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Audio

DECEMBER 1989 VOL. 73, NO. 12

Binaural Sound, page 48

Aachen Head System, page 58

FEATURES

EQUIPMENT PROFILES

MUSIC REVIEWS

DEPARTMENTS

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Apogee Loudspeaker, page 70

Goldmund Amp and Preamp, page 82

TAPE GUIDE

HERMAN BURSTEIN

Bias Puzzlement

Q. I find myself puzzled about bias adjustment for tape recording. Everyone seems to have a favorite system, and I'm not sure which ones work well.—Donald Bisbee, Columbus, Ohio

A. Ideally, bias adjustment should be accompanied by adjustment of record equalization and record sensitivity to achieve the best combination of flat and extended frequency response, low distortion, high S/N ratio, and good Dolby tracking. Simultaneous adjustment of all three parameters is a complex affair because they are interdependent, and it requires a practiced hand. The job can be done quite well by a microprocessor, as in some costlier decks.

As an alternative, a number of decks allow the user to vary bias from the factory setting. Some decks incorporate signal and metering facilities, so bias can be adjusted to produce equal playback amplitude at frequencies such as 400 Hz and 10 kHz; equality at the two chosen frequencies *tends* to produce flat and extended response through most of the audio range. Generally, this works quite well.

Another alternative is to adjust bias so that FM interstation noise has, as nearly as possible, the same playback frequency response as incoming FM noise. Some decks provide user-adjustable bias but without the signal and metering facilities described above. Users may elect, out of preference or because they lack an FM tuner, to adjust bias on the basis of program material such as an LP or CD.

Bias and other adjustments should be performed at a level of about 20 dB below 0 VU. Adjustments are easier with a three-head deck than with a two-head deck because you can simultaneously check, in playback, the results of adjustments made in recording.

In setting bias, some authorities—and I go along with them—recommend that there is a conflict between maintaining extended treble response by decreasing bias and minimizing distortion by increasing bias, the most pleasurable results are achieved by giving up some treble extension in favor of reduced distortion. In many cases, therefore, it may be unwise to aim for response appreciably beyond 15 kHz with a cassette deck.

Readers occasionally comment that their home-recorded cassettes sound better than the source. It could be that the deck is somewhat overbiased, which not only reduces tape distortion but also reduces high-frequency distortion products of the source.

Basic Wisdom

Q. Not having the money to be a high-end audiophile, I purchased a tape deck which I thought was really a great buy at $129, loaded with features. After spending a few hours in the library to take a crash course in high fidelity, I came to the conclusion that many of the features could have been dispensed with and that my money would have been better spent on a very basic deck that would probably outperform my present one. In other words, it is better to buy quality than quantity if you wish to enter the high-fidelity world on a budget. Am I right?—Tom Whang, Glendora, Cal.

A. Of course I agree with you. For any audio component, first you buy for basic performance. In a tape deck, this is wide and flat frequency response, minimal noise and distortion, accurate and steady motion (including freedom from wow and various kinds of flutter), good headroom, etc. Then, if you can afford to spend more, you look for "bells and whistles," which may or may not add significantly to your convenience and fun.

On the other hand, it is amazing what $129 (or less) can buy in the way of a decent cassette deck. In discount audio stores, I have come across decks priced this low (or substantially lower) that provide quite pleasurable listening even though they may not *measure* up to the performance of more expensive decks.

In buying decks or any other components, the wise course is to find the unit that sounds best, regardless of price. Use this as a reference. Compare other units, at prices you can afford, with the reference unit, and select the one whose performance comes closest to that of the reference.

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.

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Sound Argument

Dear Editor:

I am a little confused about how audio equipment is evaluated by magazines, audiophiles, or anyone else. The reviews of the Linn LK1 preamp and LK280 power amp in the April issue provide a good example. One source of confusion involves the evaluation of banana plugs. According to author Leonard Feldman: "The friction fit of Linn's special plugs made far better contact than would be obtained with most banana plugs." It is my understanding that Pomona Electronics, a manufacturer of standard banana plugs, specifies the resistance of their banana plugs at the contact point as less than 0.001 ohm. This seems low enough to be significant to me Am I missing something in not seeing the value in a better fitting banana plug? If not, why would a manufacturer go to all the trouble of providing non-standard plugs to achieve an insignificant improvement in performance?

Further, Feldman states that "Linn does not put too much stock in lab measurements." As anyone can see by the measured parameters of these products, there does not seem to be anything in the measured performance that is noteworthy. The distortions (those that we know how to measure) introduced into the signal chain by these components are somewhat higher than in most other products on the market. In fact, the noise peak in the preamp that resulted from the proximity of the power amp is a serious design flaw, in my opinion.

So what is it that makes these components so good? There is little said about the construction, reliability, or any other design attribute that would indicate high quality, except for r.f. shielding and microprocessor control. If these products had been far lower priced (e.g., $500 total rather than $2,500 total) and from a different company, would Feldman have likened them to a Rolls-Royce or Mercedes? I doubt it. This suggests that the author's opinion of the quality of the products might have been based more on price and brand name than on actual performance. Similarly, would Feldman's response to the sound of the components have been just as favorable? I certainly have my doubts.

Now, I know that many audiophiles have been *claiming* that there is little or no correlation between measured performance and sound quality. However, the trend to ignore measured performance is becoming more prevalent all the time. In its place, unfortunately, evaluations are based increasingly on cost, construction, design philosophy, and uncontrolled subjective listening tests. Feldman even has to apologize to some portion of his audience for measuring the equipment and presenting the results of those measurements. It seems to me he was probably afraid of offending and/or boring some portion of the audience and the manufacturer by measuring (God forbid!) the components.

Audio is, more and more often, providing readers with opinions instead of facts. Yes, *Audio* measures the component (except in the "Auricle" reviews) but, in this particular case, then proceeds to ignore the results of those measurements. There is no statement which summarizes and draws conclusions about any of the measurements. Why not? Feldman is in a far better position to draw conclusions about the measurements than most of his readers. This is sending a message to the readers that the staff of *Audio* believes such measurements are meaningless. Does *Audio* really believe that uncontrolled subjective listening tests are unbiased? Is it really possible that measured performance is totally irrelevant to sound quality?

Audio began life almost as a professional journal, with a staff of people who had careers in engineering, music, and broadcasting. The staff, today, is still composed of many who have achieved recognition in their respective fields. However, the policies of *Audio* reflect a movement away from the style of the professional journal and toward a consumer-oriented magazine. The consequence of this is that readers of *Audio* hear, more and more, what they want to believe rather than what is factual. A true journal would be more interested in publishing data and experiments rather than conjecture and opinion. Maybe Editor Eugene Pitts should spend some time reading real journals as a model for *Audio*.

Chuck Butler
Kalamazoo, Mich.

Author's Reply: Over the years, I have had countless quarrels with the "subjective listener" champions who insist that most audio measurements are meaningless. I have maintained (and still do and always will) that if measurements don't tell the full story, it is simply because we haven't learned which measurements are the right measurements to make or our measurement techniques and instrumentation are not sensitive enough to yield the correlations we seek.

I have been attacked ad nauseam by the so-called "underground press" for my steadfast insistence that measurements are important in evaluating audio, video, or, for that matter, any other electronic product I test. That's not to imply that I don't also listen to the products I test. Of course I do, and it is the reasoned combination of listening and measurement that should yield a test report that can be trusted and believed. So to have you imply that I am anti-measurement really struck me as rather odd. Had I been anti-measurement, I certainly would not have invested several thousand dollars in the Audio Precision test system I now use. I purchased this equipment because it dramatically increases the level and sophistication of the measurements I am able to perform. I am about to invest several thousand dollars more, within the next month or two, to upgrade that equipment so it will be able to measure performance digitally as well as in the analog domain. Does this sound like the actions of a person who is anti-measurement?

As to the specific product report you mentioned, please be assured that I never worry about offending any manufacturer—whether that company's products are middle of the road, low end, or high end. I do, however, take cost into consideration if I feel it has a bearing on the overall evaluation of the components I test. In short, Mr. Butler, we are really on the same side. The levels of distortion exhibited by the Linn products were a bit higher than the "triple zero after the decimal point" numbers other amplifiers and preamplifiers boast, but this did not seem to alter their superb sonic quality. Total harmonic distortion really becomes aurally significant only at about 0.5% or so.—*Leonard Feldman*

JOSEPH GIOVANELLI

Happy Holidays!

It's that time again! I can't believe another year has gone. (I've seen a number of them do that in the years I have written "Audioclinic.")

I hope you get the right toys this holiday season. I sure have, for my toys drift in over the whole year. With all of it, my main interest is to relax and listen to music. I try to avoid spending most of my time attempting to locate the "best" products. I also try to avoid spending time tweaking things. Doing too much of that spoils the real fun.

I can't help but reflect, too, on the matter of obtaining discs or cassettes just for the sake of sonic quality. Well, I do have some which show off my system. Mostly, however, I have recordings of artists I like, including many who passed on long before the CD, the cassette, or even the LP. I'll never hear these people sound the way they must have during their recording sessions. Still, their interpretations make their work stand out above many of today's sonic wonders.

Yeah, we'll still see if we can get just a bit more from our "goodies." I think, though, that we should resolve to do more listening to the music than to the "sound" of our recordings. It won't hurt to attend live concerts, even if the performances are less than stellar. If nothing else, it will help to support the arts. Also, it will give us the right slant on what music *really* sounds like.

Malfunctioning Hafler Circuits

Q. My stereo system recently developed a problem that I have been unable to pin down. For a couple of years, I have had a pair of extra speakers hooked up via the Hafler passive surround circuit. When listening to stereo signals, the added ambience was beautiful. Until about two weeks ago, these speakers were silent when I played monophonic sources, as surround speakers should be. Then, with no rewiring and with no other obvious symptoms, the Hafler-wired speakers suddenly began reproducing signals (at reduced level) when only mono, in-phase signals were present. When listening to stereo sources, I still believe I am hearing just the stereo, out-of-phase information. Any ideas as to what the cause of this problem may be?—Larry Craven, Raleigh, N.C.

A. It sounds to me as though one channel of your audio system now has somewhat more gain than the other one. In other words, there is an imbalance between channels, and the speakers therefore "think" that a monophonic signal isn't mono.

You should, if my guess is right, be able to correct this condition by a slight adjustment of the balance control. This is not a cure, but it will demonstrate if my diagnosis is correct.

Next comes the hard part: Isolating the stage which has changed its characteristics and caused the problem. If you have a separate amp and preamp, or a receiver or integrated amp with preamp-out and amp-in jacks, you must first determine whether the imbalance is in the preamplifier or the power amplifier section of your system.

Check the preamplifier by feeding a monophonic source into both channels. Turn up the volume to a level which is suitable for measuring the output voltage of the preamplifier; the output voltage on one channel should be the same as for the opposite channel. Check other inputs to be sure that the problem does not lie with just one input circuit. If you find an imbalance on your first try, I still suggest that you check other inputs to be sure the problem is constant, regardless of the inputs used.

Check the channel balance between channels of the power amplifier in a similar manner. Be sure not to feed too much signal into the power amp. In the name of thoroughness, disconnect the Hafler circuit. If you have a couple of dummy loads, use these in place of the speakers. If the amplifier shows proper balance and the preamplifier also shows proper channel balance, then it may be that there is a problem with one of your loudspeakers (perhaps in its crossover) which is affecting channel balance.

Dynamic Range of CDs

Q. The theoretical dynamic range of a 16-bit digital CD system is said to be about 96 dB. I can't make my math come out to this number. If 2 to the 16th power equals 65,536, then the loudest signal is 65,536 times stronger than the softest, non-zero signal. Because log to the base 10 of 65,536 equals 4.8, the ratio of the loudest to the softest signal (the definition of dynamic range) is 4.8 bels, or 48 decibels. Where does this factor-of-2 discrepancy come from?—Joseph J. Ferrier, Brooklyn, N.Y.

A. If each bit added to a digital signal doubled the signal's *power*, you'd be quite correct: Each doubling of signal power represents a gain of 3 dB. However, each additional bit doubles the signal's *voltage*, which is considered a gain of 6 dB. To express ratios in decibels, one multiplies the log of a power ratio by 10, as shown by your formula, but one multiplies the log of a voltage ratio by 20. Sooner or later, almost everybody mixes this up.

Playback Problems With Two "Identical" CDs

Q. My friend and I purchased identical CDs. My copy plays fine on my player. My friend's copy does not play properly on his machine, which is a different make and model. His player's "Error" indicator flashes constantly. There comes a point where the playback speed changes, and then the disc plays fine. Repeated attempts to play the disc produce the same results in the same place. My disc plays fine on my machine and on his. His "bad" CD also plays fine on my machine.

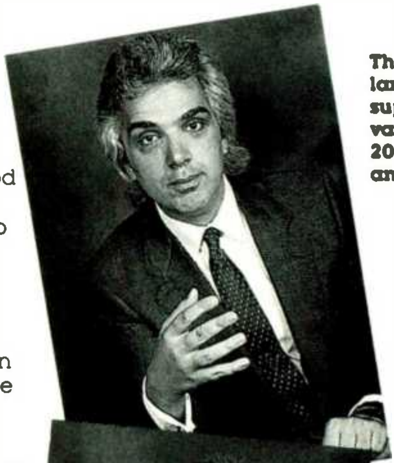
Even when "repaired," the bad CD plays poorly on my friend's machine. A quick fix was to swap discs, but it surely doesn't answer the question of how two identical CDs could behave as I have described.—William Hoehl, Hasbrouck Heights, N.J.

A. Most of the time, I have to think that when a disc plays fine on one machine, it's fine. However, in your case, we probably have a machine which is relatively intolerant of CD defects or perhaps a machine which is simply in need of repair. I have to believe that *your* original disc was freer of defects than was the second disc. The defective one may be a bit warped, or it may have picked up fingerprints or dust. Any or all of these conditions could affect the performance of a player which is just "hanging in there."

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.

Interested in a 200 Watt Amplifier? May We Suggest Something More Powerful... A 100 Watt Aragon.

An Interview with Anthony Federici, President of Mondial Designs Ltd.



The 2004 has a larger power supply than the vast majority of 200 watt amplifiers.

Q. How can a 100 watt Aragon be more powerful than a 200 watt amplifier?

A The amount of watts has become a security blanket for the consumer. Wattage and power can be measured by many different methods. A method was adopted as a standard to offer the consumer a reference for one of the many methods of measuring power. That is why it is possible for amplifiers to measure as 200 watts by this one method of test, but for the Aragon to measure more powerfully by several other methods of test.

Q. Can you give an example of how the Aragon is more powerful?

A. The standard test is a guideline for amplifier power into an 8 ohm resistive load Many 200 watt into 8 ohm amplifiers are less powerful than the Aragon into 6 ohms, 5 ohms, 4 ohms, 3 ohms, 2 ohms and 1 ohm. This includes some that are far more expensive than the Aragon 2004.

Q. How is this accomplished?

A There's no trick to doing it, you need a large power supply. The most expensive amplifiers you can purchase all have one thing in common, a large power supply. In fact the 2004 has a larger power supply than the vast majority of 200 watt amplifiers.

Q. If the 2004's power supply could produce an amplifier of over 200 watts why did you create a 100 watt amplifier instead?

A. Because we'd rather produce good sound than useless specifications. The uneducated consumer will look at the power rating into eight ohms and buy the amplifier with the higher rating. The educated consumer will listen to the amplifiers on high quality speakers to make a decision. How the amplifier powers and controls the speaker will influence his decision, not some misleading specification.

We'd rather produce good sound than useless specifications.

Q. Doesn't a "200 watt into 8 ohms" specification mean something?

A Yes—if you own speakers which are mostly resistive, and the impedance remains at 8 ohms throughout the bandwidth. Under those conditions a 200 watt amplifier with a smaller power supply will play louder before clipping However, the overwhelming majority of quality speakers are not 8 ohms throughout the bandwidth, and are not resistive.

Q. Is a large power supply the only thing that matters in an amplifier?

A. No, of course not. The amplifiers' sound quality, through a wide variety of speakers, is of paramount importance. Achieving the highest sound quality level requires a large power supply, excellent circuit engineering, the finest quality components, and the highest level of manufacturing.

Q. Does the Aragon satisfy this criteria?

A. The Aragon's circuits were designed by an internationally acclaimed engineer, designing some of the world's finest amplifiers. From the Tiffany input connectors to the tightly matched output transistors only the finest components are employed, and the 2004 is manufactured by military and medical electronic contractors to the highest standards.

Q. How much more does the Aragon cost compared to typical 200 watt amplifiers?

A. At $1150 the 2004 is a bit more expensive than some, but far less expensive than most.

The most expensive amplifiers you can purchase, all have one thing in common, a large power supply.

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DON DAVIS

MEASURING ACOUSTIC PHASE

In illustrating my article, "Measuring Acoustic Phase" (February), I made two grievous errors. I failed to credit where two of the original illustrations came from (Figs. 2 and 3) and, in the case of one of them, picked the wrong one for the point I wished to make. The illustration I used as Fig. 3 was the time-domain analytic signal for a low-pass filter, whereas I had meant to choose the same for a bandpass filter.

When Andrew Duncan of Cerwin-Vega, the creator of the software that generated Figs. 2 and 3 in my article, read the piece, he contacted me to point out the omission of the credit and the misinterpretation. Duncan was then kind enough to generate the correct illustrations for the point I was trying to make and chided me on my failure to clarify in the text what was the time domain and what was the frequency domain when I discussed the manipulation of the signals for other displays. Because Duncan deserves credit for his work, and because I don't like erroneous material in print with my name attached, I offer, with his collaboration, the following clarification.

Figure 1 shows the relationships between measurements in the time domain (left side of chart) and the frequency domain (right side). To go from the left side to the right normally requires a Fourier transform, and to come back to the left side from the right normally requires an inverse Fourier transform.

To go from the real to the imaginary requires a Hilbert operator. The real part, in the time domain, has been given the name impulse response; the imaginary part is called the doublet response (Fig. 2). If the signal acquisition is done in the frequency domain, the real part is called the coincident response and the imaginary part is the quadrature response (Fig. 3).

In my article, the illustrations of the frequency-domain real and imaginary parts and of the phase and magnitude responses are correct, but the wording in the text implies that taking the impulse response's real and imaginary parts allows these calculations without first taking their Fourier transform. That implication is, of course, incorrect.

One can plot the envelope and the phase of the impulse response as well,

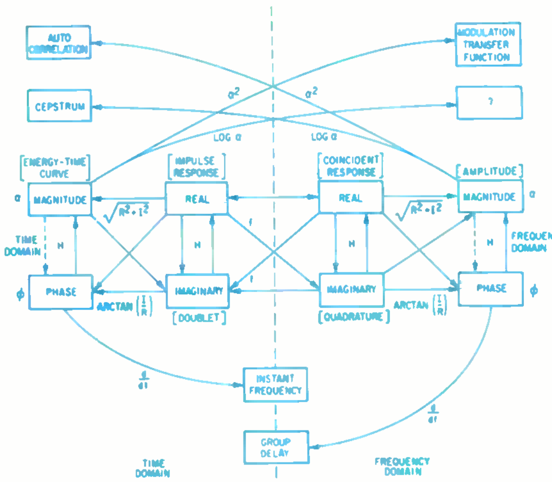

Fig. 1— A basic "road map" of acoustic measurements, in both the time and frequency domains. The box labelled "?" (upper right) is the forward Fourier transform of the complex log of the energy-time function. (After B & K.)

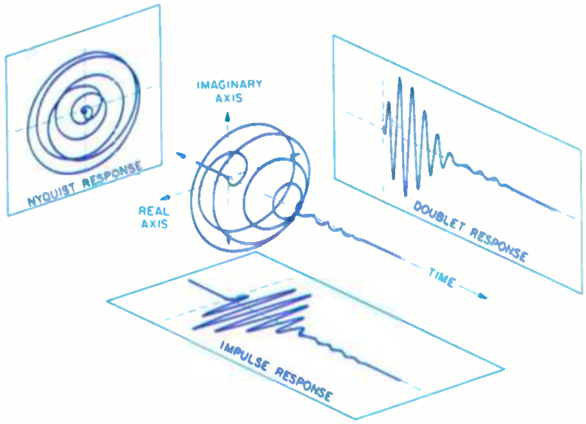

Fig. 2— A time-domain depiction of the analytic impulse response of a four-pole Butterworth ⅓-octave bandpass filter. Note the impulse response (real) and the doublet response (imaginary). All loudspeakers can be modelled as bandpass filters. (This and the following figures from Andrew Duncan.)

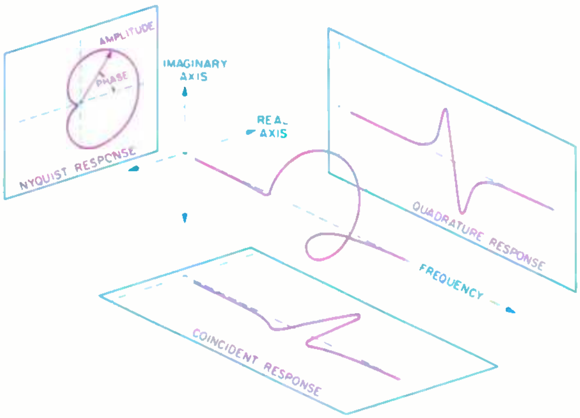

Fig. 3— A frequency-domain depiction of the filter in Fig. 2. Here, the real part is called the coincident response, and the imaginary part is called the quadrature response. The Fourier transform of the time-domain analytic signal uses this display.

in which case the envelope is called the energy-time curve (ETC) and the phase and magnitude curves are taken in the frequency domain (see Fig. 4).

Duncan further pointed out that my choice of words regarding the signal-delay display (Figs. 10 and 11) could and did cause confusion. The phase curve shown was linear, and the signal delay shown was constant.

There are few higher signs of respect than to have readers read with care and then share their thinking with you. My sincerest appreciation goes to Andrew Duncan for his constructive, helpful corrections and for the aid of his superb computer software in the depiction of these fundamental relationships.

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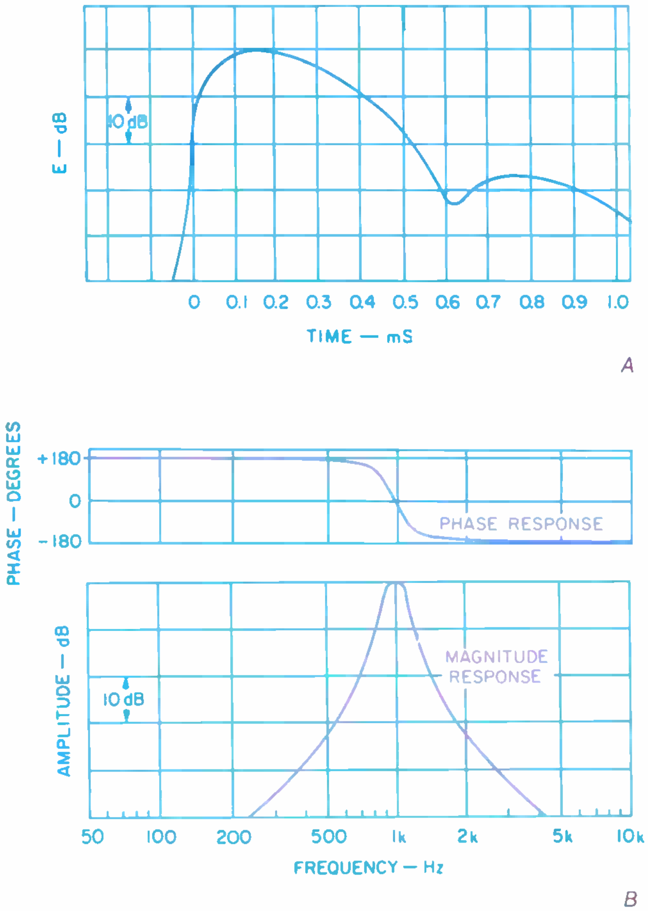

Fig. 4—In this illustration, the time-domain view shows the energy-time curve (ETC), which is the energy envelope over time (A). The frequency-domain transfer function (B) consists of the phase and the magnitude response of the signal.

THE METAL AGE IS HERE

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Each Sony Metal cassette is the ultimate in analog-recording technology. So look for Sony Metal. Because recording will never be the same.

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If you've vowed not to compromise this time around, consider the rich rewards of owning Carver. Each component includes unique innovations designed to confront and solve real-world sonic problems.

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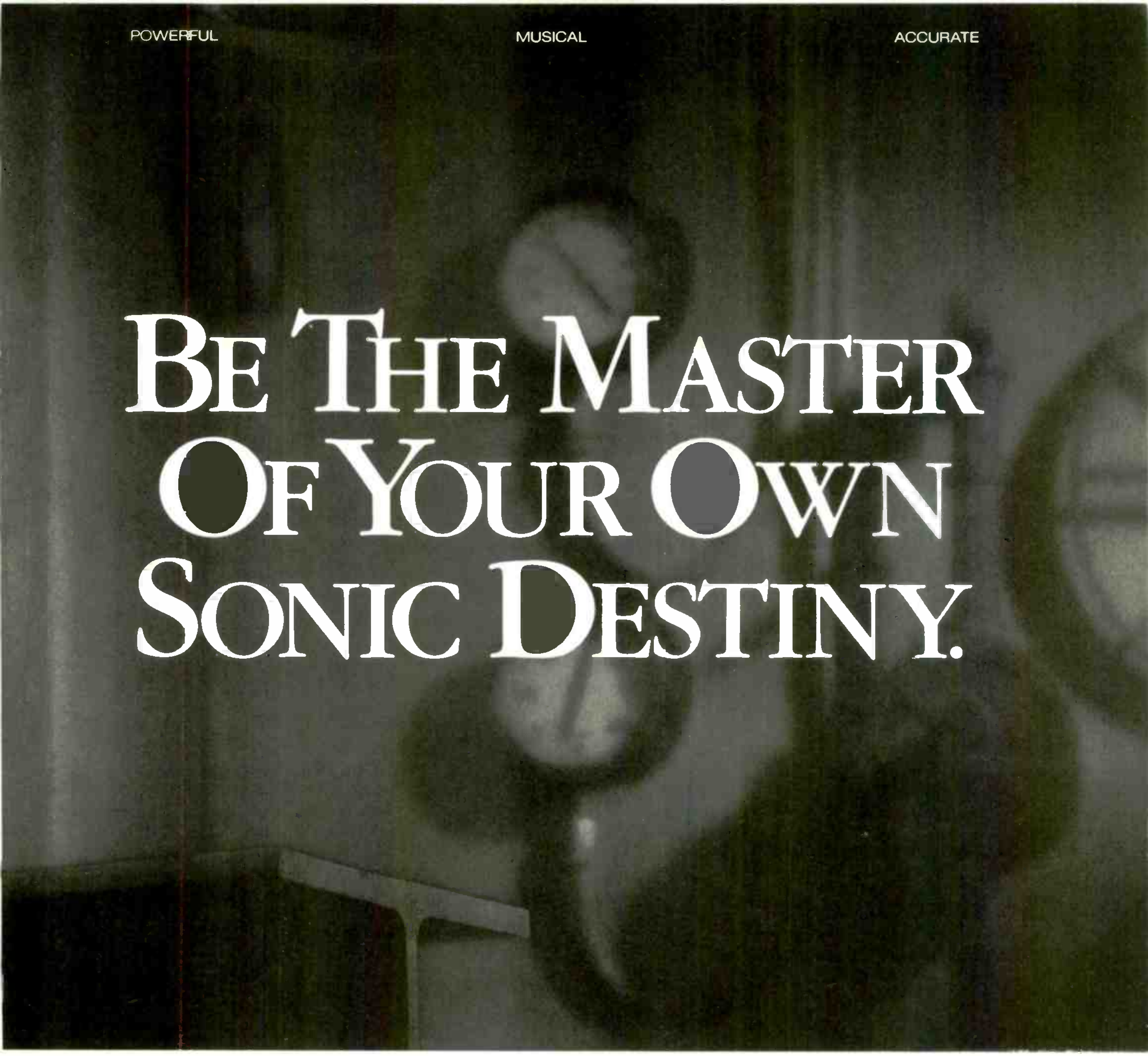
Accuracy and musicality through Transfer Function Modification. Over the past two decades, Bob Carver has worked on the problem of replicating one power amplifier's sonic signature in another dissimilar design. Through thousands of hours of painstaking tests and modifications, he has been able to closely match the TFM-25's transfer function with that of his highly acclaimed $17,500.00 Silver Seven vacuum tube reference power amplifier. When you hear the warm, natural sound of the TFM-25, you'll know that Transfer Function Modification is an audible reality.

New flexibility in a classic preamplifier design. The Carver C-16 is at once a purist, "straight-wire-with-gain" design and a wonderful wealth of sonic options. Including individual left/right tone controls with variable



turnover, full-band Spectral Tilt, and of course Sonic Holography® with a new Blend control that further extends the remarkable spacial restoration abilities of this exclusive Carver technology.

ACCD turns "dirty" FM into fresh air. Unlike any competitive tuner model, the Carver TX-12 can actually transform a noisy, multipath distortion-ravaged FM signal into clean, hiss-free music with full stereo separation. The key is the TX-12's Asymmetrical Charge-Coupled FM Detection circuitry. A lengthy name for a wonderfully fast solution to expanding your listening possibilities. When you experience ACCD's effect, you may consider the TX-12's full remote control, 20 FM/AM presets with preview scan, stereo/mono switch and dual antenna inputs, mere icing on the cake.

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IVAN BERGER

LIGHT AT THE END OF THE TONEARM

Finial's Not Finished

Tracking phonograph records with a beam of light, instead of a stylus, has been an engineering dream for at least 30 years. Lasers and computer chips would seem to make that possible, but the dream seemed dashed last January. Finial Technology of Santa Clara, Cal., which had been expected to pay off several years of promises by unveiling a laser turntable at CES, instead announced the project's death. After analyzing the results of their first pilot production run, the company realized that the turntables would cost about $10,000 apiece to produce, rather than the $3,750 originally projected. At that price, they felt, the market would be too small to warrant further production.

They may have been wrong. Due to demand from radio stations, museums, and some record collectors, Finial has put the turntable back into production, with some upgrades and improvements. The price, however, has gone up. Turntables from the original 35-piece production run, with the new upgrades, have been sold for $32,000, although the next batch is expected to be priced above $20,000.

Watts and Worms

Running comparative listening tests on amplifiers is interesting—and not just because of what it tells you about the amps. The more I do it, the more I learn just how big a can of worms it is. The pitfalls of such testing are many, and not always obvious.

For instance, reactions to the first amp auditioned are often skewed, because you have no recent basis for comparison. So I retest the first amp, halfway through the group, and base my reactions on the retest.

The order in which you listen to selections has an impact. A volume setting that normally sounds just right for a given track will sound too low if the preceding track was noticeably louder and too high if the preceding track was quiet. Conceivably, the mood-altering effects of different musical works could affect your attitudes to the sound too.

It's long been known that listening levels often have a subtle effect. A difference of several dB is instantly identifiable, but if the difference is only a fraction of a dB, the slightly louder amp will just sound "better," without you knowing why. So system levels should be recalibrated, using a fixed-level tone and a sound-level meter, each time a new amplifier is connected. If volume settings are changed from cut to cut, calibration is needed yet again.

Level calibration can also reveal listener fatigue. When your ears say a selection that sounded all right before is now too quiet, but the meter shows the system gain and levels to be just what they always were, you know your ears have tired and it's time to quit making comparisons for the day.

Another variable is amplifier/speaker interaction. I think you can often tell which of several amplifiers sounds best when driving a given speaker. I'm not at all sure, however, that it's safe to extrapolate those results to another speaker, especially if that speaker is a very different type. The complex-impedance curves in *Audio*'s speaker tests show what kind of load a given speaker presents to an amplifier. A perfect amp should do equally well with any load—but with the speaker used for the listening tests, a lesser amp might actually be chosen as sounding better. This may not be a major variable: Every time I have compared a suite of amplifiers on two different speakers, my opinions did alter subtly but were not grossly changed.

Illustrations: Beata Szpura

You Said a Mouthful

The tie-in between movies and popcorn is pretty universal. Even though I spent my childhood Saturday matinees in a theater that didn't sell it (we had ice cream, Jujubes, and frozen Charleston Chews), I grew up with the knowledge that popcorn was movie food. So it's no surprise that BASF is promoting their videotape by offering microwave popcorn—Paul Newman's, naturally—with it.

Notice, however, that there's no audio equivalent. Food is not normally consumed in concert halls, though snacks and drinks are sold at intermission. Jazz and rock clubs sell mainly drinks, and none of the foods they do serve are universal enough to be symbolic. So there's no natural tie-in for home listening.

Perhaps some enterprising tape company should offer audio cassettes with your choice of two edible tie-ins—soft, noiseless foods (Jello? chocolate mousse?) to go along with music you don't want to drown out, and crunchy carrots, celery, or potato chips for music you would really rather not hear.

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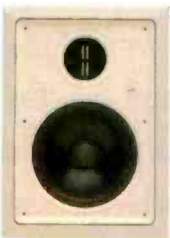

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IVAN BERGER

INTO THE JAWS OF DEAF

Gentle Kick

A black car with blacked-out windows looks sinister, even when it's basically as sporty as a Chevy S-10 Blazer, but I didn't *really* worry until Joe Gross opened its door and let me see the array of vast, black Stillwater Kicker speakers just behind the front seats—eight 18-inch woofers plus a handful of tweeters, midrange drivers, and mid-woofers, so many that Gross had had to install angled, overlapping panels to hold them all. A guy could go deaf in this, I thought.

Not all of the Blazer's 20 speakers are shown here—just enough to be a little daunting.

Joe sensed my feelings. "Don't worry," he said. "It has a volume control. And it can sound just as sweet as it sounds loud. We built it to do both."

Joe also built it as a demonstration to show installers what can be done in a car, as far as craftsmanship—and volume—are concerned. As technical rep for David Lee Marketing, in Edmond, Oklahoma, a car stereo manufacturers' representative, Joe does sales and installation training, answers questions about his company's products, and "does a lot of cheerleading."

I felt like cheerleading myself, when I heard the system. It was as clean and sweet as Joe said. I was prepared to take his word about the volume, especially when I learned its 28 speakers are powered by 4,385 watts worth of Linear Power amplifiers. "At crank-'em-ups," Joe said, "we've measured 153.7 dB SPL, unweighted average. I don't stay in the car when I do that."

The 13 amplifiers are in the rear (five are countersunk into the tailgate), as are eight Interstate Megatron batteries and two Astron 50-ampere power supplies. The Astrons charge the batteries and operate the system when it's parked near an a.c. outlet. The eight Linear Power 5002 500-watt amps are hinged, so they can be swung up and locked to expose the quality of the wiring inside.

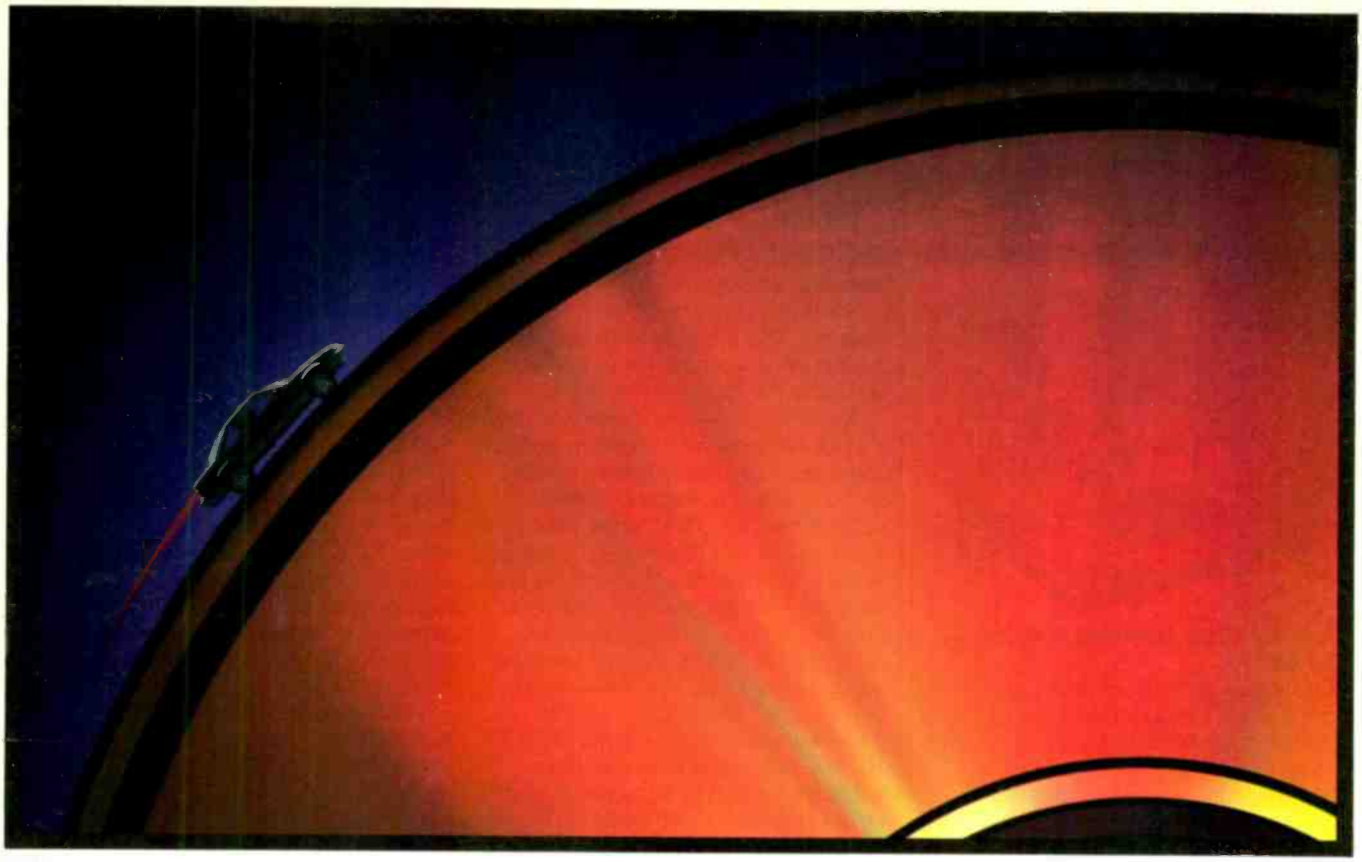
Thirteen amps, five extra batteries, and two a.c. power supplies were used in the Blazer.

Up front, Gross has two Denon head units, a DCC-8920 AM/FM/CD unit (which he uses only for CDs) and a DCR-5470 AM/FM/cassette unit. The latter is being replaced by a Denon 7870, which can also control a remote CD changer; the 8920 will stay in the system to play single CDs. Overall system equalization is set by a Denon DCC-420 selector module and DCE-250 12-band equalizer; a Linear Power PA-II preamplifier/equalizer acts as the system's main tone and volume control.

About 700 man-hours went into the installation, all crammed into the month before the Blazer's debut at the 1989 Summer Consumer Electronics Show. "I couldn't have done it in time," says Gross, "without the help of two friends, Terry Lackey and Rick Stuck, who put in more than 100 hours apiece on evenings and weekends. Rick also let me use the woodshop where he does custom installation work for Hawk Electronics, a car stereo dealer in Arlington, Texas." Gross estimates that it would cost about $25,000 to duplicate the system for a customer.

Hornet Flies Again

Racing and rally cars don't usually have stereo systems. But putting a stereo in such a car makes sense when the event is as long as the 2,178-mile, eight-day Mexican Pan-American Road Rally and the car's sponsors include Sherwood. Driven by Loyal Truesdale, the car placed second in the American division's small touring class and 11th overall. The race was run in November 1988, but there didn't seem much point in rushing the news into print when discussing the exploits of a 1953 Hudson Hornet.



Car amplifier power specs are for 14.4-V operation, but the actual voltage in cars is often lower.

"I'll Have The Traveling Wilburys . . . To Go"

Many years ago, drained by a hard day selling vacuum cleaners, I found myself so perked up by a song on the radio that I turned back 10 miles to buy a record of it. Finding a parking place, locking up the car, and walking to the record store took more time than the 10-mile drive did. That needn't happen if you patronize Dazz II, a record store in Camden, N.J.—they have a drive-in window.

Variable Voltage

Nominally, cars have 12-V electrical systems. The standards for car stereo testing, however, are for performance at 14.4 V. Is this realistic?

According to *Audio Review* of Italy, it's not—at least for European and Japanese cars. They tested 12 cars and found that voltage under load ranged from 11.3 V (Lancia Prisma 1.6 IE) to 11.8 V (Saab 900 Turbo and Volvo 750 Turbo D) when the engines were off, with an average of 11.6 V. With the engine running, voltages ranged from 12.6 V (Suzuki Santana, a four-wheel-drive off-road vehicle, and Lancia Thema IE) to 13.6 V (Maserati 422) and averaged 13.12 V. The magazine points out that an amplifier delivering 72 watts at 14.4 V would only deliver 50 watts at 12 V.

Current counts too, and alternators put out less of it as they heat up. *Audio Review* tested a Lestek aftermarket alternator from Rockford Fosgate, at 27° C (80.6° F) and at 90° C (194° F), and found this true. With its pulley turning at 4,000 rpm, the unit put out just under 160 amperes at the lower temperature but only a bit more than 135 amps at the higher one. The alternator's rated output of 190 amps was achieved only at 8,000 rpm (pulley, not engine speed), and it dropped down to about 170 at the higher temperature. Stock alternators are smaller (my Scorpio's alternator, at 95 amperes, has a comparatively high output), and makers of aftermarket alternators tell me that stock alternators' outputs drop even more with heat.

The magazine also measured the resistance of each car's body, since some installers use the body as a ground return path between trunk-mounted stereo systems and the battery. Of the tested cars, the Saab and Maserati had the lowest resistance, only 0.98 milliohm (0.00098 ohm). Highest was the Fiat Uno 45 FIRE, at 6.1 milliohms.

Illustration: Robert Zimmerman

EDWARD TATNALL CANBY

ASSAULT WITH INTENT

Illustration: Tim Bower

Film versus video? Thanks to the current promotions of HDTV and its video relatives, the conflict between the film and video approaches to color pictures with sound is looming all the way around our semidetached audio industry—with ourselves hooked into the various systems all over the place, both in film and video. This is surely one of the most interesting confrontations of technique in this century. In most of the areas, audio is of course vital, whether in professional color motion pictures or the same via video. In others, like consumer video movies, audio is inexplicably down to zero even though it is "available" as never before—and automatically, at that. You can't avoid it, but you can ignore it. We do.

On that score, you read in this column in August concerning the wonderfully misplaced hopes for "home" movie sound that were taken up enthusiastically by our industry in the early 1950s. Suddenly—magnetic tape. And easy striping of the film. It was an inspiring thought, but it mostly fizzled. Misplaced intentions.

Then again, so many years later, we suddenly had much more extensive sound via videotape, and once again the home folks aren't going along. Who can tell? They may yet, given time, because sound recording is a good idea, isn't it?

Are things going differently (than once intended) in the professional world of moving pictures? You bet. For a long time, video pictures and film movies—at least from a consumer viewpoint—kept their distance and didn't really mix. Video was best in the home; film held right on in the movie theater, with a boost from large screens, surround sound, and even 3-D. Which was which, video or film, did not concern the public very much. A movie is a movie, TV is TV—even on your VCR. And thus we thought we knew where we were going. No more! HDTV has burst upon us—at least in the media. Of course we haven't seen it, but that doesn't diminish our interest. Suddenly, a revolution! So far, it hasn't cost us consumers a cent. It's all in the hype, absolutely free.

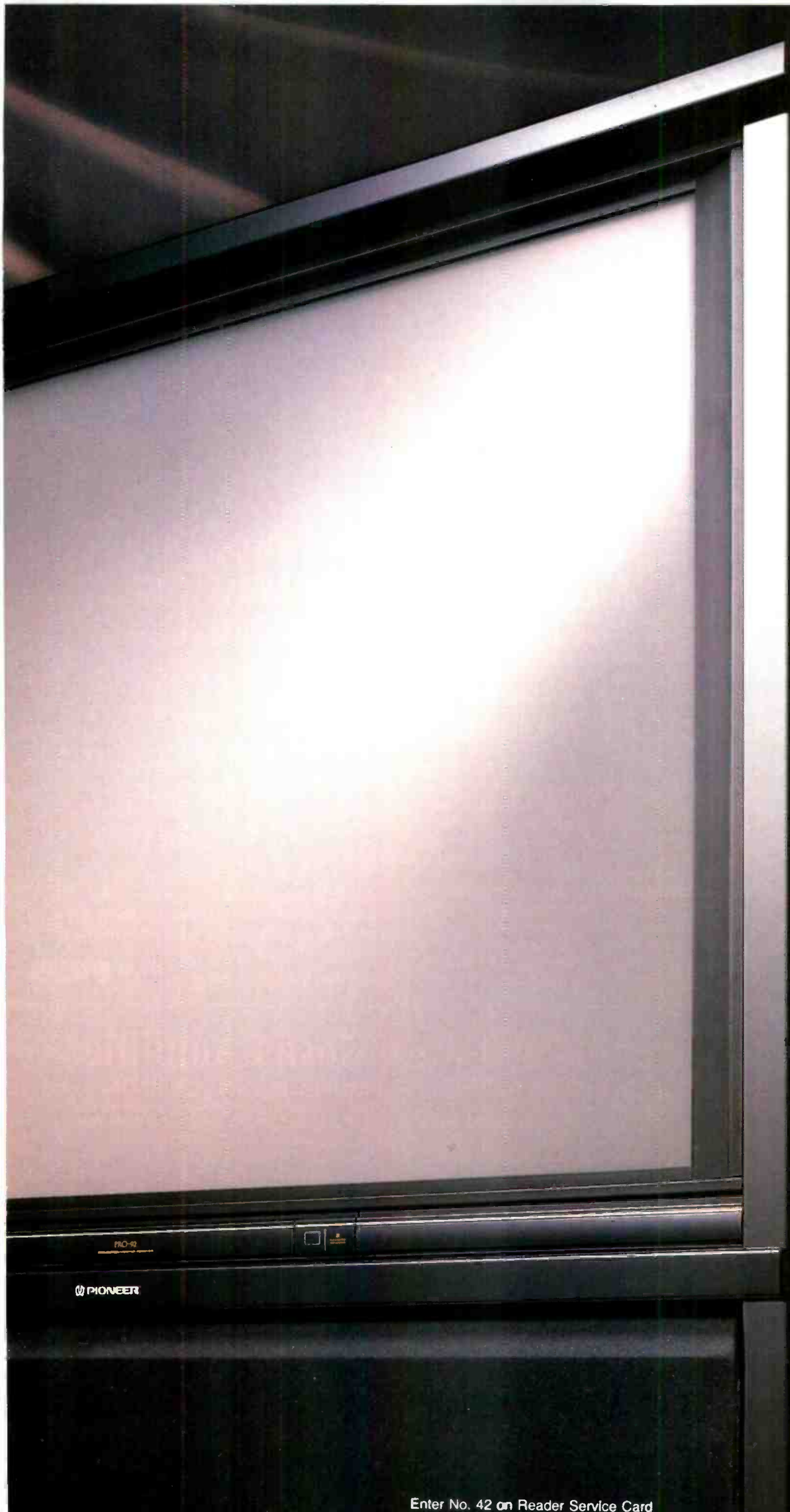
None of this was remotely envisioned, or intended, when TV first appeared as a very real revolution right after WWII. Then, its intent was to challenge and swallow up the world of radio, which it did—almost. But the movies were entirely separate, until we had reliable video recording. That took a while. Our early intentions were undisturbed, but not forever! The video fat was in the fire when, at last, home video recording/playback appeared, precipitating another and much more complex revolution replete with absolutely epochal fights, fights as to rights as well as mere technologies. And thus video came to the movies for the first time. HDTV is actually no more than a dramatic continuation of the clash between video and film technologies. Or rather, their forced interpenetration, already enormous even before HDTV.

