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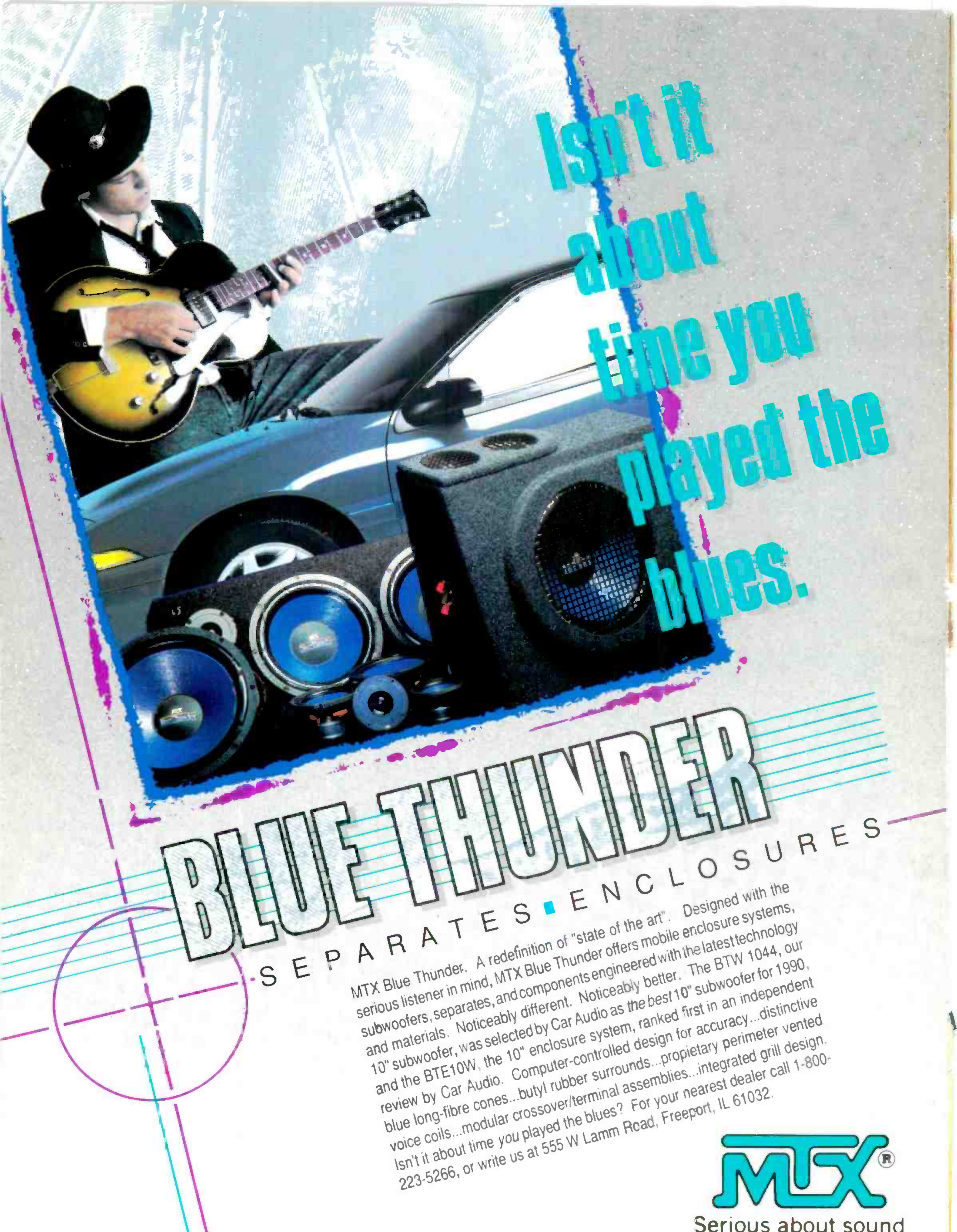
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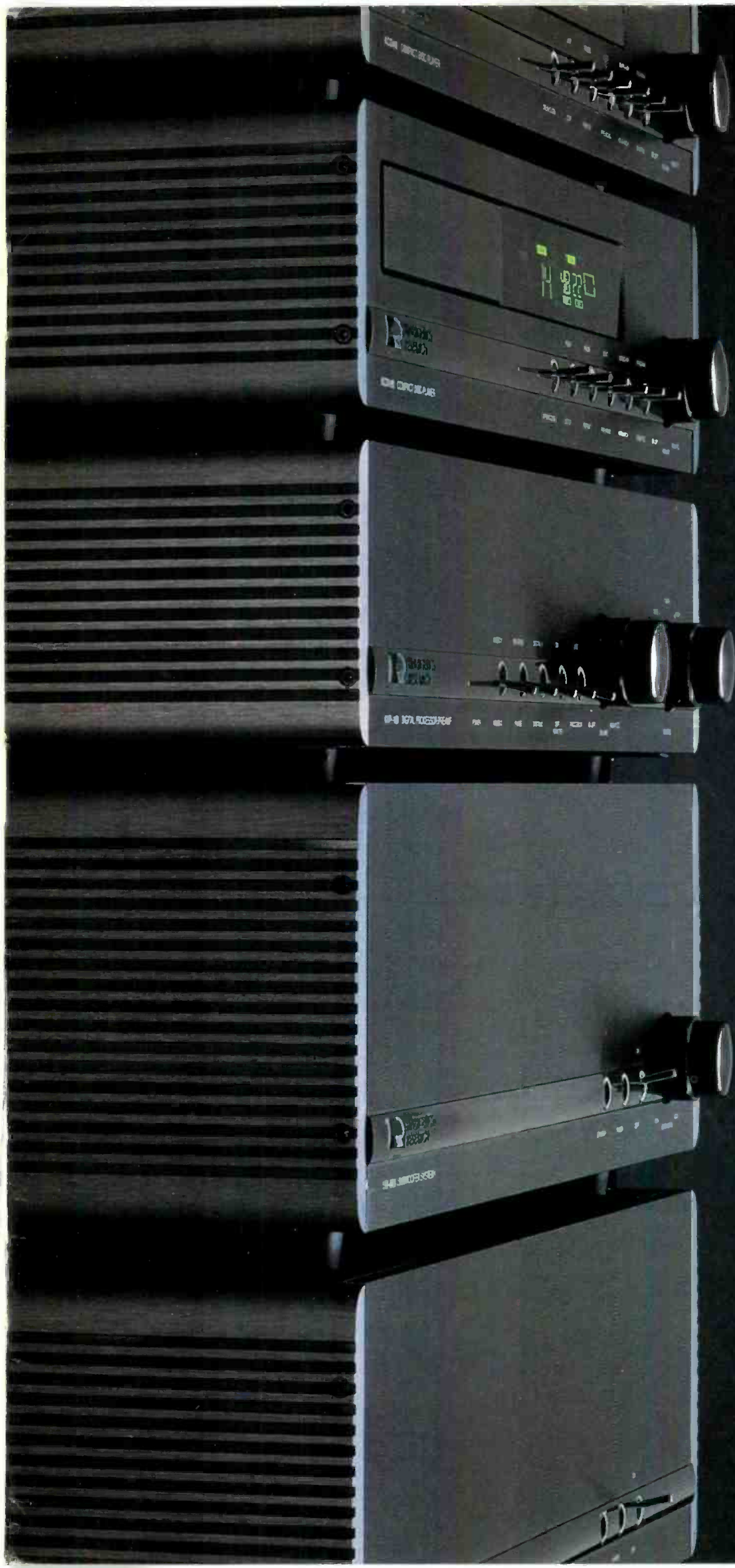

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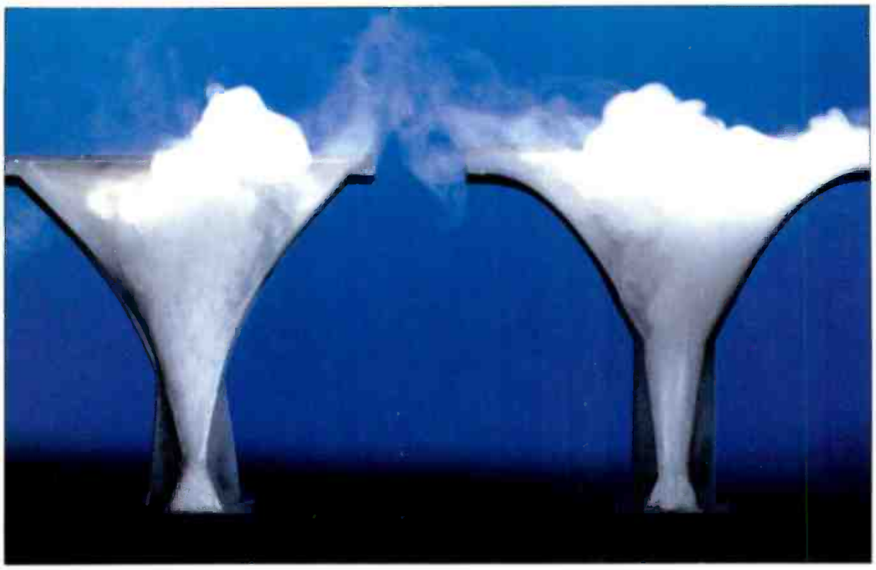

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DEPARTMENTS

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The Audit Bureau

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SIGNALS & NOISE

As Simple As DSP

Dear Editor:

As a dispensing audiologist, I read Dan Sweeney's "DSP for the Hearing Impaired" (September 1990) with great interest. I feel compelled to provide further information.

First, an error was made in describing the nature of a "simple" sensorineural hearing loss. Mr. Sweeney described it as destruction of cilia in the middle ear, when he should have specified the inner ear. By the way, a hearing-impaired individual would tell you his hearing loss is by no means "simple."

Second, at this point in time, for practical purposes the hearing-aid industry has no true digital hearing aids. Yes, Nicolet did create the Phoenix, but as I understand it, they spent about $12 million on research and development and couldn't bring it to market. Can you imagine trying to sell someone on the merits of this huge body-type aid when, for the last five to 10 years, canal instruments were available? These new hearing aids are commonly referred to as digitally programmable hearing aids.

Third, I have been told by several major hearing-aid manufacturers that what is available now is just the tip of the iceberg, and some have stated that as far as "programmable" goes, current analog hearing aids with dispenser-controlled potentiometers are programmable hearing aids.

The consumer also needs to know that these new hearing aids do come with a hefty price tag, anywhere from $850 to $2,000 each. Also, depending on which system a dispenser chooses, it can cost anywhere from $500 to $16,000 for the programming unit, a device necessary for the dispenser to program the hearing aid.

Julie A. Lohrman, M.S., CCC-A
Graystone Ear, Nose and Throat Center
Hickory, N.C.

Author's Reply: In regard to my reference to "simple sensorineural hearing loss," I am employing terminology which is in use in the industry. I do not mean to imply that such loss cannot impose a severe disability on the sufferer; I only meant to suggest that sensorineural loss is commonplace and more amenable to treatment by compensatory amplification than some other conditions.

In regard to Nicolet's Phoenix, according to a number of persons interviewed at Nicolet and the parent company, Audiotone, Phoenix hearing aids have been sold, albeit in limited numbers. I do believe Ms. Lohrman is correct in suggesting sales resistance to a body aid in this day and age, and I think such resistance has had an impact on sales of the Phoenix.

About the current programmables being the tip of the iceberg, I think that's true. I don't think programmables are a fad. I think we'll see more of them in the future, but the transition will be slow. The hearing-aid wearer is not generally a gadgeteer eager to try the latest and greatest. In fact, he's frequently someone on fixed income who is understandably hesitant to pay thousands for unproven technology.

Ms. Lohrman is right about the price, and the price is a big barrier, particularly when you consider that many wearers of hearing aids will require two aids—each one separately programmed and fitted.

One other point I didn't touch on in my article should be mentioned: Anthropological research suggests that normal humans who live in quiet environments retain acute, wide-band hearing into old age. As audiophiles and music lovers, we all should be ardent campaigners for noise control in our own environments. —*D.S.*

Cochlear Colloquy

Dear Editor:

Dan Sweeney's article, "DSP for the Hearing Impaired" (September 1990), was quite comprehensive and well written. There was, however, one error, which appeared on page 43. In the sidebar, "The Basics of Hearing Aid Hardware," Sweeney stated that 3M controls the market for cochlear implants.

This is untrue. Cochlear Corporation's Nucleus 22 offers state-of-the-art technology and greater potential benefits than the single-channel 3M device. In October 1985, the Food and Drug Administration approved the device for use in post-lingually deafened adults. It is the first and only multi-channel device to obtain FDA approval. On June 27, 1990, the FDA granted ap-

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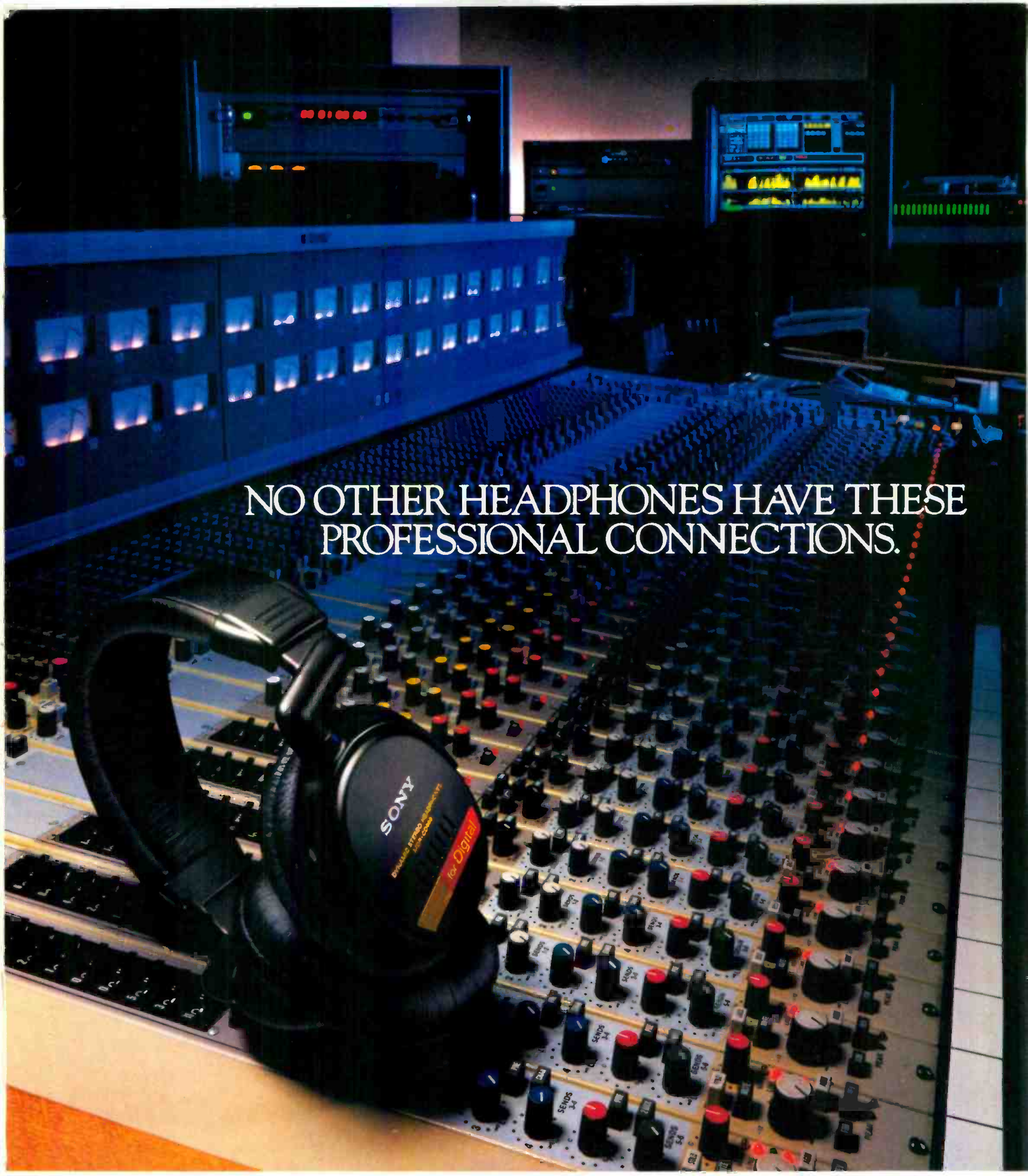

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Despite the specter of a major lawsuit, Nakamichi took considerable risk by introducing a DAT recorder in 1989.

proval for the application of the device in children from ages 2 to 17.

