, and those multi-layered funk and slow-grind numbers that, perhaps more so than any of his other work, allow Collins to deliver startling riff after startling riff.

Jon W. Poses

Deep at Night: Alex de Grassi
Windham Hill WD-1100, CD; DDD; 40:28.

Sound: A– Performance: A

Although he probably doesn't remember it, I played guitar with Alex de Grassi one evening some 14 years ago. I'd just received a Ruck classical guitar I'd ordered and was showing it off to some other guitarists. De Grassi was there and played on the Ruck some of the John Fahey/William Ackerman-style compositions that were typical of his early Windham Hill solo recordings. Years later, the Ruck has matured nicely, mellowing out with a wonderfully balanced, clearly articulated sound, and the same can be said of De Grassi.

Remaining from De Grassi's early style are the cascading arpeggios and melodic lyricism. Gone, however, is much of the high-speed technical hyperbole. Instead, his compositions have become more focused and classical, with complex and subtle rhythmic shifts (as on "Waltz #4"), shimmering harmonies ("Mirage"), and jazzy meditations (the title cut). And he's added new techniques to vary the textures, like percussive two-handed tapping on "Blue Trout" or the use of a Sympitar (a guitar with sympathetic strings, sounding much like a sitar) on "Hidden Voices."

As usual with Windham Hill releases, *Deep at Night* is digitally recorded and sounds great, although it has just a tad more delay than I prefer. This is Alex de Grassi's best recording so far, a pleasure from beginning to end. I hope, like my Ruck guitar, he'll just keep on getting better! *Michael Wright*

The Half-Life of Desire: The Either/Orchestra
Accurate AC-3242, CD; AAD; 55:23.

Sound: B Performance: B

When you find a big band that can cover Duke Ellington, Miles Davis, and Bing Crosby and then cap it off with a power cruncher by the progressive rock group King Crimson, it's clear that the 11-piece Either/Orchestra is following an erudite and rollicking course.

"He Who Hesitates," written by trombonist Curtis Hasselbring, exemplifies

Alex de Grassi

the simultaneous fusions, grafts, and collages going on in The Either/Orchestra. It opens at a mid-tempo groove with pianist John Medeski casting lines towards the bop piano of Bud Powell and a modern approach that recalls pianist Don Pullen. His solo rises, then falls to the ground like cluttered wooden sticks and miraculously rises again into a new form. Partway through, the tune slides into a slow, dirty blues, with Hasselbring snapping throaty sexual come-ons through his trombone.

The mix and match continues on the pairing of Miles Davis' free modality and Duke Ellington's swing on "Circle in the Round/I Got It Bad." Their rendition of Bing Crosby's 1931 "Temptation" would fit well in Angelo Badalamenti's hallucinatory score for *Twin Peaks*.

Of the soloists, the standouts are Medeski and Charles Kohlhase, whose alto saxophone coils around the rhythm shifts of saxophonist Russ Gershon's "The Half-Life of Desire," blurring the lines between solo and melody. Bassist Marc Rivard steps out on "Circle/Bad," as he starts by playing the bass with a mallet before switching to a punchy pizzicato solo.

It's in the arrangements and ensemble passages that The Either/Orchestra lives and dies, and the CD closer, "Red," might be the best example. Initially, it lacks the reined violence of the King Crimson original; horns just don't have the texture and force of a fuzz-toned electric guitar. But as John Dirac's arrangement moves towards the center of the piece, it's clear he's after something different, unwinding the nuances of composer Robert Fripp's odd time signatures and using the horns to create dark pastel shades around the minimalistic lines. He finds a drama that's more film noir than King Crimson's futuristic angst. At the end, Dirac emerges with his guitar amp cranked to 11, and he grinds through the reprised opening with a vengeance.

Recorded by Rudy Van Gelder in his legendary studio, the mix of *The Half-Life of Desire* accentuates the coloration in the arrangements, but some tracks, notably "Circle" and "Red," are brittle and mildly distorted on peaks. However, it fails to detract from the verve of contrasts in The Either/Orchestra. *John Diliberto*

Among offerings from Music of the World are the only extant recordings of the Igede tribe of Nigeria's Benue State.