Misplaced intentions! Our first intent is often practical, as with TV. But we are seldom very good at forecasting the future, pro and con. That part is a matter of experience. We start one way, back up, turn violent corners, and describe corkscrews of policy as we find out what *really* works in our new developments. As they used to say, this is the school of hard knocks. Live and learn. Practice makes perfect. Experience is the truth itself coming forth! Here is the true process of technological improvement, in spite of all the preplanning and R & D. Thus do we move from our early and simplistic intentions to more realistic appraisals, formerly unperceived. It's a good system, in spite of casualties en route.

A professional term from another area comes to mind. It's one of those academic terms out of a college English department, having to do with language: The misplaced epithet. Different, but doesn't it ring a bell? And so very professional sounding, like gobbledygook. Just try to say it two or three times, fast. In my non-pro language book, this one ranks with such childhood absurdities as, "She sells sea shells by the seashore"—equally unpronounceable.

Nevertheless, "misplaced epithet" is right for the present argument. You hammer away at a wrong place, until maybe you move your (linguistic) hammer to hit a better place, and things begin to work out in new ways.

Tom Edison (my usual favorite) intended his fabulous phono, and plugged it, obstinately, as a dictating machine. Music was far from mind. For years, he would go no further than the corny comedy stuff he himself enjoyed. Fortunately, others carried on as new directions for recording became evident. Henry Ford hammered away at



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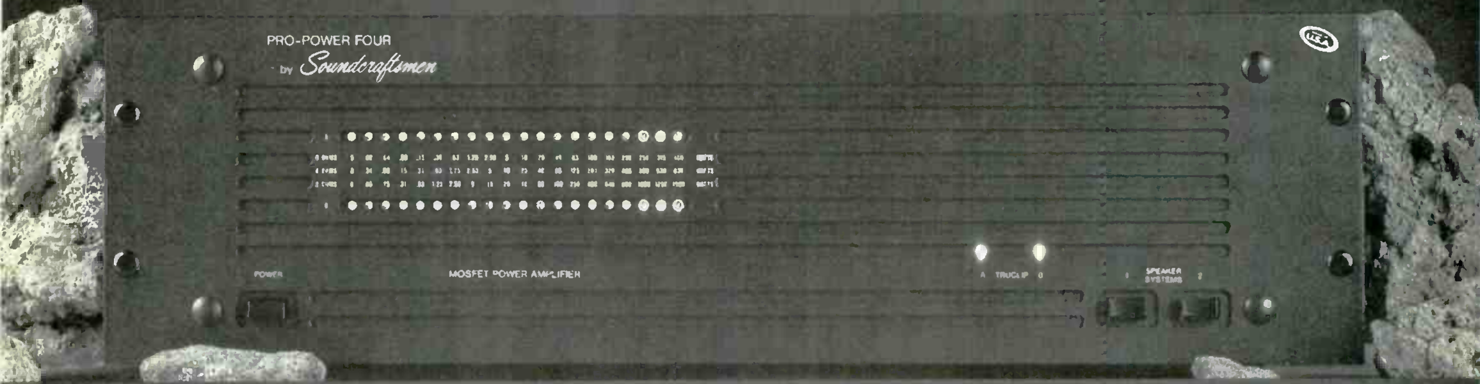

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Says Leonard Feldman in his Test Report in AUDIO Magazine, Vol. 71, No.9:

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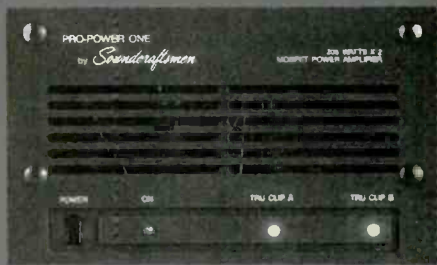

The PCR800 amplifier is similar to the PRO-POWER ONE, rated at 205 watts per channel @ 8 ohms, but with plain overlay front panel.

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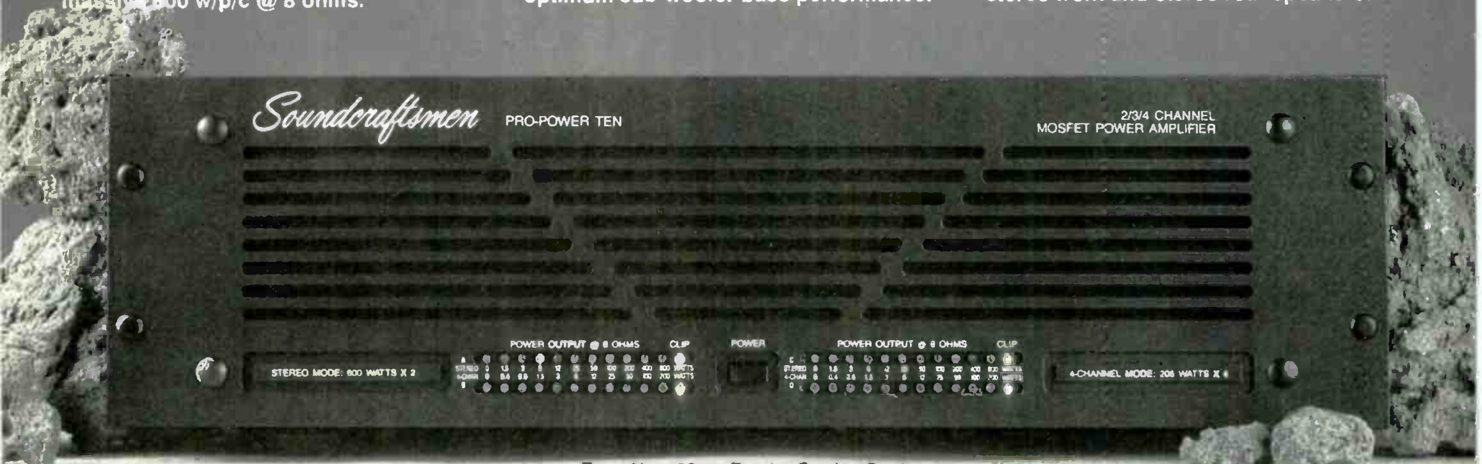

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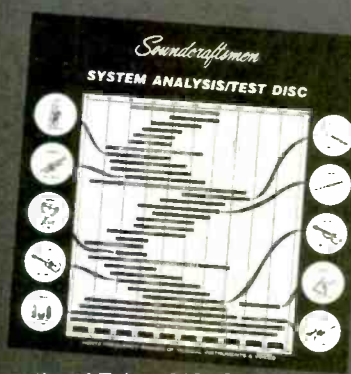

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HDTV is merely a dramatic continuation, the ultimate in the clash between film and video technologies.

the motorized buggy he built around 1900 and manufactured his very last buggy-sprung Ford in 1948 (cross springing). Again, luckily, others carried on the interplay of new technologies to turn present Fords into non-buggies. A very misplaced intention, like plenty of others.

So now, suddenly, with the hoopla about HDTV, we have reached the beginning of the ultimate video-versus-film confrontation. Clearly, we are still in the hammer stage, thanks to the unerring simplicities of the media, which rejoices in oversimplification and anything that is or can be made sensational. Yes, HDTV has been in proposition and development for a long time. Yes, it is now "practical," in that it can be seen and is even on the air, though not for US. Yes, it is an extremely legitimate area of refinement in the entire art of video recording and reproduction, inevitable these many years (see my "Sharper Image" piece in April). Yes, the new sharp image satisfies the Canby Principle which says that the dominant medium, the picture, should have the sharper, higher definition. Hi-fi is at home at last! Some marriage, and a good many very rocky years before things are settling down there.

HDTV, hype or no, is thus at the turning point. Now the accommodations begin, within the picture industry, inside the engineering fraternities. The hype is transitory. The accommodations are real and earnest and will be thrashed out and formed in the utmost seriousness, on both the film and video sides. A thousand early intentions, previously held thoughts, will have to take on new directions for new intents.

And so it is necessary right now to play down the big noise among those who, like *Audio* readers, can form a more sober and realistic judgment in this coming together of an old and highly perfected medium with a new, progressive, innovative, and stylish one that is still in erratic development, for all the claims.

Somebody, you understand, has to take on the defense of the more conservative but also enormously reliable older medium: Film, in all its present and still-advancing perfection. Luckily, it is not me, except in generalities! You will remember that I have a more knowledgeable expert to argue that case in the face of HDTV: Jac Holzman, chief technologist of the new Warner Communications/Time Inc. combo, the same Holzman who, many years ago, founded the twin LP labels Elektra and Nonesuch.

The Holzman article on film versus HDTV is already in print in a recent broadcast industry magazine, so I will merely quote succinct excerpts from the manuscript.

The Holzman introduction: "Over the past decade, certain video zealots have advocated that film is a medium destined to be replaced by high-definition video devices which will become both the new production and transmission standard. This narrow point of view ignores not only the incredible strides in film emulsion technology but the practical, cultural, artistic, and severe economic dislocations of any high-definition changeover." That's Holzman for you, in a warm nutshell. Haven't we had similar analog versus digital arguments? And aren't we now rediscovering the vacuum tube?

But back to Holzman: "For close to five decades, the bulk of serious 'reusable' entertainment television programming has been captured *on film* [my italics] and transferred readily to video. Thirty-five-millimeter film is the accepted international standard and moves readily across borders. It provides originals of the highest quality. The breadth and historical certainty of 35-mm film . . . combined with its ability to be shown theatrically or transmuted with convenience and fidelity into any video format—PAL, NTSC, or HDTV—assures all producers and artists that their creations will continue to be viable through a changing thicket of evolving standards." That sums up the first advantage of film—and, incidentally, the audio that may be attached to the film original. In this context, a video original is dangerous these days.

But what of obsolescence in the picture quality? We know a lot about early audio and the problems of updating our own product for transfer to CD. Give a heartfelt sigh—if only audio recorders were like cameras! Writes Holzman: "Film cameras built 20 or 30 years ago reliably produce films today that are indistinguishable from films produced on the latest Arri or Panaflex.

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Keep an optic fixed on the digital in film's future, if and when. There, perhaps, we in audio are ahead in experience.

The mechanical movement of a film camera is among the most reliable and precise devices ever created. Its primary duty is to move film smoothly through a gate which, assisted by an excellent optic . . . forms the finished image on the film emulsion. That's all a film camera has to do because massive R & D expenditures are primarily in the film emulsion. . . ."

The truth indeed, as I can attest from my own consumer viewpoint using stereo slides. My camera was built around 1950, but in terms of images on current film, it is *100% up to date*, lacking only the automation (thank God!) that would be provided in a new model. This, you see, is an unanswerable argument for film *in some major respects*—if irrelevant in others—and it accounts already for the almost universal present use of film for professional video originals. So don't get too fascinated by HDTV and its relatives, though they surely will be coming along in one way or another—if not to replace film, to supplement it, to combine with it.

Particularly, we should watch the whole area of synch and time coding, already familiar in plenty of pure audio. And keep an optic fixed on the digital in film's future, if and when. There, maybe, we in audio are ahead in experience. Certainly, our enormous know-how in digital is bound to affect future changes in film sound, there being plenty of analog still left in the film area.

Holzman, to go another step ahead into the matter of quality, gives a fine glimpse of the current situation as between video and film. "In the current Japanese high-definition [video] proposal, the only choice we are being offered is an electronic *emulation* of 35 mm." A good phrase. Video is all wrapped up in an effort merely to equal what 35 mm has had for decades in sharpness and lack of "noise" or grain—i.e., high definition. And how about sensitivity? "When Technicolor introduced its three-strip process to the world in *Becky Sharp*, the ASA rating of the film was 8 to 10 [the first home Kodachrome was 12], and the heat from the lights melted the actors' makeup. Not so today. We can light in just a few foot-candles, and using such new emulsions as Kodak's T-grained EXR series and Fuji's F series, exquisite and reliable images can be captured on film at ASA ratings up to 2,000 . . . without losing the richness of blacks, reducing the scale of tonality, or noticeably increasing the grain ("noise," to video engineers). HDTV cameras currently have an ASA speed/sensitivity of around 85, and there are hopes that new HDTV cameras are near where the sensitivity of the *tube* will be increased to an ASA of 125, perhaps 200. But film is already three stops faster."

Have to stop myself. I'll quote more of Holzman's interesting challenges next month—even including an audio item that was new to me.

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Remote control of the basic functions of Adcom's much heralded GCD-575 CD player is also achieved with the GTP-500 II remote system, thereby simplifying control of your Adcom system. For total music system integration, the GTP-500 II remote sensors will also receive and re-transmit commands to any other remotely controlled component. Regardless of brand, you can control your cassette tape deck and VCR, using their respective controllers through the GTP-500 II's sensor system.

This remarkable and well thought-out remote control design gives you full command of your audio system and will virtually change the way you listen to music throughout your home.

(over please)

The Adcom GTP-500 II: It's value is measured by its performance.

The overall performance of the new GTP-500 II is demonstrably superior through its evolutionary design improvements and the use of today's most advanced, high grade component parts. Adcom's fundamental design objectives of creating a quieter preamplifier, an FM tuner with improved RF performance and an AM tuner with flatter frequency response and reduced distortion were all achieved.

The Preamplifier

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.

GTP-500 II/GFA-555 (200 watts/ch)*

And to simplify the signal path and minize degradation, tone controls, contour and filters are out of the circuit until and unless they are needed.

To ensure that long term adherence to circuit design objectives is accomplished, 1% Roederstein resistors are used in all critical applications as well as a new low-loss, printed circuit board. Throughout all circuits, the GTP-500 II uses state-of-the-art component parts for the highest performance possible during its lifetime.

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Through a careful balance of sensitivity and selectivity, the GTP-500 II optimizes FM performance whether you're in an urban area troubled with excessively strong FM signals, or you're in a rural area with weak signals. Also contributing to a significant reduction in distortion is an improved IF stage. Indeed, the quality of FM stereo reproduction through the GTP-500 II is as good as the broadcast itself.

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Adcom stereo components have gained a reputation for sounding superior to components costing two and three times as much. The new GTP-500 II promises to keep faith with this tradition of more sound for less money.

Specifications

Preamplifier

Total harmonic distortion: 0.004%
IM distortion: 0.005%
Frequency response: 5 - 65 kHz ± 0.5 dB
Maximum Output Level: >10V
Input sensitivity for rated output:
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- **High level:** 320 mV

Tone controls:
- **High filter:** (20 kHz) - 4dB
- **Low filter:** (20 Hz) - 3dB

Output Impedance: 100 Ω
Voltage: 120V/50 - 60 Hz
Dimensions: 17" × 3¼" × 12¾" D (432mm × 83mm × 324mm D)
Weight: 16 lbs. (7.3 Kg.)

FM Tuner

IHF sensitivity, mono: 12.2 dBf
Signal strength for - 50 dB quieting, mono/stereo: 14/36 dBf
Capture Ratio: 1.7 dB
AM suppression: 60 dB
Alternate channel selectivity: 75 dB
Total station presets: 16
Separation at 1 kHz: 50 dB
THD/stereo at 1 kHz: 0.09%
Maximum signal-to-noise ratio, mono/stereo: 80/75 dB
Frequency response: 30 - 15 kHz ± 0.5 dB
Antenna Impedance: 75 Ω/300 Ω
Optional accessories for GTP-500 II:
Available with white front panel. XR/500 II and SPM/500 II remote sensors, RM-3 rack mount adaptors.

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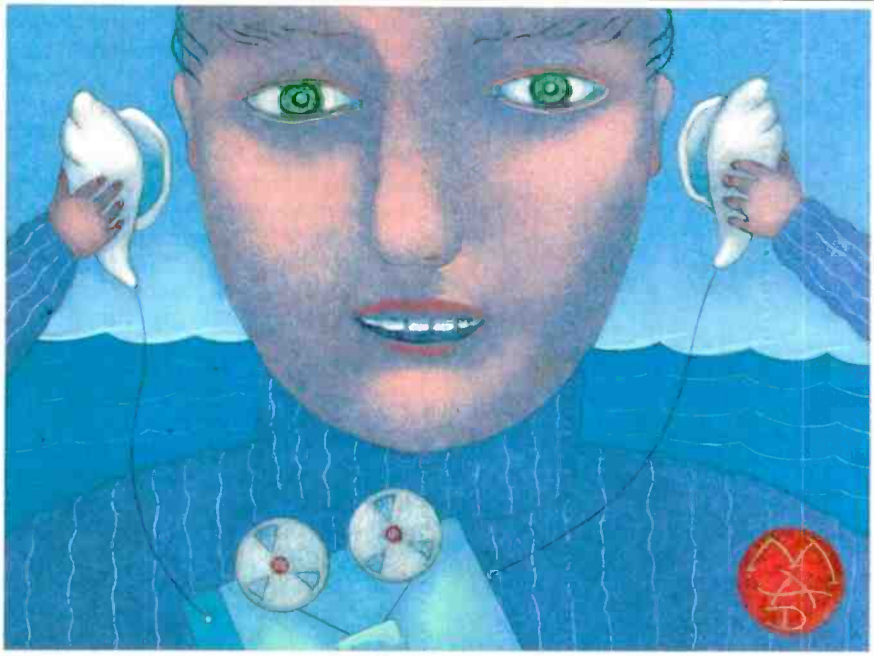


Illustration: Michael Donato

No matter what medium is employed, there can be no high-fidelity reproduction of music unless there is a corresponding high-fidelity recording of the music. This is axiomatic and immutable. The most elaborate and sophisticated audio component system cannot make a poor recording sound good; as we all know, the higher the quality of the playback system, the more we will hear the sonic warts of a poor recording.

After World War II, a certain amount of progress was made toward the improvement of sound quality in 78-rpm recordings. The culmination of all this was that in 1948, Decca introduced their famous ffrr (full frequency range recording), surely the zenith of 78-rpm sound quality. The parallel development of magnetic tape recording and the 33⅓-rpm microgroove long-playing vinyl record ushered in the high-fidelity era in 1949.

From the beginning, open-reel magnetic tape recording provided a medium that, at 15 ips, had a wide frequency range (30 Hz to 15 kHz) and a dynamic range and S/N ratio of about 55 dB. It also afforded a recording time of 30 minutes at 15 ips, and the luxury of tape editing.

Of course, it soon was realized that improvements in recording quality could be well publicized and result in increased record sales. In the early 1950s, considerable advances were made in magnetic oxide formulation, magnetic head structure, and recording electronics. Condenser microphones, as exemplified by the famous Telefunken U-47, were increasingly used. Virtually all the record companies utilized some or all of this technology, but recording advances were most assiduously pursued by the "sound labels" of the day: London/Decca, Westminster, Vanguard, and, of course, Bob Fine's highly acclaimed Mercury Olympian series.

This was still the era of monophonic recording on quarter-inch tape. As the quality of the tape masters improved, so did the need for better disc-cutting heads and electronics. I well remember Bob Fine first using a Grampian cutter and then adopting the very high-quality Miller cutter, which required a hulking McIntosh 200-watt tube amplifier to drive it optimally.

When it became apparent that stereo recording would soon supplant mono recording, Bob Fine wanted to record three channels of sound on 1-inch tape. The tape companies believed they would have trouble maintaining uniform slitting at this width and suggested the use of three channels on half-inch tape, which also made for a less expensive tape head structure. Subsequently, Ampex marketed the 300-3 recorder in the half-inch format, but obviously, the S/N ratio suffered because of the reduction of track width in using half-inch instead of 1-inch tape.

With the advent of the stereo disc in 1958, three-channel stereo mastering on half-inch tape grew enormously, followed later by four-channel recording on half-inch tape and multi-channel recording on 1- and 2-inch tape. During this period, recording engineers were trying to eke out every last iota of sound quality with respect to extended frequency response and dynamic range, lower distortion, and better S/N ratio. Much of this was accomplished with better and quieter tubes, more refined mixing consoles, and more sensitive microphones. The stereo discs benefited from more linear Neumann and Ortofon cutter heads. The sound labels tried to stay with the simpler, "purist" style of stereo microphone techniques, while the major labels started to apply multi-microphone stereo recording to classical music. Thus, anything and everything was used to improve sound quality and gain a competitive sales advantage. The sound-oriented labels had to put their emphasis on high-quality sonics because their artists were not of the illustrious stature of those on the major labels.

On my Everest recordings, we initially used three-channel half-inch Ampex recorders with considerably modified and improved recording electronics. This was easy to do since we could use the very sophisticated facilities of our parent company, Belock Instrument Corp. To push Everest to the technological forefront, we took the expensive plunge into three- and six-channel mastering on 35-mm sprocketed magnetic film. Now, with three channels—each the equivalent of full-width, quarter-inch, single tracks—we were routinely achieving S/N ratios of around 70 dB. With the film running at 90 feet per minute, this was equivalent to 18 ips and afforded extended high-frequency response.

An unfortunate aspect of analog magnetic tape recording is that a copy of the master tape will be degraded in various ways, especially in respect to S/N ratio. The problem is alleviated somewhat with Dolby A NR, but in gen-

In audio engineering, progress rarely slows for very long, and the winds of change are blowing again.

eral, copies of analog master tapes just are not as good as the original. What really prompted this month's column is that now, in 1989, 31 years after Everest started using 35-mm magnetic film for mastering, a seemingly impossible thing has happened. Imagine my surprise to find that Philips recently has licensed some of my Everest recordings: Aaron Copland conducting his "Billy the Kid" suite and Third Symphony, Stokowski conducting the Shostakovich Fifth Symphony, Ferde Grofé conducting his "Grand Canyon Suite," and Carlos Chávez conducting some of his works. Philips had the Everest 35-mm magnetic-film masters processed at Sonic Solutions, using their NoNoise digital noise-reduction system. The recordings were subsequently issued as Philips "Legendary Classics" on CD.

Incredibly, the CDs are quieter than the original 35-mm masters! Evidently, the 70-dB S/N ratio of the 35-mm masters made these tapes particularly suitable for the NoNoise digital processing. I can tell you, it was one helluva thrill to hear my recordings not only resurrected but sounding better than ever! Nothing has been changed or degraded in any way. In fact, the absence of noise provides better detail and resolution and affords a deeper insight into the music.

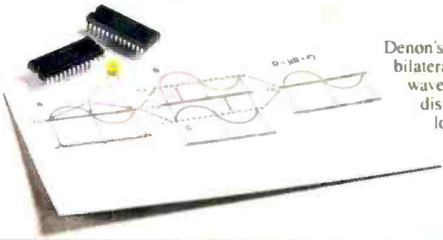
To put some icing on the cake, it should be noted that Bob Fine made many Mercury recordings on 35-mm magnetic film and that Philips owns these masters. It would seem reasonable to expect that some titles will be issued as Legendary Classics CDs.

It was quite a few years after the Everest 35-mm masters before conventional magnetic tape recording—with the addition of Dolby A NR—could equal, and then surpass, the S/N ratio of the Everest tapes.

I have pointed out before that digital recording is the great leveller. No matter what brand of digital recorder is used, the performance is very similar. The same holds true for the CD. With few exceptions, if a CD plant follows the Sony/Philips manufacturing protocol, the CDs will be like peas in a pod.

In audio engineering, progress rarely slows for very long, and the winds of change are blowing again. By general agreement, one aspect of digital re-

Starting with the first digital recording of music in 1972, Denon has produced an unbroken string of digital audio breakthroughs.



Denon's LAMBDA processor bilaterally offsets the digital waveform to eliminate the distortion that occurs when low-level waveforms cross the zero line.

The LAMBDA Super Linear Converter: Another significant digital audio first from the first company to record music digitally.

Denon's CD player innovations include the Super Linear Converter, the 20-bit digital filter, the real 20-bit converter and noise-shaping filter circuitry.

Denon's latest digital advancement is the LAMBDA Real 20-Bit Super Linear Converter in the DCD-1560. The LAMBDA system's digital offset processor and dual 20-bit converters eliminate the most common source of distortion in CD players: the zero crossings of low-level signals.

Denon's consistent leadership in digital audio technology may explain why earlier generation Denons often sound better than current competitors' models. And why a leading hi-fi journal found that a moderately-priced Denon equalled or outperformed all others tested, including machines costing over $1800.

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A new IC chip used for A/D conversion theoretically provides the equivalent of 128-times oversampling.

cording that needs a technological update is A/D conversion. With eight-times oversampling common on the D/A converters in many consumer CD players and 64-times oversampling D/A converters available on specialized processors, it is surprising to learn that two-times oversampling is generally supplied for A/D conversion on professional digital recorders.

Recently, several new IC chips for A/D conversion have become available. Among these is one from dbx/CTI: An 18-bit A/D converter operating at 6 MHz. Theoretically, this is equivalent to 128-times oversampling, a fact Chesky Records, who uses the dbx/CTI chip, proudly proclaims on the covers of their new jazz CDs. This IC chip is also being used for some Telarc recordings. In a conversation with Tony Griffiths, head of Decca recording in London, I was told that there is a new 20-bit version of the dbx/CTI chip, and that with Decca's proprietary digital recorder, he is getting 19½-bit performance!

In addition, it appears that Sony is introducing 20-bit A/D conversion chips. According to audio super-sleuth Barry Fox, a Sony 3402 DASH format digital recorder, using quarter-inch tape at 15 ips, has a modified head track pattern necessary for 20-bit recording. On this experimental unit, the A/D conversion electronics are mounted in an external black box but will be incorporated in the chassis of the production recorder, of course. Since the CD is a 16-bit system, why use 20 bits? It is somewhat analogous to headroom, with the 20-bit recording ensuring total resolution of the PCM system's 16 bits. As most readers know by now, Sony bought CBS Records; it appears they are founding a new label, "Sony Classical." These recordings will be designated "20-bit digital." Apparently, the EMI mobile recording truck had the experimental 20-bit Sony recorder aboard, so the unit was used to record Dietrich Fischer-Dieskau on some Mahler songs with the Berlin Philharmonic, and to record the Mozart Requiem with the London Philharmonic in Walthamstow Town Hall.

This appears to be quite an ambitious undertaking for Sony. The 20-bit A/D converter will probably be shown at the 87th AES Convention in New York City. Although this 20-bit recording technology would give the new Sony label a good deal of technical one-upmanship, I rather doubt Sony will use it exclusively for very long.

In any case, even if new developments in digital recording give some companies a technical advantage, there will be a return to digital equality in fairly short order. In the long run, the sonic quality of digital recordings still depends on the skills of the recording engineer, on the microphones he uses, and on the manner in which these mikes are employed after careful consideration of the acoustics. A

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No claim Sony could make for these headphones could conceivably be more impressive than this simple statement: this year, in the production of nearly 100 state-of-the-art compact discs, the headphones used as a quality control reference during the critical mastering stage were the Sony MDR-CD999.

In fact, chief mastering engineer Bob Ludwig of the renowned Masterdisk studios explains, "The 999's superior isolation allows me to experience the full dynamic range of these digital master tapes for the first time. They're also comfortable enough to wear for extended listening sessions." As Bob neatly summarized: "Everything sounds as I intended."

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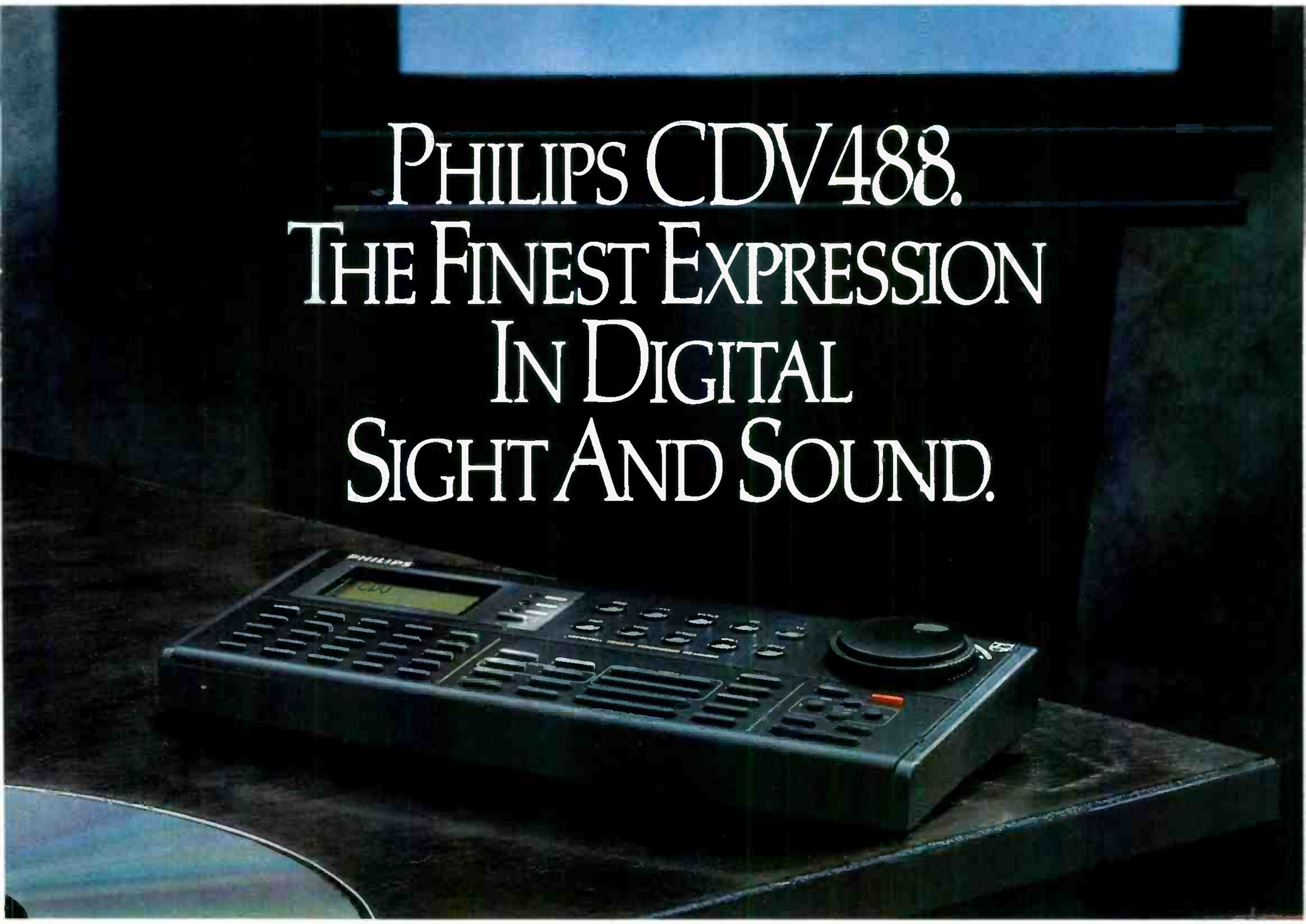

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The CDV488 provides 300% sharper color fidelity than any consumer videotape, including Super VHS. And Philips' proprietary wide bandwidth CCD comb filter with S-video output enhances color detail and color accuracy even further.

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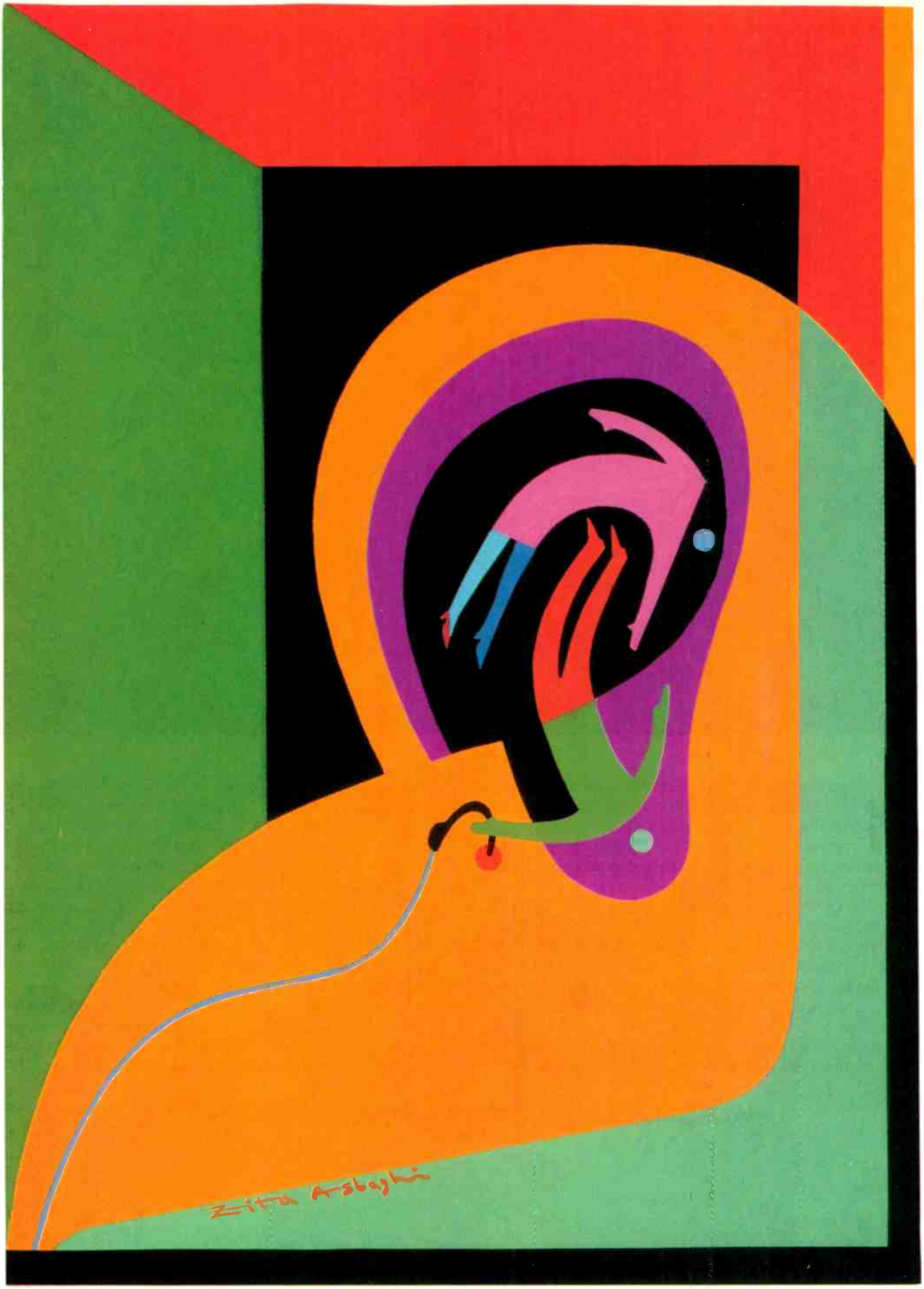

Illustration: Zita Asbaghi

BINAURAL OVERVIEW

PART II

EARS WHERE THE MIKES ARE

JOHN SUNIER

I have already mentioned, in Part I, the major differences between recording binaurally with mikes on one's own head and with an artificial head. For the amateur, the simplest approach is to wear the mikes oneself rather than tackle the immense problems of creating a perfect dummy head—problems which hundreds of researchers have devoted thousands of man-hours to solving.

Earlier, I touched on the differences between individuals' binaural hearing abilities. To draw a parallel, some people with perfectly good eyesight cannot distinguish much, or any, depth in stereo slides or photographs. A similar condition seems to occur with binaural listening, though the majority of people are totally bowled over the first time they hear true binaural sound! For those who cannot hear the effect, factors in ear/brain processing seem to be at the heart of the difficulty. Years of listening to ordinary stereo on headphones might even be a factor. What is not a major factor is ability to hear a wide frequency response in both ears—the most effective aural localization bandwidth has been shown to be only from about 625 Hz to 2.5 kHz.

One variable that does affect the accuracy of binaural localization has been found to be the method of recording. Binaural researcher Ron Cole (see Part I) rates open-reel analog recording, with a professional tape deck and no noise reduction, as the best method for preserving the subtle information required in good binaural reproduction. The more processing used, Cole found, the poorer the binaural effect. Cassette recording without noise reduction was not quite as good as open-reel; cassette recording with Dolby B NR was further reduced in quality; cassette recording with Dolby C NR was greatly reduced, and cassette recording with dbx I and II NR were seriously compromised. Accuracy of tracking was a major factor here, since results were usually much better when playback occurred on the same machine that made the original recording, rather than on a different recorder.

A good test for distortion in binaural localization is to record a noise-producing object—anything from a motorbike to an electric razor—as it moves in a straight line in front of the listener. Any phase distortions in

BINAURAL

For those who cannot
the problem seems to stem from

the binaural effect will be noted when the object is directly in front (Fig. 17).

The binaural effect varies greatly with different digital recording systems. Mine, based on the Sony PCM-F1 processor, gravely spoiled the effect for in-front sounds, giving them an amorphous character that could not be precisely located until they moved left or right. However, installing gentle-slope, phase-accurate filters (from Apogee Electronics of Santa Monica, Cal.) in the input and output circuits gave me nearly as perfect a binaural effect as open-reel tape without noise reduction. Further, Cole's recent work with Sony DAT recorders shows excellent binaural results.

The type of headphones used for binaural auditioning also plays an important part in the realism of the effect. Since, as noted above, the localization effect occurs in the middle frequencies, phase accuracy is more desirable than frequency response. West German binaural researcher Gunther Theile urges a new international standard of equalization for high-quality headphones. Instead of the current standards requiring free-field response and loudness-comparison measurements, Theile suggests using a flat, diffuse-field transfer function and testing subjects with probe microphones. Most electrostatic stereophones, while among the best for stereo listening, seem to lose much of the binaural experience. The Stax headphones (Fig. 18) are an exception and have been adopted by Genuit, Theile, and others as their reference standard for binaural experimentation. Stax has even produced a diffuse-field equalizer unit for use with their SR-Lambda Pro and SR-Lambda Signature models for the most accurate playback of recordings made with dummy heads.

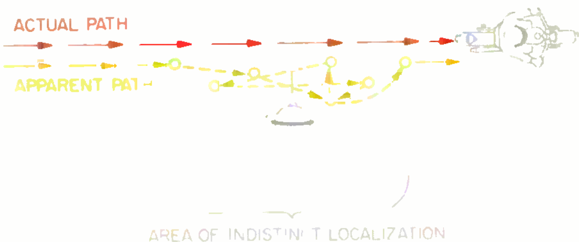

Fig. 17—Moving a noise source straight across the sound field will cause frontal-localization problems such as these if the recording or reproducing system has nonlinear phase. (After Cole.)

Cole has tested many different stereophones for binaural listening and, in the more modestly priced area, finds most of the top-line Sony dynamic 'phones, especially the MDR-M77 and MDR-M55, to be the next-best choice to the costlier Stax units. Wearing comfort is also a factor to consider; Stax and Sony 'phones are both very comfortable for longer periods of listening, and the longer the listener wears 'phones, the more plausible the binaural effect becomes.

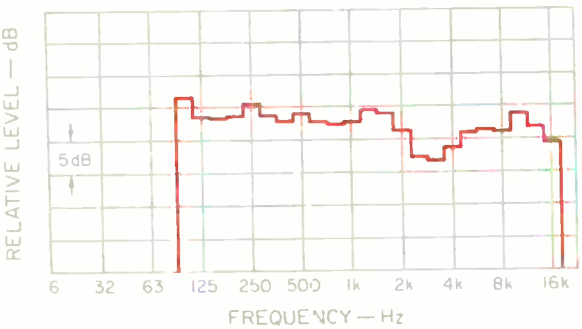

Fig. 18—Diffuse-field response of the Stax SR-Lambda Pro headphones. (After Theile.)

SIMULATING BINAURAL SOUND WITH ORDINARY STEREO

I began this article by touching on the unnatural sound image that stereo headphones produce with standard two-channel stereo. Stereo separation is greatly exaggerated since there is no leakage of left-channel sound to the right ear and vice versa, as with loudspeaker listening, and in-head localization makes sounds appear to come from inside the listener's head. Research into binaural hearing suggests some partial solutions to these problems, without special binaural equipment or recordings. This is welcome, since relatively little true binaural material is thus far available.

Benjamin Bauer described the first practical circuit for this purpose. Using passive components, it was designed for headphones of a specific impedance and processed the stereo signal to simulate the cross-feed and delay effects encountered in loudspeaker listening. A dozen years ago, Martin Thomas described a more advanced active electronic circuit that is based on the same principles and is adjustable to all types of dynamic headphones (Fig. 19). Listening test subjects reported a reduction of the in-head localization effect and an impression of spaciousness, rather than of precisely defined external sources. It was found that if there was a significant degree of reverberation, either natural or artificially added, the sensation of distance and direction of sound sources was greater.

Some headphone makers once offered control boxes with a blend control to simply cross-feed the channels, but without adding delay. Further, preamps with an L − R continuous control, such as the Apt-Holman, can blend toward mono to reduce the "in or at the ears" phenomenon.

As already noted, subtle equalization variances can have a major effect on binaural hearing. This can also be used to improve the playback of ordinary stereo material on headphones—precisely the aim of an equalization curve suggested by Ron Cole (Fig. 20). While a parametric equalizer would work best, the curve can be approximated closely enough to make a large listening improvement with only an 8- or 10-band stereo octave equalizer. The curve should be regarded only as a guideline, since your own headphones are probably not flat to begin with and your own hearing variations must be taken into consideration.

Special systems that operate on psychoacoustic principles, such as Carver's Sonic Holography, Sound Concepts' Image Enhancer, and Omnisonix's Imager, can also deliver more natural results for headphone listening. The seemingly excessive room reverberation in stereo speaker playback of recordings encoded with the Ambisonics UHJ process is natural and acceptable with headphones. And if you still have any SQ or QS quadraphonic LPs around, try them on headphones for an interesting experience that reduces some of the standard stereo exaggerations.

BINAURAL MOVIES

Supersonix, the first system for binaural headphone listening in conjunction with theatrical motion pictures, was used in April 1989 for a movie short made in New York City; the film was shot specifically to demonstrate binaural sound's potential. Supersonix (formerly Sonimax, and described in my March 1986 *Audio* article on binaural sound) uses the Brüel & Kjaer dummy head and torso for its original recording; either wired or infrared stereo headphones will be used for in-theater playback. Optimax III, Supersonix's New York-based developers, say that the system produces a realism of auditory imaging that no speaker system can rival, enabling viewers to localize precisely the direction and depth of each sound source and immerse themselves in the action on screen. It certainly promises a more satisfying experience than that provided to date by theatrical 3-D vision.

Supersonix's makers don't stop at motion pictures but want to license their technology for use with television, home video, and computers. No special decoding equipment is required at the listener's end—only stereo headphones to plug into your TV. I am looking forward to one day playing *The Hitchhiker's Guide to the Galaxy*, with binaural sound, on my Macintosh computer!

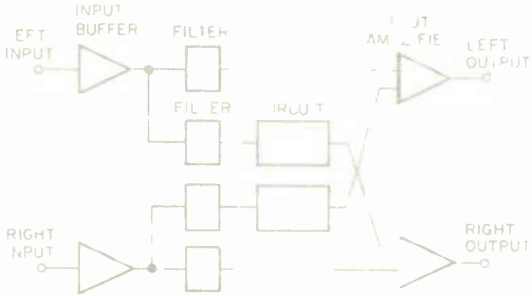

Fig. 19—Block diagram of the Thomas cross-feed and delay circuit for true stereo listening via headphones.

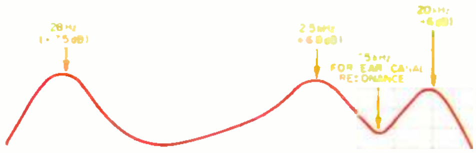

Fig. 20—Suggested equalization for adding liveness and realism to playback of stereo material through headphones. (After Cole.)

BINAURAL

Most electrostatic ordinary stereo listening, fail

Also in April 1989, the Disney/MGM Studios Theme Park in Orlando, Florida opened a binaural theater as part of its "Monster Sound Show." Entitled *Soundsations*, the theater consists of nine booths with a total of 72 headphones playing a 5½-minute sound-effects story with a plot. Among the effects is one in which guests "feel" the warm wind from a hair dryer as the sound moves from ear to ear. Early reports are that the binaural area is already the most popular feature of the theme park's sound-effects studio.

TRANSAURAL SOUND: BINAURAL EFFECTS WITH SPEAKERS

Gunther Theile has considered the problem of the compatibility of production and reproduction in binaural sound (Fig. 21). Stereo production/loudspeaker reproduction is a space-related process, while dummy head binaural production/headphone reproduction is a head-related process. They can, however, be made compatible.

In principle, any value of signal equalization can be applied at any point in the production/reproduction chain. However, standard stereo production is incompatible with headphone reproduction, and normal binaural production is incompatible with loudspeaker reproduction. Theile observes that the incompatibility arises from the processing performed at the location-determining stage of hearing. As his basic research on directional hearing has shown, equalization applied anywhere along the production/reproduction chain must not be based on a single reference direction. All transfer functions of the outer ear must be replaced by a corresponding average transfer function to ensure that timbral defects are kept at a minimum. Theile suggests taking the diffuse sound field as the reference to achieve this goal.

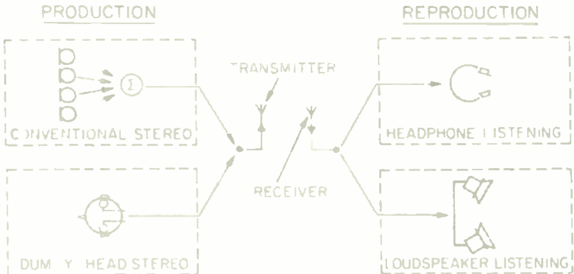

Fig. 21—Mixing sound production and reproduction processes poses problems of compatibility. (After Theile.)

Transaural stereo is a generic term for a stereo system that, like true binaural, considers the end point of the production/reproduction chain to be the actual sounds in a listener's ears. Unlike conventional stereo (which takes the loudspeakers' sounds as the end point) or binaural sound (in which the sounds for each ear are supplied by direct signal chains ending with headphones), transaural stereo's sounds occur indirectly, from the preparation of specially structured composite signals applied to the loudspeakers.

To overcome the problems caused by conventional stereo's treatment of the loudspeakers as sound sources, Jürg Jecklin suggests simulating binaural conditions at the listener's seated location. Because the speakers are fixed in place, the binaural effect is realized with the help of a compensating signal for a limited area of the room (others call this "compensation-signal crosstalk cancellation"). In addition to the direct transmission from each speaker to its respective ear, there are the cross-transmissions of left to right and right to left. A non-adaptive crosstalk pre-cancellation process is used. It consists of "planting" a crosstalk process, in advance, that is the inverse of the acoustic crosstalk expected to occur. When successful, the result is elimination of all crosstalk at the listener's ears.

Transaural stereo and binaural synthesis were first tried in 1962 by Atal and Schroeder, who used a giant early computer to perform digital finite pulse response filtering for crosstalk "planting" and equalization. To determine how accurately they could reproduce the actual sounds of known concert halls, they used binaural recordings made in those halls, playing them back for test subjects in an anechoic chamber.

Another approach, called Biphonic, was proposed in the late '70s by JVC engineers. Standard dummy head binaural recordings were processed by special electronics designed to achieve transaural reproduction via two speakers. There was also a four-channel system, Q-Biphonic, which used a pair of dummy heads (*Audio*, March 1986).

Cooper and Bauck's approach to transaural sound was to simplify the technology of the crosstalk-cancelling filters to a handful of op-amp chips or a single digital signal-processing chip. The simplification also allowed control over the equalization design, which could thus be kept independent of crosstalk cancelling. Improved performance at short wavelengths made the effect of cancellation more tolerant of listener movement around the "sweet spot."

Cooper and Bauck showed that crosstalk cancelling worked best with well-prepared binaural program material. It could produce not only good stereo via speakers but amazing natural spatial and imaging effects that were more robust, with respect to listener movement and playback acoustics, than anyone had thought possible. While stating that all commercially available artificial heads stand in need of further equalization appropriate to transaural recording, Cooper and Bauck were especially impressed with the transaural capabilities of the Aachen Head. They also observed that the only headphone that comes close to the 30° free-field equalization required of headphones for binaural listening is the Stax SR-Lambda Pro.

An interesting observation for surround-sound enthusiasts is that transaural stereo's ear-sound orientation makes it a full-spherical surround system. It can be used, Cooper and Bauck have said, to provide any of the astonishing demonstrations of speaker-oriented quad systems of a previous era; they also mention Ambisonics UHJ as an exemplary sound-field-oriented system that could be recast for the transaural format.