Cochlear Corporation acquired 3M's cochlear implant business and patents on August 15, 1989. With this acquisition, Cochlear consolidated and increased its position as the industry leader.

Jamie Sosnow
Kovak•Thomas Public Relations
New York, N.Y.

Digital Error Correction

Dear Editor:

While reading your review of the Sony DTC-75ES DAT recorder in the November 1990 issue, I came upon the following passage: "The first company to introduce DAT through authorized distribution channels in the U.S. was Sony Corporation . . . late in June of this year [1990]."

This did not sound quite right to me, so I went through my back issues of *Audio* and noted that your review of the Nakamichi 1000 DAT recording system in the November 1989 issue began: "To Nakamichi must go the credit for delivering to this country the first 'consumer' DAT recording system, despite the threats of litigation posed by certain record companies and the RIAA." Some authorized Nakamichi dealers in Southern California have been selling the 1000 DAT for over a year now. (My first audition was during the summer of 1989.)

Now, I realize that things change fast in today's world, but the events of a mere year ago hardly qualify as ancient history by anybody's standards. Despite the specter of a major lawsuit, Nakamichi took a considerable risk by introducing a DAT recorder in 1989. You should give credit where credit is due and recognize that Nakamichi was indeed the first company to distribute a consumer DAT recorder through authorized distribution channels in this country.

Ray Williams
North Hollywood, Cal.

And on the Eighth Day . . .

Dear Editor:

You recently featured high-end record-playing systems on the covers of back-to-back issues (August and September 1990). Such publishing decisions must be presumed to bolster any argument for an ultimately benevolent creator.

Will the 16-bit digital format have any adherents 40 years hence? LPs are still preferred by many of us and have been since 1950, roughly. Down with paint-by-numbers digital and up with fragile, inconvenient analog.

Audio is not ignoring those of us who believe the digital domain is a contraventive one for music reproduction, specifically for unamplified acoustic instruments. Sure, digital will improve, much as modern polyester fabrics more closely approach natural fibers in feel and texture. Thanks for your continuing coverage of analog hardware.

John Hallenborg
New York, N.Y.

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*Letterbox

EDWARD TATNALL CANBY

OUGH THE COUGH

Illustration: Mary Schuck

Ever since I began a study of public audio music by *not* listening to it—ads, supermarket music, elevator music, bank music, dentist music, please-hold music, more ads—I've found myself not listening in another direction—audio *words*. How could I help it—I'm surrounded.

Ours is the wordiest era in human history, and most of those words, billions of them, are audible. We may not listen, but they impact us just the same. To be sure, most of this wordy audio says nothing much while suggesting almost anything. The quantities are huge, but the vocabulary is micro. Neo-basic English! The Hundred Great Words. *Discover, discover*. Have you "discovered" that new luxury car yet? Plonk down the cash and you will have. Now more than ever. If we are kids, we learn our language from these, we hear them a thousand times a day. Nobody, though, is going to learn to write and to spell by listening to such messages. Does daddy's seat belt talk? Some do. The people-weigher in your bathroom? The same. These words of wisdom do not require spelling. And so, it seems, spelling is going down the drain. Along with written language.

Torrents of words, audible words. Rivers of them, mountains, deserts, oceans. In comparison, for all our junk mail and newsprint, the visible word is nothing. It's an audible age, and the age of electronics and photonics too. All the world's non-audio speech, "live" from mouth to ear, is a trickle compared to audible audio.

As soon as our kids pick up the alphabet, they begin to write, not what they have seen but what they *hear*. You don't learn spelling rules on TV, except maybe on Sesame Street. You learn *the sound of language*. Audio language. And you write that sound as well as you can and quite reasonably.

"Hi Ed glad your back for another great year," writes the nine-year-old daughter of one of my Canby Singers to me. It's on paper (in colors) but redolent of audio; her rendition of *your*, in place of *you're*, is exactly as she hears it. And isn't everything on TV "great"? Basic English. This continues, now, with kids grown a lot older. "Dear Sir, Yours of the 12th inst. received and thanks." Old-fashioned business letter. "Hi Ed, my name is John and I want to tell you all about. . . ." Newfangled business letter. Guess where that style comes from? For better or worse.

This new sound of words also goes right on into new kinds of audio sound and action. Like the phone ad. I'm a reactionary; for me the phone ad is an invasion of privacy, a trespass exactly as if someone should walk through my front door uninvited. But again it is a part of where things are going. The phone rings, I run, and hear "Hi, Ed, my name is Steve and I want to tell you all about a wonderful—" *Clunk*. That's my phone answer. No use—five minutes later, another call and it's "Hi, Mr. Canby my name is Jane and—" *Clunk*. Worst of all: "Hi, and how are you today?" *Cl*— whoops, it's the editor of this mag. Or my brother.

In a curious way, then, the enormous flood of electronically audible verbiage, totally new in the recent world, is taking our language back to its ancient origins, back before there were written words or even pictographs, hieroglyphics, or any other visible approximation of the sounds of speech. Language, remember, is all natural. It has come down with us through millennia as part of the human package. We didn't invent it. We merely elaborate it, to fit our current needs. Languages grow as people grow. Language never stands still, until dead. And for most of human existence it has been exclusively *audible*. Never visible.

Languages in this state (and there are plenty left) have no problems with spelling. There is no spelling. Indeed, there are largely not even *words*—an invention of our civilized times designed mainly for the eye, not the ear. Rather, there were (and are) sound clumps, groups of sounds that convey meaning. And as for grammar, it is simply custom—the way people say things among themselves. In small societies, no more is needed.

All the rules and spellings we have devised, then, are imposed on language after the fact. We do not create language out of a set of rules! And since languages change as people change, the rules and spellings must change too, if slowly and carefully, by degrees. *Plough* into *plow*? *Gaol* into *jail*? *As if* into *like*? *Are not* into *an't* (early 19th century), *aren't*, and then *ain't* (the tomato/potato syndrome)? Creeping progress—and inevitable.

We always need codification in modern language, standards agreed upon, as we need standards in audio engineering. Communication, interfacing, is the modern reason. Nothing matters

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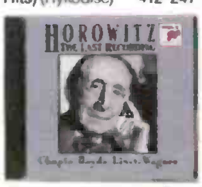

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Most of our wordy audio says nothing while suggesting almost anything; quantities are huge, but the vocabulary is micro: Neo-basic English!

as much. But the getting-together on rules for language is tough. The rules we have are often hopelessly outdated and therefore meaningless to new learners. Or merely obscure—in which case we must explain why they are so murky. Who's to believe if we merely say, "That's the way it is, and don't ask questions"? We have to be on the defensive if people are to learn to read, write, and spell as they have in the past. For kids it's primarily a sonic world. Who needs writing?

Is it really so terrible that we are returning language toward its original audible form? I think not. We'll muddle it through. We have more vital problems, such as how to avoid global war and mass murder. If we figure *that* out, our reading abilities will surely adapt to all the audio and settle eventually into new patterns, not less communicative than before. Our biggest job right now is not to put the blame on kids for being bad spellers, worse in grammar and very poor readers, but to get at teachers and persuade them to realize what is involved in this volatile audio age. They need perspective and flexibility, to cope. They must understand where language comes from and how the rules came about. And they must be emphatic as to why we stick to the rules, even so, as a working agreement that everybody understands—or should understand.

If rules are really relaxed and anything goes, according to the sound, there will indeed be a mess. There is, already. But we have no choice—we must be positive, not merely critical and rigid, if we are to stay abreast of audio language as we now have it.

I think only an older person, dating from a time before audio appeared, can really understand the pressure. Myself, for instance. I am old enough to wince at the sight of a *mispeled* (sic) word. It looks wrong. It *is* wrong. I was taught before big radio, when movies were silent (with visible subtitles), and video/TV was only a thought in the lab. And I had no trouble at all with spelling! To this day, I keep wondering howcome. Somehow, minus all our present audible verbiage, we had no problem learning spelling and writing by rote as the key to the unique world of books, magazines, newspapers, reading. We had no reason to question spelling. It was the way to exciting, joyous things, new doors to open up before us. This may sound highbrow, but it wasn't. The big world did depend, for communication, on knowing how to *read* and take in, to *write* and give forth. There wasn't any other way. So naturally we learned to spell, to the top of our ability, and few kids had trouble. Nature favors us when we are young.

In my late years, I am slow, of course, where kids are fast, in learning new languages. Computer languages, for instance. But what was once learned stays put. I scorn those built-in

Watch what

Audio Menu
1 FM Station Preset
2 AM Station Preset
3 FM/AM Preset List
4 Dolby Surround Set Up
Press number to select
Press MENU to exit menu

CD Magazine List
Mag Title
45 CHOPIN
47 BACH
48 HANDEL
49 STRAVINSKY
50 BARTOK
Use ADJUST to select
Then press ENTER
Press MENU for next

TV Tint

Time Delay Set
Front 12 Surround _8
Use 10-keypad to enter
cistance (feet) from you
to the surround speakers
Then press ENTER
Press MENU anytime for
Audio Menu

Tape Menu
1 Tape1 Counter Reset
2 Tape2 Counter Reset
3 On Screen Counter
4 Counter Search
5 Intro Scan Time Set
Press number to select
Press MENU to exit menu

VCR
REW
S E
REM 0:43
1h18m04s

you're doing.

This is something you won't see anywhere else in this magazine.

A home theater that isn't just technically advanced, but also refreshingly easy to use, thanks to one of the simplest on-screen operating systems ever devised.

Not only does it visually confirm each and every command. With the help of its on-screen

The M-R8010 receiver, with on-screen Dolby Pro Logic™ Surround setup.

menus you can narrow in on specific functions step-by-step, screen-by-screen.

As a matter of fact it works so well on our TV's and VCR's, that we've extended it to include both our M-C6010 CD changer and M-T5010 dual cassette deck.

But, as with any well-run organization, our system components work best with a coordinator. In this case our new M-R8010 Home Theater

Our M-C6010 CD changer: 8x oversampling and 18-bit dual DAC's.

receiver. With 6 audio/video inputs it can turn a TV, VCR, CD changer and cassette deck into a single, cohesive home theater.

In accomplishing this feat, our receiver is ably assisted by a learning remote. Once again, it's one of the simplest ever made. Each button

Our HS-U82 Hi Fi VCR, with S-VHS and noiseless visual search.

performs the same function across several components. For example, the play button is the same for CD, VCR, and cassette deck.

The net result is an unprecedented amount of control over your home theater.

Programming up to 20 selections from a 5-disc CD magazine takes a matter of seconds (the memory has room enough for up to 50

The M-T5010 dual cassette deck boasts Dolby® HX Pro and logic control.

different personally titled magazines).

Achieving the perfect surround sound delay is almost automatic (set your distance from the speakers and you're done).

And everything, from the simplest adjustment to the most complex program, is no sooner seen than done.

MITSUBISHI

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Our own spelling system communicates, it's easy on the eyes, and we can read it with a minimum of deciphering.

electronic aids on typewriters, word processors, and personal computers, whereby if you *misspell* a word the thing beeps. How insulting! I will not be told by a machine how I must write. See—I am a real old fogy. But I do have a certain respect, just the same, for a youngish adult who wrote me about a mild disability, a leg wound caused by a piece of driftwood hidden in long grass which was "sticken out." Isn't this the way most of us would *say* it? You can't blame him. It's that audio again.

A big part of the perspective we need is in the spelling practices of the past. Our rigid system, our agreement on what is *right*, is not very old. If you will look at 16th-century English, the glorious age of our language, you will be astonished at the haphazard spelling, any old way, even from the best minds of the time. Shakespeare? Shakspir? You could spell it as you wished. Robert Dudley spelled his name, carved in wood in a prison tower, as Robard Dudle. No rules, only a bit of agreement. But it served a small country, a few million, where things moved slowly by horse and foot and the mails were even slower than ours. Nobody seemed to mind the deciphering that had to be done when anything was read. In the face of this, our own too-rigid agreements begin to take on a lot better light.

Let me quote two segments straight from the 16th-century originals. First, a fanciful picture of Henry VIII and his royal successors, with rhyming verse along the bottom. Here's Henry:

> Behoulde the figure of a royall Kinge, One whome fweet victory euer did attende: From euery part wher he his power did bringe He homeward brought y^eConquest in y^eend And when y^efates his vitall thred had spunne: He gaue his glory to a Vertuous Sunne.

That is, he gave his glory to a son, Edward VI, who died at 16.

Considering 450 years have passed, the language is easily understandable. The spelling is not. The communication is slow, even from the very center of British Civilization, the city of London. Beyond the capital, days and weeks distant, the language was even more free in its spelling and pronunciation. For example, a ballad, a printed sheet, concerning the murder of the Regent of Scotland, a fine man much lamented by the people. This was distributed widely soon after the murder—most of the people obviously could read it, if they took the time. Can we? It begins with a sort of title:

> The Exhortatioun to all pleasand thingis quahairin man can haif delyte to withdraw thair plesur from mankynde and to deploir the cruell Murther of unquhile my Lord Regentis Grace.

Followed by seven stanzas of verse, clearly English if you can untangle them, exhorting nature to be funereal. Here's a piece:

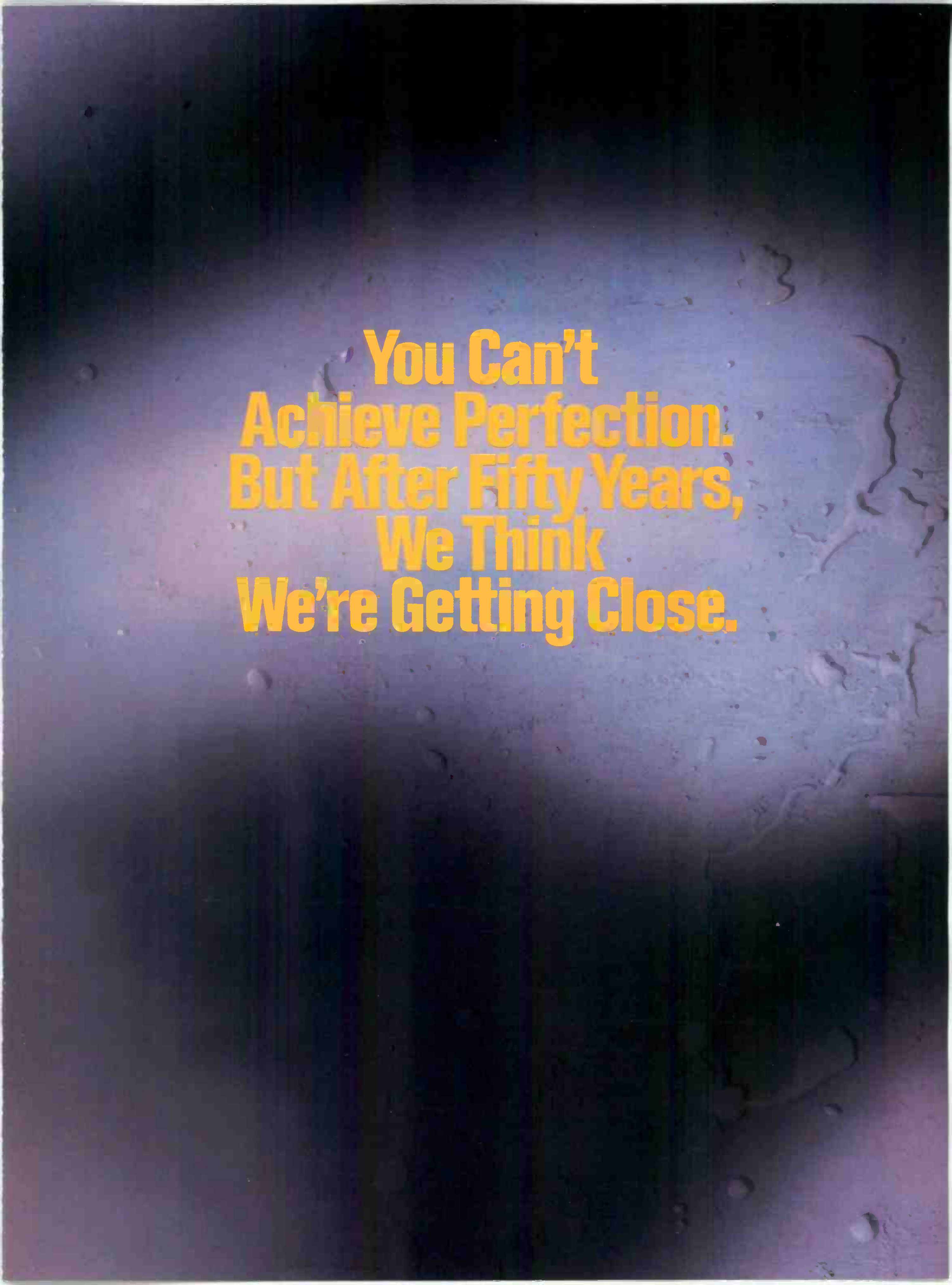
> Cum Nettilis, thornie brairis and rew, With all foull filthie weid, Now plant yow quhair thir sweit flouris grew And place yow in thir steid.