The Igede of Nigeria
Music of the World CDT-117, CD; ADD; 48:56. (Available from Music of the World, P.O. Box 3667, Chapel Hill, N.C. 27515.)

Sound: A | Performance: A–

Flutes & Strings of the Andes
Music of the World CDT-106, CD; ADD; 56:34.

Sound: A | Performance: A–

Festival of India
Music of the World CDT-121, CD; ADD; 60:04.

Sound: A | Performance: B+

Brazil Encanto: Tico da Costa
Music of the World CDT-211, CD; ADD; 42:46.

Sound: A | Performance: B+

World travel has been dealt some setbacks recently. But thanks to Bob Haddad, head of the small label Music of the World and one of those rare idealists who prefers to pursue indigenous music rather than the Top 40, all you need is a CD or cassette player to be whisked off to the far corners of the globe. *The Igede of Nigeria*, *Flutes & Strings of the Andes*, *Festival of India*, and *Brazil Encanto* represent a good cross-section of the eclectic variety to be found within Music of the World's catalog.

The Igede of Nigeria is perhaps the most curious of this quartet because it consists of the only extant recordings of the Igede tribe of Nigeria's Benue State. Recorded in 1978 and 1979 in the villages, this music preserves a way of life that's rapidly disappearing. Although the music here stands out as choral, there is rhythmic accompaniment provided by group hand-clapping and a variety of drums, percussion, and wind instruments. Different choral groups chant funerary songs, dances (in which the real lead instrument is a dancer), and polytheistic hymns combining Christian and older elements.

This is folk music in the truest sense, not the polished, professional pop of juju or other urban Nigerian music that draws on Western inspiration. You'll hear many of the polyrhythms that go into the more accessible music coming

Bob Haddad is one of those rare idealists who prefers to pursue indigenous music for his Music of the World record label.

out of Africa, but these are everyday tribesmen joining together to celebrate everyday life. Highly recommended if you want to experience something very different and exotic. And very well recorded and digitally remastered, by the way.

Flutes & Strings of the Andes continues the field-recording theme with music of Andean street musicians made in 1983 and 1984. Featured are native instruments such as a 21-string Andean harp, a charango (string instrument), a quena (bamboo wind instrument), and a bandolina (mandolin with armadillo-shell body) along with a violin, whistling, and vocals. This music, with its jangly metal strings and eerie flutes, is highly rhythmic and has the naive charm that only true folk music possesses—the product of shared culture rather than a creative ego, relating timeless rituals of love and survival. Vocals are in Quechua, Aymara, and Spanish, and the music itself reflects the South American Indian and Latin sources. The overall sound quality here is very good, and there is a presence that could easily place you on an adobe village corner somewhere in Peru.

Festival of India takes us from the Central Andes to the subcontinent of India, with its ancient traditions and mysteries. This recording presents a sampling of Hindustani music from Northern India, featuring some of the region's best-known artists. Included are selections by Sultan Khan (improvising on the sarangi, an upright, bowed string instrument), several haunting melodies by Purna Das Baul (a descendant of an ancient sect of wandering religious minstrels known as Bauls) and his Bengali folk ensemble, the renowned virtuoso violinist V. G. Jog, G. S. Sachdev on bamboo flute, and the Dagar Brothers singing an old raga in the Dagarbani vocal tradition. (You'll recognize The Beatles in this raga!) The music is highly melodic and built on minor modes that demonstrate geographic connections with the Arabic world just around the corner.