Crosstalk-cancellation work has also been done recently by Danish researcher Henrik Moller, using the Neumann KU 81i head and finite impulse response filters with digital processors. Tests with pink noise in an anechoic room showed results with two speakers that equalled the realism of stereo headphones. Many of Moller's subjects indicated even better spatial discrimination of sounds with the transaural speakers than with headphones, especially when the sounds were located in the front region. The position of the listener's head was found to be an important factor, but only when the person was seated at exactly equal distances from the two speakers.

LEXICON'S CP-1 BINAURAL SPEAKER PROCESSOR

The first home processor to achieve realistic loudspeaker reproduction of true binaural recordings is the Lexicon CP-1 digital audio environment processor (Fig. 22). The CP-1 is one of the increasingly popular surround-processing units and includes a "Binaural" mode among its many programs (*Audio*, November 1989). This unusual feature grew out of work by recording engineer/physicist David Griesinger. At the same time Griesinger was developing the CP-1's "Binaural" program, he was working on ways to improve the loudspeaker compatibility of true binaural recordings. He had several goals in mind: The amazing realism of binaural playback with headphones, the great accuracy of localization using dummy head recordings, the possibility of localization above and behind the speakers with just two speakers, the elimination of crosstalk during playback and the extended bass response gained by placing omnidirectional pressure transducers in the dummy head. Griesinger also feels that converting true binaural sound to enhanced stereo is more promising than trying to convert stereo to binaural, considering the lack of information provided by ordinary stereo.

Since few recordings are available in this compatible binaural form (the Aachen Head recordings probably come the closest), Griesinger included a crosstalk-elimination circuit in the digital surround processor, using some of the same processing chips that create the ambience and delay signals fed to side and rear speakers in surround-sound systems. Although Lexicon's surround-sound approach concentrates on intensifying a room's lateral sound energy and stresses the importance of side speakers in addition to rear, the binaural circuit uses no side speakers. Rear speakers, fed a simple L − R signal, are optional.

The side speakers are simulated via crosstalk elimination patterned on Atal and Schroeder's work, described above. Lexi-

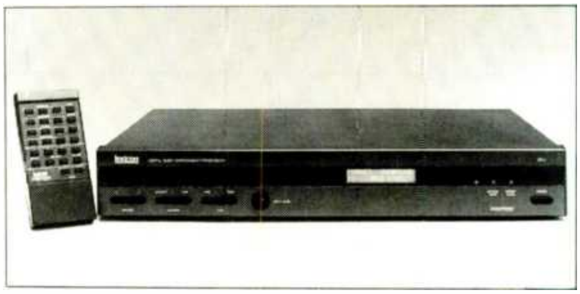

Fig. 22—The Lexicon CP-1 digital audio environment processor, a surround system which also allows binaural listening through speakers

con's measurements resulted in an algorithm very close to Atal and Schroeder's. The Lexicon system not only cancels the signal that diffracts around the listener's head but cancels the signal used for the *first* cancellation (Fig. 23). Separation at low frequencies is increased by use of an L − R boost circuit with phase compensation (Fig. 24).

There is a similar program setting for transaural reproduction of ordinary stereo recordings as well as binaural material already corrected for poor low-frequency separation. However, no digital delay is used in either of these programs, as it is in the digital surround processor's other modes. Lexicon calls crosstalk elimination without artificial ambience generation "ambience extraction." Th s program requires careful adjustment using a digital noise generator built into the Model CP-1. The listener sits in the sweet spot and adjusts balances until a left-only sound appears in the left ear, with a definite null point appearing in the right ear. The same process is then repeated for the right ear. Major differences between the two ears may be a sign of high-frequency hearing loss in one ear.

While the sweet spot for high frequencies is quite narrow—about 1 inch on either side of a straight line between the two speakers—at lower frequencies, the positioning requirements are more relaxed and listeners throughout a room can enjoy the improved sound. Best results are achieved when the room is fairly dead acoustically, especially at the speaker end, and the speakers are located well away from the walls and have good imaging characteristics. Speakers whose drivers face all directions compromise the effect. In my own listening room, minor changes too subtle to make an audible difference in ordinary stereo have a major effect on transaural playback—for example, realism is startlingly improved when I close the window drapes on both the left and right sides of the room. The positive effect of an A.S.C. Tube Trap between the two front speakers is also more pronounced than with standard stereo. Additionally, a low-level feed of L − R to the rear speakers (so low it is only noticeable when turned off) aids in localization. Griesinger reports that on recordings with rear information, he was not always able to localize the rear speakers properly on first hearing; after several listenings, however, his ear/brain seemed to train itself to take advantage of all the cues being offered and could localize to the rear.

When properly set up, as above, transaural audio can actually surpass binaural headphone listening (provided the original recordings are properly equalized), with the added benefits of freedom of movement and uncovered ears. From my own listening experiments with binaural recordings, including those made wearing the mikes myself, I would say the "Binaural" mode of the CP-1 provides the most realistic playback of height, depth, and surround I have yet heard through speakers.

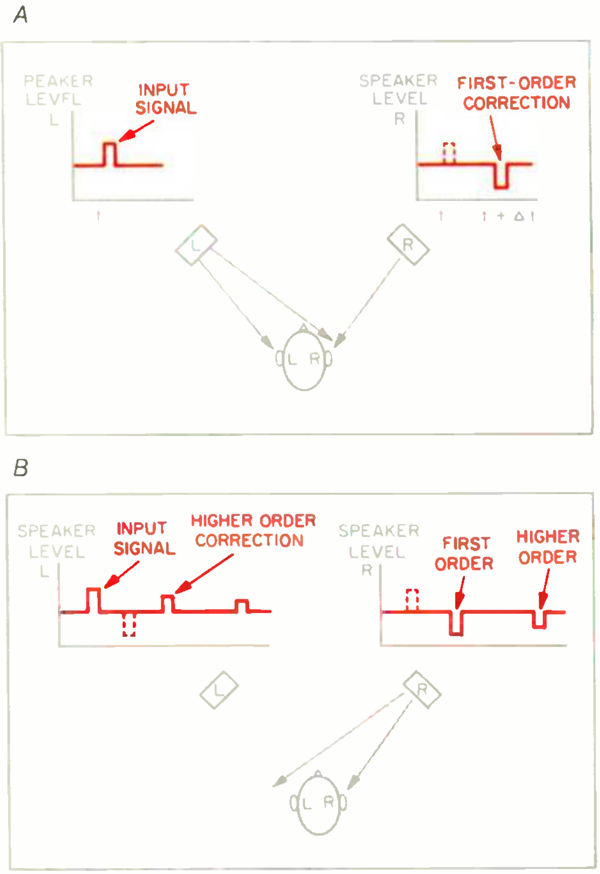

Fig. 23—In first-order crosstalk cancelling (A), sound from the left speaker reaches the listener's right ear after a delay (Δt). Supplying an equally delayed signal of opposite polarity to the right speaker cancels the crosstalk signal. However, this first-order correction signal travels to the listener's left ear, where it will be heard unless cancelled by an additional correction (B). (After Griesinger.)

Disney/MGM theme park, one of the hottest attractions.

OVERVIEW

OTHER TRANSAURAL PROCESSES

Three recently publicized processes for improving sound localization can probably also be considered transaural: Q Sound, B.A.S.E., and 3-D Audio. The publicity for some of these seems to overshadow the actual use, and at least one manufacturer fails to detail what their processor actually does. (Such a "black-box" ploy may remind readers of Hugo Zuccarelli's Holophonics system, which—Zuccarelli's denials notwithstanding—appears to be a type of binaural dummy head.)

These new processes may be startling to those who haven't heard Ambisonics, Dolby Surround, or good digitally processed surround. Whereas the latter all require special decoders/processors at the listening end and at least four loudspeakers, the new processes are carried out at the recording/mixing end and require no special playback equipment and only two speakers.

Q Sound, a technology consisting of both hardware and software, processes ordinary two-channel stereo in the mixing stage to achieve "3-D sound." Announced with major fanfare and already doing well on the stock market, the process requires only a pair of stereo speakers and is said to "give the engineer the option of placing the sound anywhere in the room instead of just in the left or right speaker," according to Lawrence G. Ryckman, president of Archer International Developments in Calgary, Alberta, Canada, which manufactures Q Sound. As of March 1989, no record company had yet decided that this little black box would increase sales enough to warrant licensing it. Nevertheless, Todd AO/Glen Glenn Sound, a major Hollywood film technology firm, has invested in Archer, and one of Hollywood's most powerful talent agencies has begun representing Q Sound in addition to its clients in the performing arts!

B.A.S.E. is the acronym for Bedini Audio Spacial Environment. High-end component maker John Bedini has designed a black-box processor which he claims will create a headphone listening experience via two loudspeakers. Like Carver, Bedini refers to a "holographic audio image." The processor analyzes and separates a stereo signal into mono and stereo components. The mono information can then be moved forward, backward, to the sides, or anywhere within 360° without any loss of stereo ambient space (L − R information), which can be increased or decreased.

There are two B.A.S.E. units available so far. One is a complex, $6,000 professional unit for use in mixing and mastering. If it is used in recording, the resulting album needs no further decoding or processing of any kind. The other is a simpler consumer unit that enables the user to control all spatial aspects of his stereo recordings. Both units have headphone jacks, and special mixes may be created for optimum headphone listening to either binaural or stereo material. The process was used in mixing the soundtracks of the movies *Halloween 4* and *Star Trek V* and is now being used on pop, country, and jazz sessions for Capitol, CBS, Elektra, MCA, RCA, and PolyGram, among others. B.A.S.E.'s parent company, Gamma Electronic Systems, hopes to make it the standard processor for HDTV sound.

Of the three processing methods, B.A.S.E. is the only one I have heard. On playback of standard two-channel material, it does impart more depth and width. Unlike some other psychoacoustic circuits, such as Sound Concepts' Image Enhancer or Carver's Sonic Holography, it does not require sitting in a precise sweet spot to hear the effect; this makes it especially suitable for movie theaters. However, it is interesting to note that not a single classical recording has yet used B.A.S.E. Perhaps acoustic music is compromised by such processing. I preferred the clarity of the "before" example on several demo tapes over the "after" sample's wider and more spectacular version. Similar problems have been noted with certain Dolby Surround processors: They are exciting for video movie use and pop music but wreak havoc with classical music, sending instruments sailing about the room and altering their timbres.

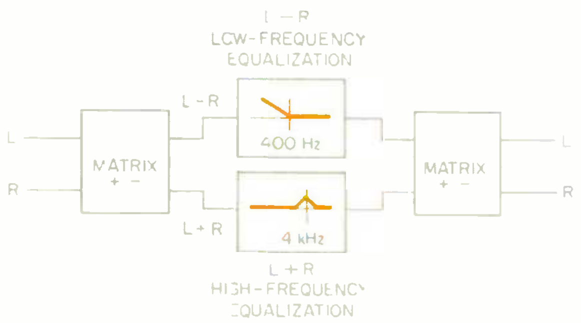

Fig. 24—Block diagram of spatial-equalization ("shuffling") circuit. (After Griesinger.)

Lexicon's CP-1 digital is the first home system to realistically

The third of these new processors is no little black box: In its current size (eventually to be reduced via LSI chips), it is a computer as big as a refrigerator. Myers 3-D Audio is the brainchild of Silicon Valley prodigy Pete Myers, who has devised a mathematical model for the way the ears and brain pinpoint sound. The technique is used to modify sounds during recording; using only two speakers (both located in front), it can trick the listener's brain into perceiving a sound as coming from any location. According to Myers' partner, Ralph Schaefer, the complex process is an example of "bionics," the electronic emulation of a biological process—in this case, localization of sounds in space. Myers created 3-D Audio while working as a NASA consultant; military contractors are currently studying ways to use the processor to help fighter pilots locate enemy aircraft aurally, lessening the visual overload of complex instruments.

Researchers throughout the world are continuing their efforts on many different fronts to perfect a more realistic psychoacoustic experience with recorded sound than that offered by present two-speaker stereo. The pace of this effort has recently picked up, and I predict it will result in further improvements in the listening experience. Whether or not a new format will soon replace two-speaker stereo is open to question, but digital and other computer technologies will surely be a part of future developments.

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audio environment processor
create the binaural effect via speakers.

OVERVIEW

CURRENT BINAURAL DISCOGRAPHY

Format, unless stated, is Compact Disc. Bracketed codes indicate: Aachen Head-compatible binaural recordings, AA; German import, G, and direct-metal mastered, DMM. No special decoders are required to listen to any of these recordings, only stereo headphones. Many of them reproduce well over loudspeakers. Most are difficult or impossible to find in stores. Addresses of four direct sources are listed at the end. The Binaural Source offers most of these recordings and will soon offer many not-yet-released albums. For more information, write to: The Binaural Source, Box 1727, Ross, Cal. 94957.

All-Binaural Special Broadcasts of the author's radio show, "Audiophile Audition," for headphone listening, aired twice annually on approximately 180 (primarily public) radio stations nationally. Next binaural broadcast is Sunday, February 4, 1990; call your local station for details.

Aura. Binaural radio drama from a story by Carlos Fuentes, directed by Tom Lopez. Recorded with Neumann KU 81i dummy head. Type II cassette (ZBS Media).

Barock: Concerto Avenna. [G] Concerti Grossi by Corelli and Handel; quartet by A. Scarlatti, played by The Warsaw Baroque Soloists. Recorded with KU 81i head (AudioStax AXCD-90201).

Binaural Audition. One-hour demonstration tape of binaural music and sound environments. Real-time Type II Dolby B NR cassette (Audiophile Audition).

Binaural Man I and II. Music, humor, and performance piece by Norman Durkee. Two 1-hour cassettes (International Binaural Institute).

The Blue Max Tape. Binaural demonstration cassette of music for headphone listening. Real-time Type II Dolby B NR cassette (In Sync Laboratories, 2211 Broadway, New York, N.Y. 10024.)

Buxtehude, Moondog, and Co. [AA] Paul Jordan, Schuke organ, playing works by Belgica, Buxtehude, Moondog, Tucker, Fischer, and Widor (Spectrum SD-1001).

Durkee: Oxymora. World's first binaural opera, adapted from diaries of ladies of the Japanese court, circa 900 A.D. Music inspired by Kurt Weill, played on a Kurzweil synthesizer. Two 1-hour cassettes (International Binaural Institute).

It's a Jungle in There. Sounds of the Costa Rican rain forest, at normal and slow speeds. One-hour Type II Dolby B NR cassette (Tapir Tapes).

Magic Secret. [AA, G, DMM] Klaus Ignatzek, playing jazz on a Bösendorfer piano. LP only (Nabel 8517).

Messiaen: Livre du St. Sacrement. [AA, G] Almut Rosler, organ. Two CDs (Motette 11061).

Midnight Sun. [AA, G, DMM] Andy Lumpp, piano; Hugo Read, saxophone; Michael Kuttner, percussion. LP only (Nabel 8312).

Glenn Miller und andere Big Band Favoriten. [G] Dance Orchestra of Radio Berlin/Martin Hoffman. Recorded with KU 81i head (AudioStax AX-90301).

The Mist. Stephen King novel in a large-cast binaural radio drama, directed by Tom Lopez. Cassette available at selected bookstores (ZBS Media/Simon & Schuster).

David Montgomery Recital. Piano pieces by Schumann, Liszt, and Chopin. Binaural direct-disc LP; cassette on special order (Sonic Arts Lab Series 5).

Mozart: Symphony No. 36 in C ("Linz"). Midsummer Mozart Festival Orchestra/George Cleve. Cassette available on special order (Sonic Arts Lab Series 5).

Nightingale (The Sound of Nature). [G] One-hour recording of nightingales. Recorded with KU 81i head (Wergo Spectrum SM-9002-50).

The Organs at Heimbach. [AA, G, DMM] Michael Führer, organ, playing works by Bruhns, Butcher, Corrette, Fletcher, Dubois, Liszt, Brahms, and C. P. E. and J. S. Bach, on 19th-century and modern Beckerath organs. LP only (Mitra).

Lou Reed: The Bells. 1979 album by rock vocalist, recorded in West Germany using a binaural dummy head. LP (Arista AB-4229).

Romantic Organ Music. [G] Christopher Dearnley, organ, playing works by Liszt, Barnekow, Rinck, Stanford, Bush, Milford, Wood, Parry, and Dearnley, in St. Paul's Cathedral, London. Recorded on KU 81i head (Motette 10911).

The Space-Sound CD. [G] Dummy head recordings made with KU 81i head and a digital processor; 21 selections, including Wagner, blues, and a visit to a clock museum, with detailed booklet (AudioStax AX-91101).

Spring Concert in Riverain Forest (The Sound of Nature). [G] Environmental sounds. Recorded with KU 81i head (Wergo Spectrum SM-9003-50).

Sticks. Binaural radio horror drama, directed by Tom Lopez. Type II cassette (ZBS Media).

Tango Diablo. Binaural cabaret by Norman Durkee satirizing Latin cabaret music and '60s cinema. One-hour cassette (International Binaural Institute).

Tango Subversivo. [AA, G, DMM] Jürgen Sturm's Ballstars jazz ensemble playing 10 satirical jazz tangos. LP only (Nabel 8413).

Then and Now. Donna Parker and Bill Vlasak at the Wurlitzer pipe organ, playing 17 selections. First U.S. CD recorded with Aachen Head (Donna Parker Productions E-1523CD).

Widor: Organ Symphony No. 2; Vierne: Messe des Defunts. [AA, G] Morisset-Balier, organ (Motette 11231).

Widor: Organ Symphonies Nos. 3 and 7. [G] Daniel Roth, organ. Recorded with KU 81i head (Motette 11241).

Widor: Organ Symphonies Nos. 4 and 6. [G] Suzanne Chaisemartin, organ. Recorded with KU 81i head (Motette 11131).

Widor: Organ Symphony No. 8; Vierne: Arabesque; Guilmant: Marche Funebre et Chant Seraphique. [AA, G] Odile Pierre, organ (Motette 11251).

Woofers, Tweeters, and All That Jazz! Jazz combo featuring pianist Art Lande. Binaural direct-disc LP; cassette on special order (Sonic Arts Lab Series 7).

Xenakis: Pleïades. Percussion work in four movements, played by the Strasbourg Percussion Ensemble (Harmonia Mundi France HMC-905185).

Binaural sound on current pop recordings: Steve Winwood, "Higher Love," *Back in the High Life* (Island); Stevie Wonder, several tracks, *Journey Through the Secret Life of Plants* (Tamla); Pink Floyd, various effects, *The Final Cut* (plus some of their other CBS albums); also see Lou Reed, *The Bells*, above.

Audiophile Audition
Box 1621
Ross, Cal. 94957

International Binaural Institute
Box 45575
University Station
Seattle, Wash. 98145-0575

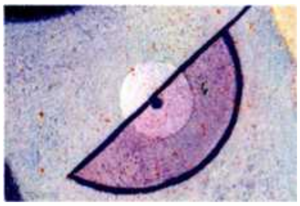
Donna Parker Productions
Box 19371
Indianapolis, Ind. 46219

ZBS Foundation
RR #1, Box 1201
Fort Edward, N.Y. 12828

THE AACHEN HEAD SYSTEM

BINAURAL RECORDING *for* HEADPHONES *and* SPEAKERS

DR.-ING. KLAUS GENUIT AND WADE R. BRAY



The result of new research on human directional hearing, the Aachen Head System represents a substantial improvement in spatial imaging of complex sound fields via binaural recording. Developed in West Germany by Head Acoustics, we feel it is currently the most advanced noise-analysis and recording device available. In this article we are going to discuss parts of the system, binaural reverberation and echo, compatibility with loudspeaker reproduction, production engineering, and applications.

The heart of the system is the Aachen Head, an artificial head that simulates our anatomy and physiology. It is constructed of rugged fiberglass. The Head and its associated signal processing electronics (Fig. 1) deliver a dynamic range in excess of human hearing (Fig. 2).

To understand how a dummy head works, it is useful to know that human spatial hearing depends on a person's anatomy (Fig. 3). Because of reflections from shoulder to ears, the distance between the ears, the shadowing effect of the head on opposite-side sound waves, and resonances in the outer ear and the ear canal, sound from each direction has its own individual frequency response and arrival-time difference. Taken as a whole, this characteristic is called the human outer ear transfer function (Fig. 4).

This function can be mathematically modeled in order to design a dummy head that, along with the appropriate electronics and a headphone playback system, duplicates human hearing. Because it is possible to model the transfer function mathematically, it is also possible to feed monaural sounds into a computer, process them, and then play them back so that they are perceived as located at any desired position in space.

The principle of the acoustic measurement system used in the Aachen Head is shown in Fig. 5. A microphone 4 mm inside each ear-canal entrance simulates the human directional pattern of hearing, picking up direction-modulated sound pressure, just as the human outer ear does. Recording sound signals at this point ensures that after they are processed and played back, your own unique ear canal/eardrum resonance system will re-create the original event. If recorded signals lack these characteristics, this analysis cannot be carried out by the human hearing process.

The transfer function and binaural ear/brain signal processing give human hearing its three-dimensional character. Since the direction-dependent filter effect of the outer ear is di-

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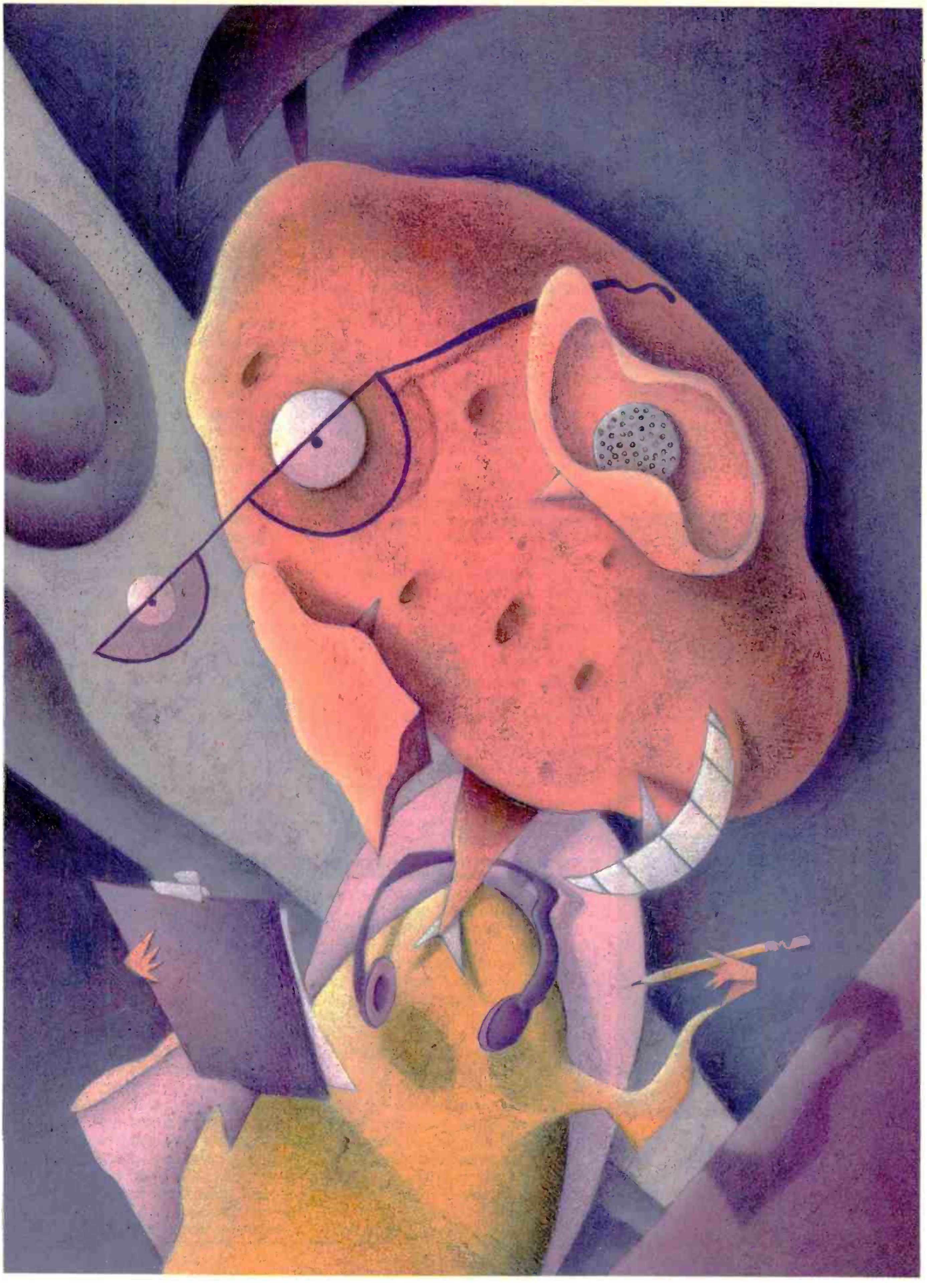
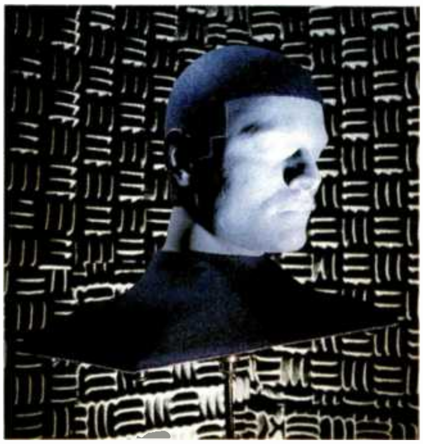
ILLUSTRATION: WALLACE KELLER





A

B

C

Fig. 1—The Aachen Head System consists of the Head itself (A), the Record Processor (B), and the Reproduce Unit (C)

rectly related to a person's anatomy, the shape of the transfer function varies from person to person (as suggested by the left part of Fig. 3). However, the shape of the Aachen Head's transfer function does not represent the individual properties of any particular test subject unless the Head system is programmed for that person's geometric-factor values.

The electrical circuit that describes the function and models human geometry is shown in Fig. 6. The elements of this model correspond to general acoustic parameters that have been assigned mean-factor values derived from the structural averaging of many test subjects. The model is divided into a direction-dependent part that simulates the directional filtering of the outer ear and a direction-independent part (chiefly consisting of various resonances) that, in combination with the first part, describes the free-field outer-ear transfer function. Using the output for free-field simulation, along with free-field-equalized headphones, the ear signals of an "average test person" can be produced during playback for any direction of sound incidence.

Figure 7 shows the outer-ear transfer function of a test subject's left ear, calculated for two directions of sound incidence. The Figure also shows the minima and maxima of the function, derived from six measurements taken from the same person. The measurements of outer-ear geometry have been simplified here for easy physical measurement, mathematical modeling, and calculation of the transfer function. Although this simplification will yield errors, the errors are smaller than those caused by the limited accuracy of the transfer function of conventional recording technology.

The Outer-Ear Simulator

The outer-ear simulator (also known as an electronic artificial head, a sound-direction mixer, a binaural mixing console, or a "dummy" dummy head) is an electroacoustic device that transforms any input signal into two head-related ear signals. The characteristics of ear signals, which can be measured inside the ear canal, depend on the sound's frequency and on the direction of incidence.

A binaural mixing console filters any input signal, whether music recorded with conventional microphones or noise produced by vehicle simulators, in a way that corresponds to the filtering of the human outer ear. It is possible to model the outer-ear transfer function of any test subject for any direction of sound incidence and to simulate it through the use of a binaural mixing console.

A binaural mixing console offers other new possibilities (Fig. 8). This device allows a fully synthetic Head-type musical recording to be created without using a dummy head. In addition to microphone signals, input signals from any sound source that can be fed to a conventional mixing console may be combined on a binaural mixing console. Effects such as echo, reverb, doubling, and flanging may also be added. And engineers are no longer limited by the usual panpots, since the direction of sound incidence can be rotated 360° around the median and horizontal planes. Because the console produces ear signals which are flat for frontal free-field incidence, recordings made this way are more transparent than those produced by stereo mixing—even when reproduced on loudspeakers.

Experiments have shown that in normal rooms, the time delay is not critical between the output signals of the Aachen Head and those of the binaural mixing console. Even if no time-delay compensation is applied, spaciousness and transparency are not really influenced. If the room has a long reverberation time, and the signal of an auxiliary microphone is strongly amplified, artificial reverberation may be added to prevent the sound source from seeming unrealistically near.

If the room has a very short reverb time, such that the energy associated with the diffuse sound field is negligible compared to the direct sound, then time-delay correction assumes greater importance. Correction ensures that a recording made using auxiliary microphones will sound natural and will not lose the high-quality transfer characteristics of the Aachen Head.

Associated Electronics

The Aachen Head System uses free-field equalization for loudspeaker or headphone playback. Equalization is divided into two parts, one part handled by the Record Processor, the other by the Reproduce Unit.

The Record Processor is an intermediate unit that outputs to the recording medium or analysis equipment. Connected to the Aachen Head, the Record Processor contains the free-field equalizers that remove the outer-ear transfer function for direct sound in front of the Head, so that these sounds will have flat response, while those from other directions will still be affected by the differential between the transfer functions for frontal and other sounds. For sounds within the frontal hemisphere, these frequency effects

Photograph: Robert Lewis

will not be radical enough to be perceived by the ear/brain system as sound colorations. Instead, these differences provide clues to the ear/brain about height, depth, and spread beyond the left and right speakers.

The Reproduce Unit contains free-field equalizers that replicate variations of air pressure at the entrance to the ear canal. These do not perform the inverse of the Record Processor's equalization but rather compensate for the transfer function of the headphones used and for the effects of the headphone's presence on the ear's resonances. Thus, the original sound event is reproduced for each headphone listener.

The effectiveness of this can be demonstrated by switching back and forth between the same event as heard through loudspeakers fed from the Record Processor's output and through headphones fed from the Reproduce Unit. The loudspeaker sound is degraded only by crosstalk from the speakers, which can be cancelled by the use of such processors as the Lexicon CP-1 and the Transaural Processor by Duane H. Cooper and Jerald L. Bauck.

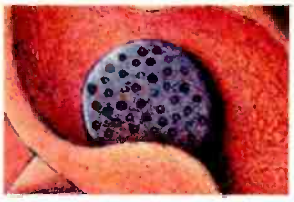
Stax SR-Lambda Professional headphones are used with the Aachen Head System for critical measurement work because of their stable transfer functions with repeated wearings and their relatively uniform response to variations in outer-ear shapes. These were derived from the original Stax-Lambda headphones. For research inside moving cars, Mercedes-Benz required more energy at lower frequencies, and the Stax SR-Lambda Professional headphones were developed specifically for that purpose. Of course, other headphones may be used, provided they are free-field equalized, either by their mechanical design or by the use of an appropriate reproduce equalizer.

Reverberation and Echo

In principle, binaural reverberation can be created by convolving (the processing of one transfer function by the characteristics of another) the impulse response of a room with a recording that was produced either by the Aachen Head or by a binaural mixing console.

When recording using the Aachen Head, the two output signals (left and right ear) can be described as a convolution of the sound source with the impulse response of the room and the outer-ear impulse response of the Head for every direction of sound incidence. Such a convolution is carried out by our own outer-ear transfer func-

The free-field equalizers in the Aachen Head System allow good speaker playback of binaural recordings.



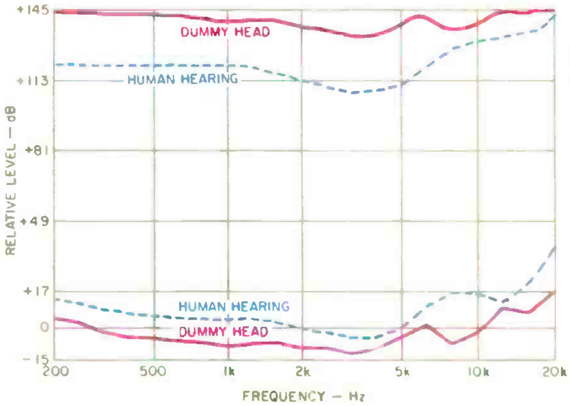


Fig. 2—The dynamic range of human hearing is less than that of the Aachen Head System.

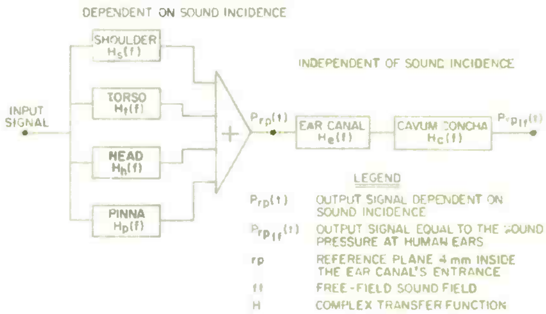


Fig. 3—The human external-ear transfer function. The cavum concha is the antechamber to the ear canal.

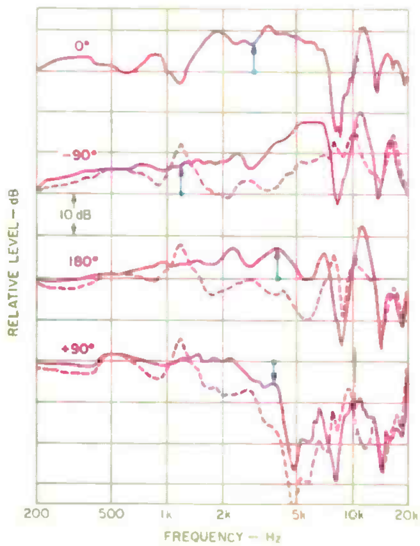
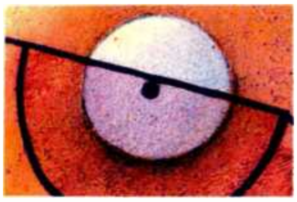


Fig. 4—Transfer function of the left ear, measured 4 mm inside the entrance of the ear canal, for four angles of incidence (straight ahead, to the left, straight behind, and to the right). The base of each arrow indicates reference SPL. Solid curves represent the free-field (direct-sound) external-ear transfer function, while the dashed curves represent the difference, at each direction, relative to frontal free-field sound incidence.



With a binaural mixing console, signals can be assigned to any point in a spherical sound field, and effects can be added.

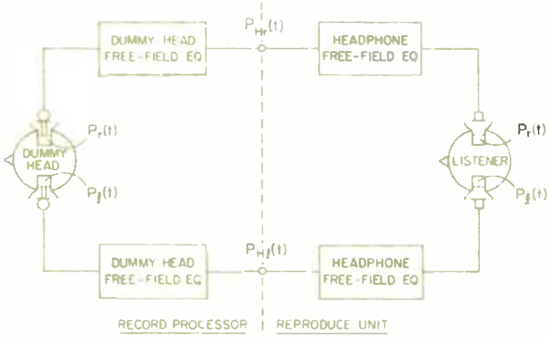


Fig. 5—Block diagram of the Aachen Head System. The two dummy head free-field equalizers in the Record Processor are adjusted to produce the inverse of the frontal free-field transfer function of the Aachen Head, thereby producing flat response at the intermediate point (dashed line). This flat signal is then recorded and can be used for loudspeaker playback and for measurement. The headphone free-field equalizers in the Reproduce Unit yield a linear free-field transfer function of the headphone, so the sound pressures presented at the entrance of the listener's ear canals will duplicate those at the entrance of the Head's ear canals.

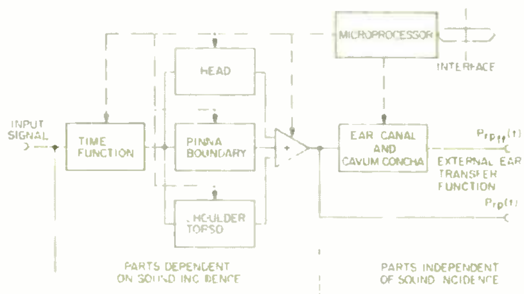


Fig. 6—Principle of the external-ear simulator (one channel shown). Note that the transfer function is subdivided into direction-dependent and direction-independent parts. The time function models the arrival-time differences for different azimuth (horizontal) angles; this time difference is zero for sound sources directly in front of the listener and is at its maximum for 90° left or right sound incidence.

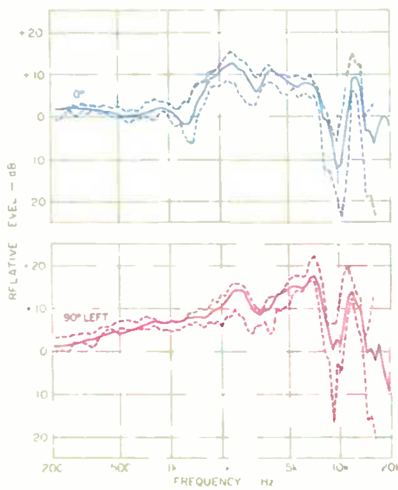


Fig. 7—Outer-ear free-field transfer functions of a test subject's left ear, for sounds arriving from the front (top curves) and directly to the left (bottom curves). Solid curves show the calculated functions, dashed curves show the measured minima and maxima derived from six measurements of the test subject.

tion when we listen to any sound. The output signals may also be viewed as a convolution of two separately recorded signals, the binaural impulse response of the room and the binaural sound source in an anechoic chamber.

The length of a room's impulse response may vary from milliseconds to seconds. This implies a convolution of the input signal with an impulse response of 100 to 50,000 calculated points, at a cutoff frequency of 10 kHz, something impossible to realize in real-time signal processing. Digital reverberation units found in nearly all studios can simulate the transfer characteristics of various room-reverberation models.

Until now, however, there were no binaural reverberation units. Such units are required when dealing with binaural technology, because the signals of monophonic reverberation units cannot be added to the original binaural signals, as is done with traditional multi-microphone techniques. Since the reverberation signal must also be directional, tests have been performed to answer the following questions:

- How many reflections have to be filtered by the outer-ear transfer function in order to replicate the original sound event in a real room?
- Which direction of sound incidence should be chosen for each of the reflections?
- Which reverberation units are suitable to simulate a natural Head-related reflection pattern?
- What filtering of the reverberation signal is necessary to provide a good analogy with the transfer function of real rooms?
- Is it necessary to add reverberation to additional microphones used during the production of an Aachen Head recording?

Our tests led to the arrangement shown in Fig. 9. First, we recorded a speech signal in different rooms, using the Aachen Head. Then, we simulated the recorded sound event, using the same speech signal without any natural reverberation, binaural processing, or digital reverberation units.

Listening tests showed that a minimum of three early reflections should be filtered by outer-ear transfer functions. The directions of the simulated sound incidence were frontal in the median plane, and to the right and left of the listener at varying angles. When simulating a large room with a long reverberation time, the sound incidence of the lateral reflections should be within an angle of 90° to 120° (Fig. 10). When simulating long, narrow rooms, the first lateral reflections should have an incidence of 45° to 90°.

Generally, an engineer must correct the color of the reverberation signals. Typical room resonances are not usually simulated by reverberation units, but by equalizers. An equalizer should also be used to compensate for the additive effect of both ear signals, which occurs in listening to binaural reverberation. At lower frequencies, this effect leads to an exponential addition of the ear signals, because they are in phase. At higher frequencies (above 1 kHz), the addition of the signals becomes stochastic (random), with a loss of 3 dB.

Compatibility with Speaker Reproduction

At the time the Aachen Head System was developed, research and many experiments with loudspeaker reproduction led to the choice of free-field equalization rather than diffuse-field equalization.

Since the Record Processor contains the free-field equalizers which remove the outer-ear transfer function for sound sources in front of the Head, this means that for a frontal source (direct sound) the function is a constant and becomes identical to the constant of standard measurement microphones. This makes the output fully compatible with other acoustic instrumentation, and it provides excellent loudspeaker playback.

For source incidences other than frontal, loudspeaker-playback imaging is improved by the differential contribution of the outer-ear transfer function, as has been previously noted.

When recording with Aachen Head technology, both headphones and loudspeakers should be used to verify all recordings. This is necessary because some characteristics of binaural processing are not active when played back on loudspeakers. For example, an effect called "binaural reverberance suppression" leads to a different balance between direct signals and reverberation, depending on whether one listens on headphones or loudspeakers. When listening to an Aachen Head recording on headphones, the human ear is able to suppress reverb, so that more reverb might be recorded than would be optimal for good loudspeaker reproduction.

In addition, sound engineers should listen to loudspeaker playback to check for undesirable changes in tone color, an effect that sometimes occurs at large angles of incidence when sound sources are filtered by the outer-ear transfer function. If this happens, the direction of the sound source, which equals a modified transfer function, should be varied until

The Aachen Head System can be employed as a miking array for recordings that allow both stereo and binaural playback.

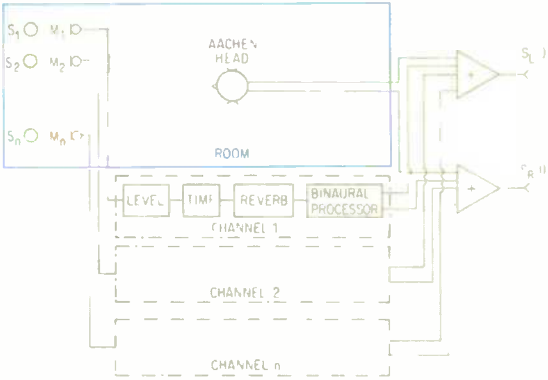


Fig 8—The binaural mixing console, showing how monaural microphone signals are processed to derive a pair of binaural ear signals (which allow placement of the original signals anywhere in the spherical sound field), and the mixing of these signals with signals from the Aachen Head.

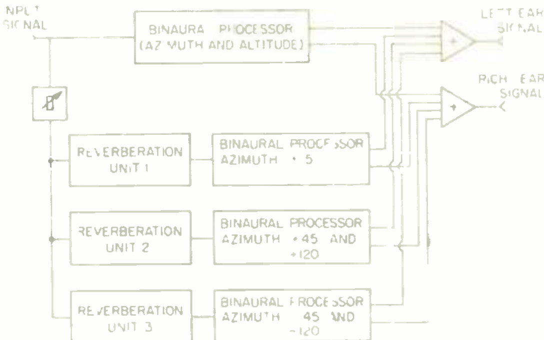


Fig 9—Use of the binaural mixing console to synthesize different rooms for binaural listening. Reverberation and reflections are appropriately directionalized and mixed to closely simulate naturally occurring sound fields as heard in real rooms. Each ear signal contains outer-ear transfer functions for that ear.

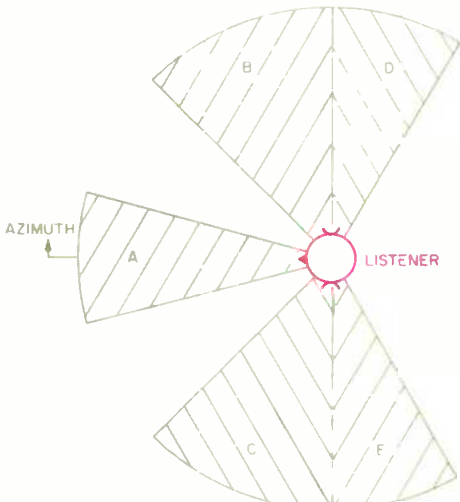


Fig 10—Angles of incidence of direct sound (segment A) and reflections directionalized to simulate real rooms. In a small hall, reflections are primarily from direction segments B and C, while for large halls they are primarily from direction segments D and E. Psychoacoustic research has shown that it is not necessary to have reflections and reverberance from all directions in order to create a highly convincing reconstruction of hall acoustics

Reverb that would be a problem in loudspeaker reproduction can be suppressed when listening to binaural recordings via 'phones.

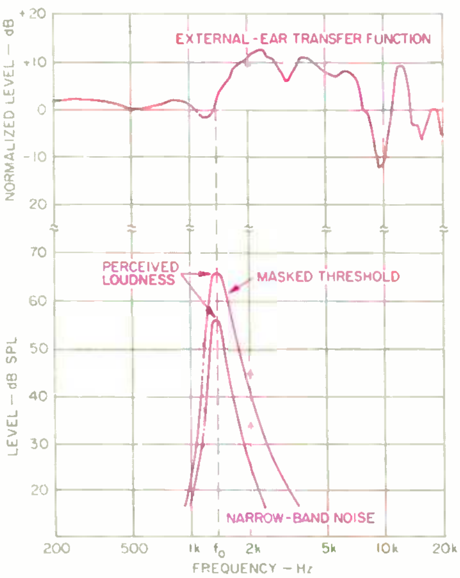


Fig. 11—At frequencies which are amplified by the ear's transfer function, tones can be discerned in the presence of noise that, to a microphone, would mask them. Here, a 2-kHz pure tone, discernible to ear or microphone at the lower of two noise levels, is discernible only to the ear when the noise level is raised. See text.

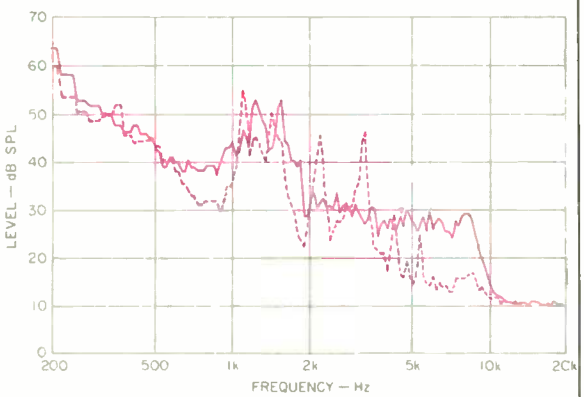


Fig. 12—Spectrum plots for two tires whose overall A-weighted sound levels were identical when the tires were run at 66 mph on a roller in an anechoic room. The tire with the solid spectral curve was rated as not annoying, while the tire shown by the dashed curve was rated as very annoying. The perceived annoyance was caused by rapid frequency modulation of spectral components at 4.8 and 6.3 kHz, due to tread-block design. Slight reduction of the output at these frequencies solved the annoyance problem without changing the dBA of the tire.

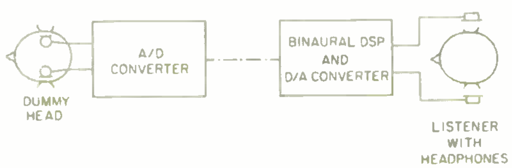


Fig. 13—Basic block diagram of the binaural analysis system (BAS). Dummy head signals, free-field equalized for frontal incidence, are digitized and then manipulated by the digital signal processing computer. This allows editing in the time domain and detailed study of the frequency domain while the signal is heard binaurally (re-creation of the original hearing event). Annoying noise factors can then be found and analyzed, even in transient events.

loudspeaker reproduction is satisfactory. Or the problem could be solved by filtering the signal.

If adjusted for these effects, Aachen Head recording technology is fully compatible with stereophonic recording for playback on loudspeakers. Most of the time, in fact, better results are obtained than if conventional stereo miking and mixing techniques are used. At the same time, a natural, realistic reproduction of the original sound event is always obtained when listening on headphones.

Production Engineering

Aachen Head recordings are usually intended to reproduce an original sound event as naturally as possible, so that editing won't be necessary. If consecutive recordings are made, as in a studio, for example, then in order to get the correct acoustic balance, such recordings should be made in the same room without changing the position of the Head. In contrast to conventional multi-track recording, the Aachen Head needs only two tracks, one for the left and one for the right ear signal. When recording in a studio having short reverberation time, the position of the Head may be changed, because the influence of the room's transfer function is negligible. The reverberation signal of a room can also be simulated by the use of reverb units, as we have described.

In performing initial experiments in splicing different Aachen Head recordings, the results were very satisfying. Recordings produced by this technique have been judged quite good, especially when rated for transparency, naturalness, and spaciousness.

We have often mixed the signals of auxiliary microphones with the output signals of the Aachen Head. If the microphones are positioned at a distance from the Head, their signals should be compensated for the time delay and then processed by applying to each the appropriate directional transfer function.

When filtering Aachen Head signals, some effects must be taken into consideration. If parametric or graphic equalizers are used, only small changes should be made, and the filtered frequency ranges should not be amplified too highly. Sound engineers who use equalizers need to remember that sound imaging by human listeners is based on signal processing that analyzes not only interaural time differences but also interaural and monaural frequency response. The special frequency characteristics of the human outer-ear transfer function lead to a differential contribution in sound imaging, especially in the median plane, where no interaural time differences can be detected.