Which is to say, in modern spelling, "Come nettles, thorny briars and rue, with all foul filthy weeds, Now plant you where their sweet flowers grew And place you in their stead."

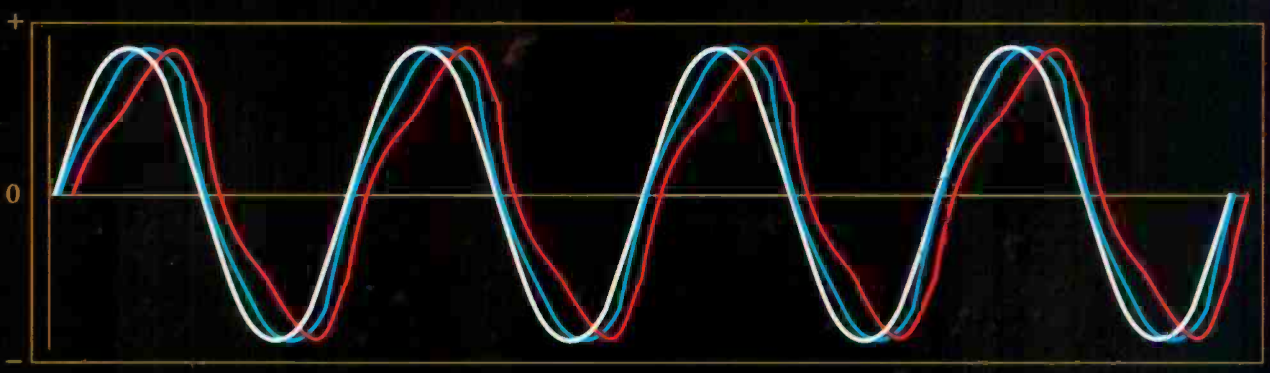
There, in so many words, is the best reason we have for our own spelling system! It communicates, it's easy on the eyes, and we can read it fast with a minimum of decipering.

Yes, spelling is arbitrary and often seems to be senseless today. What are our audio-minded kids to make of the well known *ough* words—through, plough, cough, rough, borough, though, tough, furlough? Dizzy. Suppose we had to write "off the cuff" as "ough the cough"? But these words are only accidentally the same, out of vastly different origins and times. The sounds probably always have been different. We could change that spelling—*we have already*. Plow, thru, tho, boro. These are already in use, if not official. How about coff, ruff, tuff? All in due time. We need to try out changes, without upsetting the entire system. Just bit by bit, usefully.

So teachers, be reassured! Spelling is crazy, but it fills a desperate need in this audio age for easy communication in a complex world. We need this standard, as we need those in engineering, to interconnect our thoughts. Now more than ever, I might suggest.


You Can't
Achieve Perfection.
But After Fifty Years,
We Think
We're Getting Close.

Studio Quality Speakers.



White: Waveform from amplifier.
Blue: Waveform from speaker with good transient response.
Red: Waveform from speaker with poor transient response.

"color" the sound.

The solution? We've applied Kevlar,* a super-light, super-strong space-age material, to the face of the paper cone. The result is a cone that's responsive, largely immune to distortion, and virtually devoid of discoloration. More real sound.

Another, and perhaps bigger problem with speakers is what is called transient response. That's the ability of the speaker to respond quickly to reproduce the sound without distorting it. Attached to the back of the cone is a copper wire-wrapped voice coil that moves back and forth to magnetically "drive the cone." Much like a car, once it's put in motion, it doesn't want to stop easily.

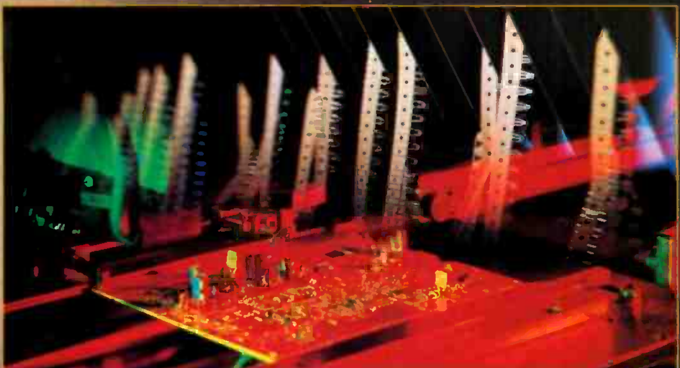
The old solution was lots of power from the amplifier. This power would stop the cone and send it back in the other direction. The accuracy of this motion determines the clarity of the sound.

But this solution doesn't really make the speaker more efficient. And if more layers of copper wire are wrapped around the coil, it takes an even more powerful amp to run the speaker. Because more wire means more resistance.

So we decided to increase the power of the coil by using square wire to eliminate the air space between the wire, effectively increasing the conductivity without adding more wire and more resistance. The result is, the power of the coil is increased, giving the driver more stopping and starting ability. Better clarity from better transient response from a more efficient speaker.

*Kevlar, Dupont®

Kentucky plant automated assembly line.

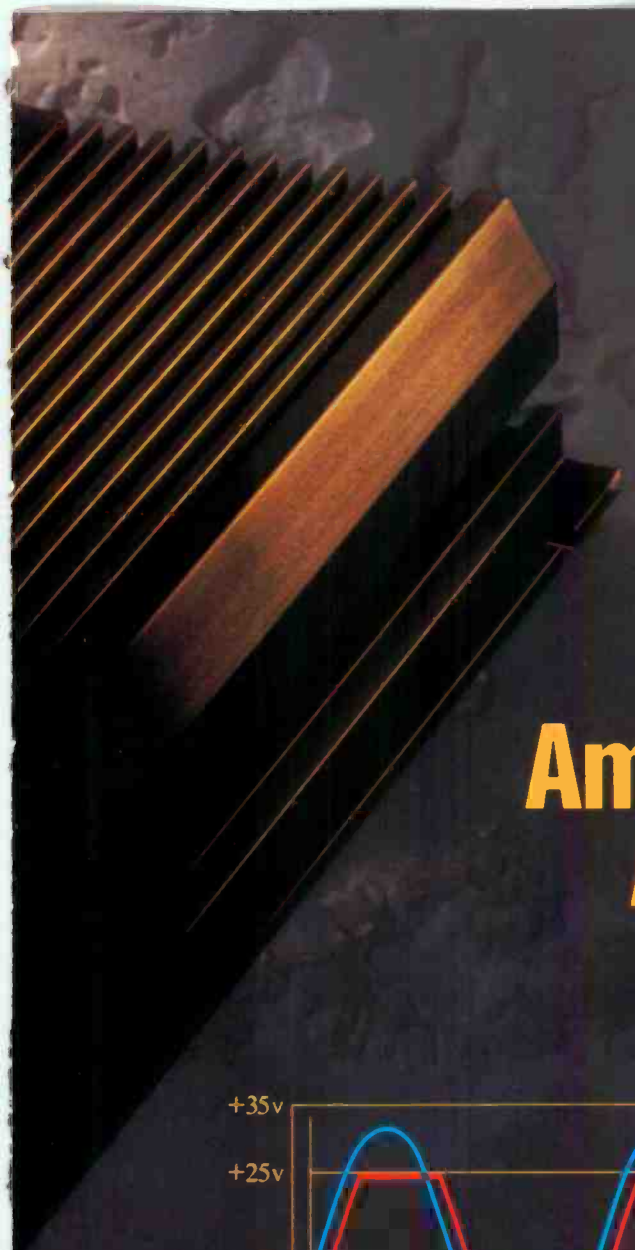


Many think the more powerful the amplifier, the better the sound. And audiophiles know that the "continuous" power rating is more important than the "peak" power rating.

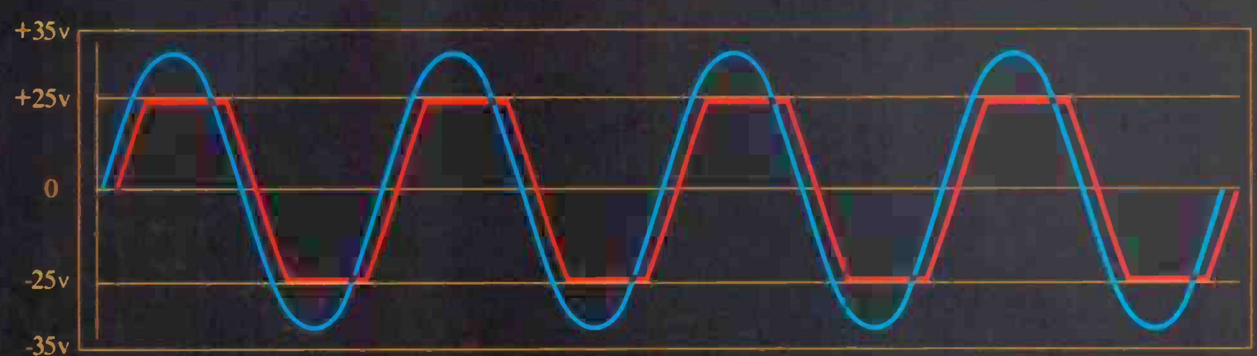
But the real test of an amplifier is not so obvious.

It's voltage. For example, a bass sound may have a sine wave, the electronic equivalent of a sound waveform, of plus or minus thirty-five volts. Not much of a problem for a 120 volt home system, but a big problem for a car whose electronic system is 12 volt.

So a car amplifier must first convert your voltage from twelve to, say, forty volts. This demands a



American Made Amplifiers.

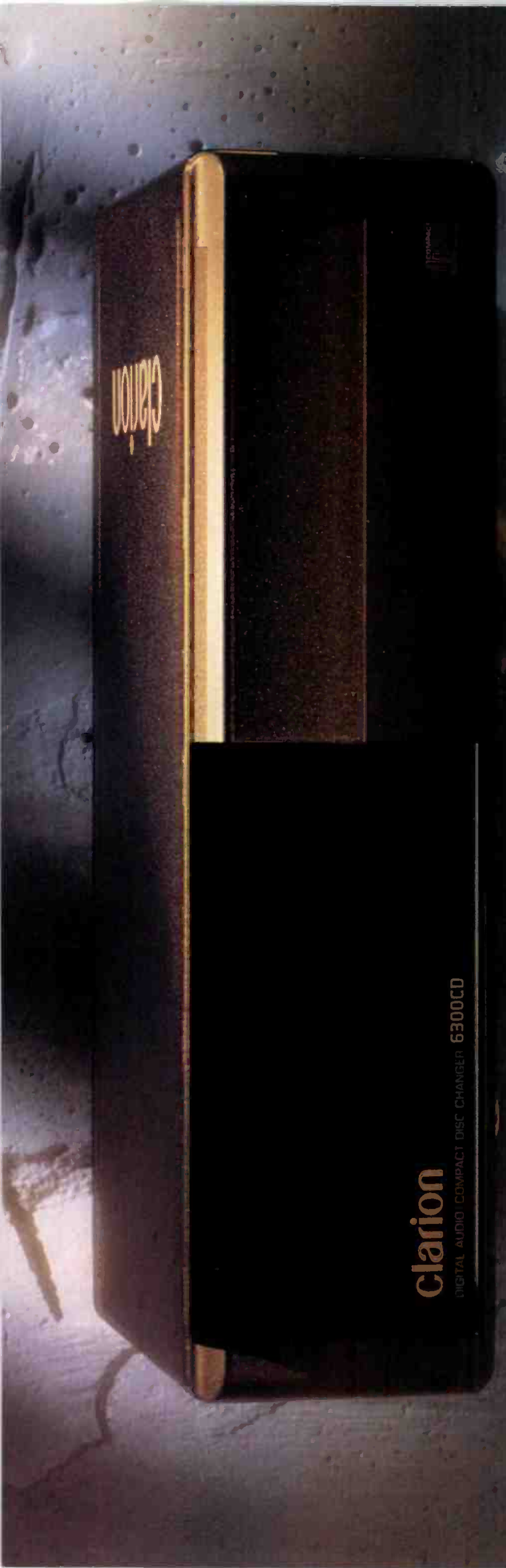


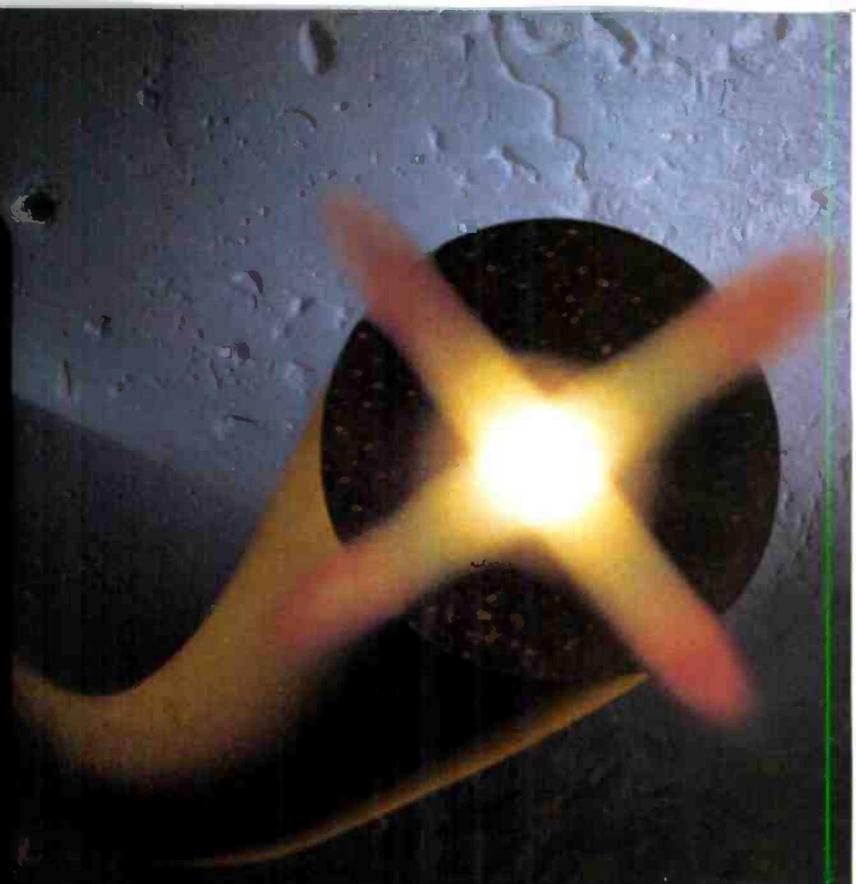
Red: Bass sound waveform of "rail-type" power supply.
Blue: Bass sound waveform of "regulated" power supply.

switching power inverter, commonly called a pulse-width modulated power supply. There are two kinds. The "floating-rail" type. And the "regulated" type used in some exclusively priced American car amplifiers built for the audiophile.