While much of Music of the World's catalog favors "traditional" music, new artists are also represented, as on *Brazil Encanto*, the American recording debut of the young singer/songwriter/guitarist Tico da Costa from Northeastern Brazil and Rio de Janeiro. Most of these pieces sound fairly typically Brazilian: Upbeat syncopated rhythms over which love lyrics float in Da Costa's native Portuguese. However, as the liner notes suggest, the Northeastern rhythms known as nodeste (which predominate on this album) are quite different than the samba and bossa nova. Da Costa, who's much better known in Latin America and Europe than in the States, has a nice ear for melodic composition and sings sweetly and convincingly in the tradition stretching back to Luis Bonfa and others. *Brazil Encanto* is a pleasant listen, although it clearly leans toward Latin pop's lighter side. *Michael Wright*

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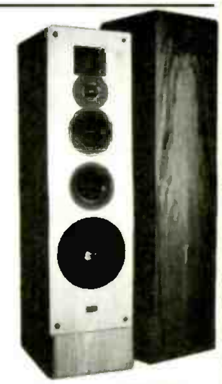

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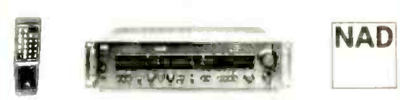

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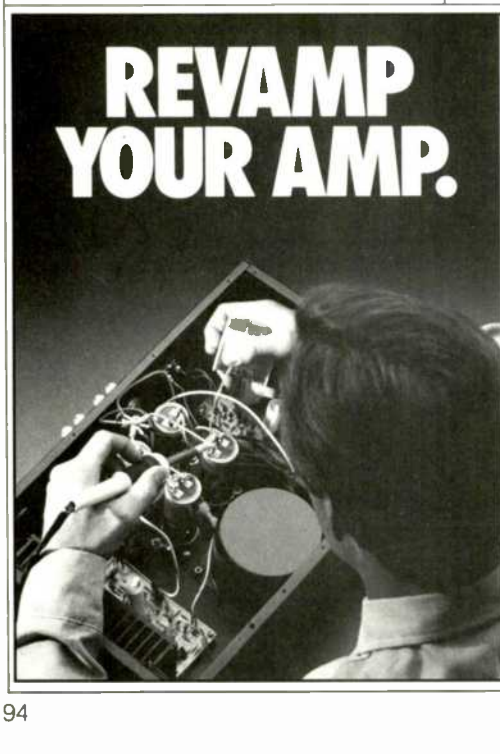

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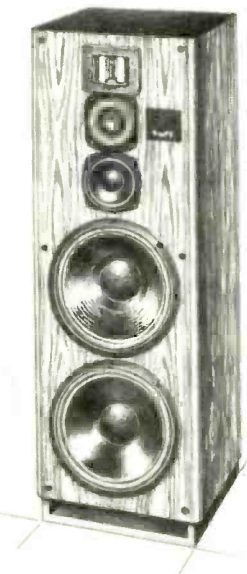

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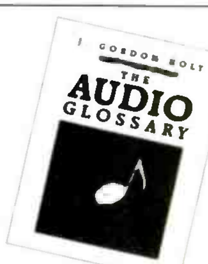

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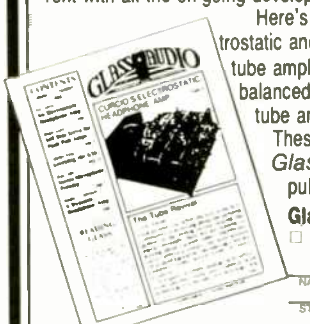

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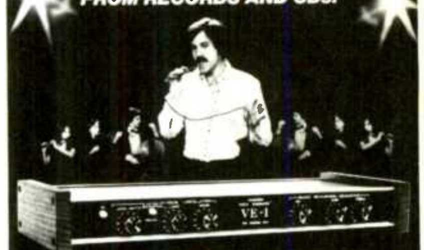

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WA- **Evergreen Audio**: Silverdale• **Hawthorne Stereo**: Bellevue• **Q.C. Stereo**: Bellingham, Oak Harbor• **Tin Ear**: Kennewick.
W.VA- **Pied Piper**: Huntington, Charleston• **Sound Investments**: Morgantown• **Sound Post**: Princeton.
WI- **Audio Emporium**: Milwaukee.
Canada- **Advance Electronics**: Winnipeg, Regina• **Audio Ark**: Edmonton• **Audio Ctr.**: Montreal, Ottawa• **Bay Bloor**: Toronto• **Boutique of Sound**: Calgary• **CORA**: Quebec City• **Sound Plus**: Vancouver.

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