The use of shelving equalizers normally will not change the structural form of the outer-ear transfer function. Filtering of frequencies below 500 Hz will also have no effect, as the influence of the function is negligible in this range.

System Applications

Since 1981, German automotive firms have used the Aachen Head to analyze interior and exterior noise. As part of the process, listening juries assemble for playback of noise samples and judge the subjective annoyance of noises associated with each design. Their work has helped produce quieter automobiles.

Engineers began using Aachen Head technology for such evaluation when they realized that a measurable and objective determination of annoyance was only rarely achieved by conventional means. Previously, they had attempted analysis using techniques such as A-weighted sound-pressure levels or ⅓-octave spectra. However, they were unable to verify by measurement the clearly perceptible effects of various noise-abatement procedures; in fact, some noises subjectively rated as very annoying showed a lower A-weighted sound pressure level than less annoying noises.

What is the reason for such disparity? The difference lies in the complex, dynamic way the human ear and brain process sound events. We appreciate not only the sound level of a signal but the distribution of amplitudes, spectral composition (simultaneous masking), and temporal structure (pre- and post-masking). Our outer ear is a complex acoustic filter and, in marked contrast to the spherical characteristics of a conventional microphone, is strongly direction-oriented.

Since outer-ear transfer functions affect how the ear and brain process signals and recognize patterns, different masking effects, and thus different sound and noise impressions, are obtained using Aachen Head technology instead of conventional microphone recordings. The Head also enables the listener to use his ability to pluck single sounds from a noisy background and to suppress others by ear/brain signal processing.

This ability is due to the differences between the sound-masking properties of human spatial hearing and those of normal microphones with linear transfer functions. In Fig. 11, for example, the top curve is the external-ear transfer function for sound sources

Photographs: Robert Lewis

If the Aachen Head stays in the same location in the recording studio, "takes" can be spliced together without problems.

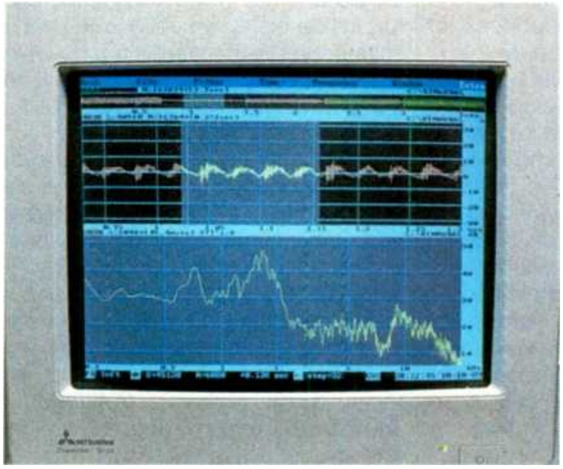
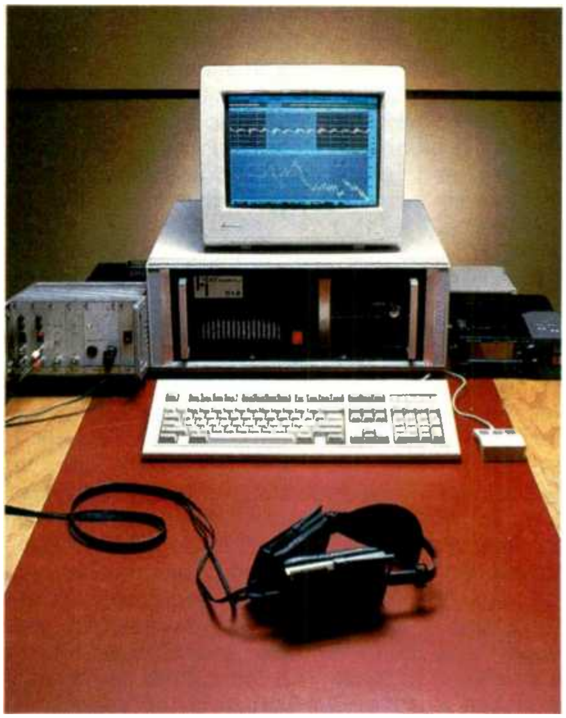


Fig. 14—This BAS display shows an edited recording that isolates an annoying noise, and the noise's associated frequency spectrum. The system's computer also performs many other functions; see text.



Head Acoustics binaural analysis system with keyboard and mouse (center), flanked by Reproduce Unit for electrostatic headphones (left) and specially modified DAT recorder (right).

The Aachen Head System helps to isolate annoying noises from those which are louder and yet somehow less bothersome.

in front of the listener. In the presence of a narrow-band noise centered at 1.5 kHz, with a perceived loudness of about 60 dB, an additional pure 2-kHz tone with a level of 35 dB can be heard by both the ear and the microphone. If the narrow-band noise is increased to 70 dB, the microphone no longer "hears" the pure tone—it will be masked. However, the external-ear transfer function amplifies this frequency by 10 dB; thus, for a listener, the tone is not masked. Such effects occur at various frequencies for various angles of incidence, so measurement and perception of noise often correlate poorly unless the nature of human hearing is taken into consideration.

An important attribute of the Aachen Head in applications is the ability to calibrate the playback level for precise correspondence with the original record level, using headphones. This makes it easy to recognize the significant signal or spectral parameter and to decide how to manipulate the components of the sound source. Such evaluation often shows that the high-energy spectral components are not always responsible for acoustic discomfort. Even greater irritation may result from lowering the components, because their masking effects are simultaneously reduced.

Figure 12 shows the amplitude spectra of interior noises caused by automobile tires at a speed of 100 kilometers/hour. The measurements were taken on a roller test stand inside an anechoic chamber using the Aachen Head System. Two different types of tires that were rated to be equal with respect to the A-weighted sound pressure level were tested. However, the tire corresponding to the dashed spectrum in the Figure was judged to cause a much more annoying noise.

What accounted for this? The spectral domain contained certain tonal components that underwent a frequency modulation (harshness) in operation. When trying to reduce the noise effects of the tires corresponding to the solid spectrum in Fig. 12, one might assume that the frequencies between 1.1 and 1.4 kHz were responsible and therefore try to attenuate this range. However, when variously filtered Aachen Head recordings were compared in subjective tests, it was clearly demonstrated that damping these frequencies would not improve acoustic comfort inside the automobile. The final results proved very interesting: By lowering the spectral components at 4.8 and 6.3 kHz, a significant improvement n acoustic comfort was achieved.

In addition to automotive applications, the Aachen Head System is suitable for fields in which measurement and evaluation of acoustic signals are connected to comfort and quality. For example, the system can be used for long-term archiving and documentation, training of service personnel, optimization of loudspeaker sound systems, quality control, evaluation of acoustical comfort, and other cost- and time-effective testing.

An important field of application has been noise analysis using a computer-controlled binaural analysis system (BAS), aspects of which are shown in Figs. 13 and 14. The BAS can calculate sound pressure level (unweighted or with A, B, or C weighting), loudness (in sones), and sharpness (the ratio of high-frequency energy to average energy); it can also perform ⅓-octave analysis and calculate and display transfer functions and binaural tracking filter characteristics. Moreover, the system can calculate cross- and autocorrelation functions, measure short-time spectra to evaluate dynamic effects, measure and show interaural levels and phase relationships, and calibrate playback levels for precise correspondence with the original sound pressure levels at the ear-canal entrances. Long time functions can be recorded and processed, and segments selected for repeated playback. Sound quality can be analyzed with respect to amplitude and frequency modulation, tone color, and other qualities. Dynamic range can be calculated with respect to pre-masking, post-masking, and simultaneous masking effects. And the system can replicate both ear signals in the original time and frequency domains.

Summary

Engineers have become increasingly convinced that conventional acoustic measurement techniques do not adequately meet their needs in noise measurement and analysis, room acoustics, and recordings. The use of the Aachen Head System yields considerable improvement in results. This has been shown by tests and by numerous applications in the automotive and recording industries. All have shown that by using what we know about the signal processing capabilities of human hearing, we can obtain a virtually objective analysis of Aachen Head signals with regard to sound properties.

Binaural measurement techniques allow for much clearer classification of sound quality, particularly with respect to judgments about the annoyance level of noise. Applying Aachen Head technology will save time and money, because the decision-making processes will tend to be more goal-oriented and faster.

Beyond offering a new dimension of noise measurement and analysis, Aachen Head technology enhances sound reproduction. If an "acoustic photograph" of a concert is desired, for example, we believe only Aachen Head technology is able to faithfully reproduce the original event in every detail, from clarity and timbre to dynamics and spatial imaging.

Engineers now have a recording tool that handles acoustically difficult sites and replicates a sound event by more adequately representing the spatial imaging of complex sound fields. The Aachen Head System also provides outstanding results when used as a microphone array for loudspeaker reproduction. Both binaural and stereo playback capabilities inhere in the same recording.

References

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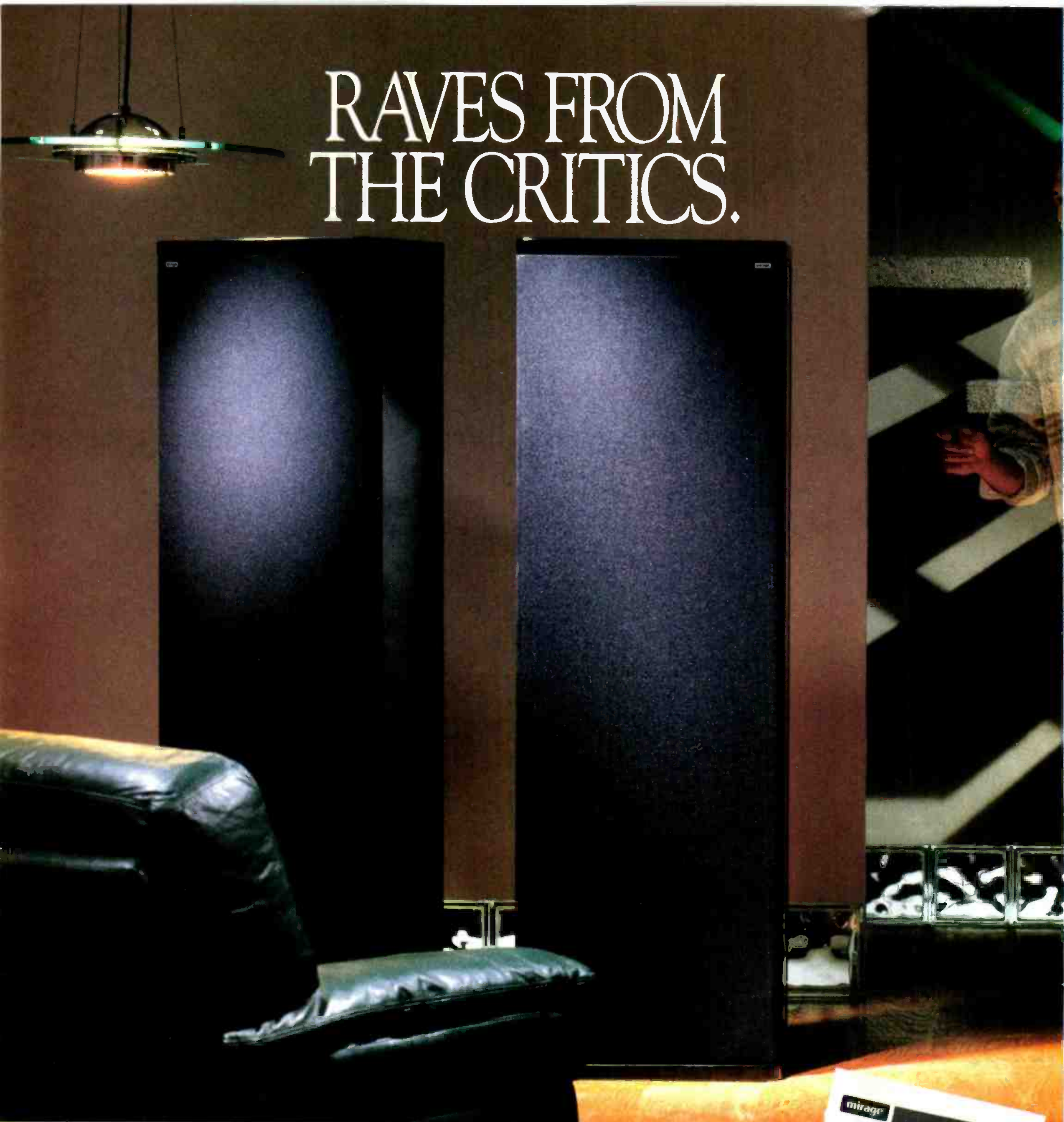

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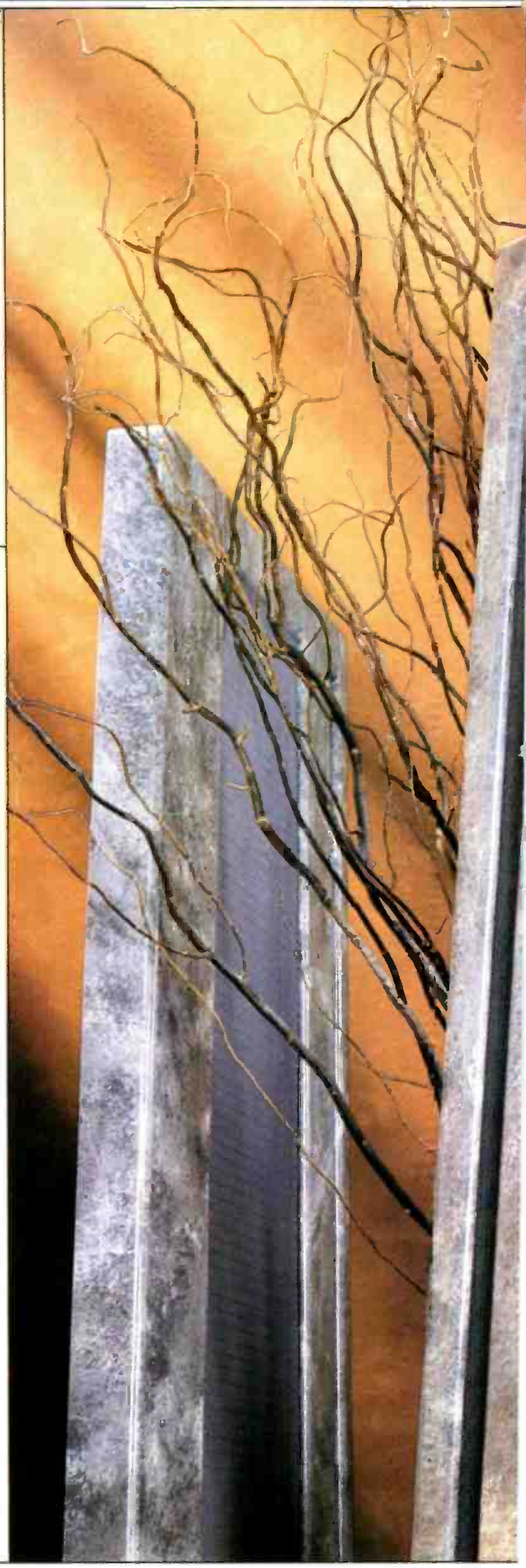
1

APOGEE DUETTA SIGNATURE LOUDSPEAKER

Manufacturer's Specifications
Drivers: Midrange/tweeter and woofer ribbons.
Frequency Response: Below 30 Hz to 20 kHz.
Crossover: 6 dB per octave, passive; nominal frequency, 600 Hz.
Output Level: 115 dB SPL peak at 4 meters.
Nominal Impedance: 4 ohms.
Dimensions: 26 in. W × 58 in. H × 3 in. D (66 cm × 142.2 cm × 76.2 cm).
Weight: 95 lbs. (43.1 kg).
Price: $3,735 per pair ($3,840 in western states).
Company Address: 35 York Industrial Park, Randolph, Mass. 02368.
For literature, circle No. 90

The Apogee Duetta Signature is very different from most loudspeakers; it is a two-way, ribbon-type system in the form of a tall, shallow monolith. The design of ribbon speakers has been neglected for many years, although the original idea can be traced back at least to the Blatthaller design of the 1930s (see *Loudspeakers* by N. W. McLachlan, Dover Publications, New York, pages 222 and 223). The Blatthaller design consisted of a diaphragm of corrugated aluminum strips which ran between rows of magnets located on each side. In the Apogee, however, each diaphragm is made of one corrugated aluminum sheet, with integral conductors, and the rows of magnets are located at the back and sides of the conductors. In either design, the signal is applied to the diaphragm, which acts like the voice-coil in a more conventional moving-coil loudspeaker driver. The signal interacts with the magnets' field and the diaphragm moves back and forth, producing the sound output.

There are a number of reasons why the design of full-range ribbon dipole loudspeakers has received little attention until recently; chief among them have been the cost of magnets (many are required) and the lack of imagination and/or audaciousness on the part of the management of most loudspeaker companies. (Most loudspeaker design engineers would find such a challenge very interesting.) The original Blatthaller used electromagnets rather than permanent magnets because they could provide enough flux to make a reasonably efficient device; the permanent magnets of that era were very weak compared to those available today. Probably the most interesting feature of the ribbon loudspeaker is that the voice-coil is also the diaphragm which radiates the sound. Because of the visual similarity between ribbon and electrostatic loudspeakers, it is easy to mistake one for the other, since both have flat, membrane-type diaphragms. This superficial resemblance can be resolved upon closer examination because, for one thing, a large ribbon loudspeaker's diaphragm is usually covered with conductive strips which traverse back and forth to form a continuous path for the electrical signal from the driving amplifier; an electrostatic diaphragm is one continuous piece. Also, the diaphragm of the Apogee is corrugated to allow for greater motion, whereas the electrostatic diaphragm must be flat. The ribbon diaphragm, which is also the voice-coil, presents a low-impedance, mostly resistive load to the amplifier, which is usually perfectly acceptable. Conversely, an electrostatic loudspeaker presents a very high, mostly capacitive load impedance to the driving amplifier. This requires that a special high-impedance output amplifier be used or that a transformer be part of the loudspeaker to present a more reasonable load to an ordinary amplifier of low output impedance.



Photograph: ©1989, Bill Kouirinis

Apogee Acoustics was started in 1981 by Leo Spiegel (a retired scientist who had worked for Honeywell and Northrop on such things as inertial navigation systems) and an associate (who has since left). Spiegel decided it would be interesting to apply some of his vast technical expertise to the design of a full-range ribbon speaker system. The first loudspeaker he produced was the Apogee Full-Range Ribbon Speaker, since discontinued, which was very well received. This led to other system designs. Apogee now offers four models, of which the Duetta Signature is the subject of this report.

Any notion that a thin panel loudspeaker would probably be light in weight and easy to handle was quickly dispelled when I unpacked the Duetta Signature systems (with help, I might add). They weighed about 100 pounds each. Attaching the metal brackets, which act as feet, was made much easier because my son-in-law, who was pressed into service, steadied and controlled the weight of the panels while I installed them. (Thanks, Terry. I may need your help again!) The systems I received had a gray marbleized finish, but the speakers are available in a variety of finishes; this is also an indication that Apogee intends to fly in the face of the usual dictum to "keep everything simple" from a marketing standpoint. It is as if they are saying, "We have a loudspeaker that sounds great. What may we do to help you make it look great in your listening room?" I think this is a wonderful attitude, and I applaud Apogee for their efforts.

The panels are very sturdy and are rounded at the outside edges and around the two openings for the bass and mid/high drivers. This helps to eliminate diffraction of the sound and enhances the appearance as well. The grille cloth is a very open screen of gray woven plastic, which makes the diaphragms clearly visible. The back is covered with a very open-weave black cloth. When set up for listening, with the long, narrow mid/high drivers to the inside, the pair of Apogee Duetta Signatures seemed to dominate the room. This is because, for best sound, they should be out away from the rear and side walls: The Duetta is a dipole and radiates sound from the rear as well as the front.

An interesting feature of the Apogee Duetta Signatures is that, while the mid/high driver is only one-tenth of the radiating area of the bass driver, its output extends from below 200 Hz to above 20 kHz. The electrical crossover occurs at

MEASURED DATA

Size of Drivers: Bass ribbon, 46½ in. long, 575 sq. in.; mid/high ribbon, 46½ in. long, 55 sq. in.
Frequency Response: 30 Hz to 20 kHz, ±5 dB.
Crossover Frequency: Acoustical, 1 kHz; electrical, 350 Hz.
Low-Frequency Resonance: 36 Hz.
Sensitivity: 69 dB SPL at 1 V per meter.
Efficiency: 75 dB SPL at 1 watt per meter.
Amplifier Power: Recommended, 100 watts per channel; maximum, 400 watts per channel.
Impedance: Nominal, 4 ohms; minimum, 2.8 ohms.
Distortion: Less than 2% below 90 dB SPL for the tone E_1 (41.2 Hz), less than 2% below 100 dB SPL for the tone A_2 (110 Hz), and less than 2% below 95 dB SPL for the tone C_4 (262 Hz).
Absolute Polarity: Negative.

Most speakers don't treat square waves very kindly, but the Duetta Signature reproduced them well.

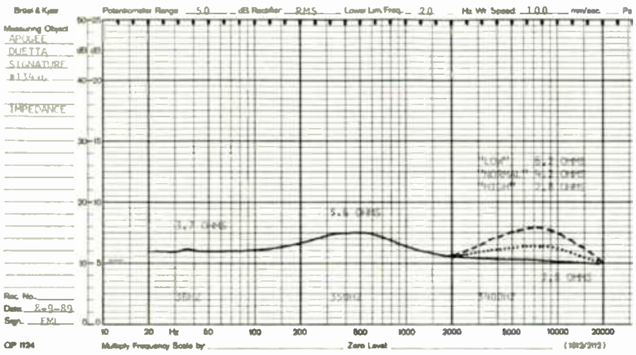


Fig. 1—Magnitude of impedance. The impedance is resistive at 36, 350, and 3400 Hz. Impedance at high frequencies changes for different positions of the midrange tweeter switch, as shown; all other measurements were made with this switch in the "High" position.

about 350 Hz, but the acoustical crossover, where the bass and mid/high drivers contribute equal acoustical outputs, is around 1 kHz. This explains why Apogee specifies the crossover as being at 600 Hz, which is a good compromise. Because it operates so low in frequency, the mid/high panel vibration .s very noticeable, and one member of my listening panel commented that "it was very exciting to see!" The directional characteristics of a loudspeaker are directly related to diaphragm dimensions, so it was an intelligent decision to roll off the bass driver early and let the mid/high driver handle most of the range.

The Duetta Signature bass driver's diaphragm is made of an integral sheet of 0.7-mil aluminum, with 82 conductive paths through which the bass signal current zigzags back and forth from top to bottom. Springs on each side of the woofer diaphragm place it under tension, to eliminate the normal tendency of a stretched membrane to snap back and forth or "oil can." The tension is carefully adjusted for each system to achieve optimum performance. The electrical connections to the diaphragm are made using a crimping technique that avoids any problems due to vibration which might arise, over time, if soldering were used; soldering to aluminum is not easy and can be unreliable.

The input connections to the Duetta Signature are gold-plated, five-way binding posts. There are separate pairs for the bass and the mid/high drivers so that either two amplifiers or separate cables from a single amplifier may be used to drive each section independently. The passive crossover inside the Duetta Signature can be bypassed to allow biamping with Apogee's $4,000 DAX dedicated active crossover. Instructions on bypassing come with the DAX. The speaker's input plate also has a three-position "Midrange/Tweeter" toggle switch, marked "High," "Low," and "Normal." The sequence may look strange, but anyone who has ever had to design a switch like this knows why the sequence is as it is; it has to be!

A pair of aluminum brackets, attached 18 inches apart, is used to hold the speaker upright. The feet are aluminum bars that have rounded ends. The bars are 12½ inches long, 1¾ inches wide, and ½ inch thick and extend 2½ inches to the front and 7½ inches to the rear of the speaker. A vertical bar extends upward from the foot bar and attaches to the back of the loudspeaker frame. An angled bar adds extra bracing between the foot and vertical bars. The foot bars have tapped holes, front and rear, for 1¼-inch-long, No. 18 × 5/16 Allen-head bolts. These bolts have been ground to sharp points so that they can act as secure connections to the floor, allowing the speakers to stand firmly even on thick carpets. The panels are angled back by about 2.5°, and Apogee supplies a plumb bob to aid in adjusting the bolts to achieve this desired angle.

Measurements and Listening Tests

There is a continuing argument between those who say that the only way to describe the performance of a loudspeaker is to eschew technical measurements altogether and rely solely on subjective impressions and those who contend that a loudspeaker can be completely defined by technical measurements. Perhaps the first group really means that they have never seen anyone describe completely the subjectively perceived attributes of a loudspeaker by technical measurements alone. The second group probably means that they don't really trust the reports of those who rely solely on subjective perception and that, if the reviewers were given enough space in a publication to present all the measured data necessary to do the job, they could describe the performance of a loudspeaker completely. Perhaps I have oversimplified these arguments, but I think that I am pretty close.

The difficulty of trying to reconcile both sides cannot be overstated. Many loudspeaker reports that I have read try for the middle ground by presenting a mixture of some technical measured data and subjectively perceived impressions. However, they do not really attempt to correlate the two, except ir a superficial way. I believe strongly that technical measurements can be used to explain why a component has certain definite, perceived sonic characteristics. As I have done in past reports for *Audio* on turntables, tonearms, and cartridges, I will try very hard to correlate comments made by the members of a listening panel with my technical measurements. Discussing certain technical measurements can be very helpful, especially with loudspeakers, because many of their sonic characteristics are definitely affected by the listening environment, their placement in that environment, and the way they react with certain amplifier and cable parameters.

Figure 1 shows the impedance versus frequency of the Duetta Signature. It is very uniform but rather low, especially at 20 kHz. When choosing a loudspeaker cable for use with the Duetta Signature, care must be taken. The cable should have as little resistance as possible, because even as little

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Center defeat bass/mid-range/treble tone controls

16-station random access preset tuning with multi-status memory

Absolute Linear Amplification (ALA) circuitry

Preset indicators with preset number and station frequency

Front panel headphone jack

Tone bypass switch

High-gain AM loop antenna

Manual or auto IF Mode selector (wide or narrow)

Auto search tuning

Manual up/down tuning

If any of these features compromised its sound, this is the first thing we'd remove: YAMAHA

The Duetta's impedance is almost purely resistive, so it shouldn't present any problems to high-current amps.

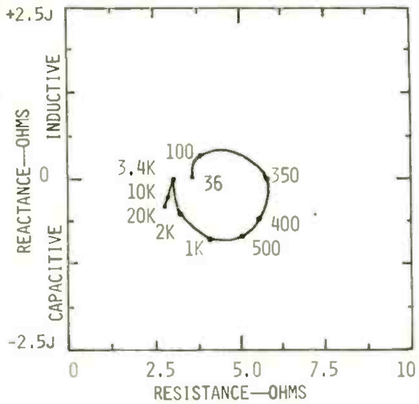

Fig. 2—Complex impedance, showing reactance and resistance vs. frequency (in Hz). Note that the two scales are not identical; see text.

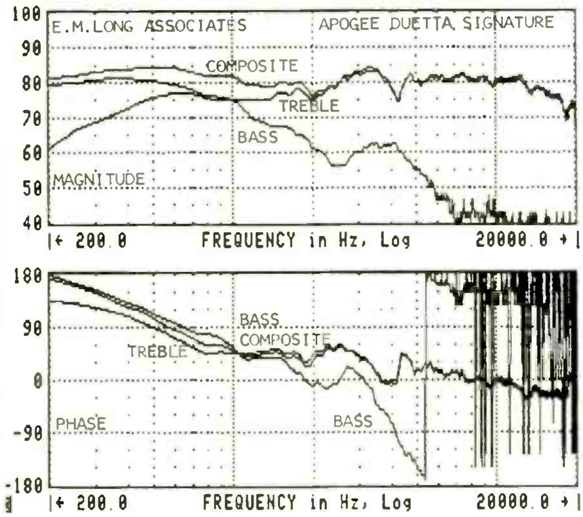

Fig. 3—One-meter on-axis frequency and phase responses, showing effects of the two ribbons separately and together. Note that only response above 200 Hz is shown.

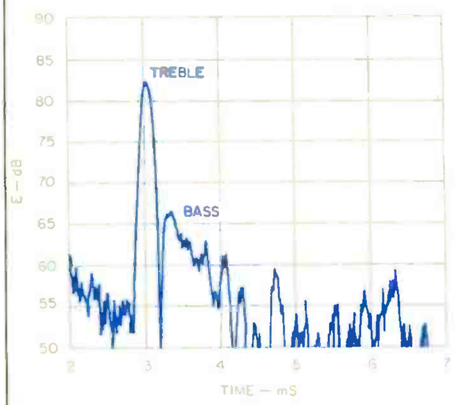

Fig. 4—Energy vs. time, with microphone in line with tweeter and 1 meter away. Most of the energy is delivered within 1 mS. Initial output is mainly treble, as bass energy spreads out over time, causing the cancellation notch shown. See text.

as 0.5 ohm total resistance can waste as much as 11% of the power at frequencies where the impedance is 4.0 ohms and waste 15% where the impedance is 2.8 ohms. The situation is much worse if the total cable resistance is 1.0 ohm, the power losses being 20% for a 4.0-ohm impedance and 27% for a 2.8-ohm impedance. On the plus side, the effects of cable capacitance tend to be ameliorated by the low shunt resistance of the loudspeaker. The Duetta Signature does require an amplifier capable of supplying rather high peak currents, because along with its low impedance, it is also not a very efficient loudspeaker.

Figure 2 is a Nyquist plot of the complex impedance, which shows the relationship of the "real" (resistive) and "imaginary" (reactive) components. The thing to remember when looking at this type of plot is that the resistive component dissipates or uses up the energy, while the reactive component stores it temporarily. Figure 2 shows that the impedance of the Duetta is almost purely resistive: Even though the impedance plot is circular because it has been scaled to show more detail, the vertical reactive scale has much smaller intervals. The speaker's almost purely resistive impedance means that the Duetta should not cause any problems for most amplifiers that can deliver high current, even if they have high overall loop feedback.

Figure 3 shows magnitude versus frequency (top) and phase versus frequency (bottom) for the composite output of the Duetta and the individual contributions of the bass and treble drivers. The microphone was 1 meter in front of, and in line with, the mid/high driver strip. This is the "sweet spot" for the Duetta; other measurements, which will be discussed later, also confirmed this conclusion. When the Duetta was auditioned by each listener, care was taken that at least part of the listening was done directly in line with the mid/high driver, with each speaker of the pair aimed accordingly. Although I refer to the listeners as panel members, the listening sessions were actually conducted with only one listener at a time. There was no switching to another system; the experience of the listener was the sole criterion for the comments, which were written, not verbal. One interesting aspect of Fig. 3 is that the output of the two drivers, which are each 6 dB down from the composite curve, blend so well at the crossover point that there is no indication of the crossover at all! The large overlap in output can cause some problems off the axis of the loudspeaker system, however.

The phase plot shows that the two drivers blend very well over a substantial range on either side of the crossover, which means that the difference in arrival time for sound produced by these two drivers is almost identical. This correlates well with the various comments by all panel members regarding the "clarity," "detail," and "analytic quality" of the Duetta Signature system.

Figure 4 shows the energy versus time with the microphone in the same position used in Fig. 3. The energy is in a tight package, spread over about 1 mS, which indicates that the Duetta produces a very coherent sound. This correlates well with listener comments about how precise the images of various instruments and voices were, even when they were recorded in very reverberant surroundings. Other measurements I made showed that the initial energy from


KCD-40

The phase plot shows that the two drivers blend very well over a substantial range around the crossover frequency.

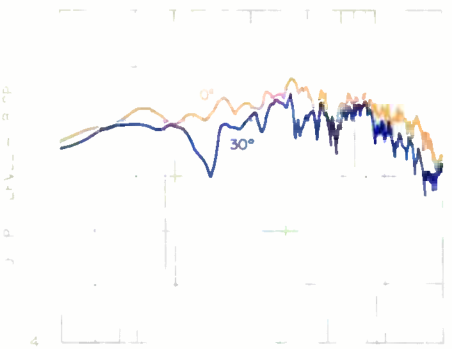

Fig. 5—Three-meter room response, measured on axis and 30° off axis.

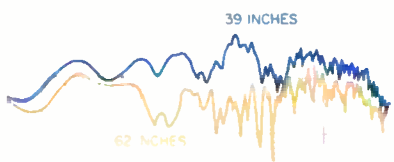

Fig. 6—Three-meter room response at microphone heights approximating seated and standing positions of listener.

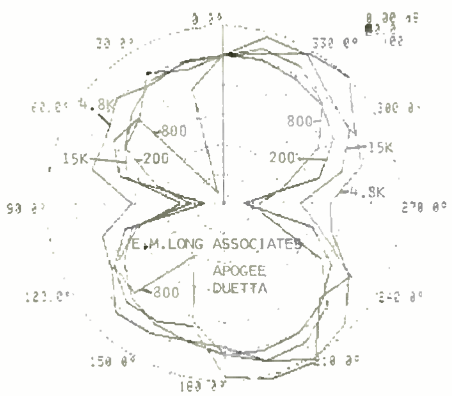

Fig. 7—Polar response of right-channel speaker in free field at 200, 800, 4800, and 15,000 Hz. The speaker is facing the top of the page, with the mid-high ribbon on the right. Note that most of the energy is toward the right front, at 330°. These curves show relative directionality, not relative output level, as they have been normalized to their 0° (forward) values. (Scale: 6 dB per div.)

the mid/high and bass panels arrived together even though the lower frequencies, because of their longer wavelengths, were spread over a greater time period.

The 3-meter room response (Fig. 5) shows that, even at 30° to the inside of the mid/high ribbon axis, the high-frequency response is excellent to about 10 kHz and holds up well to 20 kHz. This and other measurements correlated well with comments which indicated that the Duetta has excellent high-frequency performance. The drop in response at about 1.3 kHz is due to the bass panel output's delay relative to the mid/high output, which is enough to put the two at opposite polarity (180° from each other) at this frequency, causing energy cancellation. Every panel member commented that there seemed to be something missing from the sound of the Duetta systems. These ranged from "lack of body" to "something wrong with the balance of the sound." Perhaps the effect shown in Fig. 5 can be used to explain these comments, but the difference in response shown in Fig. 6, for different microphone heights, may also help explain them. There is a definite change in the balance of the sound for the two microphone heights, which were intended to show how a seated or standing listener might perceive the sound of the Duetta systems. Even though the listening sessions were conducted with the listener seated, the perception of balance is most likely affected by the total sound radiated by the loudspeaker into the room. Figure 7, a polar plot of the radiation from the Duetta loudspeaker, also has a direct bearing on these comments because the total radiated energy varies with frequency. At 800 Hz, the pattern becomes very strange. Most of the energy is radiated at the 330° angle in the front and the 210° angle toward the rear, but with the total energy reduced. This is caused by the large overlap in output from the mid/high and bass diaphragms, which are mounted side by side and produce out-of-phase energy in the range between 600 Hz and 1 kHz. The energy is exactly 180° out of phase at 800 Hz. Even at the maximum radiation angle of 330°, the level at 800 Hz is 6 dB below that of the energy at 4.8 and 15 kHz. This has to be the main reason why the sound of the Duetta was perceived to "lack body." Another reason is that the output between about 3 to 5 kHz, particularly at 4.8 kHz, is very strong. This also correlates well with the perception by some panel members that the Duetta was "very analytical" and "revealing of detail" but also very "bright" and "zippy," especially when reproducing violin and brass. The polar plot can be very useful in setting up the Duetta systems; it shows that the maximum forward radiation is at 330°, which would be angled toward a centered listener's position. This is probably why Apogee does not recommend angling the systems inward, as you might normally expect. I found that a slight angling, so that the listener was in line with the mid/high ribbon panels, produced the best balance and detail. When I placed absorptive panels to the rear of the Duetta, the precision and clarity were increased but the balance was made worse. All panel members reacted the same way in this respect. The best balance required that the reflecting surface be in the middle, between the Duetta systems, and about 3 to 4 feet behind them; the Duettas were also about 3 feet from the side walls. I am convinced, by my measurements and my experiments, that the Duetta systems are

Differences in absolute signal polarity were very easy to hear, so I rate the Duetta very high for coherence.

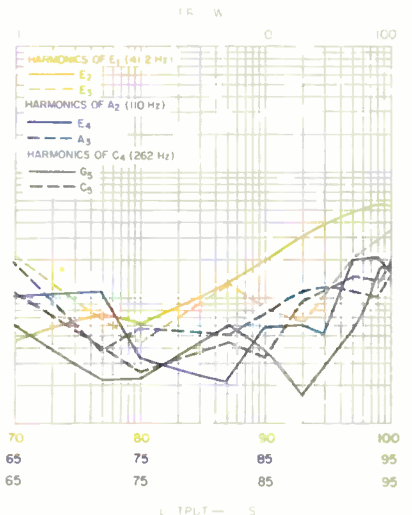

Fig. 8—Harmonic distortion for the test tones E_1 (41.2 Hz), A_2 (110 Hz), and C_4 (262 Hz, or middle C). Note that the bass output at 41.2 Hz is about 5 dB higher than at 110 and 262 Hz for the same input power.

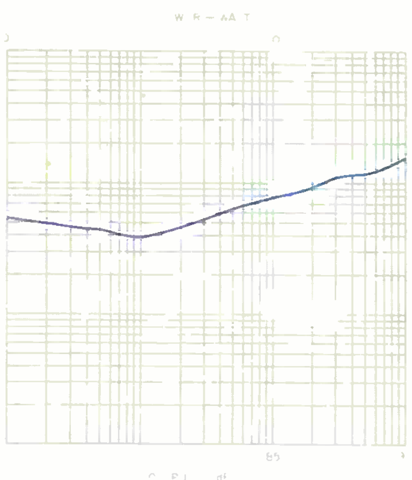

Fig. 9—IM of C_4 (262 Hz) caused by mixing with E_1 (41.2 Hz) at equal levels.

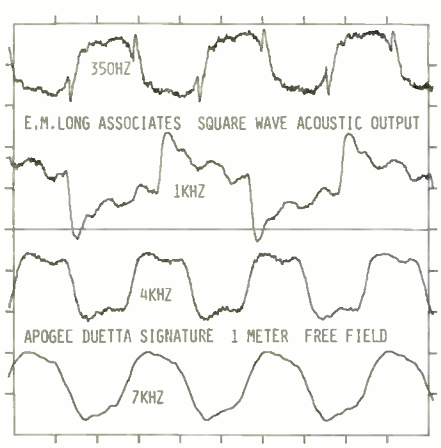

Fig. 10—Square-wave output at four frequencies, measured with microphone at 1 meter in free field; see text.

better suited to, and will always sound better in, large rooms than small ones.

Figures 8 and 9 show the harmonic and intermodulation distortion percentages, which are reasonably good. During the listening sessions, the sound levels were always less than 94 dB SPL, and no comments were made which could be directly correlated to the information in these Figures. None of the panel members complained of lack of bass. However, if you like to listen to bass-heavy music at higher levels, you might be disappointed because the distortion in the bass range can be a limitation. You will need an amplifier that can match the transparency of the Duetta as well as provide more than 100 watts per channel.

Figure 10 shows that the Duetta is capable of very good reproduction of square waves. Most loudspeaker manufacturers and reviewers don't show what a loudspeaker does to square waves because most loudspeakers don't treat these signals kindly! The square waves of Fig. 10 indicate that the Duetta does an excellent job of reproducing the fundamental and harmonics of a complex sound without messing them up. Comments by panel members about how well the Duetta reproduced the timbres of different instruments of the brass and string families, so that they were easily distinguishable, correlates well with the excellent square-wave performance.

Figure 11 shows that the absolute acoustical polarity of the Duetta is negative. This was checked before the listening sessions, and the connections were changed so that the absolute polarity of all the program material used was correct. Panel members were also asked if they could hear the difference in polarity when it was switched back and forth while listening to the Duetta. Most panel members had no trouble hearing the difference, and I rate the Duetta's coherence very high in this respect.

I haven't mentioned much about the bass response of the Duetta systems until this point because I wanted to show some things that I found very interesting. One of the most difficult tasks the designer of a dipole ribbon system faces is how to make the system produce enough bass output to match the output from the rest of the range. A ribbon system doesn't have the excursion restriction of an electrostatic, but it still has the problem of the front and rear waves cancelling each other because the baffle is so small compared to the wavelengths involved. Another problem which isn't mentioned very often is that the frame holding the bass diaphragm is subject to Newton's third law: "For every action, there is an equal and opposite reaction." The frame will try to move in the direction opposite to that of the diaphragm; if it has a large surface area, it can cancel some of the diaphragm's output!

The design strategy employed by Apogee to solve this second problem is to make the frame as stiff as possible, thus moving its natural resonance well above the bass range. Figure 12 shows that the Duetta frame's resonance is at 142.5 Hz and that, at least for a continuous tone, there is significant harmonic output. Very little frame vibration occurs below this frequency, so the "action/reaction" problem is minimal. Some comments from panel members that the quality of the bass was "strange" and "hard" may be due to the harmonic output from the frame.

The Duetta Signature is an impressive speaker which shows signs of brilliance and real ingenuity from its designer.

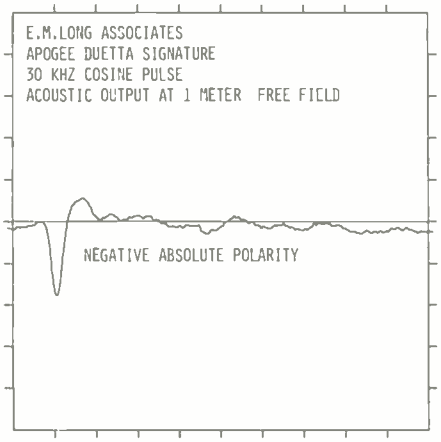

Fig. 11—Absolute polarity, measured with microphone at 1 meter in free field.

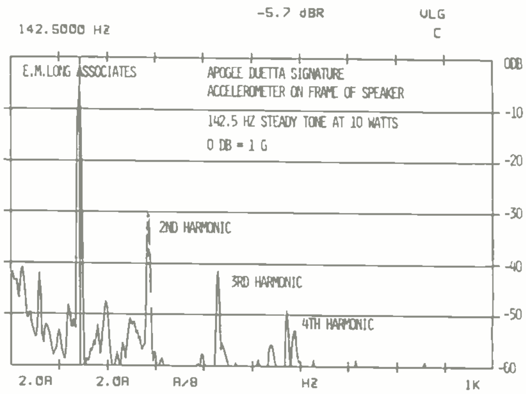

Fig. 12—Spectrum of output from frame of speaker system. The output at the 142.5-Hz resonance has a force of about 0.5 G. See text.

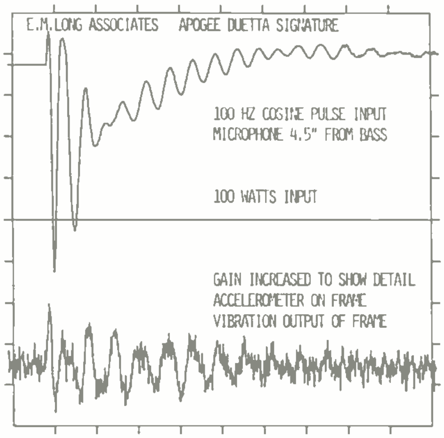

Fig. 13—Near-field acoustic output (top) and vibration from frame (bottom, and note gain increase) for 100-Hz cosine pulse at 100 watts input; see text.

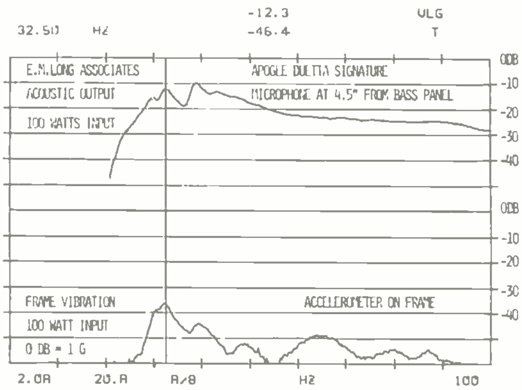

Fig. 14—Spectrum of output from pulse of Fig. 13, using same microphone and accelerometer positions. Frequency scale runs from 0 to 100 Hz, in 10-Hz linear increments; cursor line is at 32.5 Hz.

The principal means that can be used to increase the bass output of a dipole ribbon is to reduce the damping at the low-frequency diaphragm resonance. This is a side benefit from the fact that the flux density of a ribbon loudspeaker is almost always lower than that of a dynamic cone-type driver. It can result in a very pronounced, extended time response, as seen in Fig. 13. The top curve shows that the output from a 100-Hz cosine pulse "rings" at the 36-Hz fundamental resonance frequency of the Duetta ribbon bass panel. The output from the frame is also shown, but it is at an extremely low level. Figure 14 shows the spectrum produced by the pulse of Fig. 13: the output from 30 to 40 Hz is about 10 to 12 dB higher than the output at 100 Hz. By producing this much output in the near field of the diaphragm (the microphone was only 4½ inches from the diaphragm), the Duetta overcomes the difficulty of producing sufficient bass in the far field even when the rear wave tends to cancel the front wave. The trade-off is between the quantity and the quality of the bass. For orchestral music with big, reverberant bass drum sounds, such as in "The Roman Festival" track on the Delos CD *Bravura* (D/CD-3070), the reaction of the panel members was that the sound was "very impressive" and "great." However, when *The Sheffield Drum Record* (Lab 14) was played, the comments were that the drums sounded "bloated," "not like real drums," etc. Therefore, if you like tight, solid drums, the Duetta may not be to your liking.

Conclusions

The Apogee Duetta Signature is an impressive loudspeaker. It shows signs of real ingenuity and brilliance on the part of its designer, especially considering the fact that full-range ribbon dipole loudspeakers present some really difficult problems which must be overcome. The Duetta's main weaknesses are the exaggerated output in the range from 3 to 5 kHz, the underdamped bass, and the polar radiation problems caused by interaction between the long, vertically oriented mid/high and bass diaphragms. The strong points of the Duetta Signature systems are the clarity, detail, and transparency achieved when they are positioned carefully and when the listener is in the sweet spot.

Edward M. Long

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2

GOLDMUND MIMESIS 7 PREAMP AND MIMESIS 6 AMP

Manufacturer's Specifications

Preamplifier

Frequency Response for Levels to 35 V rms: 0 Hz to 150 kHz, ±0.1 dB; 0 Hz to 500 kHz, ±1 dB; 0 Hz to 850 kHz, ±3 dB.

Distortion: Less than 0.01% THD (static) or transient intermodulation distortion (dynamic), at all levels from 0 to 25 V.

S/N: Greater than 95 dB (100 dBA), 0.01 Hz to 10 MHz, on line input.

Interchannel Separation: Greater than 80 dB.

Speed: Amplification-stage slew rate, more than 500 V/µS; rise-time, less than 70 nS.

Group Delay: Propagation delay, less than 300 nS, stable from d.c. to 200 kHz.

Input Sensitivity: Nominal level, 100 mV; saturation level, 40 V rms.

Nominal Input Impedance: 100 kilohms.

Output Level: Nominal, 1.55 V rms; maximum, 40 V rms.

Output Impedance: 600 ohms.

Operating Temperature Range: Ambient temperature, –22° to +104° F (–30° to +40° C); internal temperature, +113° to +149° F (+45° to +65° C).

Power Requirements: Nominal line voltage, 115 or 220 V a.c., ±10%; maximum power consumption, 40 watts.

Dimensions: 19 in. W × 1¾ in. H × 12½ in. D (48.3 cm × 4.4 cm × 32 cm); power supply, 3½ in. W × 1¾ in. H × 6⅛ in. D (9 cm × 4.5 cm × 15.5 cm).

Weight: 11 lbs. (5 kg).

Price: With MM or MC phono preamp board, $3,490; without phono board, $2,990.