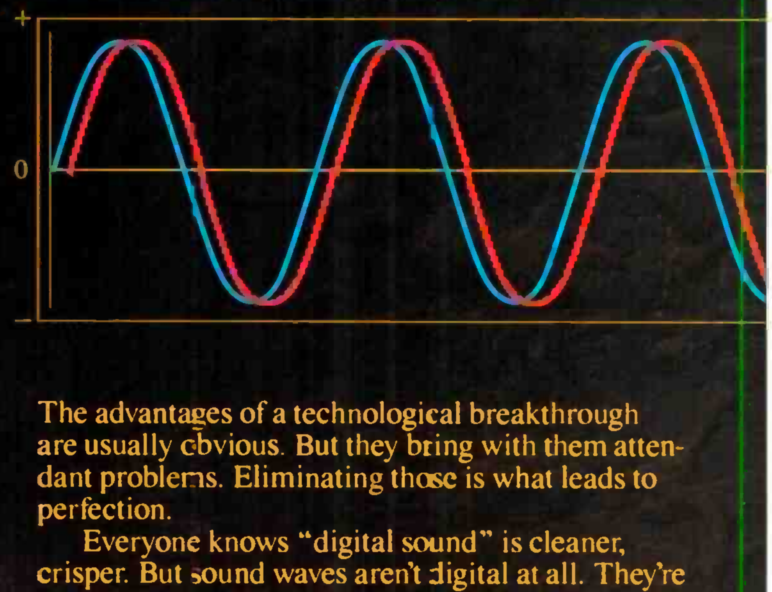
The floating-rail type works fine until a heavy bass note is amplified. Then the "rails" at the top and bottom of the voltage output collapse down to, say, twenty-five volts. If the bass sound sine wave is plus or minus thirty-five volts, the tops and bottoms of the waves get "clipped" off. So does the bass sound that you hear.

The regulated type does not collapse, even during peak demands, and therefore provides more accurate bass response. So we went to our plant in Kentucky. There we're building car amplifiers with a regulated power supply. But we're using overseas automated assembly line construction techniques. Not only to increase reliability, but to finally make the ultimate car amplifier affordable.





Blue: Output of bit stream digital-to-analog audio waveform.
Red: Output of 16-bit digital-to-analog audio waveform.



The advantages of a technological breakthrough are usually obvious. But they bring with them attendant problems. Eliminating those is what leads to perfection.

Everyone knows "digital sound" is cleaner, crisper. But sound waves aren't digital at all. They're analog. So the digital signals must be converted back to analog signals before they're sent to the speakers. The degree of accuracy of this process determines how good the sound is, how real.

The two accuracy problems involve "reading" and "converting" the digital information on the CD.

The "reading" or "sampling" occurs at 44,100 times per second. A 4x's oversampling digital filter purifies the sound at 176,400 times per second. And our 8x's oversampling CD units, 352,800 times per second. By utilizing an 8x's oversampling digital filter, virtually all harshness and coloration of sound are eliminated.

Fiber Optics Digital Sound.

With a conventional 16-bit CD, the sampled information is converted to an analog signal in this 16-bit "chunk." Big chance for error. Because the order within this chunk may be almost random. Take the numbers 1, 5, and 9. Arrange them in one order and the number is 951. In another, 519. Big difference. And in a 16-bit binary environment it could be even worse. Because the least significant bit represents the number 1 and the most significant, 32,768. A gap far greater than that between the decimal numbers of 1 and 9.

So our digital-to-analog-converters, DAC's, don't convert the data in chunks. They do it one bit at a time. It's called "bit streaming." And it ensures that the analog waveform that is sent to the speakers is the ultimate in accuracy.

And because we're reaching for perfection, three more quick features. Our CD's are almost skip-proof. So don't worry about bumpy roads. And our disc-to-disc access time is [illegible] No more twenty seconds of silence. And [illegible] CD changer unit employs a fiber [illegible] through the car up to our head[illegible] you've gone to all this trouble to [illegible] and accurate, why mess it up [illegible]

More [illegible] with our FMC [illegible] existing in-dash FM [illegible] ting and splicing. Wh[illegible] your car, just unplug [illegible] car's audio system is still just like it [illegible] the factory.

Last, but certainly not least, is DAT. Digital Audio Tape units. We not only have them, we developed the first DAT player for the car. Our current model not only plays DAT's but also controls our CD changer. The ultimate in digital entertainment.

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You've probably heard of "concert hall" sound. It artificially creates "reverb" or a delay in the sound sent to the two front speakers and puts that in the back two.

We've created a DSP unit. A digital signal processor. What makes it seem like you're "really there" is that real sound reaches your ears in two ways. Directly. And indirectly, later, bouncing off the walls. Our unit actually measures the exact delay time of this "ambient" sound, how long it lasts, and its rate of decay. This recreates the real sounds, the real environment.

Our equalizer in the DSP 959 is digital. Just like in the recording studios. So there's no added noise or sound.

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BERT WHYTE

LISTEN UP!

Although new models of headphones are introduced every year, there have not been any really significant advances in the technology of these devices recently that would constitute a performance "breakthrough." However, the inherent qualities of the digital CD—its absence of noise artifacts, low distortion, and cleanness of reproduction—have greatly encouraged headphone listening. Headphones are also beneficial to apartment dwellers who must keep sound level low, or to families who share the same space but listen to different things.

Headphone users have a very broad choice of models at various levels of cost and in quality of reproduction. Those seeking better quality headphones can choose between many models using dynamic drivers and a few models that employ electrostatic drivers. Generally, the electrostatic models are more expensive than dynamic headphones, and there is a broad assumption that the very highest reproduction quality from headphones is available only from those employing the electrostatic principle.

Until now, it has been my experience that the top electrostatic headphones do provide a superior sound, with very fast transient attack, more air and transparency, less distortion, and wider frequency response than their dynamic counterparts. This better electrostatic sound imposes a logistics problem in that a power supply is necessary to provide a polarizing voltage to the electrostatic elements. Thus, unlike dynamic headphones, they cannot simply be plugged into a headphone jack on a receiver, preamp, cassette deck, or CD player.

Needless to say, if there were a headphone with dynamic drivers which could not merely equal but surpass the quality of reproduction available from the best electrostatic 'phones, this would be a real breakthrough product with many applications. To have 'phones of this quality able to simply plug into a jack would be invaluable.

I am pleased to report that rather than imagining some fantasy headphone of the future, a headphone with these desirable characteristics is now available in the form of the Joseph Grado Signature Products HP-1 headphones. Yes, he is the same Joe Grado who has been designing and manufacturing high-quality phono cartridges for many years. He still produces his unique moving-magnet phono pickups, sold worldwide. Like all manufacturers of phono cartridges, Grado is aware of the declining market for them due to the encroachments of the Compact Disc. Thus, his diversification into headphone manufacturing is understandable. However, Grado certainly knew that there was no dearth of headphones on the market, so in keeping with his basic design philosophies, he knew that his headphones would have to possess unique qualities and cutting-edge performance to be competitive.

I've known Grado for almost 40 years. He is a remarkable person, and to call him a Renaissance man would be quite apt. In his early years as a highly skilled watchmaker, Grado worked with tiny, high-precision, delicate parts. This background was invaluable when he started to design and manufacture phono cartridges.

Grado takes a perfectionist approach to everything he gets involved with. He is strongly iconoclastic and seems to have an intuitive knack for stripping away things that are mere facade; he gets down to the basics. His interests are far-ranging—he is a high-performance car enthusiast, has flown his own plane, and built violins. Over the years he has become a materials expert. His love of audio is balanced by his love of music. Grado is a splendid tenor and has given recitals in Alice Tully Hall in New York City and has sung in such operas as *Tosca* with the Honolulu Opera Company.

Over the years, Grado and I have always agreed on one subject—the destructive effects of resonances on sound reproduction. In every component of an audio system, unsuppressed resonances wreak their havoc on the sonic integrity of the music signals. In the design of his HP-1 headphones, Grado has employed his knowledge of materials, along with special fabrication techniques, to make a headphone as free of resonances as possible.

The HP-1 headphones are very straightforward, clean in design, with a rather high-tech look to their circular, machined alloy drivers and sliding-pillar positioning devices. The headphones are made from a very hard aluminum alloy. A proprietary processing method increases the porosity of the alloy. This gives the alloy a more open structure, and further processing then fills in the structure with anti-resonant damping material. This treatment suppresses the ringing resonances of

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In the HP-1 design, Grado's knowledge of materials and special fabrication techniques resulted in a headphone nearly free of resonances.

the earphone chambers which house the diaphragm, voice-coil, and the magnetic driving system.

The diaphragm, made of a low-mass plastic which has a high internal damping factor, is modified to selectively broaden the resonant frequencies. The diaphragm mass is selected with the compliance of the suspension in mind, so as to provide the desired low-frequency resonance.

Grado says: "The mass of the diaphragm is low enough to produce a full 20-kHz bandwidth, and yet it's stiff enough to produce high volume levels with no increase in distortion compared to low-level performance. I found this direction much better than going for a very light and very fast diaphragm action, which would give me a more extended top end; such a design carries the penalty of more diaphragm breakup and much more distortion at higher levels and at all frequencies, as with many electrostatic earphones. Theoretically a lighter diaphragm is supposed to be better, but in the real world this is rarely the case. It is much more important to me to use a diaphragm that will reproduce superbly clean sound at any volume level at all frequencies rather than extend the high frequencies for no practical reason. It really is a trade-off: Do you want a little more speed with a sharp increase in distortion, or do you want low distortion with speed that is already much more than what is really needed for the fastest known music signal rise-times? Keep in mind that a light diaphragm will cause frizzy highs, distorted midrange, and—worst of all—deficient, tubby, or muddy bass."

The outer perimeter of the diaphragm is bonded to the earphone chassis and is suspended by its own elastomeric stiffness. The adhesive used in the bonding is inert, which helps to subdue diaphragm rim resonances. The diameter of the voice-coil is calculated to ensure that the full area of the diaphragm is driven with as pure a piston action as possible and to minimize diaphragm breakup modes.

The voice-coil is made of a special ultra high-purity copper wire that is drawn through the die very slowly and in extremely small increments, and it is annealed following each of these drawing operations.

The magnetic drive system of the HP-1 headphones utilizes a neodymium structure of very high power, for maximum efficiency and to control the diaphragm excursions at high volume.

In his zeal to suppress resonant colorations, Grado even researched various materials for the headband padding, and a combination of plastics and insulation provides high damping for the spring steel headband.

Grado contends that no single accepted measurement device can provide accurate data on headphone performance. He cites his experience in manufacturing his phono cartridges, in which 10 different stereo test records will provide 10 different curves. So Grado uses the Brüel & Kjaer headphone analysis system as well as several other devices, correlates the data from all of them, and uses this information in making various adjustments and modifications to the headphones. Grado states that the HP-1 headphones are flat through the full audio frequency spectrum. More importantly, he feels that the relentless suppression of resonance, in every possible way in every element of the headphones, has dramatically reduced distortion, even at relatively high volume levels.

The HP-1 headphones can be efficiently driven from the 'phone jacks of most preamps, CD players, cassette decks, etc. However, for those who want to take fullest advantage of the low distortion characteristics of the HP-1 'phones, Grado has introduced a companion headphone amplifier. The unit is 2½ in. H × 6 in. W × 7 in. D and weighs a little over 2 pounds. To avoid any a.c. line hash or other problems, the amplifier is powered by batteries. A compartment within the unit houses four standard 9-volt batteries; two of them will power the amplifier for 50 hours, and the other two are spares. The amplifier has stereo RCA line in and out jacks, an on/off toggle switch for battery power, a ¼-inch jack for headphones, and a precision volume control which is said to track from 0 to −70 dB within 0.5 dB. The amplifier circuit operates in a special, advanced Class-A mode. The unit can also serve as a line stage to feed a power amp, depending on the setting of an output switch. The Grado headphone amplifier costs $650. The HP-1 head-

Comparing the Grado HP-1 with electrostatic 'phones, it was apparent that there was more bass extension and resolution in the Grados.

phones, which are equipped with toggle-type polarity reversal switches mounted on each earphone structure, are $595. The HP-2, without polarity switches, is $495.

Apparently, these extraordinary headphones have generated great interest in the audio engineering fraternity. I was impressed to learn that such sonic nit-pickers as mastering engineer Bob Ludwig of Masterdisk uses them in his evaluations, as does Tom Jung of dmp and Dick Sequerra of FM tuner fame. The Grado HP-1 headphones are also being used by audio amplifier manufacturers as a sort of auditory measuring tool to evaluate circuit changes.

I compared the HP-1 to what is generally regarded as the best electrostatic headphone—the Stax Lambda Pro, which has been my reference unit for quite a few years. I was able to compare not only the sound qualities of the headphone, but the sound of the HP-1 driven from the output of a Sony CDP-X77ES versus its sound via the Grado amplifier.

One of the great advantages of the electrostatic headphones had been their superior bass response. To compare the HP-1 in this parameter, I used the superb Dorian CD of the organ works of César Franck (DOR 90135). The great organ of St. Eustache in Paris has awesome 32-foot pedals, and the third track, "Fantaisie in A," opens with a tremendous outpouring from them at their 16-Hz fundamental. Listening first through the Grado HP-1 and then the electrostatic 'phones, it was immediately apparent that the Grado had more bass extension and resolution, as well as significantly less distortion. The middle- and upper-frequency reeds and brass were noticeably cleaner, and there was heightened ambience presentation. My keen-eared wife, Ruth, verified my findings. We went on to the Telarc CD (80255) of Michael Murray playing the magnificent Willis organ in Salisbury Cathedral in England. The second track, "Fanfare" by John Cook, shows off this organ's absolutely incredible choral reeds. The brilliance and projection of these reeds in the vast acoustic space of this cathedral is breathtaking.

We ran the gamut of CD music, from solo piano to massive symphonic and choral works. In every case, the cleanness, low distortion, and openness of Grado's HP-1 'phones were a revelation. Voices were beguilingly smooth, and choruses were beautifully articulate. In Tom Jung's dmp recordings, all of his exciting percussion and subterranean bass synthesizers were heard with absolute transient accuracy and speed.

The Grado HP-1 headphones are clearly the best I have ever heard, and for a reviewer, they are invaluable for close, detailed analysis of recordings prior to loudspeaker evaluation.

JOHN EARGLE

FORMATTERS

Illustration: Michael Donato

Is the consumer entirely at the mercy of manufacturers regarding the introduction of new program formats for home use? Basically, yes; few standards have been promulgated by impartial engineering committees before product introductions, and most official standards are simply rubber stampings of what has already come to pass.

Consider the LP and 45-rpm war of the late '40s. Peter Goldmark of Columbia had great foresight in promoting a medium that combined low rpm (extended playing time) with reduced stylus size and quiet vinyl material in making records. Curiously enough, RCA had invented basically the same thing in the early '30s. What Goldmark did was to convince the consumer electronics industry to form a united front of software and hardware manufacturers so that marketplace success would be ensured. Rather than applaud his efforts, RCA chose to counter Columbia with a different format, the 45-rpm 7-inch disc—which failed miserably in its intended mission but became a substitute for the 78-rpm 10-inch record instead. The ancient conflicts go back to disc versus cylinder and vertical versus lateral groove modulation. More recent battles can be cited: The 8-track cartridge versus the Philips Compact Cassette, Beta versus VHS for home video use, and lately, the impact of 8-mm videotape on both VHS and Beta.

In open technological societies, companies are encouraged to develop new consumer formats on their own, and in the United States anything resembling collusion between companies is quite suspect, even if it is for the public good. The primary driving force is economic, and the rationale is often little more than developing a new format to prime a lagging marketplace. The secondary driving force is technology itself, and it is paced by the rate of progress in materials science and in manufacturing methods.

Let's first consider tape-based audio formats. Open-reel tape was a big thing in the '50s and was, for a number of years, the only way to hear stereo at home. As tape manufacturing improved significantly, it became possible to double the number of tracks and even cut the speed in half. New formats were introduced without regard for compatibility, and new machines were required. The Philips Compact Cassette put an end to the compatibility problem, and all developments through its remarkable 25-year history have had both backward and forward compatibility. That is, old tapes will play on new machines, and vice versa. With the strides made in tape quality and noise reduction, it is no wonder that the cassette has become the world's most successful medium for recorded sound. If it is to be supplanted, I don't think it will be by R-DAT but rather by the scarcely talked about Philips Digital Compact Cassette, which promises backward compatibility via machines that will play and record the new digital cassettes as well as play back the old analog ones.

When it comes to home video formats, things have not been very orderly. The war between Sony (Beta) and JVC (VHS) has been costly for all concerned, and in the end neither one will win. I believe both will fall to the 8-mm cassette, which has taken advantage of newer tape technology. And VHS-C, in my opinion, has about the same chance against 8 mm as the 45-rpm 7-inch disc had against the LP.

Even on the professional side of video, there has been little long-range standardization in operating formats. The original quad machines which used 2-inch tape are long gone, and the helical scan C-format, with 1-inch reel-to-reel tape, is now considered old. What has replaced these machines are the cassette formats, which are much easier to use and which have benefited from improved tape formulations. Of course, what really *is* standard in video is the NTSC signal format (in North America, Japan, and a few other places), which makes it possible to go back and forth between recording formats. Since the signal format is defined electrically, it is not inherent in any given recording format. (Much the same can be said for computers and their operating systems. While program conversion may be difficult, data files can be transferred easily between computers via ASCII characters.)

The motion picture industry has a different set of problems. For much of its existence the industry has had two film sizes, 35 and 70 mm. Since the medium is photographic, the "signal" is inherent in the medium and cannot be transferred from one form to another without loss. But even with the two film sizes, there are perhaps seven different projection standards, depending on aspect ratios (screen masking) and optical requirements. That indus-

In the long run, consumers benefit from rapid format changes, while corporate greed and engineering ego have had little impact.

try changes relatively slowly, and although high-definition video will offer major economic improvements in post-production, the original "shooting" as well as public exhibition will remain film-based for a long time. With the advent of digital sound in the movie theater, the 35-mm format will become the standard; 70 mm will find its home in special applications such as Showscan and IMAX, where the greater "real estate" of the larger film frame can be used to advantage.

For a consumer format to be viable in the long run, it should be economical to manufacture and should keep pace with the state of the art in quality; improvements in performance should be compatible with older playback equipment. The LP enjoyed these advantages for many years, but it eventually became obvious that the quality objectives were not being met. It had come to the point about 15 years ago where the costs of manufacturing an audiophile-quality LP demanded a list price of $18! While some may not agree, the CD *is* of audiophile quality if its producers and engineers make the right decisions—and the price tag is about $13. The stunning success of the CD is clearly a case where century-old technology had not been able to keep up with current quality demands.

In video, the rapid pace of technology has produced equally rapid changes in format, compatibility be damned. This is inevitable, since compatibility often becomes victim when weighed against improvements in manufacturing economy. In the long run, the consumer has benefited from rapid format changes—and I certainly don't feel that anyone can honestly look upon a collection of 2,000 LPs or VHS cassettes as ever being obsolete.

Corporate greed and engineering ego have had relatively little impact on the overall progress of format development. Only a few cases need be cited: The quadraphonic debacle of the '70s, the feud between RCA and CBS in both records and TV standards, and the Beta/VHS standoff are the prominent ones. These are more than offset by Philips' skillful handling of the Compact Cassette standard for more than a quarter century and the cooperation between Philips and Sony in promulgating the standard for the CD. A

IVAN BERGER

COMPETITION GROWS IN TENTS

Photographs: Ivan Berger

It's easy—but incorrect—to think of car stereo contests as sheer noisefests, with the biggest money going to the loudest car. The first contests were crank-'em-ups to see how loud, rather than how good, car sound systems could be. And even at the International Auto Sound Challenge Association's finals last November, about half the cars at the manufacturers' tents were doing their utmost to out-thump each other.

Far from the hubbub and hoopla of the manufacturers' midway were other tents, however, where the competitors' cars were judged. There, sound level took a back seat to sound quality. Under IASCA's 1990 to 1991 rules, sound pressure level can account for no more than 30 of a possible 445 points, with the rest about equally divided between the quality of sound and quality of installation.

Sound pressure level is, however, the first check made in IASCA's judging process. Contestants get one point for each measured decibel of SPL between 100 and 130. In earlier years, points were awarded for up to 140 dB SPL, but even after this reduction, few cars reached the maximum, according to IASCA judge Paul Miles of Linear Power. Miles reports, "On the score sheets I saw, most people achieved at least 10 to 12 points, but outside of the unlimited-power class, only about 35% to 40% of the entrants got the maximum point score." Certainly none of the contestants whose cars I heard tried to impress me with their system's volume, while even the systems that won no prizes this time impressed me with their sound.

The judges who check SPL also check frequency response, using a third-octave real-time analyzer. Points are awarded only for the smoothness, not the flatness, of the system's response at this stage, but the effect of curve shape shows up later, in the subjective sound-quality analyses. The measurement is based on a single microphone position, though several years ago Earl Geddes of Ford showed that, for proper accuracy, measurements should be made from several mike positions and averaged together.

Contestants can set up their systems for either smoothest frequency response or maximum sound output, but they are unlikely to manage both. IASCA points out that optimizing a system for maximum SPL can trash one's frequency response score, while systems with good frequency response lose only a few dB of SPL—good advice that's already become contestant folklore.

Contestants may, however, spend up to a minute readjusting their systems' equalization and front/rear balance (but not volume) before their cars are judged for sound quality, the next step in the process. As one contestant told me, "There's a difference between what the machine wants to hear and what you want to hear, quite a difference. When you're going for an RTA, you set all your controls for the flattest frequency curve possible, or at least one that's flowing smoothly. But for ears, since people don't listen like machines, you might like to hear your highs a little louder, your mids increased a little bit, or maybe a bit more bass punch. You try to get a little more real-life concert realism when you set it up for sound quality. Every judge is different in what he likes to hear. So you set it up for what you like to hear and hope that's what he likes."

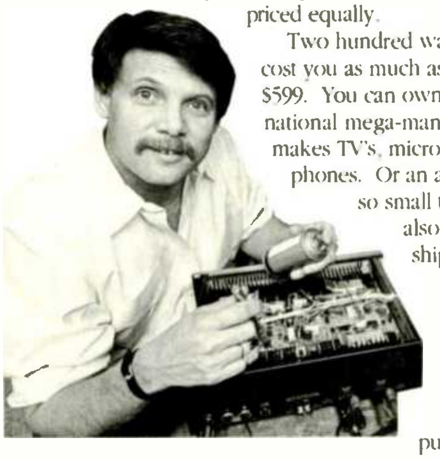
The 180 points awarded for sound quality are divided among front/rear staging (40 points), stereo imaging (40), frequency separation and clarity (40), sound linearity or frequency balance (20), and absence of noise (40). An ideal car, according to IASCA, would have front staging with some rear fill, definite left- and right-channel separation with a strong center image, clear sound in all parts of the frequency range with no mutual interactions, a balanced sound at both high and low volume levels, and no audible noise from the car's electrical system or the audio system's components when played at full volume.

IASCA judges taking a well-earned bow after rating nearly 250 sound systems and installations.

Except for the rear fill requirement and the check for car-generated noise, these would all be good criteria for judging home stereo systems too. That's less true of the criteria for installation quality, which accounts for even more points (195) than sound quality. These installation points are divided among system cosmetics, wiring cosmetics and integrity, component installation architecture and mounting integ-

HOW MUCH SHOULD A GOOD AMPLIFIER COST?

Reflections on the esoteric myths and economic realities of power amplifier design, by Bob Carver.



Thumb through *Audio's* Annual Equipment Directory and you'll see vivid proof that all power amplifiers are neither created equal nor priced equally.

Two hundred watts per channel can cost you as much as $8,400 or as little as $599. You can own an amp from a multinational mega-manufacturer who also makes TV's, microwaves and cellular phones. Or an amp from a company so small that the designer is also the assembler and shipping clerk.

Can it be that amplifiers are sonically equal? Some seem to have muscular power reserves far beyond their FTC-rated output. Others sound great until they're challenged by a dynamic passage and then sound like a Buick hitting a row of garbage cans. Some are (to indulge in audiophile jargon) so "fluid" that you practically need a drop cloth under them. Others seem to sound harsh, "metallic" and brittle at any output level.

A casual comparison of perceived sound quality versus price tags may lead to an erroneous conclusion: that an amplifier must be *expensive* to sound good.

The truth is a bit more complicated: Cosmetic glitz aside, an amplifier's cost is primarily determined by its power supply.[1] In other words, within reason, you generally do get what you pay for when you buy a conventional amp design. But the key word here is "conventional."

My decidedly *un*-conventional Magnetic Field Power Supply is capable of outperforming conventional power supplies of the same size. Result: A significantly better power amplifier value for you.

Let me explain.

NO MAGIC. JUST FOUR CRITICAL QUANTITATIVE FACTORS.

When I fervently state that "*the sound of an amplifier need not be related to its price*," you might think we're veering off into the land of Snake Oil and Gimmicks. Quite the contrary.

I and other members of the scientific audio community know that just four factors determine the sonic characteristics of an amplifier:

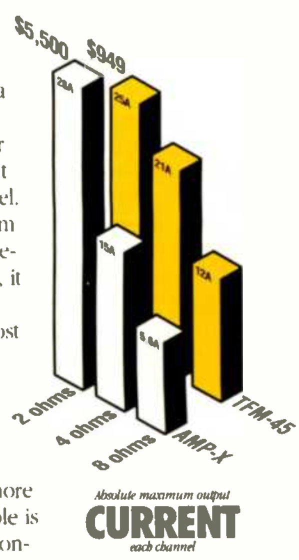
1. *Current output*
2. *Voltage output*
3. *Power output*
4. *Transfer function* ***as evidenced by the interrelationship of frequency response and output impedance.***

These factors transcend the usual trivial debates over tubes vs. solid state, MOS-FETs vs. bi-polar, Class A vs. AB, silver Leitz wiring vs. copper, gold-plated front panels, WonderCaps and my favorite: hand-ground-open transistors filled with a proprietary crystalline substance that stops ringing (honest, I'm not kidding!). An amp can have any combination of these entertaining variables (plus special bricks stacked on top) and yes, sound wonderful...provided it ALSO has high current, voltage and power output and the correct output impedance.

Thus the Four Factors explain why expensive amplifiers generally sound better than cheap amplifiers. But also why that doesn't necessarily have to be the case.

FACTORS 1-3: THE POWER SUPPLY BEHIND THE SOUND

An amplifier's power supply produces current and voltage. A preponderance of one without the other is meaningless.[2] To maximize SIMULTANEOUS current and voltage output using traditional design approaches costs serious money. For example, we recently tested a competitor's $2,000 amplifier that was rated at 20 watts/channel. Believe me, from a parts and materials standpoint, it was worth $2,000, with most of that money being spent on an amazingly rugged power supply. Another more extreme example is my own ultra-conventional Silver Seven Tube amplifier design. Its "money-is-no-object" power supply helps set the price of a pair of S-7's at around $20,000.00.



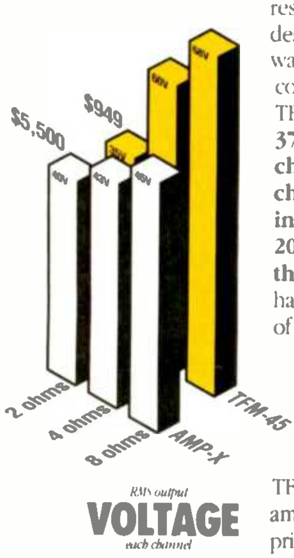
Now, since it is universally agreed among amplifier designers that current/voltage/power output directly affects the sound of an amplifier, and since good traditional power supplies are costly, price and sonic quality ARE often closely related.

But what if there was a way around the economic constraints of conventional, inefficient power supplies? What if there was a power supply that could deliver awesome simultaneous current and voltage into real-world speaker impedances without shocking your pocketbook?

TFM-45; 375 watts RMS/ch. into 8Ω 20-20kHz with no more than 0.5% THD ($949 sugg. retail.)and TFM-15; 100 watts RMS/ch. into 8Ω 20-20kHz with no more than 0.1% THD ($399 suggested retail).

That's just what my patented Magnetic Field Power Supply does. Without gimmicks, mysticism or loss of bass response. Simply put, a Magnetic Field Power Supply uses progressively more of each line voltage swing as amplifier power demand increases. It's just plain more efficient. How and why this works is explained in our new White Paper called *"The Magnetic Field Story Parts I, II & III"* which you can get free by calling 1-800-443-CAVR.

Right now, let's consider the tangible benefits. The series of comparison charts in this ad shows how my Magnetic Field Power Supply successfully challenges the previously hard-and-fast rule that high-performance power supplies must be expensive. Amp X is a highly-respected solid state design rated at 200 watts into 8 ohms. It cost $5,500. My TFM-45 is rated at **375 watts per channel both channels driven into 8 ohms 20-20KHz with less than 0.1% THD.** It has a suggested retail of $949.



Even more impressive is this same sort of comparison chart with the TFM-45 vs. other amplifiers in its own price range. In deference to how utterly we trounce similarly-priced, conventional competition, we've confined those charts to our new White Paper.

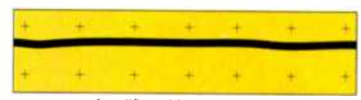
To summarize: Magnetic Field Power Supply technology allows reasonably-priced power amplifier designs to deliver simultaneous current and voltage levels previously only found in extremely expensive "esoteric" designs. Or to look at it another way, in a given price range (say $900-$1,000), Carver simply gives you far more for your money.

FACTOR 4: TRANSFER FUNCTION

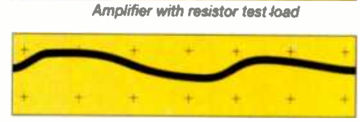
Consider two hypothetical amplifiers with identical power supplies. Same power rating; same gain, etc. Yet they still sound different when powering identical speakers through identical cables.

Why? A fourth quantifiable factor is at work. One that, unlike power supply output, is totally independent of economic constraints.

I've left Factor 4 (transfer function/frequency response/damping) until last intentionally. Because until an amplifier can deliver sufficient power with simultaneous current and voltage (Factors 1-3), transfer function is immaterial.



Amplifier with resistor test load



Same amplifier connected to cables and loudspeaker.

Frankly, I'm guilty of not making this fully clear in the past. Some readers may have gotten the impression that by magically adjusting some arcane parameter called transfer function, one could somehow cause a cheap amp to sound like an expensive one. Nothing could be further from the truth. If there's no guts (power supply), there's no glory (optimized transfer function).