Amplifier

Output: Nominal power, 80 watts per channel continuous into 2- to 8-ohm loads and 60 watts per channel continuous into 1- to 16-ohm loads; maximum power, 150 watts per channel continuous into 3 ohms; maximum voltage, 35 V peak; maximum current, 25 amperes peak.

Distortion: Less than 0.01% THD (static) or transient intermodulation distortion (dynamic), at all levels from 0 to 25 V into 8 ohms.

Frequency Response for Levels to Nominal Power: 0 Hz to 100 kHz, ±0.1 dB; 0 Hz to 200 kHz, ±1 dB; 0 Hz to 500 kHz, ±3 dB.

S/N: 80 dBA.

Speed: Slew rate, more than 100 V/µS; rise-time, less than 700 nS.

Group Delay: Propagation delay, less than 100 nS, stable from d.c. to 200 kHz.

Input Sensitivity: Nominal level, 1.55 V.

Input Impedance: 50 kilohms.

Operating Temperature Range: Ambient temperature, –22° to +104° F (–30° to +40° C); internal temperature, +113° to +149° F (+45° to +65° C).

Protection Thresholds: High-frequency, 3 V rms at 50 kHz; d.c., 5 V.

Fuses: Short-circuit protection, four 5-ampere fast-blow fuses; power-line input protection, 5-ampere slow-blow fuse for 110 V, 3-ampere slow-blow fuse for 220 V.

Power Requirements: Nominal line voltages, 110, 117, or 234 V a.c. (selectable), ±10%; maximum power consumption, 500 watts.

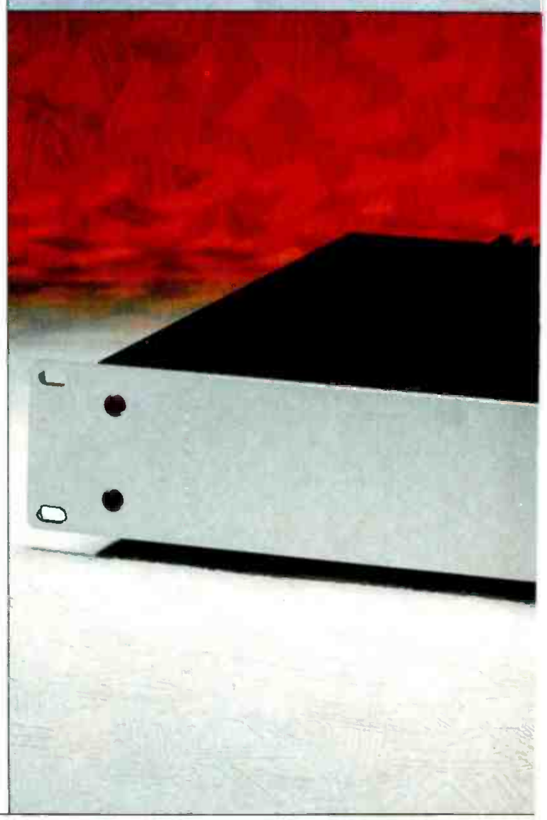
Dimensions: 19 in. W × 2⅝ in. H × 13⅞ in. D (48.3 cm × 6.7 cm × 35 cm).

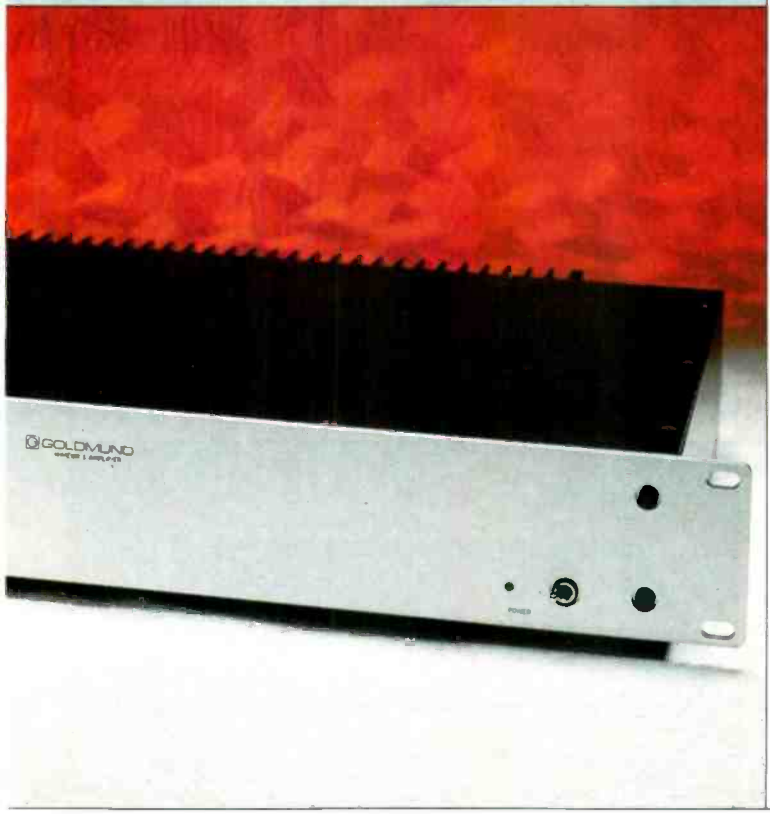
Weight: 27½ lbs. (12.5 kg).

Price: $2,690.

Company Address: c/o International Audio Technologies, 13897 Willard Rd., Suite J, Chantilly, Va. 22021.

For literature, circle No. 91





The Goldmund Mimesis 6 and 7 are a solid-state power amplifier and preamplifier imported by International Audio Technologies. These pieces are newer additions to a line consisting of a more expensive preamp and amp, the Mimesis 2 and 3, and several well-respected turntables and straight-line tonearms. If Goldmund's electronics are anything like their tonearms and turntables, they ought to be something else, sonically. (I understand that a CD player and a tuner are in the works and may well be on the market by the time this review is published.)

Physically, the Mimesis 6 and 7 are similar in size and appearance, having brushed aluminum, rack-width front panels. The amplifier's panel height is about 2½ inches, and the preamp's is 1¾ inches. The preamplifier also has an external power supply.

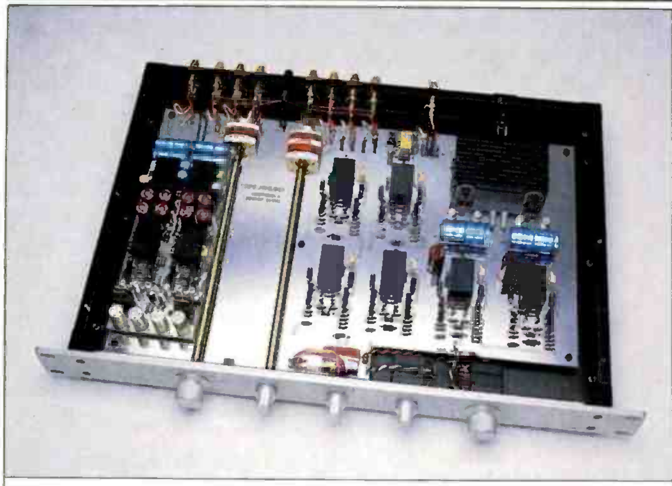
The preamplifier's phono section is an optional plug-in board and was installed in the unit reviewed here. The jacks and switch position used with this board are labelled "Phono/CD." If the board is not installed, an attenuator is substituted; the "Phono/CD" jacks and selector position can then be used for CD players or other components having extremely high output levels. An identical attenuator is in the AUX 2 input circuit.

Front-panel controls on the preamp, from left to right, are a six-position signal selector, a three-position tape monitor, a three-position "Mute/Phase" switch, and balance and volume controls. All controls are of the rotary type. On the rear panel are nine pairs of WBT gold-plated input/output jacks, a ground post, and a four-pin XLR connector for hookup to the remote power supply.

The front panel of the power amp has a small toggle switch for power on/off and an LED for indicating power on. Most of the rear panel is taken up by an extruded heat-sink with vertically oriented fins. In the approximately 2½-inch-square area at the right rear are dual, five-way binding posts for connection to the right speaker and a three-pin a.c. line-cord socket. In the similarly sized area at the left rear are the left speaker connectors and a pair of WBT signal input jacks.

Physical construction of both units is similar, consisting of a bent-up piece forming the rear and sides and, in the case of the amplifier, continuing around to form front subpanels, top and bottom plates, and the front panel. The main chassis pieces are bent over in the horizontal plane to form lips or ledges that are about ⅜ inch wide. Around the periphery

Selector switches at the preamp's rear, with long shafts to the front panel, help minimize the length of the signal path.



of these ledges are Pemm nuts for attaching the top and bottom plates. Because of the presence of controls on the preamp's front panel, its sides only extend around in the front about ¾ inch to form tabs that have two Pemm nuts each for attaching the front panel. The front panel has two vertical bars of square stock attached to it so that the top and bottom covers can be secured with two screws each along their front surfaces.

Looking inside the preamp first, we find a large double-sided p.c. board that takes up most of the interior area. Mounted above the left side of this board is the optional phono module, oriented fore and aft. It is about 20% as wide as the main board and just about as deep. Just to the right of the phono board is a shaft connecting the front-panel selector knob to the actual selector switch. This switch is located right at the rear of the board, where the inputs are. The tape monitor switch is similarly located at the rear of the p.c. board. The location of these two switches is really intelligent, minimizing the signal-path length of the high-level circuitry. Continuing on the theme of intelligent layout, the selected source then passes up to the front of the p.c. board, where it encounters the phase/mute switch, balance and volume controls, and part of the output line amplifier. Passing towards the rear of the board again, the signal goes through the last part of the line amp's circuitry to the output jacks. At the right rear of the p.c. board are the on-board power-supply regulators.

Inside the power amp, it quickly becomes apparent that we have a dual mono design. Two separate toroidal power transformers of approximately 250-VA capacity, along with separate rectifier bridges and a small p.c. board for strapping the transformer primary windings for different voltages, occupy the front half of the interior space. At the rear of the enclosure is the main amplifier p.c. board, which is attached at the rear to the horizontal surface of an L bracket on which the TO-3 output devices are mounted. This bracket, in turn, is mounted to the rear panel of the amp enclosure. Standoffs to the bottom of the enclosure secure the front edge of the amplifier p.c. board. The main electrolytic filter capacitors in the power supplies are mounted right on the p.c. board, where they are very close to their point of use. Twisted pairs of heavy-gauge MIT wire are used for the input and output connections to the board. Even the a.c. primary wiring appears to be special, heavy wire.

Parts and construction quality in these units is absolutely first-rate, and they are a beauty to behold.

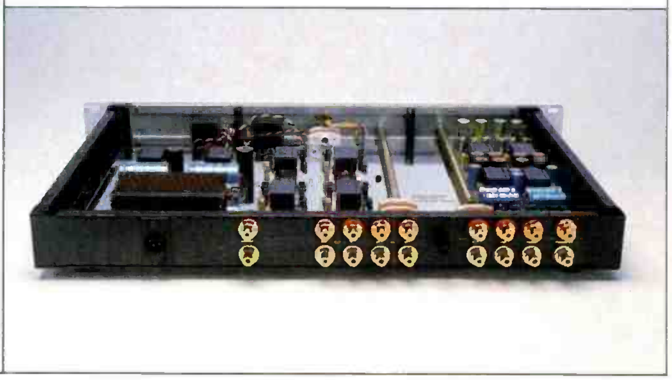
Circuit Descriptions

At my request, Bill Peugh of International Audio Technologies sent schematic information on these units, but he asked that I not reveal the details. To respect his wishes, I will have to be more general than I like in my descriptions.

One thing is apparent by looking at the units themselves: Their circuits are composed of blocks of gain that are, in turn, made up of a combination of potted modules in p.c. board sockets and some discrete parts (resistors, capacitors, and discrete amplifying devices). The modules are potted to maintain thermal stability of their internal components, according to the manufacturer. It appears that these modules are some kind of input circuit that is used in all the blocks, and that the discrete parts which follow are later-stage circuitry, ending up in complementary emitter-follower output stages.

In the phono preamp board I tested, a pre-preamplifier module precedes one of the gain blocks described above. The manual does not make clear that this board is for moving-coil cartridges and that a moving-magnet phono stage is also available as an option. It does, however, state that cartridge loading adjustment is no longer necessary due to the proprietary design of the input module. This phono preamp is designed only for moving-coil cartridges or for moving-magnet units that have very low inductance (probably less than several hundred microhenries).

The RIAA equalization is partially feedback and partially passive, with the bass boost accomplished in the feedback loop around the gain block following the MC pre-preamp and the high-frequency roll-off occurring in the interstage coupling network at the output of the phono circuit. This last point strikes me as a flaw, in that the RIAA equalization accuracy is dependent on there being a constant load impedance connected across this roll-off network. In normal operation of the Mimesis 7, a load of about 100 kilohms is presented to the selected source. When phono is selected, this 100-kilohm loading of the roll-off network gives some nominal equalization flatness. If a tape recorder or some other signal processing device is connected to tape output, the load on the roll-off network will obviously now be lower, and the equalization will take on various degrees of high-



The protection circuits of the amp are zealous about keeping high-frequency, full-power energy out of your loudspeakers.

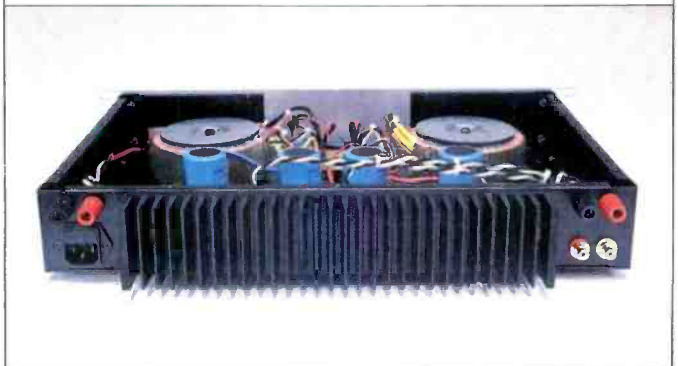
frequency boost. The degree of this effect will be shown in the "Measurements" section of this report.

After signal selection and choice of tape monitor or main selected signal, the signal enters the first gain block in the line section. The output of this first line-amp section feeds another gain block, connected as a unity-gain inverter. The front-panel "Mute/Phase" switch is fed from the gain-block outputs of the first and second line amps. When the switch is in its center (mute) position, its wipers will be grounded; in its other two positions, its wipers will carry signal with 0° (normal) or 180° (inverted) polarity to pass on to the balance and volume controls. The output of the volume control then feeds the input of the last line-section circuit block. From the foregoing, it is apparent that one listens through two circuit blocks in the output amplifier or, if inverted polarity is chosen, three. Note that in this design, the input impedance for the selected inputs is a nice, constant 100 kilohms and that the balance and volume network is between the first and second line-section blocks, where the control values can be low in resistance for extended high-frequency response.

The outputs of the last gain blocks of the line-amp section are coupled to the main signal output jacks through two series resistors whose values add up to 600 ohms. The midpoint of this resistor pair is tied to ground through a pair of normally closed relay contacts. A time-delay circuit controls these relays, providing a turn-on delay of several seconds at power up before the contacts open. Incidentally, the Mimesis 7 has no power switch, the intent being to have the unit continuously powered for best sound.

Power-supply voltage for the circuitry of the Mimesis 7 is higher than usual for solid-state circuitry. Incoming rectified d.c. from the separate power supply is about ±85 V. The on-board regulators in the preamp regulate down to ±60 V. Each circuit block is decoupled, in both the positive and negative supply lines, with series resistors and shunt capacitors. The phono board has an active capacitance multiplier for both positive and negative supply lines. These circuits isolate the supply lines of the phono circuitry from the main regulated supplies by providing the equivalent of some hundreds of thousands of microfarads of shunt capacitance.

Not surprisingly, the circuitry of the Mimesis 6 power amp is like the line-amp blocks in the preamp, with the addition of two pairs of complementary power MOS-FETs connected as source followers for the output stage. A time-delay and protection circuit operates a series relay in the positive



output line. Presumably, if excessive d.c. is present at the output, the circuit opens the relay to protect the load. This circuit also functions as a turn-on delay, not connecting the load until a suitable interval has passed. The series feedback resistor for the overall feedback loop is broken into two parallel paths—one from the output stage and the other from the load side of the relay, to help linearize its contacts.

Another function of the relay circuit was discovered when I tested the amp in the lab. The relay opens when frequencies above 2 to 3 kHz are steadily applied at full power. As steady-state power is reduced, the frequency at which the relay opens goes up.

The overall feedback loop is direct-coupled, and since there is no input blocking capacitor, the whole amp is d.c.-coupled and should have a d.c. gain the same as its a.c. gain. As always with d.c.-coupled power amps, one must be sure that the preamp used doesn't have any significant d.c. offset—no more than, say, 50 mV. The Mimesis 7 has no problem in this regard, having very low d.c. offset.

Preamplifier Measurements

Measured gain and IHF sensitivity figures for the Mimesis 7 appear in Table I. The input resistance of the phono board is very low, on the order of 3 or 4 ohms, caused by inverting feedback and/or by common-base-connected input devices. My normal way of measuring gain of high-gain phono stages is to utilize a precision voltage divider consisting of one resistor each of 990 ohms, 9 ohms, and 1 ohm. From this, one gets 40 or 60 dB of attenuation with output impedances of about 10 ohms and 1 ohm, respectively. I usually put something like 1 V into this divider and feed the circuit under test from the 1-ohm output (−60 dB), yielding a known 1-mV signal level into the device under test. With devices having normal input impedances (hundreds of ohms or higher), any voltage error caused by the device's input impedance loading down the divider will be negligible. The phono input impedance of the Mimesis 7, however, would seriously load the 1-ohm source of my divider, so I had to directly measure the input voltage and the stage output voltage to calculate the gain and sensitivity. This low input impedance is apparently what Goldmund is talking about when they refer to special proprietary circuitry that

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David Clark–*Audio* Magazine Sept. '89

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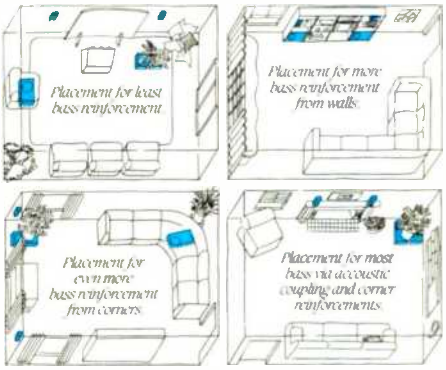

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Stereo Review

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Both the A-weighted and band-limited noise figures for the preamp were among the lowest I've measured.

Table IA—Gain (in dB) for Mimesis 7 preamp with IHF and instrument loads, at low and high gain settings.

	Left Channel		Right Channel	
	Instr. Load	**IHF Load**	**Instr. Load**	**IHF Load**
Low Gain				
Phono to Tape Out	59.6	56.5	59.4	56.3
Phono to Main Out	86.5	86.0	86.2	85.7
High Gain				
Phono to Tape Out	65.3	62.3	64.7	61.6
Phono to Main Out	92.4	91.9	91.7	91.2
AUX to Tape Out	0	−1.2	0	−1.2
AUX to Main Out	26.8	26.4	26.8	26.4

Table IB—IHF sensitivity of Mimesis 7, at low and high gain settings.

	Left Channel	Right Channel
Low Gain		
Phono to Tape Out	0.75 mV	0.79 mV
Phono to Main Out	25.0 µV	25.8 µV
High Gain		
Phono to Tape Out	0.38 mV	0.41 mV
Phono to Main Out	12.7 µV	13.7 µV
AUX to Tape Out	580 mV	580 mV
AUX to Main Out	24.1 mV	24.1 mV

Table II—Phono-section noise referred to input, for zero-ohm source impedance. Some measurements show noise ranges, due to "bouncing" caused by noise with a frequency-inverse characteristic ($\frac{1}{f}$).

	Referred Input Noise, mV	
Bandwidth	Left Channel	Right Channel
Low Gain		
Wideband	100 to 150	100 to 200
20 Hz to 20 kHz	100.0	60 to 70
400 Hz to 20 kHz	24.0	28.0
A-Weighted	27.0	30.0
High Gain		
Wideband	100 to 150	100 to 200
20 Hz to 20 kHz	100.0	60.0
400 Hz to 20 kHz	23.0	25.5
A-Weighted	25.5	27.0

Table III—Phono overload vs. frequency for right channel of Mimesis 7, with low gain setting.

Frequency,	**Instrument Load**		**IHF Load**	
Hz	Input, mV	Output, V	Input, mV	Output, V
20	2.0	16.5	2.5	14.0
50	2.42	16.2	3.1	14.2
100	3.8	16.4	4.9	14.5
300	9.8	16.6	12.3	14.4
700	15.2	15.2	15.2	10.5
1k	15.8	13.3	15.8	9.0
3k	16.0	7.7	16.0	5.8
5k	17.0	5.3	17.0	4.2
7k	17.0	3.9	17.0	3.1
10k	17.0	2.8	17.0	2.2
20k	17.0	1.4	17.0	1.1

eliminates the need for cartridge loading adjustment. It does tend to equalize the phono stage's output level for MC pickups with different output voltages, to the extent that pickups with higher output voltages tend to have higher output resistances and hence get attenuated more in the input circuit. There is, however, a 6-dB gain switch on the phono board.

Noise as a function of bandwidth and circuit gain is shown in Table II. An interesting property of an input stage like the one used in this preamp is that the apparent noise gets lower as the source resistance goes up. The reason is that the circuit gain is dependent on the input source resistance. Therefore, when a high terminating resistance is used, the gain is lower and so is the apparent referred input noise. For my noise measurements, I put a known voltage of 100 µV at 1 kHz into the phono input by compensating the input to my precision divider just enough to get the desired voltage into the phono input despite the loading effect. The input termination was a short-circuit. Both the A-weighted and band-limited (400 Hz to 20 kHz) noise figures were among the lowest I have measured.

The IHF S/N ratio for components having MC inputs is measured by applying a known 500-µV signal at 1 kHz into the MC input, noting the output level, and calling that 0 dB for reference. The input signal is then removed, and the input jack is terminated with 100 ohms. The residual noise is measured through an A-weighting filter, and the IHF S/N is the difference in dB between the residual noise level and the reference level. When one does this for the phono input of the Mimesis 7, the figure comes out to a fabulous 95 dB. When one applies the 500-µV signal through a 100-ohm resistor, the actual input voltage is a lot lower and the resultant IHF S/N comes out to about 71 dB, more in the neighborhood of what other circuits measure.

Phono equalization error is shown in Fig. 1 for a variety of conditions. As was mentioned earlier, you can see the effects of loading the phono stage at the tape output. The top three curves were measured at the Mimesis 7 preamp's main output, so the phono stage was loaded with the line section's normal 100-kilohm input impedance. My RIAA pre-equalizer is terminated in 475 ohms, in series with 10 ohms to ground, so as to provide a normal output at the top of the 475 ohms and a lower impedance, lower voltage output at the top of the 10-ohm resistor. The top curve shows the phono high-gain mode with the circuit fed from the normal output of the pre-equalizer. The second trace is for the low (normal) phono gain. There is some difference in frequency response between the two, in that the relative gain is higher by some 0.15 dB in the high-gain mode below 1 kHz. The third curve down is low-gain mode for a signal from the 10-ohm output of my pre-equalizer. Comparing this curve to the one just above it illustrates how the Mimesis 7's phono circuit equalizes output levels for different input levels with different source impedances: Even though there is a difference of about 34 dB between the unloaded voltages from my pre-equalizer's two output points, the difference between the Mimesis 7's output levels for these two signals was only 1.5 dB! One little subtlety to point out in the third curve is a slight roll-off between 10 and 20 kHz. This suggests that some shunt input capacitance is acting against

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With a high-voltage power supply, you get a large output-voltage swing, and the Mimesis 7 preamp has that in spades.

the 10-ohm source; it does not show when fed from the pre-equalizer's normal output, which looks more like a capacitive source.

The shape of these equalization error curves suggests that Goldmund wanted the middle and high frequencies shelved down (or the lower midrange and bass shelved up, depending on your point of view) for sonic reasons. The fourth curve down from the top is for the measurement at the tape out jack, which, for instrument loading, puts another 91 kilohms across the phono preamp output. Now the response between 1 and 2 kHz is starting to tilt up. For IHF loading of 10 kilohms in parallel with 1,000 pF, the effect is more pronounced—and with a load of 3.3 kilohms (an admittedly unrealistic value chosen just to show the point), egad, what a treble boost! Shriek city! My advice is to use a tape recorder with known input impedance of 100 kilohms or higher, if you want reasonable equalization accuracy, and keep any signal processors with input impedances below 100 kilohms out of the tape loop.

Figure 2 is a 'scope photo of pre-equalized square waves as they appeared at the preamp's tape output jacks with instrument loading. The top trace is for 40 Hz and shows the general frequency characteristics of Fig. 1. The next trace down is for 1 kHz with an output of about 0.4 V peak to peak. Response here is linear, and the effect of low-frequency lift is evident. The next trace is again for 1 kHz but at a higher output amplitude. The effects of high-frequency compression are now showing, as the change-of-state amplitude is smaller than the steady-state peak-to-peak amplitude. The bottom trace, for 10 kHz at 0.2 V per division, shows nice high-frequency behavior.

Crosstalk between channels in the normal gain mode was found to be very similar in both directions. It was better than −80 dB up to 400 Hz, rising to about −77 dB at 1 kHz, −69 dB at 10 kHz, and −66 dB at 20 kHz. Crosstalk was in phase.

Phono overload versus frequency and loading is shown in Table III for the right channel, which was slightly worse than the left. Input acceptance levels for the high-gain mode are about half of those shown in the Table for the normal gain mode. Another consequence of having the final RIAA high-frequency roll-off at the output of the phono circuit is that the ultimate input signal acceptance becomes constant with frequency above about 1 kHz. In full-feedback equalization designs, it would increase with frequency. This is because the output of the gain block preceding the final high-frequency roll-off starts to rise with frequency above 1 kHz and runs into clipping sooner. The input acceptance of this design at 1 kHz is probably okay, as a pickup with an output of, say, 1 mV will produce somewhat less than 1 mV at the Mimesis 7's input. This is due to voltage-divider attenuation of the pickup's output impedance against the input impedance of the phono circuit. The Mimesis 7 nicely meets my criterion of a 20-dB headroom margin over the output at 1 kHz, for a stereo groove modulated at 3.54 cm/S. But at 20 kHz (and this may be excessively stringent), the output theoretically could be 10 mV, and allowing for a 20-dB headroom would require an input acceptance of 100 mV. In view of this, the Mimesis 7's high-frequency acceptance may be marginal for high-output MC pickups that have low

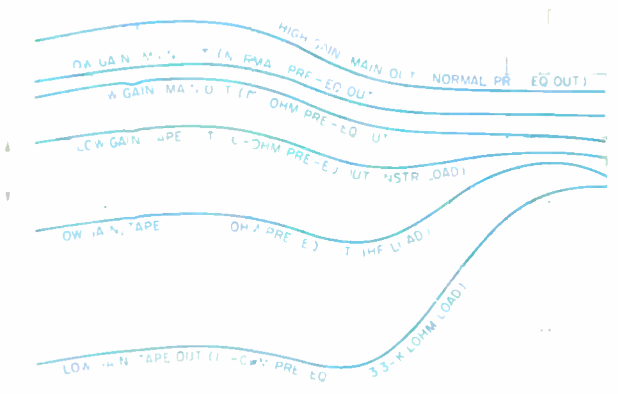


Fig. 1—RIAA equalization error of the Mimesis 7 preamp under a variety of conditions; notes in parentheses refer to source and output loads. The low, 3.3-kilohm load which produced the bottom curve would probably not be encountered in normal use. See text.

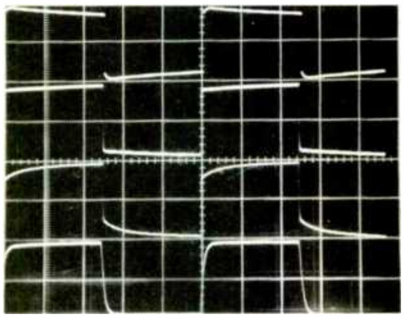


Fig. 2—Response to pre-equalized square waves through the Mimesis 7's phono input, for (top to bottom) 40 Hz at 0.4 V p-p, 1 kHz at 0.4 V, 1 kHz at 1.0 V p-p, and 10 kHz at 0.4 V p-p. All traces were measured at the tape output, with instrument loading. (Scales: Vertical, 0.2 V/div. for 0.4-V curves, 0.5 V/div. for 1.0 V; horizontal, 5 mS/div. for 40-Hz signal, 200 µS/div. for 1 kHz, 20 µS/div. for 10 kHz.) See text.

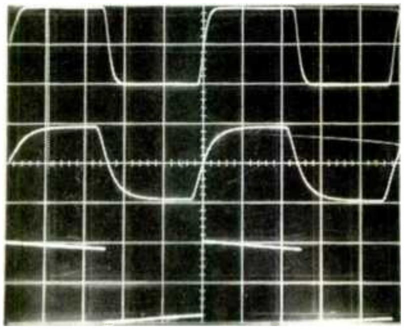


Fig. 3—Response to square waves through the Mimesis 7's line input (top to bottom) 100 kHz into instrument load, 100 kHz into IHF load, and 20 Hz into either load. (Scales: Vertical, 5 V div.; horizontal, 2 µS/div. for 100 kHz, 10 mS/div. for 20 Hz.)

Square-wave tests showed that the preamp was fast and had excellent response at very low frequencies.

Table IV—Line-amp section noise of Mimesis 7 preamp (in microvolts) referred to input, with volume control fully clockwise and balance control centered, for normal and inverted positions of polarity switch. The IHF S/N ratio was 93.0 dB for both channels and for both polarity positions.

	Left Channel		Right Channel	
Bandwidth	**Normal**	**Inverted**	**Normal**	**Inverted**
Wideband	4.3	6.1	4.3	6.1
20 Hz to 20 kHz	1.4	1.9	1.4	1.9
400 Hz to 20 kHz	1.35	1.85	1.35	1.85
A-Weighted	1.26	1.75	1.27	1.75

Table V—Mimesis 6 amplifier output noise and IHF S/N.

Bandwidth	**Left Channel**	**Right Channel**
Wideband	300 µV	540 µV
20 Hz to 20 kHz	292 µV	520 µV
400 Hz to 20 kHz	92 µV	166 µV
A-Weighted	92 µV	160 µV
IHF S/N	89.6 dB	85.0 dB

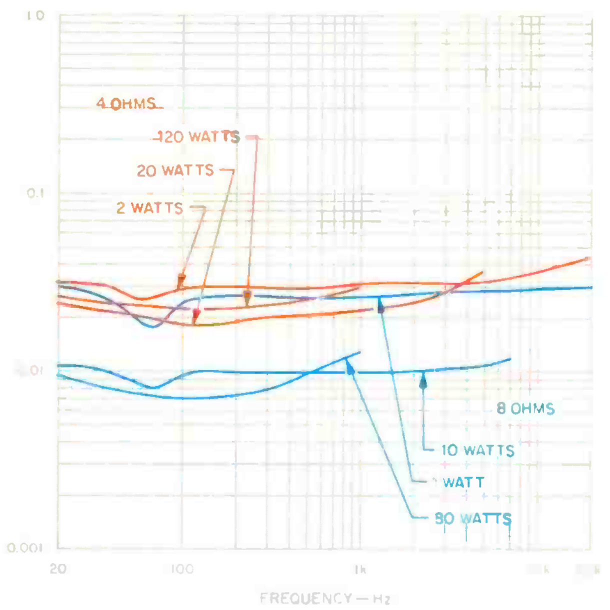


Fig. 4—Mimesis 6 amplifier THD + N vs. frequency for 8- and 4-ohm loads, each at three power levels. The high-frequency cutoffs at higher power levels are due to the protection circuitry; see text.

output impedances. With this in mind, I wouldn't consider using the high-gain mode for any pickup with an output level higher than about 100 µV at the standard cutting level (which is 3.54 cm/S).

The phono circuit's THD + N was found to be about 0.01% at 10 V rms output from 20 Hz to 1 kHz. For 0.01%, the output attainable decreased to 2.5 V at 10 kHz and 1.1 V at 20 kHz.

Some aspects of the output section's performance can be seen by comparing the gain and sensitivity figures measured at the main out with those measured at the tape out (Table I). One advantage that comes with high-voltage power supplies is a large output-voltage swing capability. This circuit has it in spades, putting out some 35 V rms at the onset of clipping into my instrument load, decreasing to 32 V with the IHF load, and finally 15 V into 600 ohms. The THD + N into an IHF load was less than or equal to 0.01% from 20 Hz to 20 kHz at 15 V rms output level. Into 600 ohms, the output level for 0.01% or less was 2.5 V.

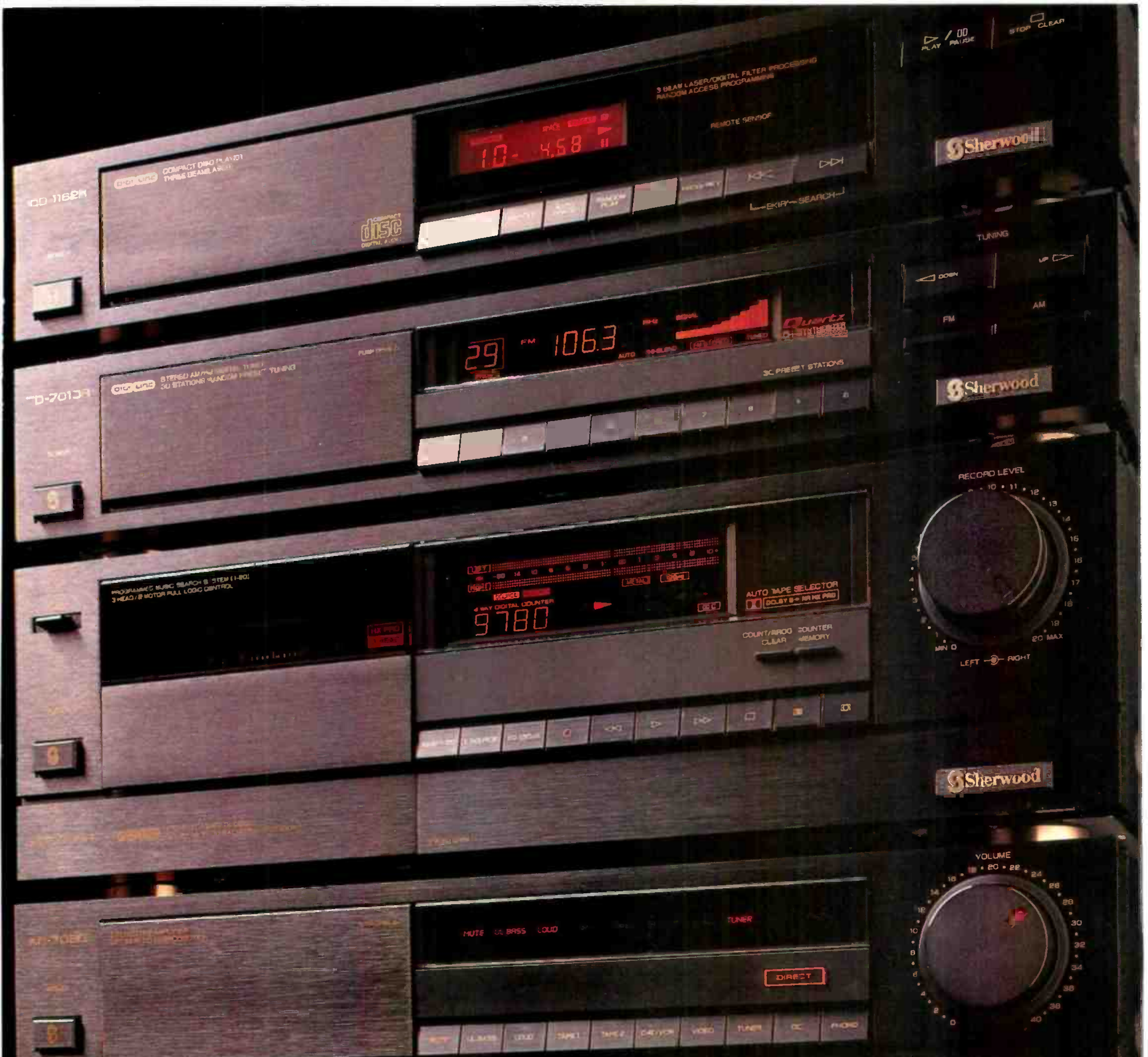
The a.c. line draw of this design is about 0.4 ampere. This is not entirely negligible, being about the power consumption of a 40-watt light bulb. The unit gets very warm in operation. Its top should be left uncovered so as to allow some of this heat to be dissipated.

The referred input noise of the line section is enumerated in Table IV. In the Table, noise is shown for both the normal and inverted polarity positions; the noise is a little higher in the 180° position because of the additional noise from the phase-inverting gain block. As was the case for the phono section, the line section was very quiet. Unlike the majority of other designs, whose balance and volume controls directly feed their line-amp inputs and whose noise gets worse at about the −6 dB point on the volume control, the Mimesis 7's referred input noise stays fairly constant as the volume control is taken down from maximum.

This line-amp section is a fast one. Rise- and fall-times into the instrument load were 0.5 µS. With the volume control down 6 dB, the rise- and fall-times increased to 0.6 µS. They stayed relatively constant and exponential in shape up to output clipping; therefore, this output amp doesn't slew under these conditions. With the IHF load, rise- and fall-times were 1.4 µS. Square-wave performance of the output amp is shown in Fig. 3. The top trace is for 100 kHz into the instrument load. The middle trace, also for 100 kHz, is with the IHF load. The bottom trace, for 20 Hz, shows excellent response at very low frequencies.

Output section crosstalk versus frequency was within a few dB of being symmetrical, with the left-to-right direction being the worse. Crosstalk in this direction was better than 80 dB down, from 20 Hz to a few kilohertz, decreasing to −76 dB at 3 kHz, −66 dB at 10 kHz, and −60 dB at 20 kHz. Of note here is that when the volume control was taken down from full clockwise or the balance control was moved from center, the crosstalk at high frequencies did not come up or get worse, as happens in most designs. Crosstalk was, once again, in phase.

The volume control's tracking was found to be within +0.4 to −0.15 dB down to −65 dB of attenuation. Below this point, the channels diverged rapidly, with the right channel dropping out (output going to zero) first. An inter-



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The amplifier's bandwidth is wide, with response that started at d.c. and was down by only a fraction of a dB at 100 kHz.

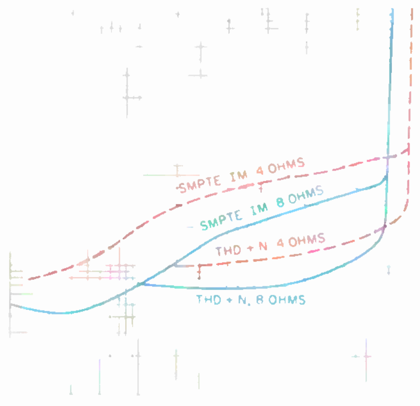

Fig. 5—SMPTE IM and THD + N vs. power for 8- and 4-ohm loads. THD + N is for 1-kHz test signal.

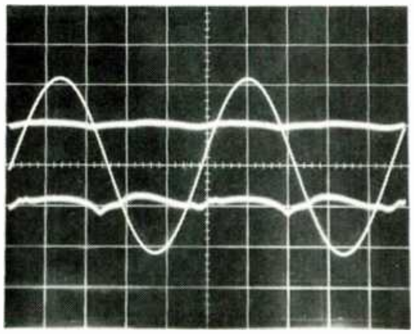

Fig. 6—Typical harmonic-distortion residue for 1-kHz test signal. Top residue curve is for 10 watts into 8 ohms (0.005% THD + N); bottom residue curve is for 20 watts into 4 ohms (0.009%).

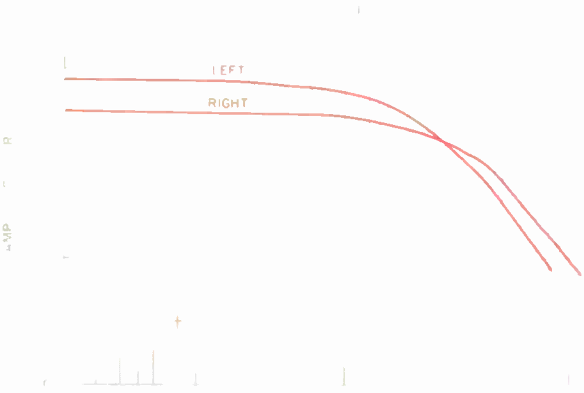

Fig. 7—Damping factor vs. frequency. The high-frequency cutoffs are due to the protection circuitry.

esting peculiarity was noticed when I looked at the balance control's operation. When this control was turned to attenuate the measured channel, attenuation was smooth with rotation, as would be expected. However, when turned the other way for the same measured channel, the output level dropped to a maximum of about 2.8 dB at about 30° off center. This means that when the balance control is rotated off center, the overall volume will drop, which might be a bit confusing when trying to alter balance for a particular program source.

Amplifier Measurements

The Mimesis 6 power amp's heat-sinks run pretty hot in normal operation. Thus, when I set up to precondition the amp for the one-hour test at one-third rated power (27 watts per channel), I was wary of how hot the unit might get. Sure enough, about halfway into the hour, the sinks got too hot for me to touch. That's too hot, in my considered opinion, so I aborted the test. Since I didn't see any thermal cutout devices in the amp, I didn't want to take a chance and have it fail. However, I must mention that in normal operation, the sinks don't get much hotter than at idle.

When setting up to measure THD + N, it became apparent that the protection circuitry is very zealous in its task of keeping full-power high-frequency energy out of one's speakers. Attempts at full power above about 1 kHz resulted in the speaker relay's opening. The threshold is obviously level- and frequency-dependent; the threshold is about 3 watts at 20 kHz. Results, such as I could get, are shown in Fig. 4 for 4- and 8-ohm loading. The 1-kHz THD + N and SMPTE-IM distortion for 4- and 8-ohm loading are plotted in Fig. 5. Typical harmonic distortion residue for a 1-kHz signal is seen in Fig. 6 for 10 watts output with 8-ohm loading and for 20 watts output with 4-ohm loading. The top residue trace is at 0.005% for 8-ohm loading, and the bottom residue trace is at 0.009% for 4-ohm loading. More high-order nasties are evident in the bottom trace.

Voltage gain of the Mimesis 6 was found to be 30.3 × or 29.6 dB. IHF sensitivity for 1 watt into 8 ohms was 94.5 mV for both channels.

Output noise, in terms of absolute noise level as a function of bandwidth and in terms of S/N relative to 1 watt output, is shown in Table V. The difference between channels tended to disappear when the channels' input grounds were tied together, a condition that would be the case in practical stereo use.

Channel-to-channel crosstalk as a function of frequency was set up to be measured with the reference driven channel at 10 V rms for good, crosstalk-dominated results. However, the protection circuit prevented data from being collected above about 7 kHz. Results were not symmetrical with direction, with the right-to-left direction being worse. In this direction, crosstalk was better than −80 dB up to a few hundred hertz, rising to −72 dB at 500 Hz, −58 dB at 3 kHz, and −46 dB at 10 kHz before the protection circuit cut in. Crosstalk was in phase.

At the excitation level I generally use (1 ampere rms into the channel under test), the test of damping factor versus frequency ran afoul of the protection circuit at high frequencies. Results are plotted in Fig. 7.

The Mimesis 6's sound was open and spacious, with good bass and dynamics, and it transmitted the music's emotional quality.

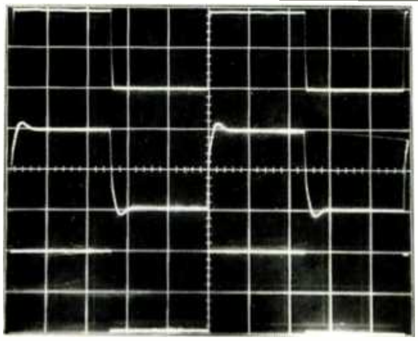

Fig. 8—Square-wave response. Top trace is 10 kHz with 8-ohm load; middle trace is 10 kHz with 2-μF capacitance across the 8-ohm load; bottom trace is 40 Hz into 8 ohms. (Scales: Vertical, 5 V/div.; horizontal, 20 μS/div. for 10 kHz, 5 mS/div. for 40 Hz.)

Frequency response at 1 watt output was flat from d.c. to above the audio range, being down about 0.35 dB at 100 kHz into 8 ohms and down about 0.6 dB at this frequency into 4 ohms. Clearly, this is a wide-bandwidth power amp.

Rise- and fall-times at an output of 10 V peak to peak were 0.8 μS into 8 ohms and 1.0 μS into 4 ohms. Again, the protection circuit's vigilance prevented my looking at the edge-transition behavior at a higher level.

Square-wave performance of the Mimesis 6 is shown in Fig. 8. The top trace is for 10 kHz into 8 ohms at an output level of about 10 V peak to peak. In the middle trace, the effect of an additional load of 2 μF across the 8-ohm load is shown. Lastly, the bottom trace is for a 40-Hz signal; as expected for a d.c.-coupled design, there is no tilt in the exhibited waveform.

IHF dynamic headroom came out to 2.6 and 4.8 dB for 8- and 4-ohm loading, respectively, based on the manufacturer's rating of 80 watts nominal power output for 2- to 8-ohm loads. Corresponding power levels in the 20-mS time period of the test-tone burst were 144 and 242 watts. Clipping headroom, again based on 80 watts, came out to 0.61 and 2.1 dB for 8- and 4-ohm loading with power of 92 and 130 watts, respectively, being delivered at the visual onset of clipping.

Use and Listening Tests

The operation of the Goldmund pieces was flawless, with no surprises or glitches. I would recommend leaving the preamp on continuously, as intended, and warming up the amp for at least an hour before critical listening.

Equipment used to evaluate the Goldmund pair included an Oracle turntable fitted with a Well Tempered arm and Koetsu Black Goldline cartridge, a California Audio Labs Tempest CD player, a Nakamichi 250 cassette deck, a Technics reel-to-reel recorder, a Cook-King reference tube phono preamp, and YBA_3 and EAR 519 amplifiers. These amps drove Siefert Research Magnum III speakers and/or Stax SR-X/Mk3 headphones with the Stax SRD-7 Pro energizer.

First listening impressions of the Mimesis 6 power amp, after it had warmed up for about a day, were that it was a pretty good amplifier. The sound was open and spacious, with good bass and dynamics. Something about it seemed to transmit the emotional quality of music. The amp also sounded very good in a friend's system, with Apogee Duetta loudspeakers.

I have listened extensively to the Goldmund units as a pair, and on the Siefert speakers, the spectral balance is pretty good. Records sounded good but not outstanding. The sound of CDs through the line section became noticeably more electronic, although the musical quality was generally good. Bass extension and quality were outstanding. I have enjoyed a lot of music while listening to this setup. A brief audition with a pair of Fuselier 3.8D speakers and also with some Jecklin Float electrostatic headphones produced a sound that was too bright and spitty on vocal sibilants when playing CDs. When the same program material was used, but with my EAR 519 tube power amps driving the above-mentioned loads, and using my reference passive switched attenuator volume control instead of the Mimesis 7 preamp line stage, the sound was more balanced spectrally; the spittiness was virtually gone with the Jecklin Float headphones. The sound was still a bit bright on the Fuselier speakers, but that appears to be their characteristic. In a final round of listening, using my Stax electrostatic earphones, I again noticed a spitty quality to female vocals when playing CDs.

I then went through the following changes in the setup: I fed the output of the Mimesis 7 through my stepped attenuator volume control to drive the cable to the power amp location from a different (higher) source impedance, changed to tape out in order to eliminate line-section electronics, bypassed the Mimesis 7 preamp entirely, and finally changed from the Mimesis 6 power amp to my EAR 519 tube amps. There was not much change when going through the stepped attenuator volume control. Eliminating the line amp of the Mimesis 7 by feeding my attenuator from its tape output improved things a bit, and bypassing the Mimesis 7 entirely yielded a small improvement. Changing from the Mimesis 6 power amp to my EAR 519 tube power amps made the biggest difference, with the sound then being free of excessive sibilance and being of quite extraordinary quality.