By transfer function, I mean the effect an amplifier's output impedance has on real world frequency response. I don't mean the flat, "DC to light" Rated Full Power Bandwidth found in column 11 of *Audio's* Equipment Directory, which is measured using a resistor as a load. Rather, I'm referring to the frequency response curve that occurs when an amplifier and speaker cables interact with a specific speaker.

As distinctive as a fingerprint, this curve determines the "sound" of each amplifier design. Its warmth or harshness. The quality of the bass. The definition of its upper registers. Even the configuration of the stereo "sound stage" it can create.

My engineering department and I are capable of making one amplifier design sound like another amplifier design to within 99 parts out of 100 (a null of 40dB). For example, we've used Transfer Function Calibration to closely emulate the sonic characteristics of my reference Silver Seven in our TFM-45 and TFM-42 solid state designs. In other cases we've used the process to simply adjust the sound of an amplifier to have pleasant but unique sonic characteristics: in general, a warm "tube" sound with rich, rolling bass and soft yet detailed treble (such as our TFM-22/25, S-7t and TFM-15). Either way, we use painstaking measurement and adjustment processes to finetune output impedance frequency response. Not magic.

And, needless to say, we start with highly capable power amplifier designs before the Transfer Function Modification process.

ARE YOU INTRIGUED...OR THREATENED?

My Transfer Function Calibrated power amplifiers have suggested retail prices of from $399 to $1,000. That I even dare to suggest they can sound as good as designs in the $2,000 to $6,000 price range has not endeared me with some audiophiles or underground magazine writers.

That's a real shame, because I have absolutely nothing but respect for well-made, high-ticket conventional amplifiers. Like Rolexes and Lamborghini's, they are a joy to own if you can afford them. But just as a Rolex doesn't tell time any better than the inexpensive watch I'm wearing right now, good sound does not necessarily have to be costly.

If this concept intrigues you, please visit a Carver dealer soon. Bring demo material you're familiar with and be willing to do some critical listening. Compare my designs to competition costing about the same amount as well as to more expensive models.

Your ears alone should be the final arbiter. I feel confident that you will join the tens of thousands of audiophiles who have gotten the best possible value by owning Carver.

Bob Carver

Bob Carver, President

CARVER

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[1] My definition of cosmetic glitz is any part of an amplifier whose sole audio contribution is to cause one's friends to go, "Ooooo!!" when they see one's new purchase. My own Silver Seven amplifier's hand-rubbed piano lacquer and solid granite surfaces meet this definition

[2] Since power (watts) equals voltage times current, the same wattage can represent significantly different combinations of voltage and current — and thus very different performance into the same load

Music with the breath of life.
Until now, only vacuum-tube or hybrid amplifier technologies could deliver the vivid dimensionality and fine textures of living, breathing music. Solid-state amplifiers were a musical promise largely unfulfilled.
The new D240 stereo power amplifier from Audio Research changes the picture. Gloriously. At last, there is a solid-state amplifier to actually rival vacuum-tube designs in their ability to mimic the complex envelope of real instruments sounding in a real space.
Better yet, the D240 offers this stunning musicality in a mechanical enclosure that is compact, cool-running and maintenance-free. Once you install the D240 in your home music system, you can sit back and forget everything but the music.
If you're a music lover who appreciates the glories of the vacuum tube, but wants to breathe easy when it comes to maintenance, the D240 is the promise of solid-state fulfilled. Best of all, it comes from the audio manufacturer with over 20 years of experience and leadership advancing the art and enjoyment of music reproduction: Audio Research.
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In IASCA contests, loudness still counts but the goal is maximum accuracy, not maximum thunder.

Installation details like these boost an entrant's score. This fake spare tire concealing a CD changer and easily accessed fuses helped Greg Cassis of Wheeling, West Virginia take second place in the Amateur 501 to 1,000-watt class with his Buick Riviera.

rity, ergonomics, attention to detail, and general creativity.

Competitors are given three minutes at this stage to explain unusual aspects of their systems. Larry Frederick of Phoenix Gold, a chief lane judge, told me that many contestants beat this time limit by preparing an album that highlights the construction of the vehicle, with photos, diagrams, an equipment list, and so on. "It's getting so technical now that people really need to see and list all the things, because you can't remember it all," he said.

Cosmetic factors (40 points) are based on how well each part of the system is made to look like a real or idealized factory installation or how well it's highlighted to look like the one-of-a-kind system it is. Wiring and electrical systems (45 points) are judged on neat layout of visible wires and concealment of those that should not show, proper wire size and fusing, and the use of high-output alternators and additional batteries. Simple formulas are used to determine if the wires are big enough to carry the current the system demands. A wire may be heavy yet still not heavy enough; Frederick tells of one "ground-pounder" playing so loud that it melted a 1-gauge (about 0.3-inch) wire!

The component installation category (55 points) covers neatness and physical security of installation, proper amplifier cooling, and ease of servicing. Ergonomics (the ease with which judges can operate the system from the driver's seat, with no prompting from the contestant) is good for up to 20 more points. Attention to such details as the car's interior and exterior cleanliness, and matching of fabrics and paint colors, can garner another 15 points

Up to 20 points can be awarded for general creativity and ingenuity in improving performance and installation quality, but these are bonus points and are awarded sparingly. Judges may give only one point for each idea that merits it, and must jot that idea down on the score sheet. Frederick feels that the creativity level of the cars in the IASCA finals is extremely high—but then, it has to be: "When you work on a car, especially at this level, you have to become an audio engineer to figure out how to make the car sound good."

All this evaluation takes place behind the scenes, which lets the judges work in peace and quiet. It also keeps the crowd from realizing that the judging, as a spectator sport, ranks between chess and watching grass grow. Only the competitors really feel the tension and excitement.

The only judging open to spectators is the unlimited SPL contest, in which cars measured as high as 149 dB SPL. IASCA's rules specify that ear protection must be worn by anyone within 10 feet of the vehicle being tested, although there was a small, half-empty patch of bleachers just outside the 10-foot perimeter. Even beyond that nominally safe distance, I could hear and feel the SPL-busters at work. But this category earns no points towards the main awards. Its just a sideshow, an historical reference to the crank-'em-up contests where car sound competition started.

Normally, there might have been more pure spectators at the IASCA weekend s grand finale, the awarding of the prizes. But there were so many competitors at the 1990 event (245 entries, about 60 more than the previous year) that the final scores weren't ready until after 8 p.m. on Sunday, three hours later than originally scheduled. By that time, most of the casual visitors had gone home. Yet with so many contestants, and their families and friends, there was still quite a crowd to await the outcome, congratulate the winners, and cheer up those who didn't win this time. Ⓐ

TRACTRI

IMPROVED IMAGING *and* PHASING

Most loudspeaker performance characteristics can be measured scientifically. Agreement is almost universal about which characteristics are of major importance and, thus, which to measure. Such measurements quantify our progress toward development of the ideal loudspeaker. The problem is that the ideal loudspeaker, in its purest sense, is unattainable (at any cost) due to the limits of contemporary technology. For the purposes of this article, therefore, characteristics of a *practical ideal* loudspeaker have been established. The relative importance of these characteristics is a subjective judgment that we will not attempt to address in this article. Yet, in our view, the practical ideal loudspeaker should exhibit the following characteristics:

- High efficiency and dynamic range. Though different characteristics, they usually parallel one another.
- Low distortion. In our experience, distortion is generally inversely proportional to efficiency.
- Controlled coverage. Basically, this is the ability to maintain a desired coverage angle over the full spectrum of music, and to minimize room aberrations to the response.
- Flat frequency response. Need we elaborate?
- Phase coherency. This affords smooth response, homogeneous sound from the drivers, and proper recreation of soundstage.
- Reliability. A loudspeaker should work continuously and with repeatable performance.

This practical ideal assumes that you can achieve all the good qualities of a drive system while avoiding its compromises. In practice, the compromises involved in real systems are

PHOTOGRAPH: ©MICHAEL GROEN

X HORNS

ROY DELGADO, KERRY GEIST, *and* JIM HUNTER

Cutaways of exponential horn (left) and tractrix horn.

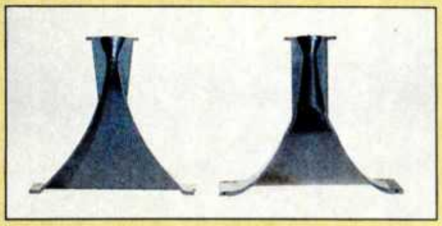
often significant. For example, a given drive system might exhibit extremely flat axial response but have very low sensitivity.

Two basic drive systems are in use today, the direct radiator and the horn-loaded compression driver. (We classify direct radiators as any drive system which directly couples to air, i.e., acoustic suspension, vented box, electrostatic, etc.) A knowledgeable listener will have certain expectations from a good example of each system type relative to the practical ideal. Good systems of either type should be capable of flat frequency response. Beyond this, a good direct radiator system should be able to provide moderate efficiency and dynamic range, low harmonic distortion, wide (though not necessarily controlled) polar response, and good phase coherency. A good horn-loaded system should be able to deliver high efficiency, wide dynamic range, low harmonic and modulation distortion, controlled (though not necessarily wide or narrow) coverage, and reliability.

As you can see, both system types lack and share some performance characteristics of the practical ideal system. As makers of both types of drive systems, this is no surprise to us at Klipsch. Because our company has long espoused the superiority of horns over direct radiators in most applications, any shortcoming of horn-loaded systems relative to the practical ideal is

Roy Delgado and Kerry Geist have been design engineers at Klipsch & Associates in Hope, Ark. since 1986. Jim Hunter, who has been with the company since 1978, is Design Engineering Manager.

THE TRACTRIX CURVE COMBINES PROPERTIES OF OTHER TYPES



WITHOUT BORROWING TOO MANY OF THEIR PROBLEMS.

of particular interest to us. We therefore quickly noted that the list of horn speakers' virtues does not include phase coherency. Why is this?

Phasing is basically a product of interaction between two or more sources which are delivering the same frequency. The sources can be drivers or drivers and reflections. Thus, multiple drive systems and coverage patterns of the drivers in a system influence the phase coherency of that system. Room acoustics and boundaries also influence phase coherency because of sound reflections.

Phase coherency is more difficult to achieve between a midrange and a high-frequency driver than between a midrange and a woofer. This is because sounds at normal midrange/treble crossover frequencies have relatively short wavelengths. At the same time, phase coherency at this crossover is important due to the enormous amount of musical information at these frequencies. With horn designs, there are yet other problems to overcome.

Relative to tweeter horns, midrange horns are typically longer from throat to mouth, that is, from driver diaphragm to room. Therefore, the frequencies in the narrow band that both drivers reproduce simultaneously, due to practical crossover roll-offs, may arrive at the listening position milliseconds apart. This can cause phasing irregularities. The area expansion of a midrange horn is also critical in control of phase coherency. If the flare rate of the horn is too fast, more interference between the midrange and tweeter may be experienced due to broad vertical coverage. If the flare rate is too slow, the sound waves may reflect from the horn mouth and cause phasing irregularities within the horn itself, thus producing ragged frequency response.

Over the years, Klipsch has improved the phase coherency of horn-loaded drivers and systems, and the recent advance of using the tractrix horn is particularly significant. About two years ago, we were seeking ways to reduce the depth of some of our midrange drive elements. We hoped that the new drivers, when developed, would give us greater coverage control and interact favorably with other system drivers to give us better phase coherency.

Depth easily could have been reduced by switching from a horn to a direct radiator. However, such a driver's sensitivity would not match that of the other drivers in the system, nor would a direct radiator allow for control of angular coverage. So this design was rejected.

We thought an answer to our problem might lie in some type of new or existing combinational equation for a horn, and began working in that direction. One day, we stumbled upon an article by Dr. Bruce Edgar in the May 1981 issue of *Speaker Builder* magazine. Edgar advocated the tractrix equation for *woofer* horns of shorter length.

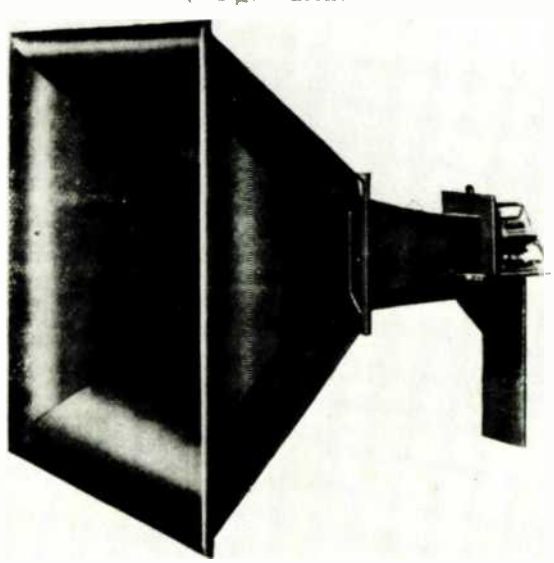
The tractrix equation, per se, isn't new. It was first described to Edgar by P.G.A.H. Voigt in a letter written in January 1981. In the letter, Voigt wrote that in the late 1920s he had been developing an equation for a woofer horn contour that allowed a sound wave to expand naturally. Voigt described how he presented a sketch of "his" contour to a draftsman. He wanted nothing from him but a better rendering. The draftsman quickly recognized the sketch as a type of mechanical curve known as tractrix. (It is also known as Schiele's anti-friction curve.)

Voigt was likely the first to apply the tractrix equation to a horn. Yet, to our knowledge, the equation had never been used in a horn of the small dimensions we desired and had never been used in a typical midrange application.

Various horn designs are routinely named for the curve of the horn wall between the throat and mouth. The ex-

A tractrix horn built from a Voigt design by Edison Bell in Britain.

Edison Bell Power Loudspeaker
(Voigt Patents)



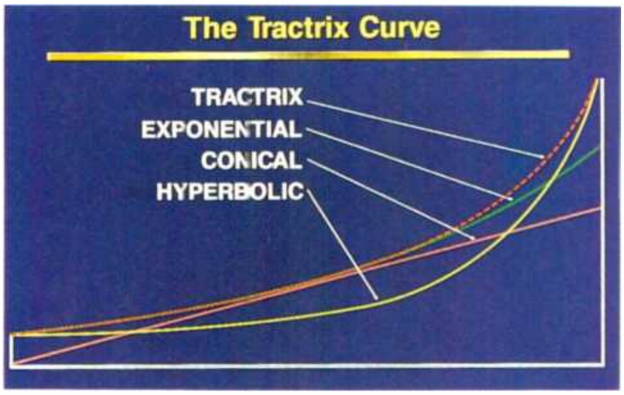


Fig. 1— Flare rates of four horn types. At various points, the tractrix curve mimics the flare rates of other curves traditionally used in horn designs.

Fig. 2— Acoustic phase of the Klipsch-designed tractrix horn and the Klipsch K-701 exponential horn. The tractrix horn's more consistent phase angle shown here is only part of the reason it outperforms the exponential horn; see text.

Fig. 3— Horizontal and vertical coverage of the Klipsch tractrix and K-701 exponential horns. Horizontal coverage is similar, though the tractrix horn's coverage is smoother.

ponential, conical, and hyperbolic horns may be the best known. The tractrix curve (Fig. 1) essentially combines properties of the other three curves without borrowing too many of their compromises.

Near the throat, the tractrix horn is most like an exponential horn. A pure exponential horn is extremely efficient at transferring acoustic energy from a high-impedance source (such as a driver diaphragm) to a low-impedance source (such as air). In the middle section, the tractrix horn is most like a conical horn. A pure conical horn offers excellent control of directivity and uniform polar response. At the mouth, the tractrix horn is most like a hyperbolic horn which has a large mouth and an exit angle approximating 90° from axis. The large mouth expands bandwidth capabilities, while the exit angle minimizes sound reflections within the horn.

Thus, the tractrix curve is, in itself, a hybrid of other curves, and the tractrix curve ultimately used by Klipsch has been further "hybridized." The pure tractrix equation necessitates a horn which is circular from throat to mouth. We built a pure tractrix horn designed to operate smoothly from 600 Hz upward. In tests, we noted a very smooth coverage angle of approximately 45° from 1.2 to 8 kHz. At 8 kHz, the coverage pattern began to narrow, becoming 30° at 20 kHz. Because the horn was circular, this coverage pattern was the same horizontally and vertically. Our design goal was horizontal coverage of 60° and vertical coverage of 40°. So we were mildly encouraged by this data and hoped that we could get the tractrix coverage closer to our design goal by converting the horn from a circular configuration to a rectangular one.

Making this conversion required more than math. In a trial-and-error process over many arduous months, various geometric configurations were attempted. Finally, our horn gave us the horizontal and vertical coverage angles we wanted, and those coverage angles were smooth up to 20 kHz. Almost within grasp was more than we had ever hoped—a high-frequency horn for a two-way system! Yet, without equalization, we couldn't keep the sound pressure level uniform (or up) as we climbed in frequency. We therefore opted to further test the horn for its originally intended application, a midrange driver, and selected 7 kHz as a crossover frequency. Then came the time to test this horn in a system.

We built a pair of Klipsch Forté speaker systems, using tractrix instead of exponential horns. We then performed an A/B listening test between these modified Fortés and a pair of Fortés which use exponential horns, the Klipsch Model K-701. (See inset photograph, at the beginning of this article, for a comparison of the two horn flares.) From the first, we preferred the system pair with the tractrix horns. On and off axis, the tractrix system sounded much smoother. We heard a more homogeneous sound: All drivers seemed to work as one, and the image had better definition and stability. We assumed these improvements were a result of better phase coherency within the system; however, this turned out to be just partially true.

On a Techron TEF analyzer, we ran acoustic phase tests of the tractrix horn relative to the exponential horn. (See Fig. 2.) The tractrix horn revealed just slightly better (more consistent) phase angle. We honestly had expected to see a greater improvement. Surely such a small improvement in phase angle could not create such big changes in our perception.

We took a second look at the coverage angle. (See Fig. 3.) Again we com-

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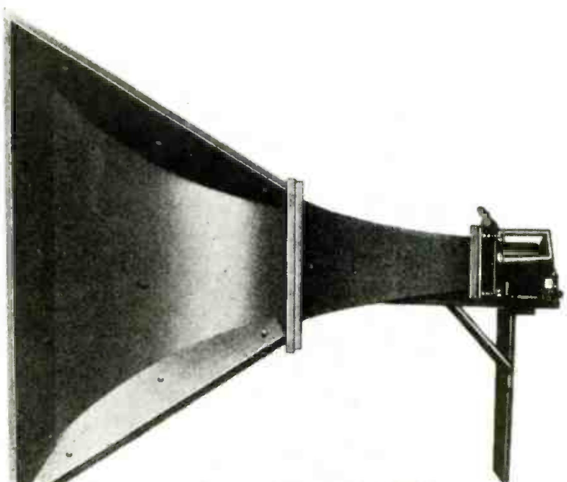

VOIGT LOUDSPEAKER
with 4 ft. mouth
STRAIGHT "TRACTRIX" HORN

A Voigt loudspeaker with tractrix horn.

pared the tractrix to the exponential and noted that, within the operating passband, the tractrix had a much narrower vertical coverage angle. Obviously, some of the improvement we heard could be attributed to reduced interference between the tractrix and the other system drivers. Also, the narrower vertical coverage angle of the tractrix horn was reducing room reflections, and this, apparently, was also improving phase coherency. Simply stated, the tractrix horn was living in harmony with its neighboring drivers and the room.

Though we still may not have the ideal loudspeaker, the tractrix design has significantly advanced us toward that elusive goal. The tractrix can greatly improve the phase coherency of horn systems and, in fact, phase coherency is now something one can expect from a horn-loaded system. Our original intention with tractrix was to release it in a "new" system or systems. Because much of our experimentation was conducted with our existing Forté speaker, we first released it as an improvement to this system and named it the Forté II. Tractrix horns have since been employed in the new Quartet (a smaller version of the Forté II) and in the Chorus II (an improvement to the previously existing Chorus). We remain confident of the sonic improvements of tractrix design and are incorporating this technology where appropriate in our line. ⍋

GLOSSARY

Efficiency: The measure of how much incoming electrical energy a loudspeaker converts to outgoing acoustical energy. Generally expressed as a percentage.

Sensitivity: The measure of the sound pressure level (SPL) generated by a loudspeaker at a given level of electrical power input.

Dynamic range: The difference, in decibels, between ambient noise level and maximum output level.

Distortion: The addition of acoustic information that was not present in the original signal.

Coverage: Expressed in degrees, the pattern or physical area where a loudspeaker radiates the bulk of its acoustic power. A coverage angle is traditionally defined by the points off axis where sound pressure level falls to 6 dB below the sound pressure level delivered on axis at a given frequency. Assume, for example, that a system delivers a 3-kHz signal at 100 dB SPL at a given distance on axis, that this SPL remains near constant at the same distance from the system until 30° off axis in either direction horizontally, and that the SPL then falls below 94 dB. Such a system is considered to have a horizontal coverage angle of 60°.

Phase coherency: The ability of a loudspeaker system or driver to maintain a consistent acoustic phase angle; the ability of two or more sound sources to act as one, without peaks and dips in the response, throughout the summed coverage angle of all sources. Note that excessive room reflections add to the number of apparent sources.

Reliability: The ability of a loudspeaker to operate continuously and with repeatable performance in its designed application.

Tractrix: When used in a horn, a curve with a flare rate which maintains an approximate 90° angle at each intersection with an expanding sound wave.

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- *Sound & Vision Magazine*

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The Phonograph's Forgotten Heroes

In August 1936, Ted Hunt, with whom I was only casually acquainted at the time, was overloaded in his efforts to finish building some remarkably advanced equipment for making phonograph records of the proceedings of the Harvard Tercentenary Celebration. Ted had induced the Tercentenary authorities to give him the financial help needed for his desired instruments by suggesting the importance of preserving for the fourth centenary celebration a complete audible record of the activities of the third. While the idea of making such records was exciting, I suspect that Ted's greatest interest was in procuring equipment that he could use later for research purposes. He had bought professional quality turntables and other record-cutting gear, and run high-quality telephone lines through the steam tunnels to connect the most important buildings with the proposed recording room in the Research Laboratory of Physics. Being dissatisfied with any of the available recording amplifiers, he began building his own to very advanced standards; it was in completing the construction of these that he was falling seriously behind a tight schedule. As was expected, there was also an uncertain amount of testing and experimental record cutting to be done before the activities began.

JOHN ALVIN PIERCE

The Harvard Tercentenary was by far the greatest academic celebration in my experience, or perhaps in my lifetime. After two or three weeks of Conferences on Arts and Sciences, the formal proceedings lasted three days. It was like a glorified Commencement. The Harvard Yard was decorated by, among other things, hundreds of white poles topped with gilded Cambridge lions. Sixty-two honorary degrees were awarded. Delegates from about 500 universities and colleges and 50 learned societies marched in the academic procession in order of the institutions' ages, beginning with al-Azhar University, founded in 970 A.D. The President of the United States was allowed a part in the festival; John Masefield, the poet laureate of England, read a poem, and musical portions were performed by the Boston Symphony Orchestra. Seats were provided for 15,000 guests in the quadrangle between the Memorial Church and the Widener Library.

This Tercentenary Theater was served by a remarkable sound system contrived and supplied by the Bell Telephone Laboratories and the Western Electric Company, allegedly at a cost of over $100,000. The Theater has been used for Commencements since 1936, and the sound reinforcement system has come down through the years surprisingly well, with only occasional modifications and replacements of equipment. The sound system for the Tercentenary was so free of distortion and so artfully supplied from loudspeakers in the trees and on surrounding buildings that most members of the audience did not realize that electronic assis-

Illustrations: Philippe Lardy

tance was providing what they heard. It was commonplace to hear people ask each other, "Why don't they have a public address system?" not realizing that if there hadn't been one in place, they could have heard almost nothing from their distant seats.

With such a tempting program to be recorded, it is not surprising that I volunteered and worked very hard with Ted to help complete his equipment and to learn how a recording was made. We worked day and night and, in classical fashion, completed the last changes and adjustments within the hour before the ceremonies began. From my point of view this rush had one sad effect: Ted claimed that I was the only one who could be trusted with the actual cutting of the records. I therefore spent the entire Tercentenary perched on a high stool in front of the recording turntables and saw nothing of the pageantry, although I must admit that I heard everything remarkably well.

In the weeks following the Tercentenary, we cut still more test records and learned to make optical studies of the record grooves, microscopically and in other ways. We discovered that we had, perhaps largely by accident, made records of what was then phenomenally high quality. This knowledge placed us in an intoler-

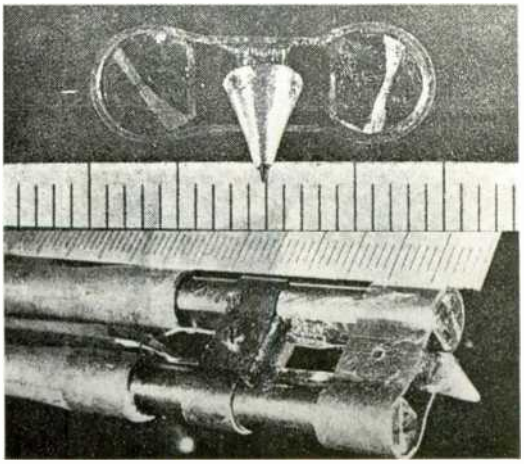
Lighter pickups were better for records but had reduced output; this was okay because good amplifiers were easy to make.

able position because there was no phonograph pickup in existence that could reproduce what we had recorded. Even worse, there was no pickup that could be used without damaging the records. We had had an instinctive realization of this fact, and therefore did not allow any of the Tercentenary records to be played back, with the exception of a few short sections at points where Harvard President Conant insisted on finding out exactly what expressions had been used, or where he wished to know whether certain off-microphone remarks had been picked up and recorded, as they usually had been.

Knowing the excellent quality of today's phonographs and records, it is hard to realize how bad nearly all of them were in 1936. In the preceding decade, the old mechanical reproducers had been replaced by electric pickups, amplifiers, and loudspeakers. The pickups and the amplifiers, at least, followed the old designs because they were intended to play the same records, which were, to be honest, awful. To get enough acoustical power from the record groove through a mechanical pickup, the stylus had to be pressed hard against the record. In ordinary practice, the unbalanced weight of a pickup was as much as 4 ounces. This weight rested on a needle whose point had dimensions of only a few thousandths of an inch (mils). The resulting pressure was in the range of 20,000 to 50,000 pounds per square inch, which exceeded the elastic limit of the record material. The sharp point of the usual steel needle would gouge out the groove, erasing the higher recorded frequency components, and tearing the surfaces of the record groove so that random (scratch) noise increased each time the record was played. Teddy's favorite simile was to suggest that the effect was like dragging a cannon ball along the furrow in a plowed field. To decrease the tearing effect, abrasives were added to the record material so that a new needle would be ground to fit the groove after a few revolutions of the turntable. This distributed the weight over a larger contact area so that the tearing was reduced, but it had two serious disadvantages. The larger area of contact meant that the highest frequencies could not be reproduced, and the roughness of the abrasive produced unnatural, and unwanted, noise. It was therefore common practice to limit the high-frequency response of the reproducing system to about 3,500 Hz, or little more than the frequency range of an ordinary telephone circuit.

The only exception to this unfortunate situation was in the case of transcription records made for distribution of radio broadcasts. These had recently been greatly improved by the Bell Telephone Laboratories and the Western Electric organization. The transcription records were in vertical cut on 16-inch lacquer-coated discs that would play for almost 30 minutes. In retrospect, it is clear that their virtues were a result of a new order of care used in their making.

Our records were cut in vinylite, without abrasive, so that they exhibited even less noise than the transcription records. Because this plastic was softer than the commercial shellac records, our records were even more subject to tearing of the grooves and wearing off of the high-frequency components of the sound. The obvious direction to be taken in making a suitable pickup was to reduce the pressure on the record to the point where all stresses were below the elastic limit of the record material. This would mean that the entire mechanism would have to be very light. It was clear that the power available from a pickup would be proportional to the mass of material vibrated by the modulation of the record grooves; making the pickup light would reduce the power output. This fact did not disturb us, as good amplifiers were easy to make. We felt that even if the output should be as low as that from a microphone, we would still have a useful device.



Head-on and top views of the HP-6A "reproducer," from the March 1938 issue of *Electronics*.

We began our experimenting with a simple "hairpin" of thin phosphor-bronze ribbon. At the front, or closed end, of the hairpin, the ribbon's breadth was perpendicular to the record. This loop was coupled to a sapphire stylus by a very light aluminum cone. Lateral vibration of the stylus thus produced a rotary motion of the hairpin in a magnetic field produced by a permanent magnet, so that the front part of the hairpin was a single-turn coil and formed a small a.c. generator. The rotation of the hairpin was made easier by twisting the ribbon in the rear part, outside of the magnetic field, into the horizontal plane. A defect of this device was that the front center of the hairpin had to be supported by a block of viscous damping material to maintain the right pressure on the record, and the acoustical characteristics depended in part on the size and shape of the block of damping material. The pickup did, however, show great promise. One inconvenience was that the impedance of the generator was very small, about 0.005 ohm, so that heavy wires had to be used if the output were to be conducted very far. We solved this problem by having a small transformer that brought the impedance up to 500 ohms, and we used the transformer itself as a counterweight at the far end of the tone-arm on which the pickup was mounted.

We worked our way through many variations of this device. Each time we made a major change in the design, we raised the model number, while minor variations were accounted for by letters, in alphabetical sequence, appended to the number. By the time we graduated from the Model HP-5G to the HP-6A, we felt that we had a pickup worth demonstrating and whose characteristics were worth publishing. The hairpin had now become a little tube of phosphor-bronze, about 0.03 inch in diameter and with walls 0.002 inch thick. The needed flexibility toward the rear, where the hairpin was fixed, was provided by simply crushing the tube into flat strips. This construction gave us good rigidity in the "coil" part, where it was needed, and flexibility where that was essential. The electrical performance was sensational for those days, extending from 30 Hz to 18 kHz. The power output was admittedly very low, about one-thousandth of "normal," but this did not constitute a serious problem.

One of the most fascinating features was the light "weight" on the record—about 2 grams. This produced pressures so gentle that it was impossible to damage a record. We would astonish guests and audiences by dropping the pickup from 2 to 3 inches onto a fresh uncut disc. This would produce no visible or audible dent. An even more startling test was to place a finger on each side of the tonearm and scrub it back and forth across the grooves while a record was being played. Any other pickup would instantly ruin the record. With ours, the noise from the loudspeaker during the scrubbing was, of course, intolerable, but afterward the record continued to play with no sign of damage. These characteristics and the tonal quality of the reproduction were quite unheard of, and we demonstrated them to any audience we could muster. Most "experts" found it hard to believe that our audiences consistently voted "No" when we inserted electrical filters to cut off the frequencies above 11 kHz. Such a result contradicted the assumption that people did not want high-frequency response—they did if distortion and noise were sufficiently reduced.

We had reached this state in November 1937 and reported our results first at the Acoustical Society meeting in Ann Arbor, Mich. Our paper on the HP-6A was published in early 1938 and drew about 200 "fan letters," a remarkable response for a scientific paper. Some of these correspondents kept us writing letters for years; in fact, I think the file was not closed until 1946.

We continued to improve our pickups until 1940; I think the last was the HP-23. We finally learned how to make them without any damping material, which in reality had been needed only to provide mechanical support or to control unwanted modes of vibration.