I realize that all this may be a bit confusing. What I'm trying to say is that tne Goldmund pair yielded very listenable reproduction on my Siefert speakers and undoubtedly will with other speakers in other systems. When I put on my pure state-of-the-art hat, started listening through my Stax 'phones, and compared these units to the best I've heard, I found I got better sound using my personal reference setup.

As always, I recommend making one's own listening evaluations of any prospective purchases, and doing so in a variety of circumstances. And I certainly recommend going out to listen to the Goldmund gear. *Bascom H. King*

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Polk Audio's SRS: The Quest for Perfection

The goal of Matthew Polk's Signature Reference System (SRS) speakers is to bring an unparalleled level of life-like musical reproduction to your home. Perfect musical reproduction, long the dream of every speaker designer, is approached so closely by Matthew Polk's SRS's that it will seem as if the musicians are performing right in your listening room. This stunning achievement combines technology and creative insight to bring you a listening experience that you will never forget.

1. **Patented SDA True Stereo Technology** — The first and only speaker systems to maintain full stereo separation all the way from the source to your ears. (see pg. 9 for a more complete description). SRS speakers seem to disappear as musical images fill your listening room and seem to immerse you in a fully three-dimensional soundfield of startling realism.

Matthew Polk with the ultimate expressions of loudspeaker technology: The SRS 1.2 tl and SRS 2.3 tl.

2. **Multiple Driver Arrays** — The use of multiple drivers allows each separate element to work less hard and lowers distortion even at live concert levels. Power handling is increased to 1,000 watts per channel, providing a seemingly limitless dynamic range.

3. **Time-Compensated Driver Alignment** — Time-coherent driver placement insures that the entire spectrum of sounds reaches your ears at the same time. The sound is better focused, balanced and less fatiguing.

4. **Wavelength Optimized Line-Source** — Vertical driver arrays focus the sound waves into the room in a way which greatly reduces floor and ceiling reflections. Progressive reduction of the acoustical length of the arrays maintains constant vertical dispersion and eliminates "comb" filtering effects that limit other multiple driver systems. The result is extraordinary clarity and detail, great flexibility in room placement and precise stereo imaging from virtually any place in the room.

5. **Planar 15" subwoofer** — SRS bass performance is breathtaking. The use of small active drivers (eight in the SRS 1.2 tl, six in the SRS 2.3 tl) coupled to a huge sub-bass radiator achieves a bass response that is extraordinarily tight, fast (no boominess), deep and distortion free. In fact, the distortion at 25 Hz is lower than that of many audiophile-quality tube amplifiers.

6. **Bi-amp Capability** — The optional use of separate amplifiers for the high and low frequencies further improves clarity, lowers distortion and increases dynamic range.

7. **Hand-Crafted Limited Production** — The one-at-a-time attention that goes into the production of every Polk SRS speaker system means that your pair will sound and look as good as Matthew Polk's own.

3

YAMAHA CDX-2020 COMPACT DISC PLAYER

Manufacturer's Specifications

Frequency Response: 2 Hz to 20 kHz, ±0.3 dB.
De-Emphasis Equalization: ±0.3 dB.
THD Plus Noise: Less than 0.003% at 1 kHz.
S/N Ratio: Greater than 120 dB.
Dynamic Range: Greater than 100 dB.
Channel Separation: Greater than 100 dB at 1 kHz.
Output Voltage and Impedance: 2.0 V, 47 ohms.
Headphone Output and Impedance: 280 mV, 150 ohms.
Number of Programmable Selections: 24.
Power Requirements: 120 V, 60 Hz, 25 watts.
Dimensions: $18\frac{5}{8}$ in. W × $5\frac{3}{16}$ in. H × $15\frac{7}{16}$ in. D (47.3 cm × 13.2 cm × 39.2 cm).
Weight: 35 lbs., 3 oz. (16 kg).
Price: $1,499.
Company Address: 6722 Orangethorpe Ave., Buena Park, Cal. 90620.
For literature, circle No. 92

Yamaha has come up with their second-generation Series 2000 Compact Disc player featuring the company's Super Hi-bit technology and hand-selected, matched electronic components. The unit is distinctive looking, with a titanium-finished front panel and walnut side panels.

Super Hi-bit technology consists of series-loaded, 18-bit D/A converters combined with four-floating-bit circuitry. Yamaha claims this achieves the effective linearity of a 22-bit system. (For more on the floating-bit approach, see my review of Yamaha's CDX-1110U CD player in the September 1988 issue.) To eliminate one source of noise spikes, the player uses series-loaded D/A converters rather than the more common parallel-loaded type. Four D/A converters are used, in a "balanced processing" system. In this system, the output of the digital filter is fed to two converters per channel, one of which operates in normal polarity while the

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Yamaha's D/A conversion system makes it possible to listen with or without analog final filtering.

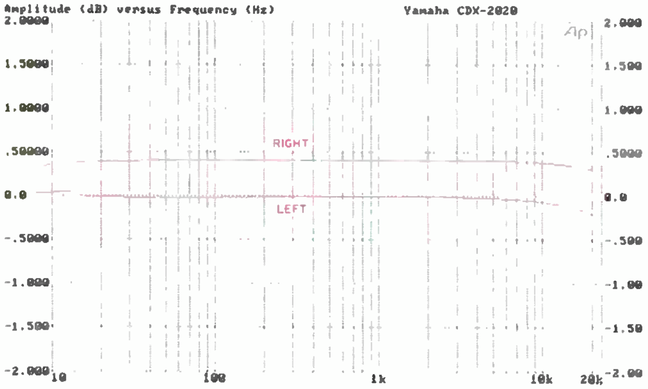

Fig. 1—Frequency response; see text.

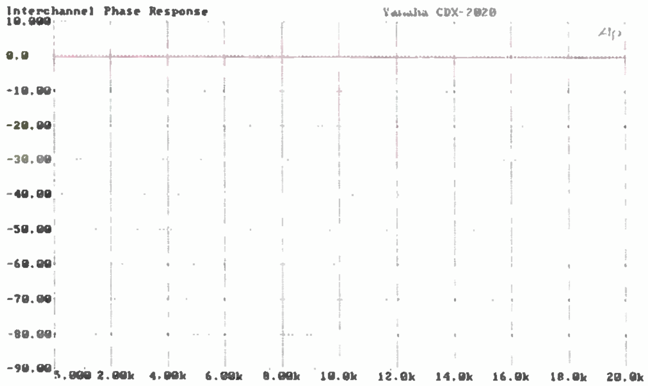

Fig. 2—Interchannel phase response, from 5 Hz to 22 kHz.

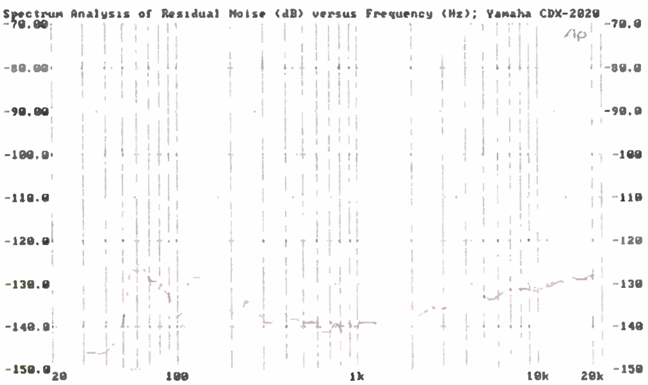

Fig. 3—Residual noise vs. frequency for "quiet" track of CD-1 test disc. Note low noise level at 60-Hz power-line frequency and its multiples.

other operates in inverse polarity. This design, according to Yamaha, achieves an excellent common-mode rejection ratio. The player also employs 20-bit digital filters with eight-times oversampling, an LSI digital de-emphasis circuit, and a 20-bit digital volume control.

Shunt-regulated power supplies and independent transformers on separate circuit boards are used for digital and analog stages. The suspension and damping systems, and a new heavy-duty chassis, are said to minimize the effects of external and internal vibration or resonance.

Other features incorporated in the CDX-2020 include four-way repeat play (of the entire disc, a single selection, a marked segment, or a programmed sequence of tracks) and random play. Time readouts on the multi-function display are for total time, remaining time, elapsed time of the present track, and remaining time of the present track. Programming of up to 24 tracks is possible, as is direct track access via the player's front panel or the supplied remote control.

Control Layout

Yamaha has cleverly divided the operating controls into primary and secondary categories. The controls visible at all times on the front panel are a power switch, a headphone jack, an "Open/Close" button for the disc tray, a "Play" button, and a "Pause/Stop" button. Also normally visible is a large display window that shows track and index numbers, the various selected time displays, repeat modes, programming information, the output level setting (on a dB "meter" scale), disc emphasis (when applicable), and various other status indications. A "track calendar," consisting of numbers 1 through 24, runs along the entire lower edge of the display area.

When a hinged panel along the bottom right of the front panel is lowered the many secondary controls are exposed. At the far left are the display "Mode" button (which blanks all parts of the display except for time and track) and "Time" button (which selects total disc time, total elapsed time, or elapsed time within the track), followed by the buttons for repeat play. Next comes "Auto Space," which puts the player in pause for 3 S after every track; when transcribing CDs onto cassette, this ensures there will be enough blank space between tracks for a cassette player's search system to find them. To the right are the buttons for programming, "Random Play," fast search, track skip, and "Index." Along the bottom row are buttons for the numbers 0 through 9 as well as a "+10" button for accessing track numbers in the teens and higher. (I found accessing index points to be a bit awkward. When you push the button for indexing, the word "Index" begins to flash in the display, following which you must press the appropriate index number by using the number buttons.)

Finally, at the lower right corner of this control area are an "Up/Down" rocker switch for volume control and a "Hi-Bit Direct Out" button which allows bypassing of the analog output filters. This switch is used to determine whether the analog signals available at the player's output terminals should have no analog final filtering or if the signals should be passed through analog low-pass filters. Yamaha's D/A conversion system makes it possible to listen to the player

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The LS1 offers owners the exceptional convenience of seven inputs, including the new Direct Gain Path, which bypasses all major controls except Gain—and provides a degree of resolution that challenges the best preamps in the world.

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The A-weighted S/N ratio was greater than 122 dB for either channel, among the highest I've ever measured for a CD player.

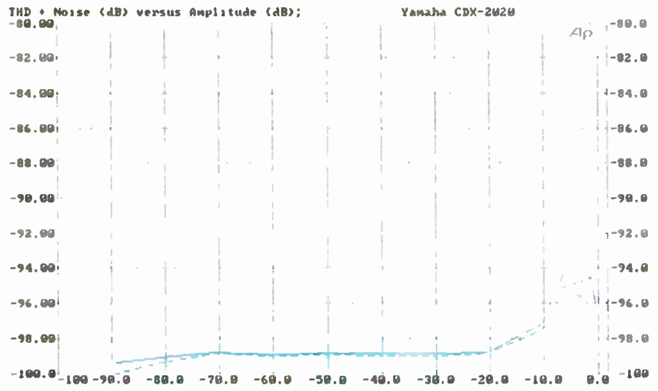

Fig. 4—THD + N vs. signal level for left channel (solid curve) and right channel (dashed curve).

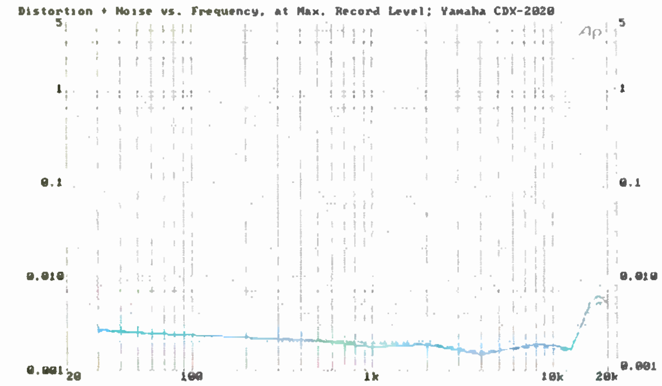

Fig. 5—THD + N vs. frequency for left channel (solid curve) and right channel (dashed curve).

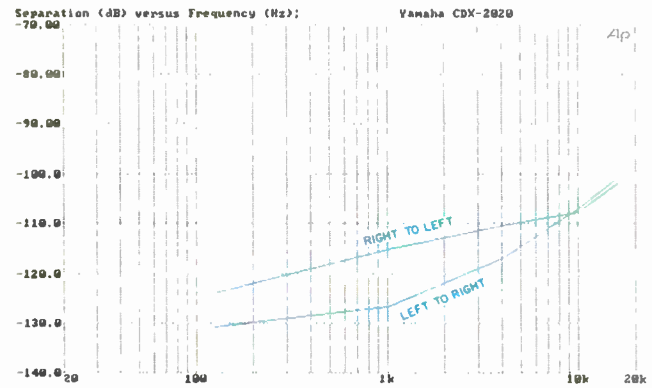

Fig. 6—Interchannel separation vs. frequency.

even when no final filtering is used. However, in my measurements and listening tests, I perceived no particular advantage in doing so.

The supplied remote control duplicates every control on the front panel. The only difference is the presence of 24 numbered buttons in addition to the "+10" button; this allows still higher track numbers to be accessed.

The rear panel of the CDX-2020 is equipped with the usual left- and right-channel analog line output jacks as well as with coaxial and optical digital output terminals, should you want to use a separate D/A converter. In view of the excellent D/A conversion circuitry I found in the player itself, I can't see why anyone would go to the extra expense—especially since the digital-to-analog converters on those amplifiers which are so equipped have, in the main, proven to be no better than the D/A conversion systems in players such as this one.

Measurements

Figure 1 shows the frequency response of the Yamaha CDX-2020, plotted from below 10 Hz up to 20 kHz. While response was certainly well within the tolerance limits specified by Yamaha (it was off by no more than −0.2 dB at 20 kHz), I was surprised by the difference in output *level* between the left and right channels. The right channel's output was nearly 0.4 dB greater in amplitude than the left channel's. This condition can be easily remedied with the balance control on your amplifier, but in my sample, at least, it was surprising that tolerances of the analog output amplifier stages were not held closer.

If outputs of both channels were not precisely equal in amplitude, they certainly were in terms of phase. As shown in Fig. 2, interchannel phase response was virtually perfect from 5 Hz to 22 kHz—that is, the signals from both channels were perfectly in phase, within a fraction of 1°, at all measured frequencies.

A-weighted signal-to-noise ratios were among the highest I have ever obtained for any CD player: 123.7 dB below maximum recorded level for the left channel and 122.5 dB for the right channel. Figure 3 is a spectrum analysis of residual noise emanating from the player when I played the "no-signal" track of my CBS CD-1 test disc. Even at the power-line frequency of 60 Hz, noise was more than 125 dB below maximum recorded level.

Figure 4 shows how THD + N varied as a function of output level. Plotted values are recorded in dB relative to maximum recorded output level, which is defined as 0 dB. Over most of the range from −90 to −20 dB, THD + N was 99 dB or greater. Expressed as a percentage, this corresponds to 0.0011%. At levels approaching maximum recorded output, the analog stages obviously were responsible for a very slight increase in THD + N; readings around the 0-dB level were approximately −95 dB. Again expressed as a percentage, this amounts to 0.0018%.

Figure 5 shows how THD + N varied with frequency for signals at maximum recorded level. There was excellent correlation between this test and the test shown in Fig. 4. At 1 kHz, THD + N was below 0.002%, while at 20 kHz, it rose very slightly, to around 0.005%. (Remember when early CD players exhibited THD + N readings of as much as 1% at

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The chief distinguishing performance characteristic of the CDX-2020 was its excellent linearity when playing low-level signals.

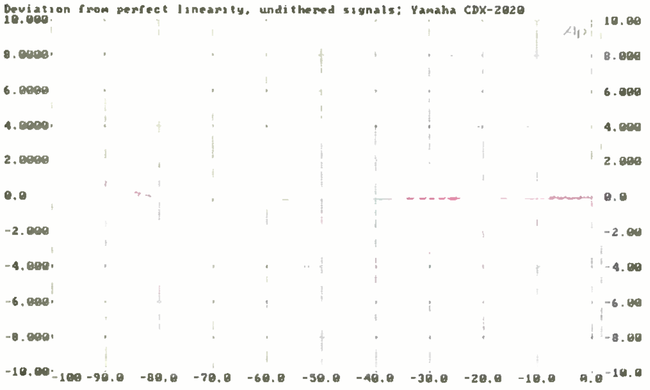

Fig. 7—Deviation from perfect linearity for undithered 1-kHz signal; solid curve is left channel, dashed curve is right.

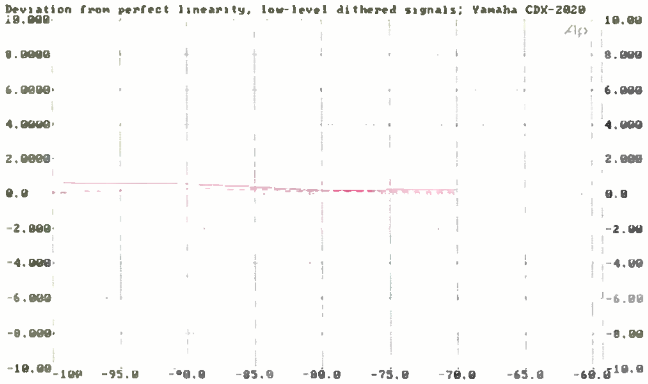

Fig. 8—Deviation from perfect linearity for low-level dithered signals; solid curve is left channel, dashed curve is right.

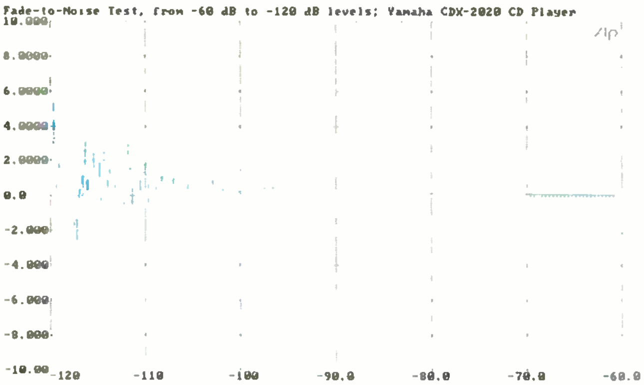

Fig. 9—Linearity deviation for "fade-to-noise" test of dynamic range.

20 kHz? Most of those readings were caused by out-of-band "beats"; no beats were detectable with this player.) I also measured SMPTE-IM distortion at maximum recorded level and found it to be 0.0051% for the left channel and 0.0053% for the right.

Although channel separation was not the same for left-to-right crosstalk as it was for right-to-left (Fig. 6), in either case it was superb, remaining below 100 dB even at 16 kHz (the highest signal I have available for making this test). At 1 kHz, separation from left to right amounted to 127 dB; from right to left, it was 115.5 dB.

As has been the case for several superb-sounding CD players recently, the chief distinguishing performance characteristic of the CDX-2020 was its excellent low-level linearity. Figure 7 shows that the deviation from perfect linearity at 90 dB below maximum recorded level, when the player was reproducing undithered signals, was no more than +0.8 dB for the left channel and just a bit less for the right. Results using low-level dithered signals, in the range from −70 to −100 dB, were even more remarkable. As shown in Fig. 8, deviation at *100 dB below recorded level* was no more than +0.6 dB for the left channel and a negligible +0.2 dB for the right.

The superb low-level linearity and noise-free performance of this player were further confirmed when I plotted deviation from linearity using the fade-to-noise signal on my CD-1 test disc. In Fig. 9, you can see that the signal decreases in perfectly linear fashion right into the residual noise at −120 dB. From this graph it is also possible to determine the CDX-2020's effective EIA dynamic range, which was approximately 110 dB. If dynamic range is measured in accordance with EIAJ procedures, the results are lower, yielding 98.2 dB for either channel.

The last track of the CD-1 disc contains a test signal useful in checking the monotonicity of a player's D/A conversion system. Ideally, the "steps" of this square waveform should be equal in amplitude, for both positive- and negative-going waveforms, as the peak of the waveform progresses from "digital zero" and increases by one LSB (least significant bit) every five cycles to a maximum of 10 LSB. The results shown in Fig. 10 come about as close to this ideal as I have seen for any player.

Clock accuracy, which in turn determines pitch or frequency accuracy of reproduced music, was −0.0046%. Figures 11 and 12 show how a 1-kHz square wave and a unit pulse were reproduced by this player. The polarity of the unit pulse output reveals that the CDX-2020 does not invert signal polarities.

I used a special Pierre Verany test disc to determine how well the Yamaha can track CDs that have missing data. For passages having normal "pitch" between them, this player was able to track signals in which a full 2 mm of the digital data was missing. That's almost three times the length of missing data provided on the Philips disc that I formerly used for this test! When track pitch was reduced to the minimum acceptable value, the CDX-2020 was still able to successfully track signals where there were 1.5 mm of missing data. The same held true for signals in which two successive dropouts of 1.5 mm length were "read" by the laser pickup.


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The CDX-2020 can be cited as an example to those who ask if it pays to spend more than a few hundred dollars on a CD player.

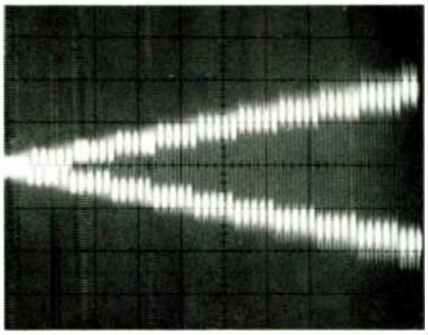


Fig. 10—Monotonicity test.

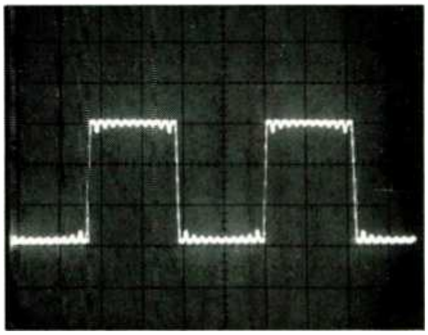


Fig. 11—Reproduction of 1-kHz square wave.

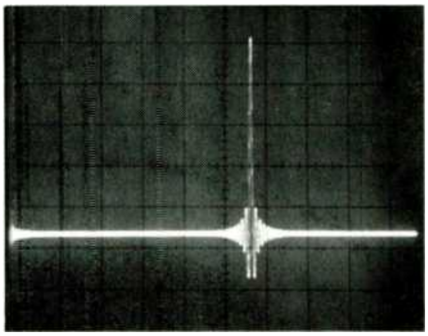


Fig. 12—Single-pulse test.

Use and Listening Tests

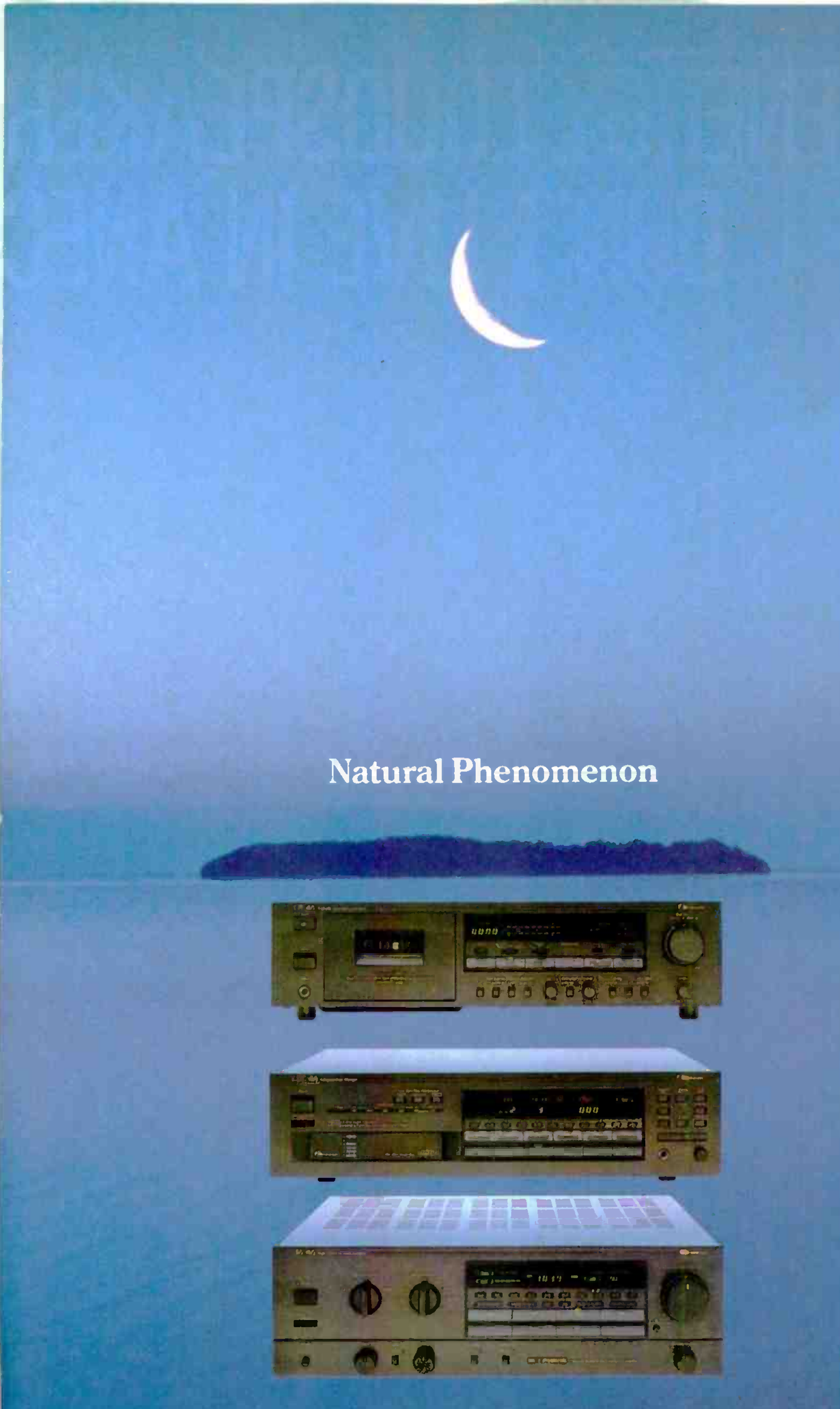
Generally, I like to do listening tests for CD players with some of the latest discs I acquire. I have found, with few exceptions, that recently issued discs often sound better than my earlier favorites. For evaluating the Yamaha CDX-2020, I chose some of Telarc's latest releases, such as their recording of Bruckner's Symphony No. 7 (CD-80188) and a two-disc set of Benjamin Britten's *War Requiem* (CD-80157). The latter gave me an opportunity to judge the accuracy of singing voices in three ranges (soprano, tenor, and baritone). The voices of the soloists and chorus were marvelously clear and clean, as were the softest orchestral passages. The dynamics in the Bruckner recording also came through in all their glory, with never a trace of distortion at any point in the wide-ranging and widely varying levels of sound which characterize this work.

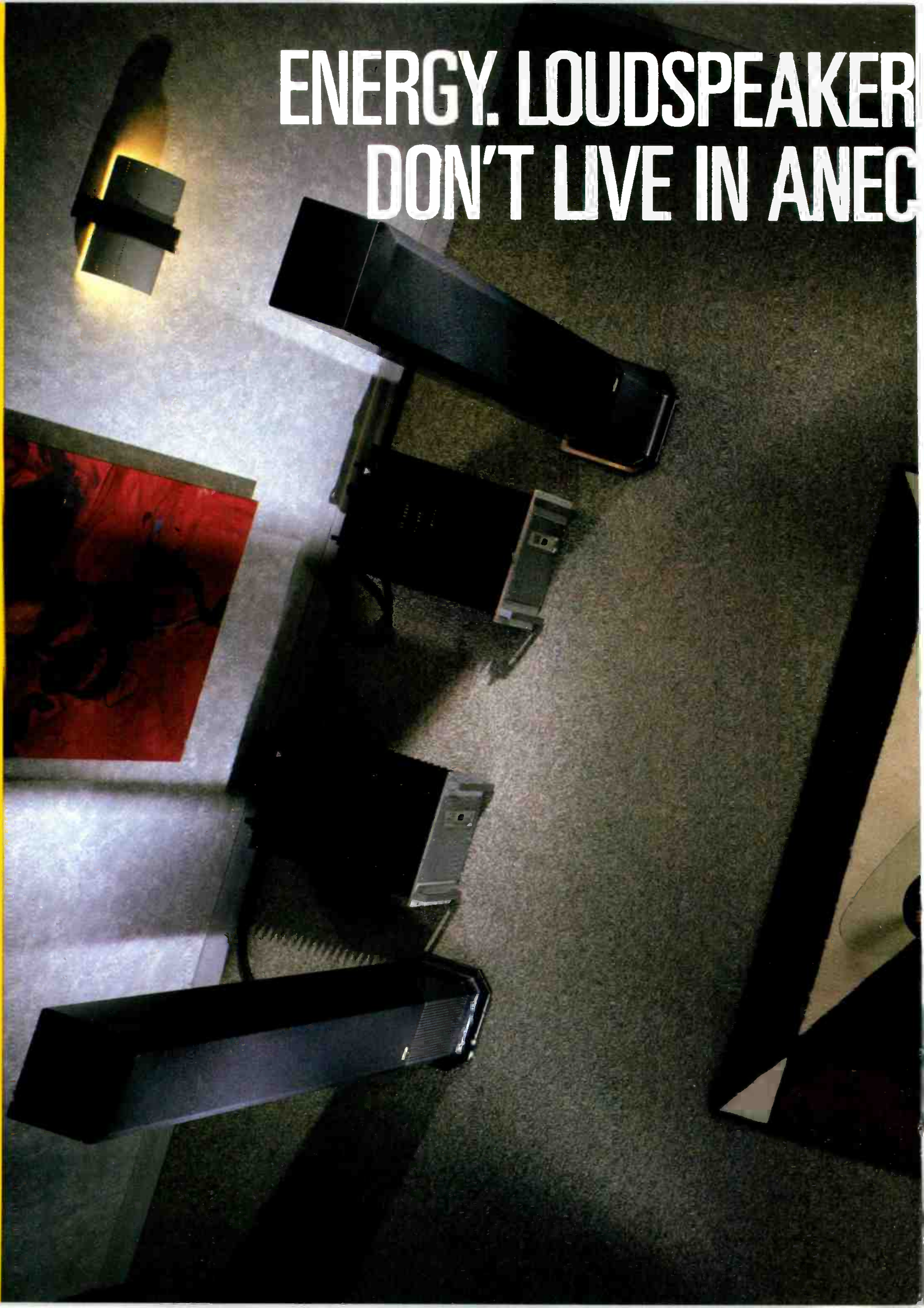
I suspect that users of this CD player will appreciate the fact that *all* functions are accessible from the front panel as well as the remote control. All too often, the remote for some CD player I've had connected to my system for long-term evaluation has not been readily available. If the remote is the only way I can directly access tracks (or, more often, index points), then I feel as though I am being denied some of the player's features. The Yamaha CDX-2020, by contrast, enabled me to do whatever I wanted, whether from the comfort of my listening chair or while standing up close to the front panel.

I'm still often asked whether it pays to spend more than a couple of hundred dollars on a CD player: "Aren't they all pretty much alike? Don't they all sound about the same?" I now have an excellent example to prove to these cynics that, yes indeed, some CD players are worth many times that amount, both in terms of operating features and the sound delivered. Such a player is this latest gem from Yamaha.

Leonard Feldman

Dropping the hinged panel exposes the secondary controls.

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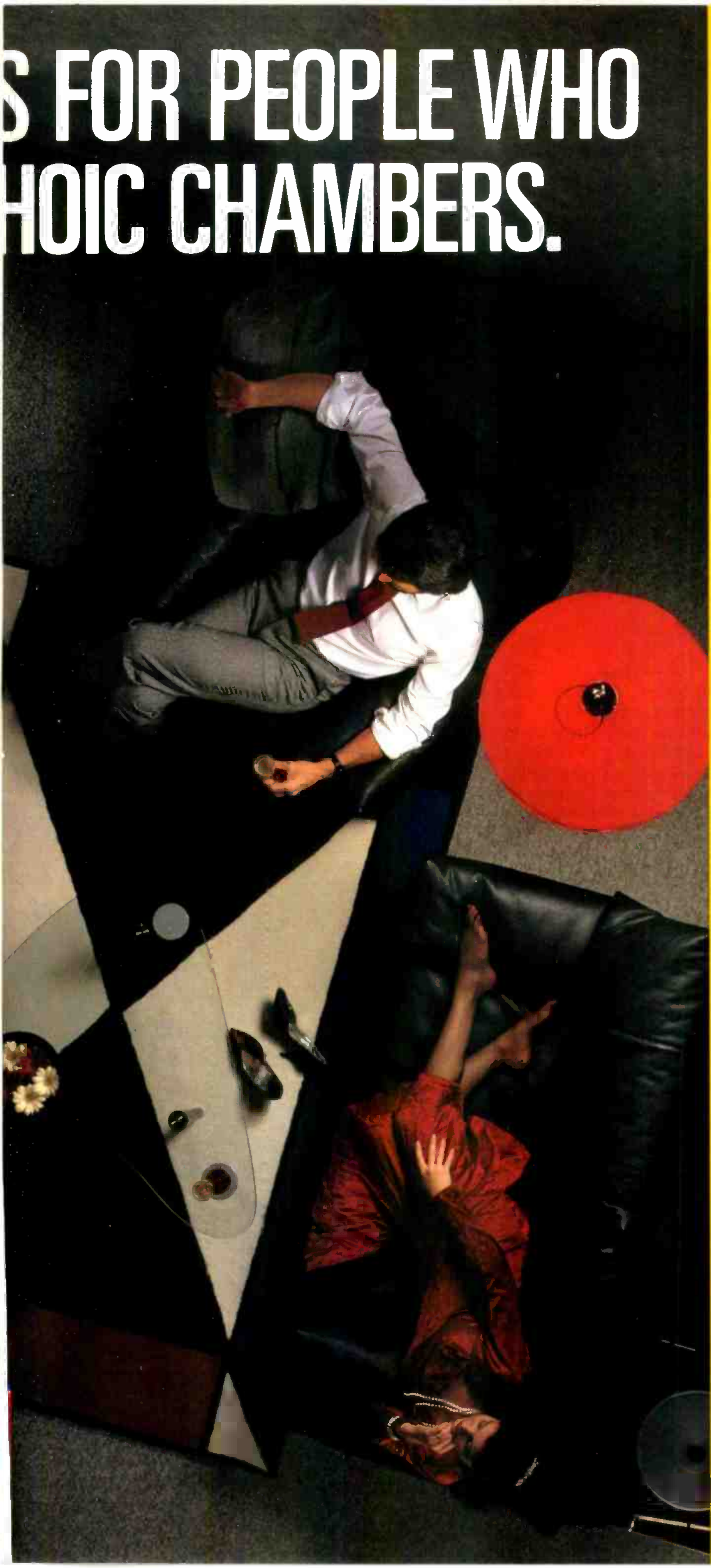

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THD: 0.05% at 2 V rms.
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For literature, circle No. 93

Superphon's C.D. Maxx is an unusual-looking but attractive, not too expensive preamplifier without a phono equalizer. Like a number of similar products, this preamp serves a need for signal selection, volume and balance control, and line-level amplification. Many systems now use CD players as the prime signal source, with no turntable (can anyone who really knows what records sound like imagine that?), which gives line-level preamps like this one a legitimate reason to be.

The C.D. Maxx is cleverly conceived as an overall design. According to the manufacturer, its unique appearance is a matter of form following function. The top cover and front is

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Many systems now use CD players as the prime signal source, giving preamps like this a reason to be.

a piece of smoked Plexiglas that has the signal routing printed on the top surface, with input routing in blue and output routing in red. This handy little feature makes the unit's operation so easy and obvious that reference to the owner's manual for operational help is rather unlikely.

Superphon drew heavily on the technology embodied in their Revelation II preamp; they wanted to leave plenty of clearance around the p.c. board and to use materials with benign dielectric and magnetic properties for the chassis enclosure. Accordingly, a single p.c. board sits about 1 inch down and parallel to the top surface of the unit. Mounted on this board, in addition to the output line-amplifier components, are three three-position toggle switches for various functions and two linear straight-line volume controls mounted side by side. This construction eliminates long signal path traces and wiring harnesses, thus simplifying the signal path. The handles of the switches and the sliders of the volume controls protrude through slots in the top surface. Knobs are placed on the volume control sliders. Continuing with the visual aspect, six red LEDs on the p.c. board serve as bias reference elements in the circuitry and look rather neat when the unit is powered up. Finishing up with the physical configuration, a black anodized piece of aluminum is bent in the shape of a U to form the back, bottom, and front subpanel. Half-inch-wide ledges are bent on all sides of the chassis and have Pemm nuts installed. Attractive walnut sides are bolted to the chassis via these Pemm nuts. All in all, this preamp is a rather bold, innovative-looking piece of gear.

Four signal inputs are provided: "CD," "Tuner," "Video (AUX)," and "Tape Mon." The leftmost toggle switch selects between the first three of these inputs. Whichever signal is selected goes to one input of the tape monitor switch and to one pair of tape output jacks. The tape input feeds directly to the other pair of tape out jacks (labelled "Dub Out") and to the other input of the monitor switch. The output from the tape monitor switch is routed into the two volume control potentiometers.

From the volume controls, the signal goes to the line amplifier and to the "Outlets" selector switch at the right rear of the top panel. This switch, which feeds two pairs of output jacks wired in parallel, can select the signal from the line amp, an unamplified signal direct from the volume control wipers ("Bypass"), or ground ("Mute").

The power transformer is in a small black plastic box that plugs right into an a.c. socket. A two-wire interconnect cord is permanently attached to both the preamp and this transformer box. Components on the p.c. board look to be of

Table I—Gain and IHF sensitivity for both channels.

	Gain, dB Instr. Load	Gain, dB IHF Load
Line Amp Engaged	15.3	15.0
Bypass Mode	0	−0.1
At Tape Out	−0.1	−1.8

	Sensitivity, mV
AUX to Main Out	90.0
AUX to Main Out, Bypass Mode	505.0
AUX to Tape Out	620.0

Table II—Line-amp noise, referred to input, for three volume control settings and different bandwidths; source impedance, 1 kilohm.

	Referred Input Noise, µV LEFT			RIGHT		
Bandwidth	**CCW**	**WC**	**CW**	**CCW**	**WC**	**CW**
Wideband	10.0	16.0	12.5	10.0	16.0	12 0
20 Hz to 20 kHz	3.2	5.0	3.8	3.3	5.7	4 3
400 Hz to 20 kHz	2.45	2.9	2.6	2.55	3.0	2.75
A-Weighted	2.45	2.9	2 6	2.5	3.0	2 75

Notes on volume control settings: CCW is counterclockwise or full down, WC is worst-case or near full up, and CW is clockwise or full up.

reasonable quality and consist of discrete amplifying devices, metal-film resistors, and tantalum bypassing and coupling capacitors. Not a film capacitor is to be found.

Circuit Description

As a schematic was not supplied with the unit, I'll start by quoting a letter from the manufacturer which accompanied the preamp I received for review:

> The circuit is as novel as the package. Amplification is by single-ended Class-A, differential MOS-FET. This unique wide-band circuit is followed by an FET current-sourced, Class-A MOS-FET buffer. Three shunt-type regulators per channel are woven into the circuitry to place each near the part that it regulates. Each regulator is marked by a light-emitting diode (LED) to allow quick visual confirmation of proper circuit operation.

After tracing the circuit, I can attest to the correctness of this description. To flesh it out a bit, the sources of the input differential amplifiers, which are composed of N-channel MOS-FETs, are degenerated by separate source resistors and returned to ground through what appears to be a current-regulating diode. The drains are connected to a PNP bipolar turn-around circuit, with the stage output taken from the junction of the PNP collector and the right-hand (schematically) MOS-FET drain. This point is direct-coupled to the gate of a third N-channel MOS-FET acting as a source

The C.D. Maxx has a most unusual circuit topology for an audio gain block. It's one I had not seen in a MOS-FET device.

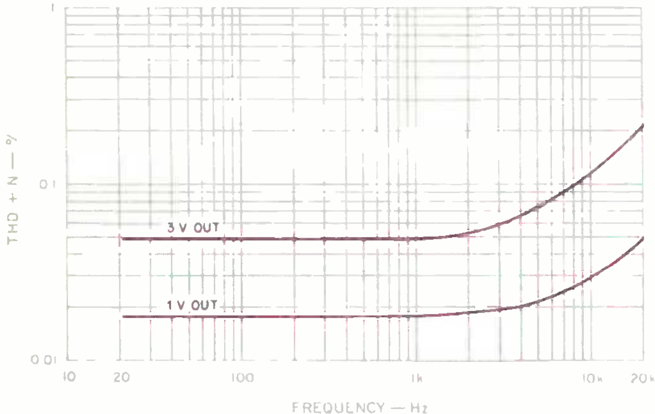

Fig. 1—THD + N vs. frequency, with instrument loading, at two output levels. With IHF loading, distortion was slightly higher at 3 V out and slightly lower at 1 V.

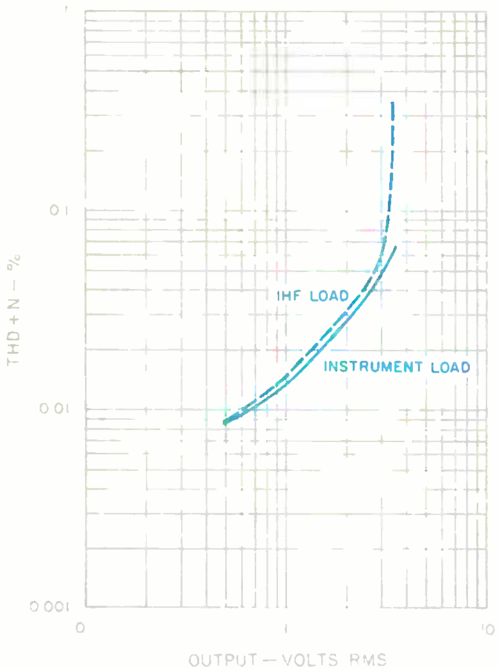

Fig. 2—THD + N as a function of output level, for IHF and instrument loads.

follower. The load to ground for this follower is a fourth N-channel MOS-FET, interconnected with some other devices as a constant current source. Output of this source-follower stage is coupled to the "Outlets" switch through 20 µF of tantalum capacitors. A direct-coupled feedback divider, from the output source of the follower back to the inverting input of the differential amp, serves to set the a.c. closed-loop gain at about 14 dB, and to d.c. divide the desired output operating point down to a level that matches that set into the noninverting input. The shunt arm of this divider is made up of two resistors in series, with the lower one being a.c. bypassed to meet the different a.c. and d.c. gains required. The d.c. level into the noninverting (signal) input is set by an interesting circuit of unusual complexity. According to Superphon, its purpose is "to provide exceptional power-line ripple immunity and to permit shifting the d.c. reference point, which affects sound quality and distortion content." In this circuit, three shunt voltage regulators, made up of zener diodes and LEDs in series, are placed in shunt with the circuit for input-stage d.c. level setting, the input stage itself, and the follower output stage. The incoming a.c. voltage is separately bridge rectified and smoothed with a 330-µF capacitor for each channel. All in all, this is an unusual circuit topology for an audio gain block. I have seen and used it myself for non-audio purposes but haven't seen it employed with MOS-FET devices, as embodied in the C.D. Maxx.

Measurements

Line-amplifier gain, with instrument and IHF loading, as well as IHF sensitivity measurements are shown in Table I.

Output impedance, with the line amp in, was about 440 ohms; with the "Bypass" mode engaged and the volume control wide open, the output impedance was 100 ohms. As the volume control is turned down to where attenuation is about 6 dB, the output impedance in "Bypass" mode will be a maximum of 10 kilohms (the pot's impedance value) divided by 4, or 2.5 kilohms, plus the 100 ohms of the series output-buffering resistor, for a total of 2.6 kilohms. Output impedance at the tape out jacks was 2.2 kilohms, plus that of the connected source. Input impedance was 10 kilohms, which, in my opinion, disqualifies the C.D. Maxx from use with most tube circuit sources unless those sources are specified as being able to drive 10 kilohms with grace and have output coupling capacitors of at least 10 µF. Since people using tube sources with the C.D. Maxx are probably in a distinct minority, this will not be any real limitation.

Total harmonic distortion plus noise is shown in Fig. 1 for two output voltages with instrument loading. Using IHF loading increased the distortion slightly at 3 V out and decreased it slightly at 1 V out. The dominant distortion product was second-order harmonic. Clipping occurred at about 3.5 V rms output with either instrument or IHF loading. The line amp put out 2 V rms into 600 ohms at the onset of clipping. In all cases when clipping occurred, the positive half cycle squared off first. Figure 2 shows THD + N, at 1 kHz, as a function of output level.

Interchannel crosstalk was down at least 80 dB at frequencies to about 1 kHz but decreased to −66 dB at 5 kHz and to −54 dB at 20 kHz. These results were for the slightly

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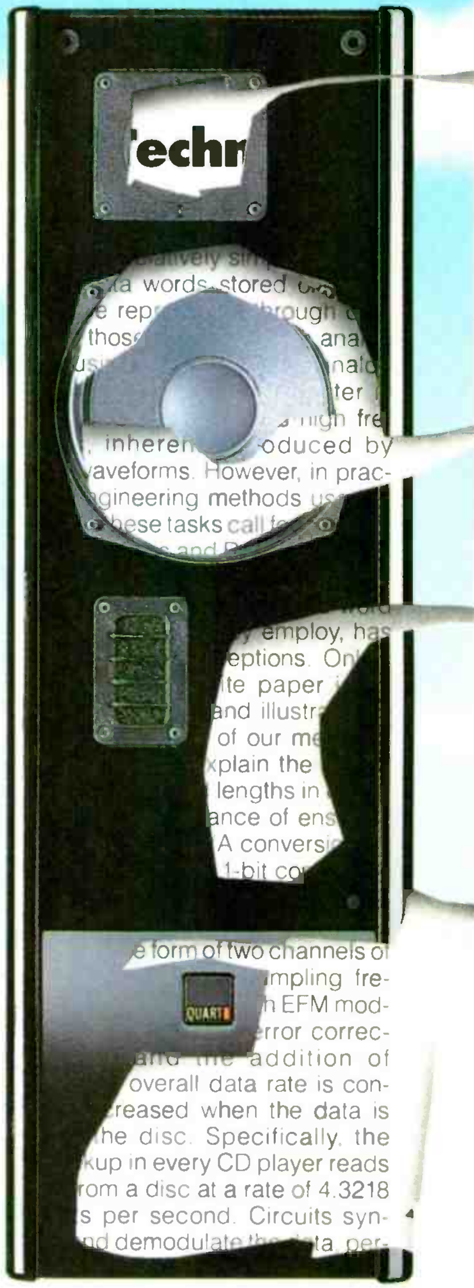

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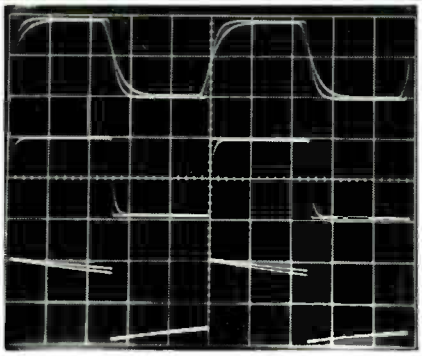

Fig. 3—Square-wave response for 100 kHz with line amp engaged (top) and bypassed (middle), and for 20 Hz with line amp engaged (bottom). Waveforms for both IHF and instrument loading are superimposed in each case. (Scales: Vertical, 2 V/div. for top and bottom traces, 1 V/div. for middle trace; horizontal, 2 μS/div. for top and middle traces, 10 mS/div. for bottom trace.)

worse (right-to-left) direction, with the volume control at maximum and the line amp engaged. Crosstalk was similar in the "Bypass" mode.

Referred input noise of the line amp is shown in Table II as a function of bandwidth and volume control position.

Rise- and fall-times, with the line amp engaged and at ±2 V output, were 0.7 μS for instrument loading and 1.4 μS for IHF loading. Rise- and fall-times were not noticeably lengthened as the volume was reduced from maximum. Edge shape was exponential, up to the level of clipping, with the instrument load; therefore, no slewing was evidenced. The IHF load did cause slewing of about 5 V/μS on the negative-going edge transition at ±5 V output. With this load, slewing stopped when the output level was backed down to about ±2 V. In "Bypass" mode, at an output level of about ±0.9 V (which, as an input level to the still-driven line amp, is just pushing it to clipping), rise- and fall-times were on the order of 100 nS with the instrument load, lengthening to about 360 nS with the IHF load. The C.D. Maxx is fast.

Oscilloscope photos of square-wave performance are presented in Fig. 3. The two superimposed traces at the top are for 100 kHz, with instrument and IHF loading, and with the line amp engaged. The middle traces are for the same 100-kHz frequency but in "Bypass" mode; again, the two superimposed traces are for instrument and IHF loading. The bottom traces are for a frequency of 20 Hz, with the line amp engaged and for instrument and IHF loading. With the "Bypass" mode engaged, there was no low-frequency tilt, as the signal passes through no series capacitors and is therefore d.c.-coupled.

Use and Listening Tests

Equipment used to evaluate the C.D. Maxx included an Oracle turntable fitted with a Well Tempered arm and a Koetsu Black Goldline cartridge, a California Audio Labs Tempest CD player, a Nakamichi 250 cassette deck, a Technics 1500 reel-to-reel recorder, and EAR 519 mono tube amps driving Siefert Research Magnum III speakers or Stax SR-X/Mk3 headphones via a Stax SRD-7P energizer. Records were played through a Vendetta Research SCP-2A phono preamp and the Cook-King reference tube phono preamp.

First listening with the C.D. Maxx was with the Vendetta Research phono preamp as a signal source. I compared the sound of this phono preamp, going through my reference passive switched attenuator (very good sound, by the way), to the sound going through the C.D. Maxx in both its "Bypass" and normal modes. Much to my surprise, the sound through the C.D. Maxx was just about as good. Detail and space weren't quite as good, but otherwise the reproduction was most acceptable. The sound in the "Bypass" mode was closer to the reference but maybe a bit harder. Using the line amp softened the sound slightly, and I preferred the sound with the line amp engaged.

I quickly overcame my reluctance to use the tube CD player, as I wanted to hear some of my music on CDs. The California Audio Labs Tempest player has a 1-μF output coupling capacitor, and when combined with the Tempest's output resistance of about 5 kilohms and the C.D. Maxx's input impedance of 10 kilohms, the low-end cutoff frequency is about 10 Hz. The low end did not sound as good as it did through my reference setup, which loads the source with about 50 kilohms; the deep bass wasn't as strong, and the damping sounded looser in the range from 50 to 100 Hz. This is not a fault of the C.D. Maxx but a fault in the source's reaction to being loaded with 10 kilohms. Aside from the bass, the rest of the range sounded very good with CDs, and I found myself listening happily, with no feeling that I needed to take the C.D. Maxx out of the setup and go to my reference volume control.

Finally, I used the Cook-King reference tube preamp to play records. This circuit can drive 10 kilohms with grace, and its output coupling capacitor value is 20 μF, so there is no problem using it with the C.D. Maxx. Using this preamp as a signal source, the sound was noticeably less open and detailed when going through the C.D. Maxx, though in this case, I preferred the sound not going through the C.D. Maxx line amplifier.

Operationally, I got used to the side-by-side volume control sliders and found them easy to set for level and balance, adjusting them with the thumb and index finger of one hand or with the thumb only. The selector switches felt a little clunky and coarse but functioned okay.

In conclusion, for the price (which is cheap, for this sound quality), and even without considering the money involved, the Superphon C.D. Maxx preamplifier is one terrific-sounding little device.

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Anyone who has frequented a "record store" lately has discovered that it now is really a CD or tape store. The economic pressures of having to stock several different media in a limited space, and the higher profit margins of CDs, are rapidly pushing records off the shelves. It appears to me that the industry is also solving the controversy of CD versus LP by letting the quality of analog mastering and pressing drop so that good analog records are increasingly difficult to find. Even a number of re-pressings of great older recordings often exhibit major quality-control problems.

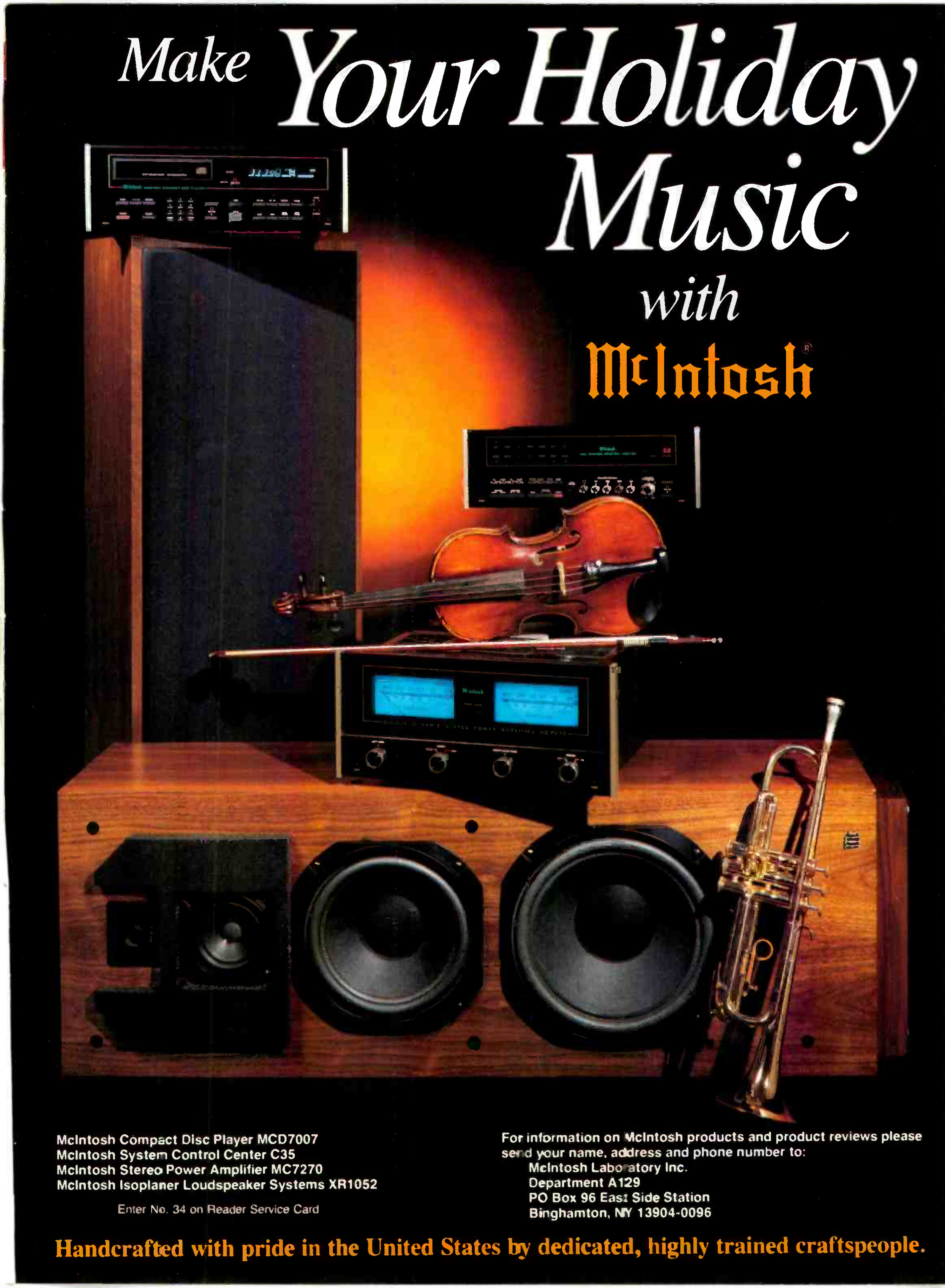
The facts remain, however, that most serious music collectors have hundreds of LP records and that many great classical, jazz, and rock performances will probably never be available on CD. If you love music rather than simply the technology for reproducing it, you still need a turntable. Further, if you love both sound and music, you will want a great turntable. The advent of CDs has made most audiophiles far more conscious of the problems in mediocre analog systems: Record noise, limited signal-to-noise ratios, wow and flutter, limited dynamic range, and problems in timbre. Problems in turntable sound that were tolerable three or four years ago now seem far more grating to the ear.

Fortunately, the twilight of analog is a twilight of the gods of analog as well. The best turntables, tonearms, and cartridges available today are far better than anything available in the not-too-distant past. They not only offer all of the smoothness and sweetness, soundstaging, and other virtues of analog, they also offer greatly improved freedom from mechanical distortion, far better apparent signal-to-noise ratio, and superior ability to extract the music from the record with a minimum of surface noise. Today's reference-quality phono systems redefine the state of the art in analog, and the best phono systems remain fully competitive with the best CD and DAT units.

Every reviewer is going to have his personal prejudices as to which turntable, tonearm, and cartridge now rank as the top reference units in this twilight of the analog gods. Speaking personally, I would include the top-of-the-line Alphason, Goldmund, Linn, Micro Seiki, Roksan, SOTA, Versa Dynamics, and VPI models in my short list of reference-quality turntables; the top-of-the-line Air Tangent, Alphason, Eminent Technology, Linn, SME, and Versa Dynamics in my short list of tonearms; and the Monster Cable Alpha Genesis, Madrigal Carnegie, Grado XTL, Koetsu Rosewood Signature, Talisman Virtuoso DTi, and van den Hul MC-One in my short list of cartridges. My list, however, is necessarily based on limited experience with all the products available and on personal taste. There are many candidates I have not had the opportunity to hear, and in spite of the problems in obtaining good records, the number of truly fine record players seems to increase daily.

This brings me to the VPI TNT turntable. It is a high-priced (about $3,000) unit whose manufacturer is ambitious enough to boast that it is an "archival-quality turntable." Like a number of the very best turntables, it is visually attractive enough to qualify as a piece of sculpture. It has exceptionally clean lines, and its motor unit, turntable, dust cover, base, and black vinyl towers have the kind of high-end look that would make the VPI TNT impressive even if its sound was not of reference quality. It is also available with a separate accessory stand whose legs can be filled with sand or lead shot, which adds an important increase in resistance to acoustic breakthrough.

As for features, the VPI TNT is an attempt to perfect classic turntable design. It does not use new techniques like vacuum-coupling the record to the turntable, or an air bearing, or some radical suspension. The TNT does, however, introduce a number of other innovations in classic turntable design.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A listen to the TNT shows why many audiophiles still feel that records provide more transparency and detail than CDs or tapes.

• The VPI TNT uses a precision synchronous motor. VPI rejected servo motors because they felt that the self-correction in a servo leads to audible modulation of rotation speed; they rejected direct drive because they felt that such motors create too much vibration in the turntable. Instead, VPI created a separate, quartz, phase-locked-loop frequency-synthesizing power supply. This power supply allows precise adjustment to any speed from 33⅓ to more than 45 rpm; it ensures that the turntable has a power supply with precisely the right voltage and line frequency and that the motor operates at the point where it has just gone synchronous. Finally, it reduces motor vibration and provides an optimal match between motor torque and that of the belt loading.

• The VPI TNT uses three pulleys and two belts. One pulley is on the motor shaft; the other two are at the points of a triangle opposite the motor. The use of three pulleys, which I believe was pioneered in a Stromberg-Carlson design in the 1950s, largely neutralizes the side load that is inevitable in a single-pulley design; this reduces both bearing wear and rumble. The three-pulley system also allows the two passive pulleys, which have a viscous lubricant, to load the belt and smooth out the cogging that is usual in even the best motor designs.

Use of two thin belts is intended to minimize the irregularities of one large belt, and to make the pull on the platter more uniform. It also helps break up standing waves on the drive belts, stabilizing belt motion. The belts remain at their correct height on the platter without apparent up-and-down motion, and this helps reduce wow and flutter.

• The VPI TNT is suspended so that a separate chassis floats on four suspension springs. VPI states that this four-spring system is "self-stabilizing" because it offers excellent stability when each spring is properly loaded, so that there is no tendency to jiggle out of control. The center of mass of the chassis is also located below the suspension springs to help eliminate the pendulum effect that may occur when the turntable chassis is hung from its springs. The adjustment of the springs is extremely easy; turning the knobs at the top of each of the four columns holding the springs brings the turntable back to level and brings the chassis back to the proper position.

The TNT's suspension system also has the advantage of letting you use virtually any modern tonearm without adjusting the turntable. This is a real godsend for audiophiles who wish to experiment with different tonearms, and it is enhanced by the fact that the TNT is one of the few top-quality turntables with enough mounting area and dust-cover clearance to allow the use of virtually any tonearm without running into space problems or having to give up the dust cover.

• The turntable bearing is always a key test of turntable quality As with all great turntable makers, VPI pays special attention to this aspect of design. The TNT's platter rides on a precision-machined bearing with a 4-inch-long shaft. The supporting bushings are widely spaced at the top and bottom to provide stable, totter-free rotation with minimum bearing surface, and the well of the bearing shaft is viscous-damped.

• The TNT platter is machined from a solid cylinder of high-density acrylic, matched to its specific bearing shaft. Three equally spaced ball-bottomed screws around the center of the platter allow it to be individually levelled and ensure that it contacts the bearing flange at three small contact points. This helps isolate the platter from bearing noise, and an O-ring is used to center the platter while again reducing platter vibration from contact with the bearing shaft.

The platter is mass-loaded with a 15-pound lead ring. This reduces both wow and flutter and any minor effect from stylus drag. At the same time, the use of nonresonant acrylic helps terminate energy from the stylus, tonearm, and record by distributing it evenly throughout the platter, minimizing its storage and rerelease back into the record. Since the same material is used in the arm board and platter, this leads to exceptional energy control throughout the turntable system.

• VPI uses a screw-down record clamp rather than vacuum coupling. The clamp pushes the record down over a rubber washer so that its rim touches the turntable first; the rest of the record's surface is then pushed down firmly to contact the balance of the platter surface. While I have found vacuum clamping to provide excellent performance, the VPI clamping system seems to work as well as vacuum clamping in coupling disc and platter and does a better job of dealing with moderately warped records.

Perhaps the most impressive aspect of this turntable is that it is the result of years of experimentation and that the end product represents carefully balanced design ideas based on both technical measurement and extended trial and error. There are many different ways in which given designers have produced great turntables—and competing reference-quality turntables like those from SOTA and Versa Dynamics demonstrate how successful completely different design approaches can be. What the top turntables do have in common is great attention to detail, a coherent mix of features which produce a synergistic result, and a solid combination of technical theory with extended and highly demanding fine-tuning based on listening.

Turntables do not lend themselves to easy descriptions of their individual "sounds." To start with, they are part of a record-playing system. A turntable must be evaluated in terms of the quality of the arm and cartridge used with it, and careful attention must be paid to the impact of location and acoustic breakthrough on its sound.

In making my comments about the VPI TNT, I should note that I have had the opportunity to try it with the Air Tangent tonearm as well as the Dynavector, Eminent Technology Two, SME Series V, and SME 309 tonearms. I have also tried it with many different cartridges, and in four different high-end systems: My own (with a wide range of different electronics and speakers, but generally using the Mark Levinson No. 26 preamp, Classé Audio DR-9 amplifiers, and Apogee Diva speakers) and those of three friends. I cannot say that my comments about the VPI TNT's performance will apply to all systems in all locations, but I believe they should be representative of its performance in most.

Based on my listening tests, the VPI TNT is the best turntable I have yet heard in terms of its ability to play records with minimal coloration of its own.

The TNT's soundstage seems to extend in an unbroken arc from well to the right to well to the left of the loudspeakers.

If you are used to mid-fi turntables, or even to a lesser but still outstanding high-end turntable, you will be amazed by the TNT's apparent signal-to-noise ratio. You hear virtually none of the mechanical variations, rumble, or other noises that disguise how good records can really be. In fact, you will often hear aspects of low-level detail, hall sound or ambience, and transient information that simply are not apparent with any but a few select turntables.

If you are an LP fan, you will rediscover your record collection. If you are a tape or CD fan, you may discover why many high-end audiophiles still feel that records provide more musically realistic detail and transparency than even the best CD and tape recordings and playback systems.

The VPI TNT also has superb bass. Most turntables lose much of the low-bass energy and information on records; many of those that do reproduce deep bass with adequate power have something of a one-note character. The TNT provides power, definition, and control. There is neither the tendency to emphasize the midrange at the expense of the bass nor the tendency to provide bass at the expense of midrange energy and life.

The midrange is smooth, from the lower midrange to the upper midrange. There is remarkably little coloration, and it is interesting to compare the midrange sound of the VPI TNT to the midrange reproduced by a top digital decoder like the Theta Digital DS Pre or a Wadia system. The resulting midranges are remarkably similar in timbre, with no leanness in the lower midrange or emphasis or loss in the upper midrange.

The sound characteristics of given cartridges and tonearms become far clearer with a turntable of this quality. With a carefully damped SME Series V tonearm and a Monster Cable Alpha Genesis cartridge, the VPI not only reproduces midrange frequencies smoothly, it also reproduces midrange detail and transient information with an exactness that rivals the best digital decoders and a sweetness and musicality that often outperforms them.

The upper octaves and treble in the VPI TNT are equally outstanding. The vast majority of high-end turntables seem to dull the upper octaves and "overdamp" them or to emphasize some frequencies in the upper midrange and the treble in a way that increases apparent record noise (as well as the tape hiss on older records) and makes you more conscious of the fact that you are listening to a recording. Like a few other top turntables, the TNT gives you all the musical information present in the upper octaves but avoids any clearly apparent coloration of its own. The end result is upper octave performance much closer to a top analog or digital master tape than to a turntable playing a record.

The VPI TNT produces a superb soundstage. This is an area where the very best turntables still outperform consumer-level digital equipment, and the TNT has superb soundstage width and depth. With really good recorded material and a properly set-up system, the TNT's soundstage seems to extend in an unbroken arc from well to the right to well to the left of the speakers. Depth is excellent, and the imaging is not only stable from right to left but clearly places instruments in depth. The VPI even provides this kind of imaging data with complex percussion music, something that only a few turntables can do.

Finally, the TNT provides an excellent mix of dynamics and transient speed and detail, with consistently realistic musical dynamics at all levels of recorded sound. Many turntables seem to perform best at a given level of musical energy and have trouble reproducing the dynamics of very soft or loud passages. The TNT provides an amazing amount of transient information with really good recordings. The speed and resolution on bells, the handling of complex percussion, the ability to resolve choral music, and the ability to locate and separate complex passages by mixed wind instruments are all outstanding. Rock fans will discover just how much additional information a really good turntable can reveal. Many tend to strip the life from rock recordings and give them a two-dimensional character; the VPI TNT restores the kind of transient information and dynamics necessary to make rock music come alive.

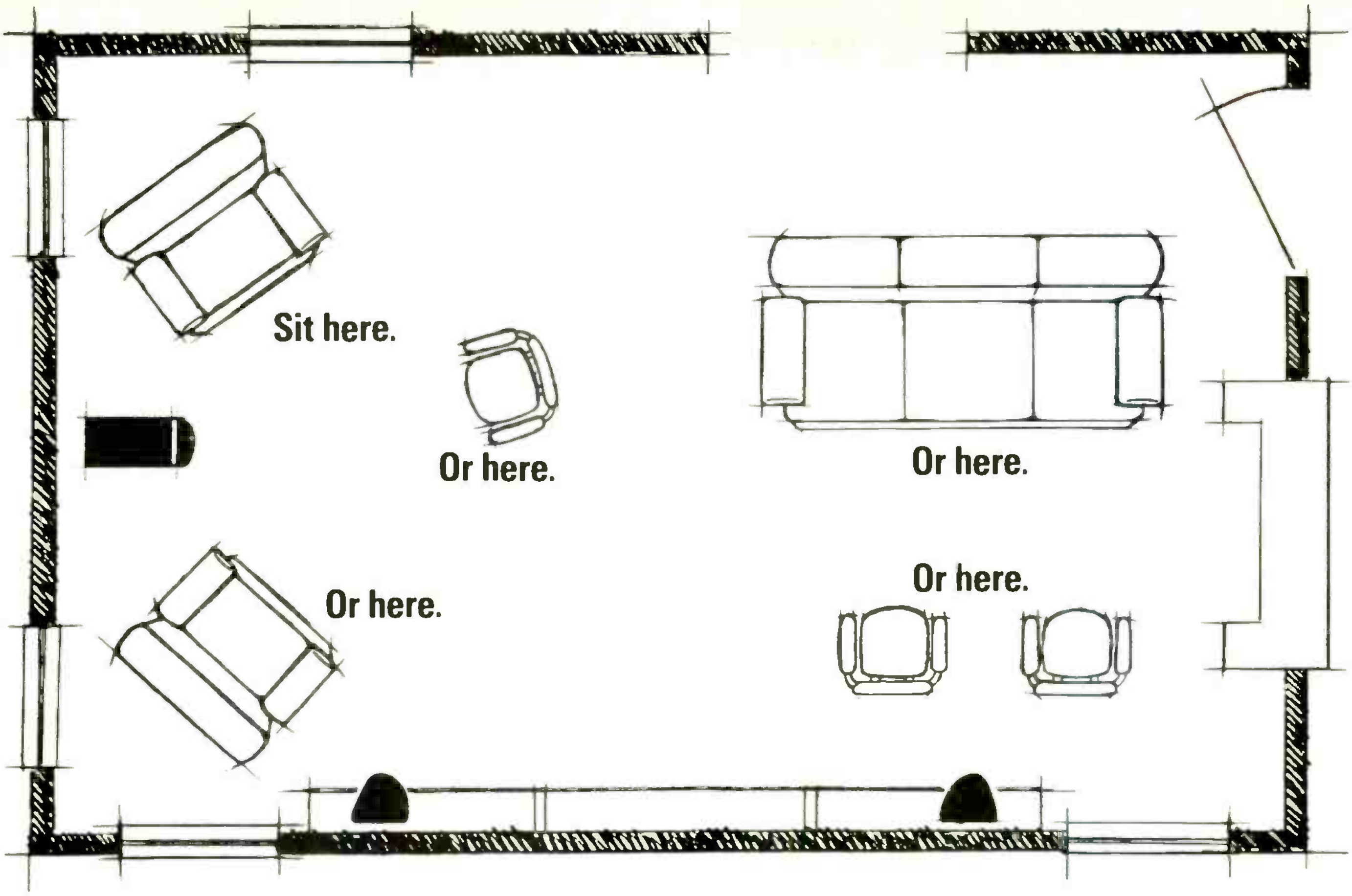
It should be obvious from the above comments that I feel a properly set-up VPI TNT, as with a handful of other top turntables, can rival the best digital playback systems and often surpass them. (I should stress that I am talking about digital playback systems in the $5,000 to $14,000 range, and not ordinary CD players or consumer DAT decks.) You can confirm these comments for yourself, if you have a high-end dealer, by listening to both the CD and analog versions of some top-quality recordings. There is no golden-ear mystique involved; I am confident that you will hear what I hear.

I should stress, however, that getting great reproduction from a great turntable often requires the help of a great dealer. Virtually any literate audiophile can plug in a leading digital system and get the best out of it. However, if you do not have extensive experience in turntable setup or in matching turntables, arms, and cartridges, you are going to have to work closely with the kind of high-end dealer who really cares about what he sells.

In practice, I would suggest that you begin by listening to the VPI TNT in comparison with some of the other top turntables mentioned previously. In the process, you will probably hear the TNT with one of the arms I have listed. You should, however, try several arms once you have firmly chosen the turntable you feel sounds best. You should very definitely try the turntable and tonearm combination that you choose with several cartridges, in order to make sure you are getting the synergy between components that suits your particular taste.

Once you buy a unit like the VPI TNT, I recommend that you have your dealer carefully walk you through the setup instructions—or, better, have the dealer set up the turntable in your home, advising you on location. You cannot, incidentally, expect a dealer to provide this kind of service *and* a discount; a charge for home installation is perfectly legitimate. Unless you have a great deal of personal expertise, however, I think you will find the added cost more than worth it. I have seen and heard far too many phono systems that were marred by poor matching of turntable, tonearm, and cartridge, as well as by poor final setup and placement. A reference-quality component like the VPI TNT deserves to be heard at its best.

Anthony H. Cordesman



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AUDIOPRISM 7500 INDOOR FM ANTENNA

Company Address: RF Limited, P.O. Box 1124, Issaquah, Wash. 98027.
For literature, circle No. 95

Seems as though there's a trend toward tall, pipe-shaped devices in the world of audio. The June 1989 issue contained an "Auricle" review of Phantom Acoustics' Shadow acoustic controller, a tube which stands 83½ inches high and has a diameter of 9½ inches. This device is intended to serve as the last component in the audio chain—a component that can alter room acoustics.

The AudioPrism Model 7500 indoor antenna might well become the *first* component in your audio chain if you have FM reception problems that stem from the use of an inadequate FM antenna. The 7500 is even taller than the Shadow, standing 89½ inches high, with a tube diameter of only 4 inches. At its regular price of $149.95, it comes with a base 13 inches in diameter, but a 17-inch base is available for an additional $3. The tube is coated with a coarse woven fabric, in black or beige. AudioPrism will also custom apply your own fabric to the outer casing. The base material is solid wood.

Because of the odd physical dimensions of the 7500, it is shipped in two cartons: One for the long, pipe-like antenna tube, the other for the flat wooden base.

The electrical design of the 7500 is based on sound principles of physics. The most efficient FM antenna will present as much surface as possible to arriving signals. The antenna elements of the 7500 consist of a full half-wave section (7 feet, 2 inches) over a quarter-wave matching stub that is shunt-fed for true 75-ohm operation. By utilizing a full half-wave design, without the use of loading coils to reduce antenna size, the AudioPrism lets the receiver or tuner operate at its maximum dynamic potential without introducing additional noise. Of course, there are some excellent small indoor antenna designs around, some of which I have tested in the past, but the nice thing about this one is that it is completely passive—no transistors, FETs, or circuitry other than the antenna elements themselves. Therefore, the 7500 does not need to be connected to any power source, yet it has as much gain as most amplified antennas, or more, without any accompanying problems. The antenna's voltage standing-wave ratio (VSWR) is rated as 1.9:1 or less across the entire FM frequency band, and 1.2:1 at the band's center.

As a side note, the manufacturer advises that the 7500's antenna elements are heavy enough to permit the antenna actually to *transmit* approximately 150 watts if hooked up to an FM transmitter! Because of its configuration and length, the 7500 can receive low-angle transmitter signals with less fading and flutter than most other indoor FM antennas. AudioPrism rates antenna gain at 5.1 dB, and its vertical orientation makes it omnidirectional. Despite this omnidirectionality, however, I found the antenna exhibited better

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Across the band, the 7500 outperformed a standard dipole on every station, sometimes with double the output signal strength.

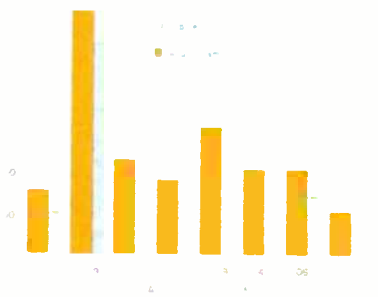

Fig. 1—Signal strength vs. frequency for AudioPrism 7500 and simple wire-dipole T antenna.

multipath rejection than most other smaller indoor antennas I have tested.

Assembly of the AudioPrism 7500 took only a few moments. The hardware needed to connect the wooden base to the long tubular section is provided. All you need is a 7/16-inch socket wrench with which to tighten two 1½-inch-long machine screws that hold the two parts together. It's important not to overtighten the screws since the underside of the wooden base is coated with an aluminized "ground plane" that is part of the antenna configuration; overtightening the screws can destroy the integrity of this ground plane. A push-on F-type connector is packaged with the antenna, as is a 75/300-ohm transformer, in case your tuner or receiver does not have a coaxial 75-ohm input connector. I used a high-quality coaxial cable about 10 feet long to connect the antenna to my reference tuner and, during bench measurements, to my Blonder-Tongue field strength meter; AudioPrism now supplies such a cable, which they claim has only 0.26 dB of total loss.

As in previous antenna tests, I compared the signal strengths of various stations across the FM band, as picked up by the 7500 and by a wire dipole of the type normally supplied with tuners and receivers. Both antennas were at ground level. The simple wire T antenna was oriented for best reception of signals arriving from the World Trade Center and the Empire State Building in New York City, some 18 airline miles from my lab.

The bar graph of Fig. 1 shows how much greater signal strength was obtained with the AudioPrism 7500 than with the simple dipole antenna. In every instance, the 7500 outperformed the dipole in this regard—in some cases, by an increase in signal strength of 2:1 or more.

The superior performance of the AudioPrism 7500 as an indoor FM antenna is not confined to signal strength alone. In listening tests conducted over several days, I noted that some signals I normally receive with a fair degree of multipath interference seemed cleaner and less subject to such problems. During my listening tests, I logged no fewer than 52 usable signals, of which 46 were received in stereo with satisfactory quieting. Since my reference tuner, operated in the automatic stereo mode, mutes at signal levels below about 30 dBf, all 46 stereo signals were received at signal strengths exceeding this level. Noise levels suggested that most were well above that minimum, or muting-threshold, level. With my roof-mounted (30 feet above ground level) multi-element outdoor antenna and a rotator, I can receive only 56 usable signals. The T-wire indoor antennas supplied with tuners and receivers are seldom able to receive more than 30 usable signals in my location.

Of course, even though the makers of this antenna have attempted to "clothe" the tall pipe-like structure in fabric, the 7500 is still an imposing piece of gear. It would take a very understanding spouse (especially if that spouse is not as dedicated to good FM reception as you are) to tolerate this structure as a permanent fixture in the living room or den. Fortunately, I have a separate lab where I reign as king, and no one dictates how I furnish it.

In this respect, the people at RF Limited, of which AudioPrism is a division, have advised me that they have a couple of somewhat smaller models on the drawing board. Hopefully, these will be available soon for those households in which installing the superior Model 7500 is absolutely out of the question. Until those other models are available, or if you want a no-compromise indoor FM antenna to bring out the best in your tuner or receiver for a not unreasonable $149.95, my advice is to install the 7500—even if you have to hide it in a closet! *Leonard Feldman*

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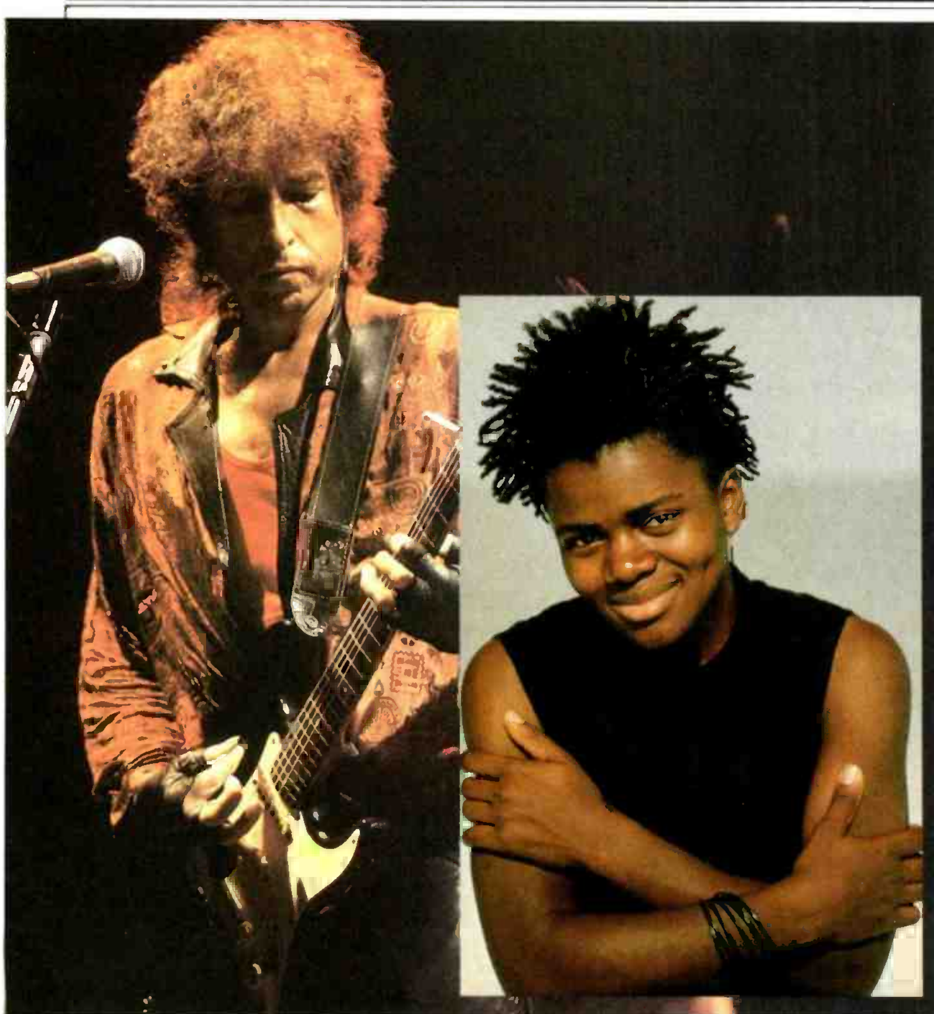


Photographs: ©1986, Ebet Roberts (Dylan); Herb Ritts (Chapman)

Oh Mercy: Bob Dylan
Columbia CK-45281, CD; ADD; 39:00.

Sound: B+ Performance: B+

It's hard to tell: Are the words "Oh Mercy" a world-weary sigh or a plea for forgiveness? I have to lean toward the former, since this is Dylan's darkest, starkest album since back in the days of mono. *Oh Mercy* is so stripped-down it makes *Nebraska* sound like a Phil Spector production. Yet there is indeed a cry for mercy here too—not from his audience, whom Dylan characteristically chides in "What Was It You Wanted," but from God (which I'm pretty sure Dylan spells with a capital G). *Oh Mercy* by no means harks back to Bobby's quasi-Christian stage—there's no proselytizing here—but it clearly declares that everything is pretty screwed up so we probably shouldn't close off any options, no matter how abstract.

He sums up this latest stance in two songs, "Political World" and "Everything Is Broken." These are cyberpunk-meets-the-blues, stark, *Blade Runner* landscapes where the average person is truly helpless and global power brokers reign. "Political World," with its harsh drumbeats evoking an urban jungle, addresses the endless reach of a world where no matter where we go, we remain "under the microscope" of, presumably, governments and their informal enforcers—banks, the media, credit bureaus. "Everything Is Broken," with its litany of cracked and crushed people and household items ("broken bodies, broken bones, broken voices on broken phones"), heightens this sense of helplessness and (kinda smugly) points out that no matter how slick the power brokers are, they trip over their own feet as much as anyone.

Elsewhere, Dylan invokes gospel music and gospel literature in the lovely "Ring Them Bells," a haunting recitative on acoustic piano, highlighted by a sad, sepulchral organ. He checks back into his old school of cinematic ballads à la "Mozambique" and "Joey" with "Man in the Long Black Coat," a minor-key *film noir*, almost a ghost story, about a woman who takes up with an eerie stranger who could be a preacher, the Devil, or Clint Eastwood in *A Fistful of Dollars*. Turning vaguely autobiographical in "Most of the Time" ("I don't compromise/But I don't pretend") and in the gently musing "What Good Am I?" Dylan unfortunately goes overboard on "Disease of Conceit," an exceedingly twee, silly song—a pot cutely calling itself black—that points out the virtues of erasable cassettes. (Now that we're on formats, the CD pressing is certainly an improvement over the pop-riddled LP, but the latter is inexplicably fuller-sounding. Maybe the tube-heads are right, after all.)

On each of the songs, skeletal instrumentation accentuates the lyrics, in some cases producing a nearly rap effect that echoes, 30 years on, the beat movement's marriage of poetry and music. A lot of the credit must go to producer Daniel Lanois, who, I guess, helped recruit Cyril Neville and Mason Ruffner for the proceedings. The guest guns seem held in check by the deliberately understated charts, but as in a good pointillist painting, the dabs of color that *are* there satisfy.

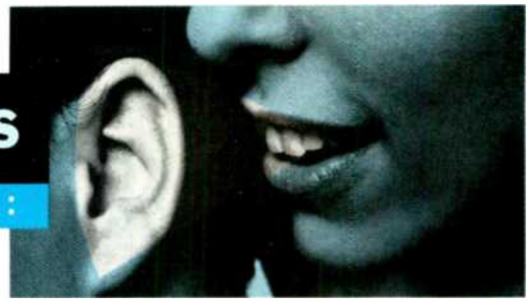
Spare as *Oh Mercy* is, its muted *Sturm und Drang* has resulted in Dylan's best studio album since . . . geez, has it been *13 years* since *Desire*? It's a modest album in the context of Dylan's *oeuvre*, but at least it's listenable. Which has rarely been the case for . . . geez, 13 years?

Frank Lovece

Crossroads: Tracy Chapman
Elektra 60888, CD; DDD; 43:03.

Sound: B+ Performance: A

Tracy Chapman's music video for "Fast Car" triggered a powerful response to her music among critics, ra-



COMPACT DISCLOSURES

December CDs of Note:

On record, no one's been in and out of love more often in the past 25 years than BARBRA STREISAND. On the other hand, no one's been more consistently successful in sales: Streisand has had 36 certified gold albums, more than any other star. Her latest, "Till I Loved You" (featuring the hit duet with DON JOHNSON), is Streisand's first studio album in three years. Including Barbra's inimitable rendition of "All I Ask Of You" from *The Phantom Of The Opera*, "Till I Loved You" is sure to keep love songs (and out-of-love songs) in style for at least another 25 years.

Don't be alarmed: Despite the title, "Everything's Different Now," 'TIL TUESDAY's third album builds on all the things you loved in the group's first two smash hit albums. And of course that includes lead singer/bassist Aimee Mann's ethereal voice and 'Til Tuesday's hauntingly unique sound and unusually powerful lyrics. And in addition to all that, "Everything's Different Now" also includes a song called "The Other End (Of The Telescope)," not to mention 'Til Tuesday's new hit single, "(Believed You Were) Lucky."

The new BROADWAY BEST VALUE CDs continue to open to raves. Including the first-time-ever stereo version of JUDY GARLAND's *A Star Is Born*, this is a series selected – and priced – to seduce every Broadway and Hollywood musical addict into rejuvenating their collection. The titles range from rarities like Sondheim's *Anyone Can Whistle* to standards like *My Fair Lady* and *West Side Story*. Now with 46 releases in total, including 17 new releases, the Broadway Best Value Series has something for practically everybody, a good thing to remember with the holidays approaching.

And speaking of the holidays, the BANGLES are on their way to becoming as enduring a tradition as silver bells and mistletoe. Now ready to dominate the charts for the third December in a row, the band's latest collection of irresistible four-part harmonies and pop-rock wisdom makes the perfect gift for someone who thinks they have "Everything." Because chances are, they won't have "Everything," which is, of course, the Bangles' new album. Their most mature – and varied – recording yet, "Everything" will appeal to everybody.

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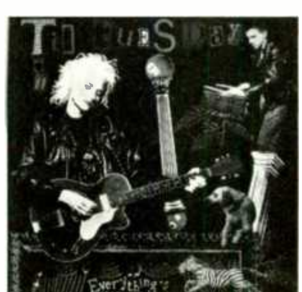
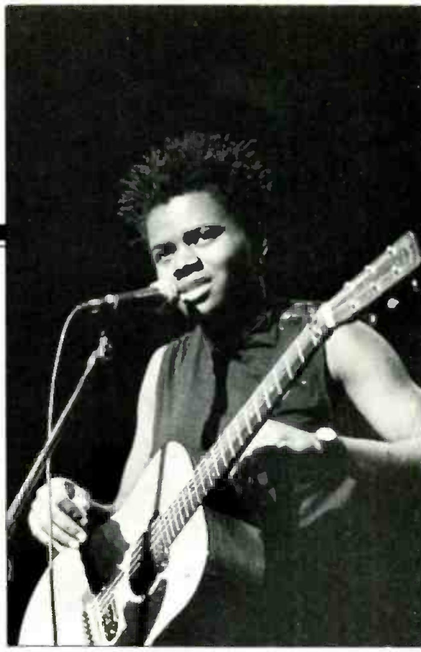


COMPACT disc DIGITAL AUDIO

Crossroads has lots for Tracy Chapman fans; still, sentiments that sounded remarkable the first time around seem less so now.



Photograph: ©1988, Ebet Roberts

dio programmers, and the public, propelling the songwriter to international prominence last year as a sort of heroine of conscience for the MTV generation. Her debut album, *Tracy Chapman*, won Grammys for Best New Artist, Best Pop Female Artist, and Best Contemporary Recording and gained for the singer the kind of status and acceptance it usually takes years to attain.

Putting a new spin on folk music tradition, Chapman offered an attitude of resolute compassion, snapping into focus the desperation of existence and addressing universal sociopolitical themes from an individually remonstrative point of view. Chapman seemed to fill a need—an alternative to corporate pop—and, perhaps surprisingly, she sold a *lot* of records. From out of nowhere, she quickly became a concert headliner who moved in superstar circles, celebrated as a New Voice on the scene yet acknowledged as more hip than hype.

Crossroads begins aptly, with a title track contemplating the pressures of spiralling success. Chapman avoids dwelling on the theme, opting to follow the course she set on her first album, even including songs dating back to 1984. However, sentiments which some regarded as remarkable on *Tracy Chapman* seem less so the second time around. Most of the songs basically rework the material of the previous collection, though there is nothing on *Crossroads* as immediately diverting as "Fast Car."

Yet if you're into Tracy Chapman, there is much to like. The sound on *Crossroads* has been subtly redefined—it's even leaner—and wraps around Chapman's guitar. The band, composed of studio stars like Russ Kunkel (drums) and Larry Klein (bass), with Neil Young playing acoustic guitar and piano on one track, gives a subdued lesson in musical ergonomics.

It is perhaps unfair to compare *Crossroads* to *Tracy Chapman*, but the performer is now basically competing with herself—the sincere songwriter versus the RIAA-certified Recording Artist. One suspects the album will be judged less for its merits than for its commercial success as the follow-up to a blockbuster. In the long run, however, an artist is judged by something other than the number of records sold—and the jury's still out on Tracy Chapman. *Michael Aldred*

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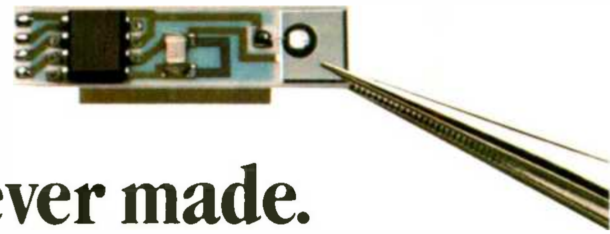

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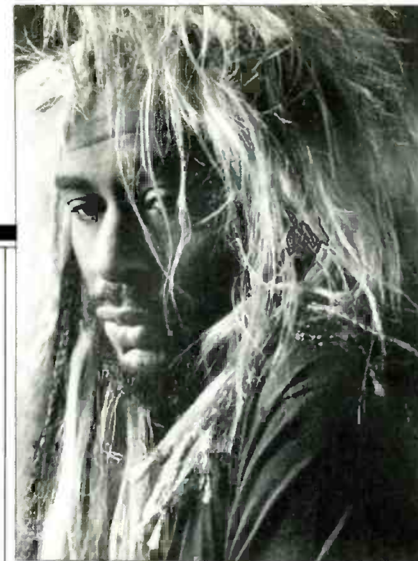
George Clinton knows his fans, and that's who this album is for: The faithful, whom Dr. Funkenstein will never desert.



The Cinderella Theory: George Clinton
Paisley Park 25994-4, cassette.

Sound: B– Performance: B

George Clinton. The funkster from outer space. Dr. Funkenstein. The man who wants the groove so low you can't get under it. If you put James Brown, Bootsy Collins, and George Clinton in the same room, you could learn all there is to know about funk.

Clinton's latest, *The Cinderella Theory*, is on Prince's label, Paisley Park, distributed by Warner Bros. Fitting, because Prince has certainly borrowed several pages from the Clinton book of style: Listen to this album's title track, and you'll be reminded of Prince's "1999." That wild funk style continues on this collection.

Few have stayed as dedicated to funk as George Clinton. Strong bass and kick drum tersely punctuate guitars and horns, and lyrics vary from pointed social comment to intergalactic nonsense rhymes. But the groove is the thing, and George champions the cause.

It's that dedication to funk which has prevented Clinton from reaching a larger audience. His influence can be heard on rap and dance hits, but his own records are not huge sellers. Clinton's variety lies in his lyrics and original wit. He can, as he does here, begin an album with a song like "Airbound" (a tongue-in-cheek homage to flying which, amazingly, sounds like the Swingle Singers Meet James Brown), then flip to the grittily serious lyrics of "Tweakin' " (where he is joined by Public Enemy's Chuck D. and Flavor Flav), and then jump back to humor again with his rendition of "The Banana Boat Song."

The Cinderella Theory came to me in cassette form. Recorded using the dolby HX Pro format and with Dolby B NR, the cassette is actually very punchy and clean-sounding. It offers an extremely solid low end, essential for this recording, and a good high end, although the instruments don't play much outside the mid-frequency range. The Dolby B NR keeps tape hiss way down. However, Warner Bros. should check the master tape machines in their duplicating rooms more closely, because either a poor bias adjustment or some other electronic problem has created a thump at the start and finish of this cassette. The effect is that of a tonearm dropping onto an LP, which is unacceptable.

George Clinton knows his audience, and that's who this new record is for: The faithful, who know Dr. Funkenstein won't desert them. In many respects, Clinton has made this record before, so while *The Cinderella Theory* is positively groovatating, it won't make George many new friends.

Hector G. La Torre

Cycles: The Doobie Brothers
Capitol C1-90371, LP.

Sound: C+ Performance: C

The Doobie Brothers' *Cycles*, which marks their return from musical purgatory, is indeed a puzzlement. Has no one ever explained to these very experienced musicians that playing music is one of life's few endeavors where one is encouraged to step beyond the established boundaries and reach for a higher plateau? Well, if *Cycles* is any evidence, I guess not.

This latest reincarnation of the Doobies contains Tom Johnston, Patrick Simmons, Bobby LaKind, Tiran Porter, John Hartman, and Michael Hossack. The album offers 10 songs—eight originals and two covers ("Need a Little Taste of Love" by the Isleys and "One Chain Don't Make No Prison" by Lambert and Potter), and a very tame offering this is: Undistinguished lyrics wrapped in forgettable melodies. Lyrics such as, "There's a town south of the border/South of El Paso they say, Where the nights are long and the winds are warm/And the women they love to play . . ." (from "South of the Border") simply aren't necessary.

Doobie fanatics will be pleased to note that some venerable Doobie

Eurythmics' bold artistic leaps have more to do with production than songwriting, yet their new album doesn't disappoint on either score.

Brothers musical signatures are here: Layered vocals, harmony-guitar parts, and multiple rhythm guitars. But this material doesn't stand up in comparison with earlier work—especially when comparison is unavoidable, as in such songs as "The Doctor" and "Need a Little Taste of Love," where the melody and rhythmic structure emulate past hits ("China Grove" and "Listen to the Music," respectively). Even the excellent producer/engineer Rodney Mills, who handled much of the recording chores on *Cycles*, couldn't save the day. A weak song is a weak song, no matter how well produced and well recorded it is.

If the Doobies aren't breaking new ground, and their present material isn't as strong as the old stuff, what results? Boredom. *Cycles* is an album for true-blue Doobie fanatics and for those trying to recapture the past.

Hector G. La Torre

We Too Are One: Eurythmics
Arista ARCD-8606, CD; ADD; 47:34.

Sound: A Performance: A−

Eurythmics have gotten short shrift, but this record is catch-up time. Although they were tremendously successful in America at first, when they changed from a quirky pop band to a substantial rock group their label (RCA) dropped the ball and lost their audience. Their best album, *Revenge*, went practically unnoticed in America, and they were reduced to solidifying their European base. For this Arista debut, leaders Dave Stewart and Annie Lennox have fashioned a record which is something of a compromise between their two styles and which is sure to keep fans happy. The bold artistic leaps have more to do with production than with songwriting, but *We Too Are One* is not disappointing on either score.

As far as major changes go, there's the new backing vocalist, Charlie Wilson, who also helped write "Revival," one of the album's best songs. Formerly a key member of The Gap Band, a seminal R&B group, Wilson's as strong a front person as Annie Lennox; he provides the vocal foil that we've never heard here before, and it's refreshing.

Annie's in fine vocal form here too, doing much of her own background work, and even Dave Stewart gets into the act for a moment or two with character vocals on "(My My) Baby's Gonna Cry." Stewart's guitar is uncharacteristically distorted on a few songs, and one wishes he would lean a little less on a Prince-type fuzztone/flange; his axe starts to blend in too well with the clavinet/synth. Part of the beauty of Eurythmics has been that the instruments do more than just service the songs, and that continues here—Stewart's guitar work has rarely sounded so deliberate and confident.

The songs are beautiful, but we should expect nothing less. Particularly striking are "When the Day Goes Down," which closes the album in a melancholy way instead of hitting you over the head, and "Don't Ask Me Why," a return to the kinds of things Eurythmics were doing on their second and third albums.

Is this as good as *Revenge*? It's more consistent, but if one were to pit this album's five best songs against *Revenge*'s five best, *Revenge* would win hands down. This record does have a little something for everyone, though, and no true Eurythmics fan will be disappointed in *We Too Are One*.

Jon & Sally Tiven

Homeland: Tish Hinojosa
A&M CD-5263, CD; AAD; 41:01.

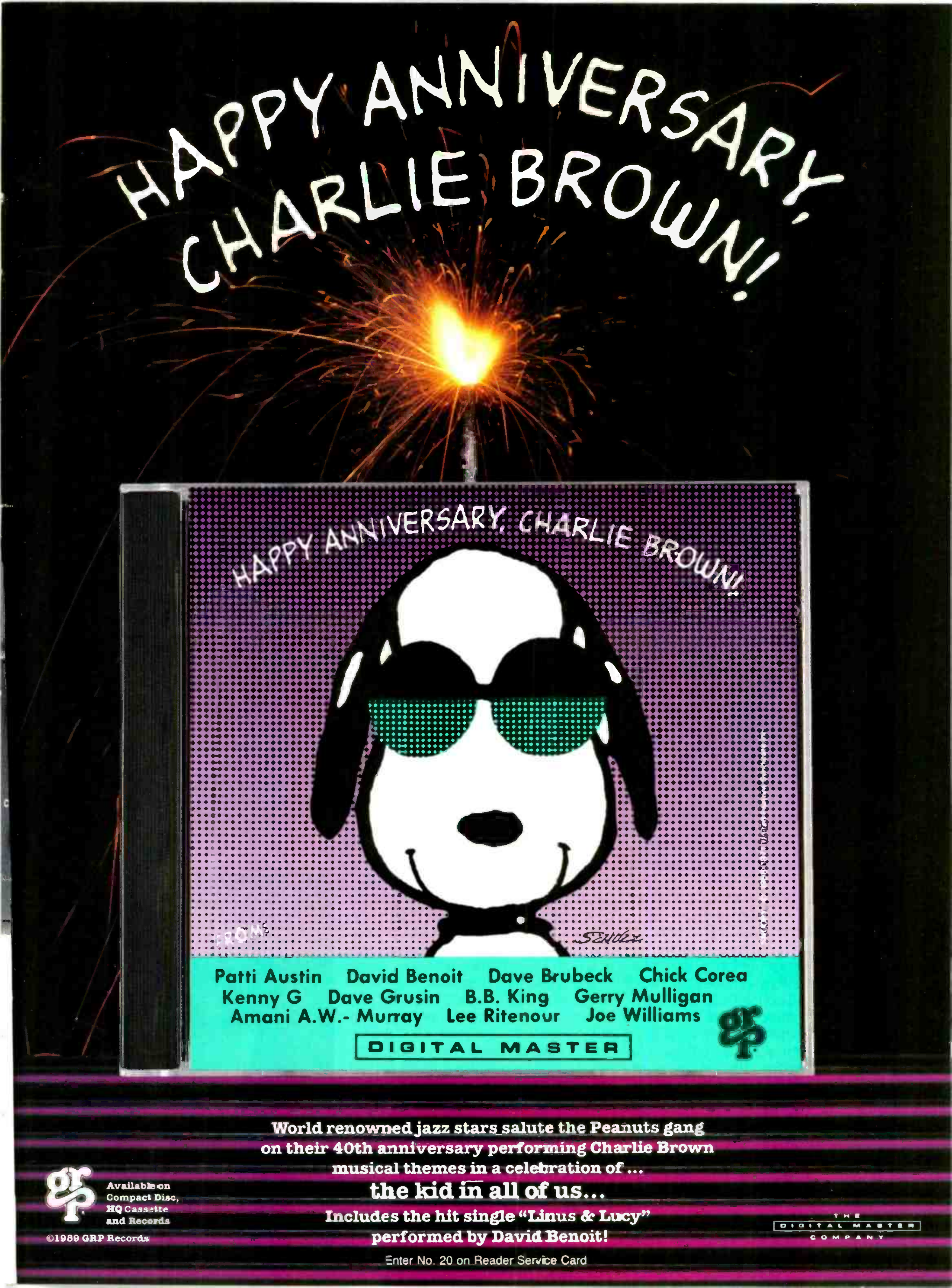
Sound: A− Performance: B+

Tish Hinojosa's debut is also the debut of a new series of releases A&M calls Americana, a songwriter-oriented series. Produced by Steve Berlin of Los Lobos and recorded in San Marcos, Tex., this is one impressive introduction. Clear-voiced Tish sings about growing up in San Antonio and of an Hispanic heritage she wears proudly. The opener, "Joaquin," quickly paints the scenery: A poor Mexican yearns for a better life in the U.S. despite the obstacles to his efforts, legal and illegal, to take his shot at it. "West Side of Town," set to a jaunty *norteno* beat, is a *corrida* about Tish's parents. These and "Donde Voy," one of three songs entirely in Spanish, form what Tish calls her "Border Trilogy." The last is a haunting slow waltz, and as she does throughout *Homeland*, Tish seems to put a little something extra into singing her Spanish lyrics. The sound she makes with these words is astonishingly lovely.

With only a couple of weaker songs—the more overtly pop ones—the quality of the material remains very high. The one song Tish did not write—Johnny Harris' paean to working cowboys, "Voice of the Big Guitar"—is a real beauty, too.

Berlin's production is most sympathetic. Instrumentation is mostly acoustic and beautifully executed by some of East Texas' best. *Homeland* has a far more western than a country sound. It summons up clear visions of the land that inspired it.

Michael Tearson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NATIVE SON

Illustration: Rick Tulka

Hanson: Symphony No. 1 in E Minor ("Nordic"); Elegy in Memory of Serge Koussevitzky; Symphony No. 2 ("Romantic"). Seattle Symphony Orchestra, Gerard Schwarz.
Delos D/CD-3073, CD; DDD; 70:39.

Wahoo, Nebraska (pop. 3,835) produced three celebrated native sons; years ago, *Life* published a photograph of a sign at the little town's portals, proudly claiming Darryl Zanuck, Howard Hanson, and a third, whose name has vanished into the mists of my memory.

As a composer, Hanson (1896 to 1981) won the Prix de Rome in 1921, and at 25 became the first American laureate to take up residence there. He spent three years in Rome, and you can frequently hear echoes of Hanson's teacher, Ottorino Respighi, in his orchestration, particularly at the opening of this "Romantic" Symphony's finale. Like so many of his compatriots, Hanson also enjoyed the patronage of Serge Koussevitzky, who commissioned Hanson's Second for his Boston Symphony Orchestra. Hanson paid homage to that great champion of 20th-century music by composing this moving Elegy as a memorial to him.

As an educator, Hanson put Rochester's Eastman School of Music on the map—not only nationally but internationally—and he remained to guide its destinies for 40 years, until 1964. His annual American music festivals there gave serious music in this country a unique shot in the arm. Hanson's most famous pupils at Eastman included Jack Beeson, William Bergsma, and Peter Mennin. One former acolyte, Arthur Cohn, says today, "Howard Hanson did more for promoting American music than any other man active at the time." Another, Kent Kennan, recalls, "I don't think there was another school in the country where student composers could regularly hear their works played by the orchestra." He adds, "Hanson's greatest legacy was his tireless promotion and recording of American music, at a time when no one else was doing nearly so much." Bergsma, in a favorite Hanson story, says, "Once he was being fêted at a large dinner party, and someone complimented him on so many of his students' having become faculty members at the Juilliard School [of which Bergsma himself became president]. Hanson waited for an appropriate silence, then said he certainly was proud that so many of his students were teaching at one of the best community colleges in New York City."

Like so many of his contemporaries, Howard Hanson in time became a victim of the worldwide dodecaphony wave which followed World War II. A proud descendant of Swedish immigrants, Hanson himself listed his own primary influences as Bach, Palestrina, Respighi, and, most of all, Sibelius; one can also detect residual traces of Grieg, Bruckner, and Vaughan Williams. At almost all times, his music remains mellifluous, solidly tonal, foursquare, even purely diatonic; chordal harmonies rarely venture beyond the triad, and only an occasional unexpected modulation places the music identifiably in time. Even a momentary shift into 5/4 meter, for example, sounds almost incongruous; a fillip of polytonality (as at the end of this Second Symphony) brings the auditor up with a bit of a start.

Hanson had an unusually rich gift for soaring, rhapsodic, at times even rapturous lyricism, and he had no misgivings whatever about wearing his heart on his sleeve. The second theme of his "Romantic" Symphony's opening movement (4:24 into it)—probably the best-known theme Hanson ever contrived—evokes Bruckner's own "Romantic" Symphony (No. 4) and even Liszt's tone poem "Les Préludes."

Gerard Schwarz and his excellent orchestra deserve our gratitude for this revival recording. Schwarz revels unapologetically in these three works' unabashed Romanticism without ever descending to wallow in it. The high strings occasionally sound incongruously thin, but otherwise the technical

Gerard Schwarz

Photograph: Yuen Lui

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niveau of the recording measures up to the exceptional standards of that spunky little California firm, Delos.

Surely enough time has now passed for us to reexamine and reevaluate the entire catalog of Howard Hanson's compositions. Like so many victims of the 12-tone wave, he does not deserve the neglect the past few decades have inflicted upon him. One welcomes the news that Delos plans to have Schwarz and his Seattlers record Hanson's complete symphonies (not to mention the complete symphonies of Walter Piston and David Diamond, to boot—a stunning project!). Even the conservative listener today can understand and assimilate Hanson's warm, endearing music at first hearing, and for music lovers who have grown up during his eclipse, it provides just about the best possible introduction. *Paul Moor*

Rachmaninoff: Symphonic Dances (1940); Vocalise. Dallas Symphony Orchestra, Donald Johanos.
Athena ALSW-10001, LP. (Available from East Coast Music Distributors, 311 Willowbrook Rd., Staten Island, N.Y. 10314.)

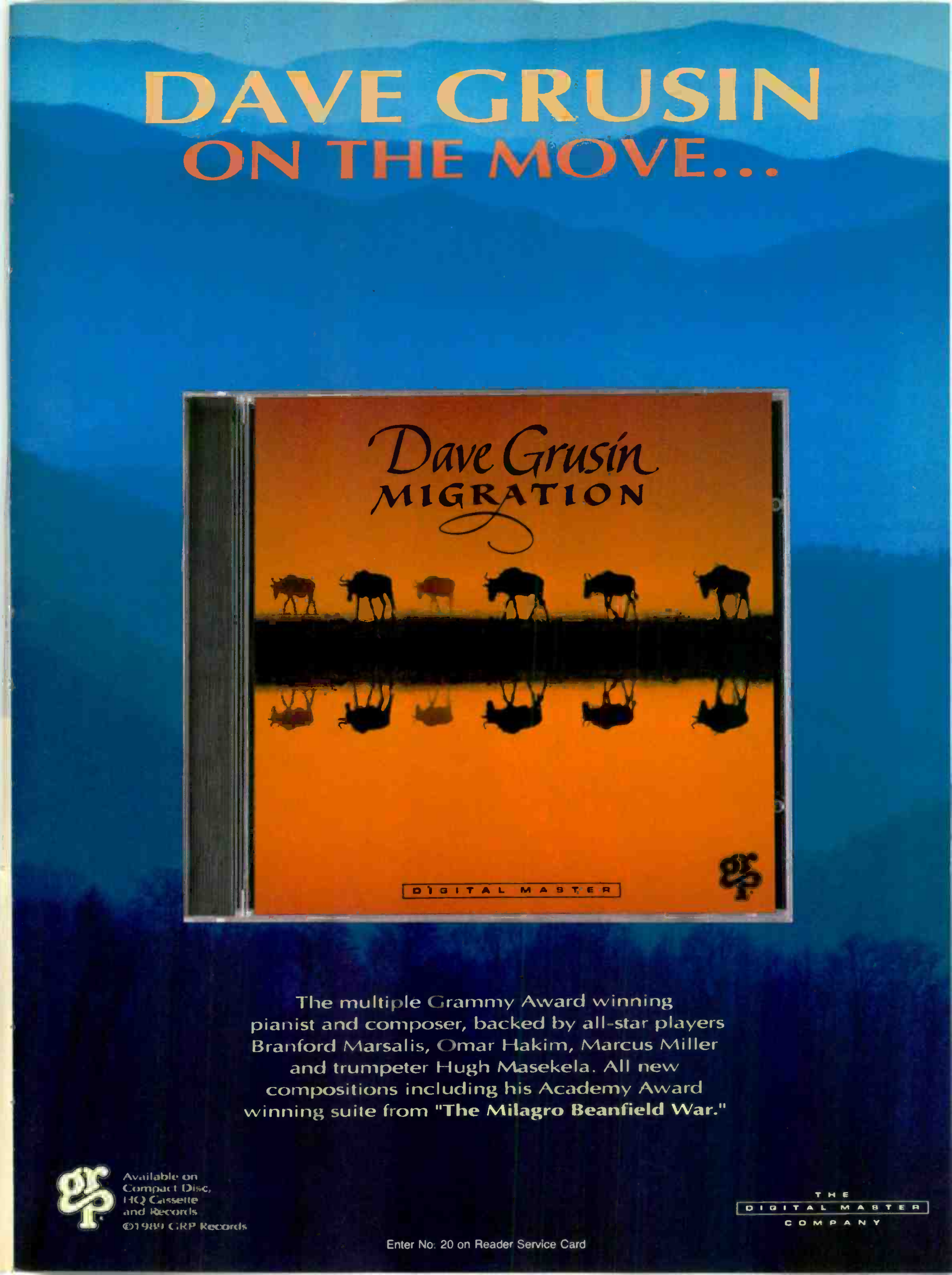
"100% analog." That statement appears on this latter-day LP, just out, and next to it is a logo: A red circle with a bar across the word digital. Seeing that, I decided I'd better read further before playing, though when I got around to it, I found the music—the last piece Rachmaninoff composed—entirely enjoyable.

Isn't it wonderful the way each time a new audio format appears, a cult of those adamantly dedicated to the superiority of the old springs forth? There were those, around 1950, who were just as energetic about the virtues of the venerable 78 shellac. These feelings rarely lead to useful evaluations. Too emotional. There are comparisons to be made, needless to say, but let's judge each item on its merits—whatever the format.

So I began to read. Is this a *brand-new* analog recording on LP? (That would be of interest.) Or is it a state-of-the-art oldie, reissued? (That, too, is always interesting.) Nothing is said directly! No dates for the recording, oldie or new. But it soon became clear to me, as I went through the Texas-style account of the recording's wonders, that it was actually quite old. Why all the obfuscation? I had to guess at the info I wanted, which wasn't there. But I fooled 'em. Lots of clues, both technical and musical.

Rave reviews for the Dallas Symphony, evidently on its first tour to New York. The reviewers are, I know, mostly not around any more. And one newspaper has been dead for a generation. Given some research, I could probably date the recording, more or less, on this basis alone. But there's more.

The recording, it says, was made on equipment "including an Ampex ste-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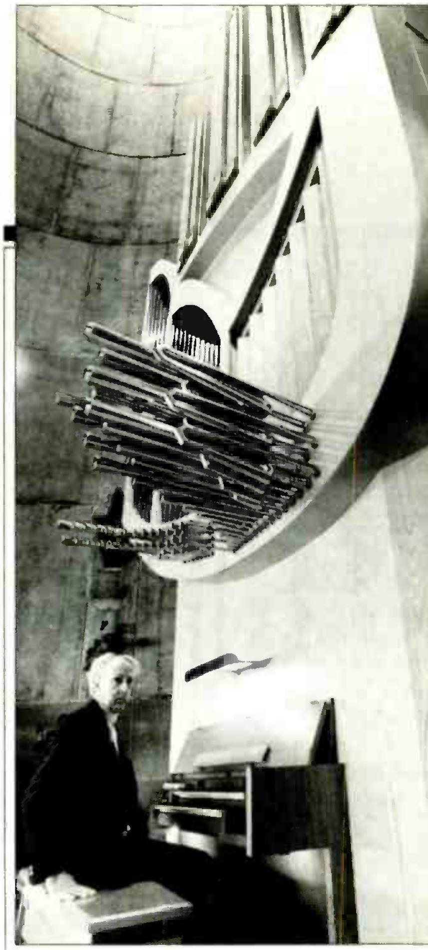


Photograph: Brian Levine

Organist Jean Guillou is understanding, real, and communicative. Bach, who admired French music of his day, would approve.

reo vacuum tube recorder operating at 60 inches per second." *That* says something. Could it have been the sturdy old Ampex 350-2, workhorse of the industry before solid-state technology entered the Ampex line? That suggests a date. The 60-ips data, too, is interesting. That tape-devouring speed was particularly useful for optimum signal and low tape noise before Dolby NR became widespread. No doubt 60 ips went on in spite of Dolby, but Dolby A and its successors, plus better tapes, have surely reduced the need—even in analog recording.

The lacquers, it says, were cut with a vacuum tube amplifier. More tubes. There was no signal processing: "No compressing, limiting, expanding." For a moment, I thought that this, too, was way back then, and it would have been a very forward-looking technique! But instead, it is *now*, and an implied slap at Dolby, et al., characteristically a purist viewpoint but not exactly radical. So the tube-made tapes are old, the tube mastering new. I looked at the LP, which seemed to confirm this; the lacquer imprint showed no tell-tale older numbers, and the pressing, with the Athena label on excellent vinyl, was obviously new.

But the payoff was a brief note which says this recording is under license from the Moss Music Group and originally appeared as Turnabout TV-34145. Aha! Moss is the successor to Vox, and Turnabout was Vox's semi-pop label, relatively speaking, and ran for many years, starting in the 1960s. I rushed to my record collection to see if I had it. No, but nearby numbers indicate that the Turnabout version from Vox appeared between *1966 and 1969*, which neatly fits the evidence.

So this *is* a real golden oldie, very good in the sound, though a bit dead in the acoustics (as of the period). It won't appear on CD—remember, *no digital*. The Rachmaninoff is worth anybody's ears, too, so LP lovers, take note. An exclusive for you.

Edward Tatnall Canby

Bach: The Goldberg Variations. Transcribed for organ and performed by Jean Guillou.
Dorian DOR-90110, CD; DDD; 53:56.

The Goldbergs of Bach constitute one of those epochal works that many of us discover, to our amazement, as not only brilliant, humorous, colorful music, but a sort of Bach that most people do not expect—graceful, human, easily understood despite incredible complexities, a kind of listening that sells itself and continues to grow as we listen again and again.

That is, in the original, for two-keyboard harpsichord. Or even in a few piano renditions, forcing one keyboard to act like two.

This is an unexpected new version, for organ, a tracker organ (mechanical) of Bach's own type, more or less. The transcription is logical. The Goldbergs were written for one of Bach's primary instruments, the harpsichord, with fixed layers of tone color and two keyboards for maximum contrast. The baroque organ, his other primary instrument, was very much the same in principle. It also had a fixed set of tones (unaltered by finger pressure) and an array of different keyboards plus a pedal board. Big bass is always *implied* in Bach. The organ bass merely makes it literal and less inferred.

Most of all, for us today, the Goldbergs are astonishingly close to the structures of jazz. No, not in the sound, but in the use of an easily heard melodic line and, even more, a series of

The Sibelius songs do call for a dramatic reading, and the soprano, Ritva Auvinen, conveys the elegiac element with passion.

harmonies, repeated again and again to ever new improvisation—here written down with mathematical accuracy. If you can follow the basic song in jazz, you can even more easily hear the Goldberg harmonies, set up in two halves and easily recognized in variation after variation. And yet on top of this simple basic shape, Bach puts effortless structures of brilliant complexity—canons (rounds), from the unison all the way to the octave, every third variation. Equally, in each set of three there is a brilliant keyboard showoff and a piece for two keyboards. One of the canons is even upside down: When the first melody goes down, the second melody goes up.

All of this you can learn to hear effortlessly. The Goldbergs satisfy even a beginner, who can immediately follow the variations, one after the other, and soon sense the basic repeated harmony. With more time, the astonishing details begin to register on the mind. It really is not difficult.

Both the organ and the organist (who transcribed the music for his instrument) are unusual here. The organ is a modern German baroque tracker machine (mechanical), but its characteristics, commissioned by this French organist, are subtly French in a curiously piquant way. The playing is also very French—colorful, speedy, with somehow a decided whiff of the French Romantic school, however unlikely this may seem. But French or no, the organist is understanding. His Bach is real and communicative, if original. Bach, who admired French music of his day (note his "French Suites") would surely approve.

This is indeed a lovely Franco-German organ and well worth the recording. Those who know the Goldbergs in any other version should acquire this unusual rendition for a remarkably interesting comparison.

Edward Tatnall Canby

Sibelius: Songs. Ritva Auvinen, soprano; Gustav Djupsjöbacka, piano.
Ondine ODE-728-2, CD; 70:02.

Any issue that pairs one of Finland's most distinguished singers with the songs of Finland's most distinguished composer is welcome. Ritva Auvinen must classify as a distinguished singer; she has sung at the Met (in 1983), among other major opera houses. That fact, however, suggests the weakest element in this otherwise very satisfying record: Auvinen's rather operatic approach. Her phrases are consistently blustery, even where a gently floated tone would be more appropriate.

Many of the 27 songs in the collection (approximately one-third of Sibelius' output in the form) do call for a dramatic reading, of course. But the overriding mood is one of joy in nature, and Auvinen conveys the elegiac element in them with passion.

Robert Long

THE BRAZILIAN GAMBIT

Non Stop to Brazil: Luiz Bonfa
Chesky JD29, CD; DDD; 46:57.

Sound: A– Performance: C+

Rio After Dark: Ana Caram
Chesky JD28, CD; DDD; 58:50.

Sound: A– Performance: B–

Here are two of the latest additions to the Chesky Records library—one showcasing a veteran who hasn't released a record in 15 years, the other introducing a new artist. The veteran is guitarist/composer Luiz Bonfa, the newcomer guitarist/vocalist Ana Caram. Both are Brazilian; they offer a similar type of Brazilian music—the light, samba-esque variety popularized in the '60s by Antonio Carlos Jobim and by Bonfa himself, whose many compositions include the film score *Black Orpheus*. Jobim joins Caram on two tracks, contributing the compositions, playing piano, and singing.

There is plenty of music to be had on these CDs, with each dishing out 15 tunes. Yet neither album ever jumps out and demands your attention. There seems to be a lack of real emotion; the performances are generally flat and uninspiring. Talent is not the problem. Over the years, Bonfa has shown himself to be a very capable writer and guitarist, and Caram is no lightweight, playing strongly and singing in a musical, if somewhat thin, voice. If her voice has yet to develop real character, she is a solid talent searching for a style.

Part of the problem with these albums lies in the musical settings. Each artist is called upon to carry the tracks, with a minimum of sidemen. Caram has more support, with a bassist, alto flutist, and percussionist joining her on most tracks; Cuban saxophonist Paquito D'Rivera also appears on two tunes. Bonfa has only a percussionist, except where he is joined by another guitarist on three tracks. The result of this limited accompaniment is an inability to arrange songs outside the musical confines of the acoustic guitar. Strings, horns, or just additional keyboards would have allowed more drama and dynamics to be written into the compositions.

The lack of musical dynamics is also partly the result of Chesky's recording techniques: Digital recording, with "minimal miking techniques and without overdubbing or artificial enhancement. . . ." Recording digitally poses no problems, but minimal miking without overdubbing can result in a smaller—not more intimate—sound, as well as overly simplistic arrangements. Further, you sometimes wind up miking the lead instrument closer than the backing instruments (as is the case here), and the accompanists wind up too far back in the mix—check "Alagoas" on Caram's disc and "Dança India" on Bonfa's for examples of this effect. The lead instrument is in your face, while the bass and percussion sound as if they are in another room. When there's no immediacy in an instrument, there's neither drama nor dynamics.

Audiophiles needn't take these recording techniques too seriously because in many respects they're merely a simpler—not necessarily more creative—way of recording. Fewer players, plus fewer microphones, minus special effects, plus digital recorders, plus RCA's Studio A, equals fewer problems. You want problems, try recording Megadeth live, in a garage, and throw in strings—*there's* a problem! Talk about creative miking. . . .

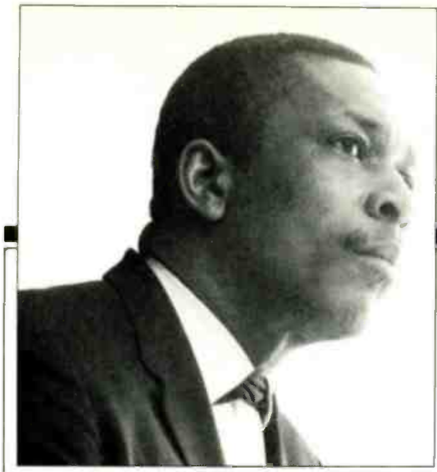
Chesky's slogan is, "You can hear the difference," implying, I assume, that their CDs sound better than others on the market. Different? Yes. Better? Not by me. There is certainly greater room ambience (which, incidentally, often manifests itself as tape hiss); when everything's mixed properly, there's also a clearer spatial perspective. It's true that today's close-miked pop recordings often don't provide as natural a feel, but their quality is no better or worse.

It's good to see Luiz Bonfa back in the saddle, and it's good to be introduced to Ana Caram. However, next time out, the musical selections and arrangements should be considered as important as the recording techniques. *Hector G. La Torre*

Tribute to John Coltrane—Live Under the Sky: Wayne Shorter, Eddie Gomez, Jack DeJohnette, Dave Liebman, and Richie Beirach
Columbia FC-45136, LP.

Sound: B Performance: B

It's been more than 20 years since John Coltrane's death in 1967, and his influence remains pervasive on contemporary saxophonists from David Murray to Kenny G. But despite his dominating presence, albums like this, paying tribute to his genius, have been rare since the years immediately following his passing.



Live Under the Sky's stars respect John Coltrane's '60s experimentalism; they don't filter it through today's jazz styles.

This all-star, one-shot group has a better claim to the Coltrane legacy than most. Their selection of material shows a respect for 1960s experimentation and spiritualism, without filtering it through the revisionist bop-traditionalism and fuzak commercialism dominant today.

"India" is taken from Coltrane's later period, when he delved into Indian spiritualism and music. It's launched with a surprising, string-popping bass solo from Eddie Gomez, who creates machine-like repetitions that might be a comment on how far we've come from the centering drone of the Indian tamboura which opens Coltrane's original. But it's not long before Gomez, drummer Jack DeJohnette, and pianist Richie Beirach lock into the cyclical modal rhythms. Dave Liebman and Wayne Shorter solo in succession on soprano saxes, creating spiralling arabesques into the upper registers.

Richie Beirach, who never finds the drive of "India," comes up to speed on "Mr. P.C." and "Impressions," with pounding left-hand chords against his cascading right-hand flurries. These two Coltrane works lend themselves to extrapolated blowing, with DeJohnette and Gomez's constantly churning, shifting rhythmic pulse. Liebman's solo on "Impressions," however, lacks direction, ending in hoarse and scratchy upper-register cries. By contrast, Shorter's solo is a blueprint of architectural logic and design. It builds from short staccato passages into long, swirling, impassioned lines. The group also plumbs Coltrane's often neglected lyrical side with a Beirach and Liebman duet on "After the Rain/Naima."

Recorded live in Japan in 1987, this LP captures the live excitement while maintaining a closely miked, intimate sound. The flaws in this performance can be traced to musicians who occasionally lose their way (especially Wayne Shorter) and to facile fusion constructions. John Coltrane always followed an unerring path, and the timelessness of his music is testimony to his conviction. *John Diliberto*

Carry the Gift: R. Carlos Nakai and William Eaton
Canyon CR-7006, CD; ADD; 59:15.

Earth Spirit: R. Carlos Nakai
Canyon CR-612, CD; DDD; 57:44.
(Both available from Canyon, 4143 North 16th St., Suite 4, Phoenix, Ariz. 85016.)

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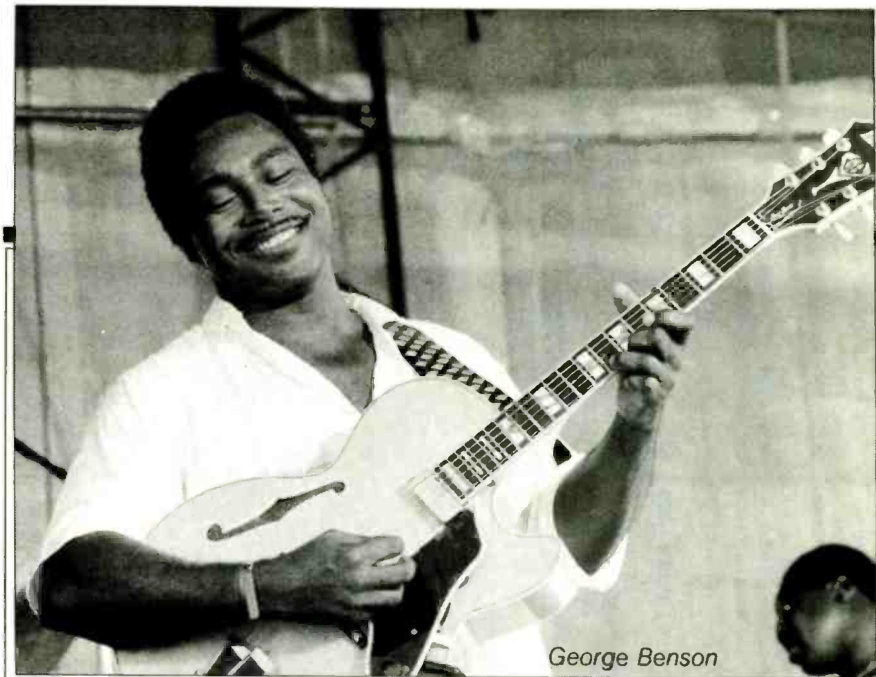
Over the years, Canyon has been releasing incredible albums of Native American music—including these two Carlos Nakai discs.

al music to contemporary Native American pop. But most people outside the Native American community aren't aware of the incredible treasures Canyon has been issuing over the years. These two discs feature Carlos Nakai playing the Native American flute. The compositions are his own, but they are based on the traditional melodies and forms of the Plains and Woodlands tribes.

At first, *Carry the Gift* sounds like a typical New Age recording. At times, it almost sounds like John Renbourn—but with some obvious differences in the melodic contours and scales. According to Nakai's notes, "a good flute melody should be as free sounding and soothing as possible." That accounts for the New Age sound and the quiet, contemplative spirituality of his music. On *Carry the Gift*, Nakai uses rain, thunder, crows, tree frogs, wind, coyotes, and other environmental references as part of his musical texture. Some are nicely synthesized, but others may be real. He paints with watercolors, so his effects are understated. But for an attentive listener, these effects open the soundstage from the small, intimate space where he is playing to the entire earth, expanding your thoughts in a gently pleasurable way. Nakai also uses the flute and various musical turns of phrase to remind us of these sounds and the thoughts that went with them. Many others have done similar things, but not with Nakai's delicate, graceful style.

William Eaton accompanies Nakai, playing several string instruments which he built himself. Of special interest is the harp guitar, a guitar with a 12-string harp incorporated into it. The resonances and colors Eaton draws out of his instrument are wonderful. He plays Nakai's music with understanding and artistry.

On *Earth Spirit*, Nakai performs unaccompanied on several flutes, including one made from the wing bone of an eagle. His virtuoso control over each of those instruments is remarkable but always in a quiet, unshowy way. Often, his techniques for producing unusual sounds suggest the extended playing techniques for the Japanese *shakuhachi*. On the title track, he makes the eagle whistle imitate the high-pitched squeals of an eagle, and on "Gateway"



George Benson

Photograph: ©David Gahr

he suggests barking dogs or coyotes with a quick flourish at the end of his notes.

Both discs have a clean sound that lets all these subtleties on the flutes and strings shine through. The flute sounds on *Earth Spirit* seem to be surrounded with a spacious aura of reverb. I'm not sure whether it's natural or synthetic, but it feels just right. On *Carry the Gift*, the intimate sound is part of the musical style, but a longer delay time makes the distances seem greater. I recommend both discs for their many levels of beauty, and I encourage everyone to explore the Canyon catalog of recordings—and the musical culture of Native Americans.

Steve Birchall

Tenderly: George Benson
Warner Bros. 25907-2, CD; AAD; 38:31.

Sound: A Performance: A–

Keeping us guessing about each new release has become something of a professional pastime for George Benson, and *Tenderly* is no exception. No, it's not a collection of "urban contemporary" ballads; instead, Benson brings together jazz stars McCoy Tyner on acoustic piano; Ron Carter on upright bass; drummers Louis Hayes, Herlin Riley, and Al Foster, and percussionist Lenny Castro to do a set of standards in a Hoagy Carmichael-ish sort of mode. The result is an entertaining pastiche that manages to sound both nostalgic and contemporary.

Benson croons on most of the numbers, which include "You Don't Know What Love Is," "Stella by Starlight," "Stardust," "At the Mambo Inn," and the Lennon/McCartney tune, "Here, There and Everywhere." Strings and horns by Marty Paich are crisp, sparing, and non-intrusive, and add a pseudo-'50s touch. Scat and that sweet Benson guitar-playing abound. Benson's solo guitar variations on the title cut and the ensemble jam on "I Could Write a Book" are mainstream jazz at its best.

The album is recorded cleanly, with excellent balance and presence that capture all the instruments. My only criticism is that Benson's vocals seem a bit stretched at times—almost as if he should have relaxed and opened his mouth a little more. Still, if you long for the good old days or just want to hear some jazz giants taking a gentle stroll across a chestnut-strewn lawn, check out *Tenderly*. Now, what next?

Michael Wright

King of the Blues Guitar: Albert King
Atlantic 8213-2, CD; 52:38.

Sound: B Performance: A

Talk about doing a reissue right!

The 17 tracks here are the entire contents of 1967's *Born Under a Bad Sign* (originally on Stax) *and* 1969's *King of the Blues Guitar* (five songs appeared on both releases). This CD's got blues classics like "Born Under a Bad Sign" and "The Hunter," plus "I Love Lucy," in which Albert relates the love story of himself and his guitar.

The collection truly represents King's best work. End to end, it's vintage material, with that great Stax/Volt soul sound on great songs played with authority. Thrilling stuff.

The resequencing for CD, incidentally, is excellent. *Michael Tearson*

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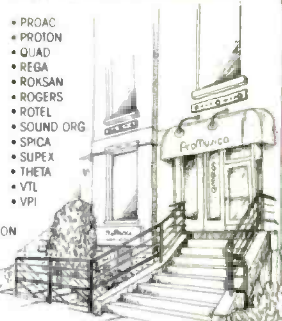

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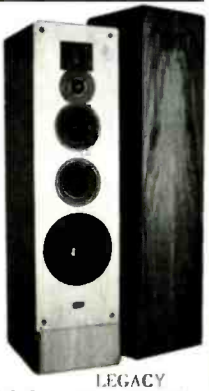

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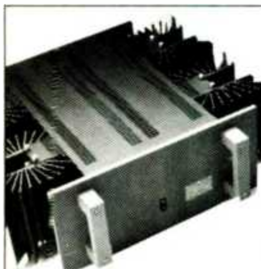

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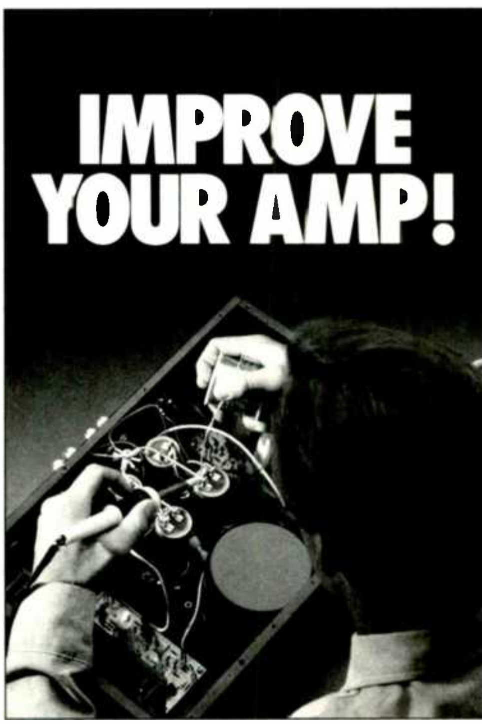

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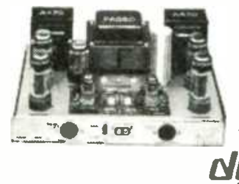

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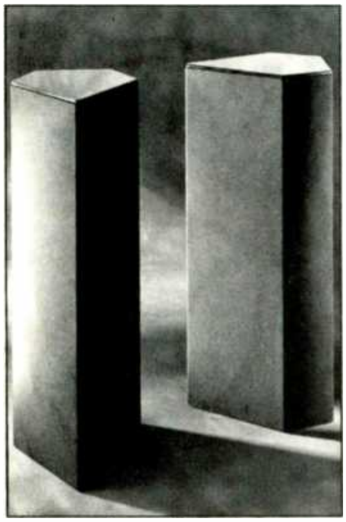

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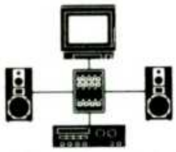

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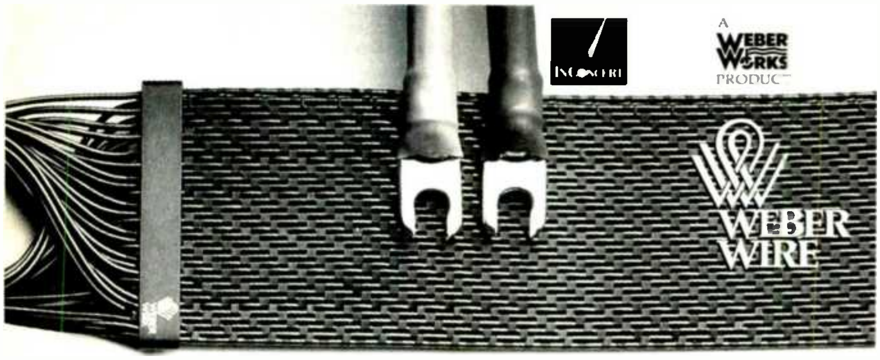

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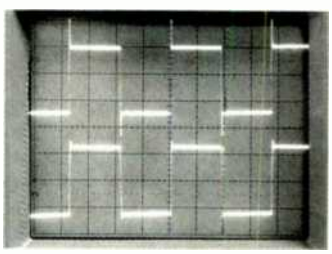

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Fig. 1
Transmission characteristics for 15 ft. of WeberWire—1Ω source, 8Ω resistive load—communicating a 100 kHz square wave. The upper limit of WeberWire is just beginning to be observed as the extremely high harmonics of the overshoot from the signal generator (upper trace) are noticeably reduced. Nevertheless, the bandwidth of WeberWire permits the wave itself to be reproduced without tilt or other anomaly.

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The kit is designed to be as easy as possible to assemble. The cabinet is already finished. The holes for the drivers and the input cup are pre-cut; the crossover is preassembled, and the grill cloth is stretched on the frame. The assembly of this kit does require some soldering ability.

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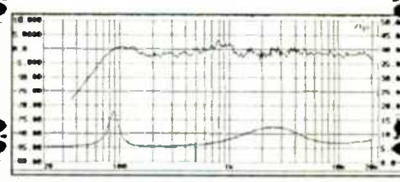

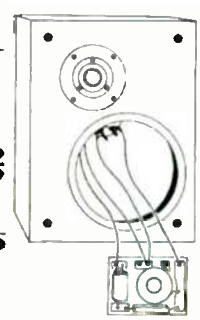

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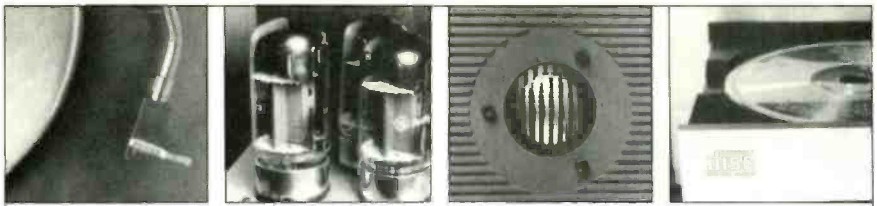

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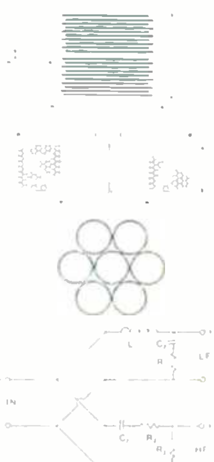

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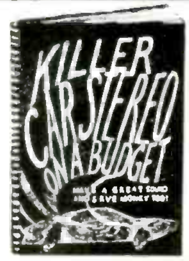

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AD INDEX

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SUBJECT INDEX

1989 INDEX

FM Reception

Forum

Headphones

Hearing

History of Audio

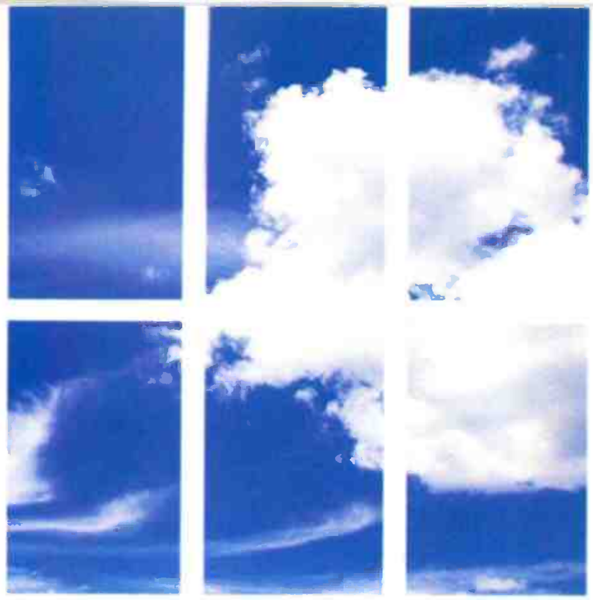
International Audio

Interviews

Loudspeakers

Measurement Techniques

AUTHOR INDEX



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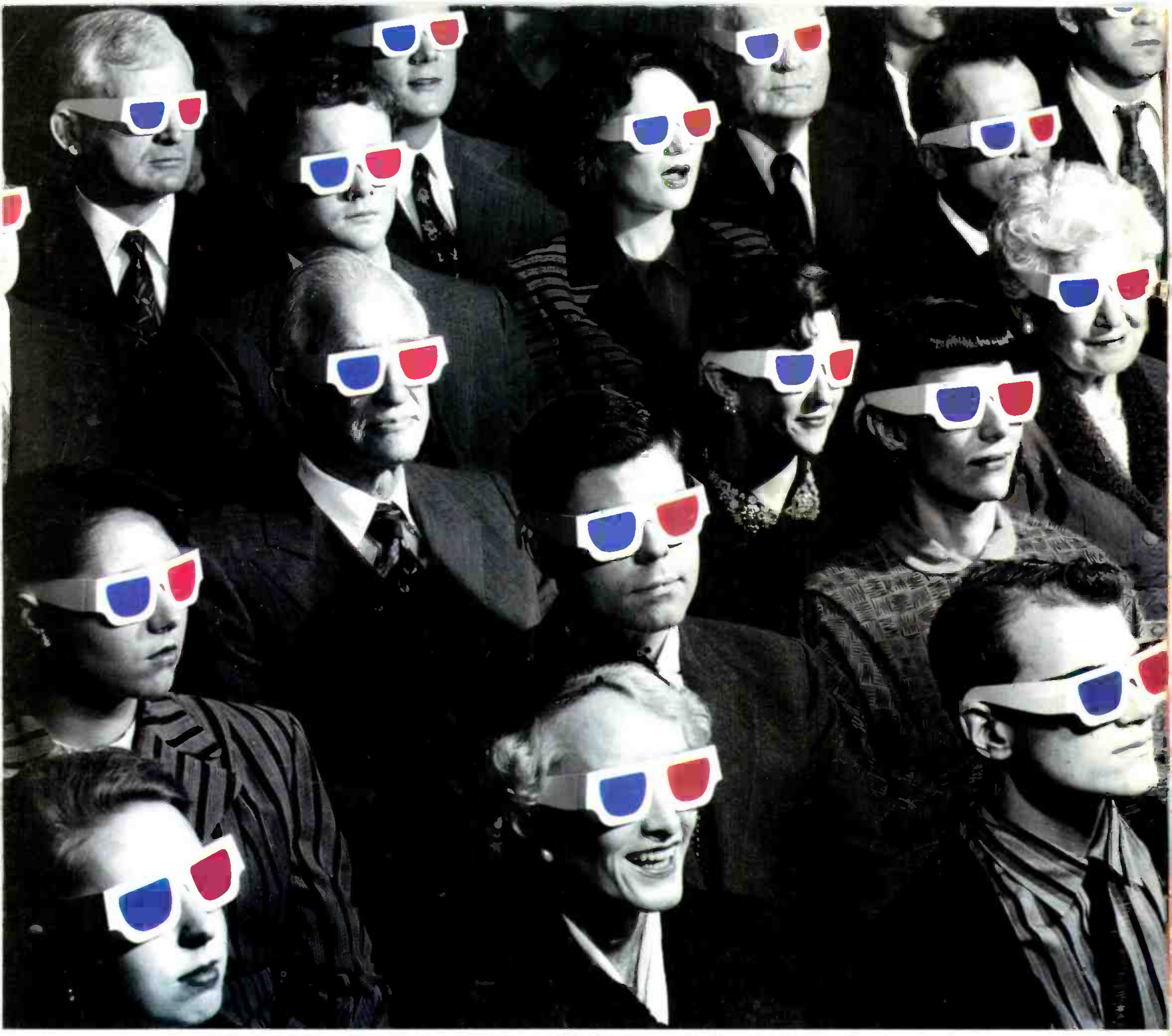

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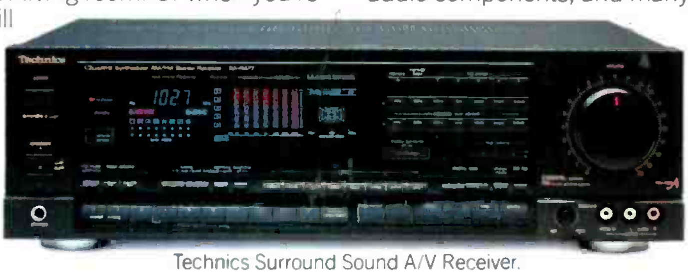

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