Although Ted and I no doubt had the ideas about what we wanted, most of the credit for these remarkably light pickups must go to Harold Benner, the elderly chief machinist at Cruft Laboratory. So far as I know, he could make anything. I remember an occasion when one of the rich young men around the lab had bought his wife a tiny Swiss watch. The works were so small that two of them could have been placed side by side on a dime without overhanging the edge. One of the watch jewels had broken, and a number of major jewelers refused to undertake repairs. Appropriately challenged, Mr. Benner took the job home, where he had a more delicate jeweler's lathe than he had at the lab, and ground and drilled a satisfactory new jewel.

Presenting a challenge was an important part of getting the best from Mr. Benner. We learned to approach delicate jobs by saying, "We don't believe it can be done, but what we really need is . . . ." An excellent example is the kind of cone we used in our later pickups. These were about 0.2 inch long and 0.1 inch in diameter. At the top was a narrow cylindrical section to which a thin silver band was later cemented, and there was a little button at the end into which a sapphire or diamond stylus point was inserted. Mr. Benner would start with a rod of duralumin. After boring a cylindrical and then conical hole in the end, he would cement this end to a correspondingly tapered arbor so that he could reverse the rod in his lathe. He would then turn down the outside of the cone until the remaining structure had a thickness of 0.0005 inch, except at the little bump at the end. The completed cones weighed an average of about 4 milligrams; it would have taken 7,000 of them to weigh an ounce. I must admit that occasionally one of these cones would be torn during the final cutting, but, even so, this remains one of the most remarkable examples of fine machining that I ever watched. Certainly, without Mr. Benner we could have done nothing important.

It is hard to understand the combination of flexibility and structural stiffness required in a phonograph reproducer. The acceleration in a record groove can easily reach a thousand times the acceleration due to gravity. If an automobile could tolerate such acceleration, it could reach a speed of 50 miles an hour after the first inch of travel. For a pickup to withstand such forces, the "effective mass referred to the stylus tip" must be a thousand times smaller than the "unbalanced weight on the record." For use with lateral-cut records, much of the mass of our pickups was concentrated relatively near to the axis of rotation. We could then have a total mass perhaps as large as 10 milligrams and yet achieve a "playing weight" of only 2 grams.

If an automobile could tolerate the acceleration of that in a record groove, it would reach 50 mph after the first inch of travel.

Our best proof of the value of light pressure on the record was a commercial Beethoven recording that we played over 2,500 times in tests and demonstrations of various pickups. After all of this use, it still had the "gleam" of a new one. We used to annoy Briggs and Briggs, the fine music store in Harvard Square, when we went to choose a new test record. After listening to many, in an effort to select passages that were hard to reproduce accurately, we would say to the store clerk, "This one is good; now go get us a new record that has *not* been played." One of our finest and most difficult tests involved the "singing strings" passage in the third movement of Brahms' First Symphony. Any pickup that could reproduce these measures without audible distortion was clearly of the first rank.

Consideration of the pickup behavior led us into a long study of the geometrical relations

As A. L. Lowell, a president of Harvard, once said, "You may get results or you may get credit for results; you can rarely have both."

between the stylus tip and the record groove. The details of this research are too complex to discuss here, but the important point is that although a groove is cut with a very sharp-edged tool, we must play it back with a smooth (spherical or ellipsoidal) stylus tip. For this reason, the motion of a playback stylus is not the same as the motion of the cutting tool with which the record was made. We realized that the center of a spherical stylus traced a curve that remained at a constant distance from each of the surfaces of a record groove. If, for purposes of analysis, we took each wall of the groove as following a sine wave, the stylus would move along a path that was completely determined by the amplitude and wavelength of the sine wave and the radius of the stylus. A defined curve of this sort seemed to deserve a name. We originally called it the "Pierce-oid," partly because I had first suggested the existence of such a family of relationships, but chiefly because I made the very tedious calculations required to determine the amount of distortion produced in this way. This name seemed unduly awkward, however, and we shortened it to the "Poid" before we used the term in print. I am still occasionally pleased to find poid defined in a technical dictionary.

Ted and I came to the interesting conclusion that, in the matter of distortion, lateral-cut records had a distinct advantage over those that were made with vertical motion of the cutting stylus. Knowing, by now, the physical requirements (the right amount of stiffness, the small mass, and the capability to withstand high acceleration) for a good pickup, we were able to define the criteria for a satisfactory reproducer and to establish the kind of groove that might be used to make long-playing records. Because we could not conceive of a cutting head that could *simultaneously* record both vertically and laterally, we failed explicitly to predict stereo disc recording. The paper we wrote about these matters was the most important one in our collaboration. It was simultaneously published in the journals of the Acoustical Society and the Society of Motion Picture Engineers, a somewhat rare happening that was possible because the editors of both publications wanted the paper and did not feel that their membership lists overlapped too much.

We gave the subject matter of this paper verbally at several meetings of scientific societies. This became something of a road show; wherever we went, Bell Telephone Laboratories sent two or three of their engineers to try to refute our claims about the superiority of lateral recording. This was a great deal of fun because, by the time of each meeting, the opposition had thought up new arguments in favor of their excellent vertical records. As their new ideas were always presented in discussion periods after we had made our exposition, we were forced to think fast to find satisfactory counter arguments extemporaneously.

Perhaps the most interesting proof of the soundness of our work did not come until 18 years later, in 1956, when the Audio Engineering Society decided to make me an honorary member. This surprised me, as I had had no connection with audio engineering for fully 15 years. I could not resist going to the convention in New York to be awarded this honor. It turned out that when the industry was getting ready to produce stereo records, people had found the mathematical basis they needed in the 1938 Pierce and Hunt paper. I was lucky in this instance. Ted and I had a policy of alternately assuming the position of senior author, and this most important of our papers happened to fall into my share.

In the course of this work, Ted and I had secured two patents that seemed to be very sound. They *were* fundamental, as we claimed the physical features that would cover any phonograph pickup that could trace a groove in accordance with our teachings, and these teachings defined the criteria for satisfactory freedom from distortion and record damage. We thought that these patents were valuable properties, but most of the industry correctly judged that we were academic types who would never know how to fight a patent suit. An exception to this general pattern was nearly provided by Columbia Records, which got far enough to offer us each $3,000 a year, for the life of our patents, for the rights. I tried hard to get Ted to accept this offer, but he had an inflated idea of the value of a patent. It had happened that, some years before, Ted had invented the electronic frequency meter. His friends at the General Radio Co. were interested in manufacturing it, and offered him his choice of two deals: $1,000 outright or a 5% royalty on whatever they sold. It did not seem that the sales would be large, and Ted chose the royalty chiefly out of friendship, not wanting the company to pay too much in case the frequency meter should not be a commercial success. Over several years, his receipts were showing some signs of reaching the thousand dollar level. By the time our phonograph patents were finally issued, the United States had entered World War II and the U.S. Navy had decided to put Ted's frequency meters into nearly every ship and shore installation. When the Columbia patent deal was being negotiated, Ted was collecting thousands from the frequency meter. This led him to feel that Columbia would pay more, but his stubborn attitude outlasted Columbia's patience. The deal collapsed, partly because Ted and I were by then both deeply involved in work for the war effort and had little time or interest for anything else. As a result, we never collected a penny on our patents.

It has always interested me that Columbia's Peter Goldmark, after the war, emerged as the "inventor" of long-playing records. Goldmark did a magnificent job of development, reducing our ideas to practice. I was to learn that this is usually a harder and much more critical part of bringing a new device before the public than is the invention of the idea, but, for a time, I sorely missed having a share of the credit. I did not then know one of Harvard President A. Lawrence Lowell's well-known aphorisms, "You may get results or you may get credit for results; you can rarely have both."

1

LEXICON CP-2 DIGITAL SURROUND PROCESSOR

Manufacturer's Specifications
Frequency Response: 10 Hz to 16 kHz, +1, −3 dB.
Minimum Input Level: 100 mV rms.
Maximum Output Level: 4.5 V rms.
Input Impedance: 50 kilohms.
Output Impedance: 500 ohms.
S/N Ratio: 80 dBA, referred to maximum level at 1 kHz.
Power Requirements: 120 V a.c., 60 Hz, 30 watts.
Dimensions: 17 in. W × 2½ in. H × 12½ in. D (43.2 cm × 6.4 cm × 31.8 cm).
Weight: 11 lbs. (5 kg).
Price: $895.
Company Address: 100 Beaver St., Waltham, Mass. 02154.
For literature, circle No. 90

The Lexicon CP-2 is the junior brother, as it were, of Lexicon's CP-1 surround processor reviewed in the November 1989 isssue. A number of simplifications in the CP-2 result in its being about one-third less expensive than the CP-1. Nevertheless, the CP-2 does include Lexicon's Auto Azimuth system for automatic correction of azimuth and channel-balance errors. This processor uses proprietary, all-digital signal processing and offers extremely accurate Dolby Pro-Logic decoding for Dolby Surround-encoded films. The unit also includes a "Music" logic program mode for playing music through a surround speaker setup and a "Mono" logic mode for enhancing monaural film soundtracks. The programs have selectable parameters to augment their performance for particular conditions and preferences. The CP-2 incorporates selectable center-channel modes to match the user's speaker configuration. Both balance and delay setting are remotely adjustable. A built-in noise-sequencer calibration signal and trim pots on the outputs make it easier for the user to balance the surround system.

Control Layout

The front panel has quite a few white labels on its black background, but it isn't threatening. "Input Level" at the lower left is the only knob to turn, and "Power" at the lower right is the only button to push. Above them is a display panel covering the unit's entire width. When power is first turned on, all of the indicators are exercised, from left to right, and then the annunciator for the last-used program illuminates. A horizontal five-LED-per-channel meter is just above the input level pot; the first four LEDs are green and the final one is red, indicating overload.

To the right of the meters is the "Parameter" section of the display. The "Rear Dly" (delay) and "Enhance" annunciators are to the right of the meters. Further to the right of "Enhance" are other annunciators, "<B," "F>," "Volume," "<L," "R>," and "Steering." Above "Steering" is "LF Spread." (I'll cover how this display section works when I discuss the remote control.) The "Program" display section is to the right. From left to right its annunciators are "Mono," "Music," "Pro-Logic," and "Calibrate." Next to the right are the muting annunciators for the "Surround" and "Main" channels. All annunciators appear to be white labels when not turned on. When they are on, the "Surround" and "Main" muting annunciators are red, and all others are incandescent yellowish. The remote-control sensor is at the far right, above the power switch.

The remote is relatively small and light in comparison to many other controls. It is easy to hold in one hand and operate its buttons with your thumb. Near the transmitting end of the remote are two rows of four buttons with clarifying labels between the rows. From the left (top and bottom) are "F," "B," "R," and "L" for "Balance"; increase and decrease for "Rear Delay," and increase and decrease for "Param" (parameter). Each button has an arrow to show what change will occur with a push. At the right, below "Param," are "Program" buttons for "Mono Logic," "Music Logic," and "Pro-Logic." Further below, from left to right, are "Main" and "Surround" for "Mute," and down and up buttons (with arrows) for "Volume."

Pushing any remote-control button that corresponds to an annunciator in the front-panel "Parameter" section turns on a 12-segment, green-LED bar graph positioned between the "Rear Dly" and "LF Spread" annunciators. The number of segments illuminated depends on the setting of that parameter. All of these parameter settings are saved for all three programs ("Music," "Mono," and "Pro-Logic") even when power is off. When a front/back or left/right balance button is pushed, "<B" and "F>" or "<L" and "R>" turn on. The display conveys the setting immediately. The LEDs at the far left and right are always on. When the control being adjusted is precisely centered, the two LEDs right above "Volume" turn on; shifting the setting moves one of these two spots of light toward the appropriate end point and turns off the other spot. The first push of a button does not change the setting but turns the display on. The second push will effect a change in the value of the parameter but will not necessarily cause the next segment to turn on. That may require another push or two, or holding the button in.

Exact values are not shown in these displays, but it is easy to read acceptably accurate values from the listening/viewing position. Listening is the final arbiter most of the time, in any event. Five seconds after the last button push, the display turns off. Holding a button in causes a continuing change to the limit of the parameter, which takes 5 S from one end to the other for F/B or L/R balance. Adjusting delay (possible in "Music" and "Pro-Logic" modes) turns on "Rear Dly" and the 12-segment display. At zero delay, no LED is on. At the first step, the left-most and right-most LEDs turn on. With increasing delay, additional LEDs to the right are illuminated until all are on at maximum delay. The total range is covered in about 2 S when the button is held in.

Other displays are the same as for rear delay: All LEDs off at minimum setting, etc. These displays are for "Volume," "Enhance" ("Param" in "Mono" logic mode), "Steering" ("Param" in "Music" logic), and "LF Spread" ("Param" in "Pro-Logic"). "Volume" and "Enhance" require 5 S from end to end; "Steering" and "LF/Spread" require 2 S. The "Enhance" parameter of "Mono" logic mode adjusts the level of all channels *except* the center, letting the user set the balance between center dialog and synthesized stereo/surround. The "Steering" parameter of "Music" logic affects the depth of dynamic steering. Also, when "Steering" is increased, the filter roll-off to the rear channels is increased in frequency. The "LF Spread" parameter of "Pro-Logic" mode can be increased to shift low bass from the center channel to the left and right main stereo speakers. (Keeping bass out of the center speaker may be needed in systems whose center speakers are small.) "LF Spread" also works in the "Music" program mode.

The stereo input phono jacks are at the extreme right of the back panel. To the left are all of the output jacks. First are the main stereo jacks, with the output level trim pot further to the left. Next to the left in this line is a large pushbutton switch, "Phantom/In" and "Center/Out," which is needed to direct center/dialog sound to match the speaker configuration. The switch is in a good location because its setting does affect the main outputs. Also on the panel are output jacks for the center channel, the two rear channels, and for a subwoofer, each with a trim pot for level adjust-

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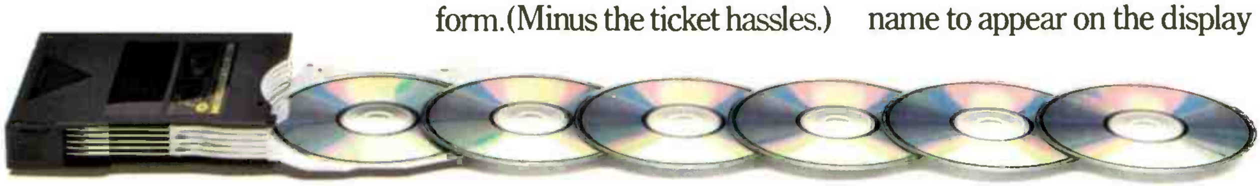

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We could go on, of course. But we think you've probably heard enough.

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Rear-channel crosstalk was so low that I initially feared I hadn't properly hooked up my test gear.

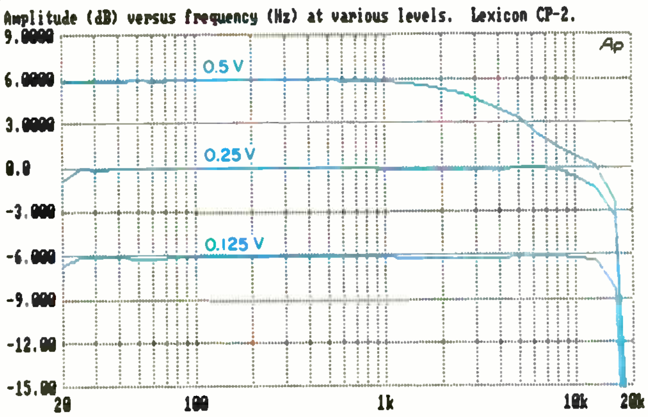

Fig. 1—Frequency response of main channels at various input levels.

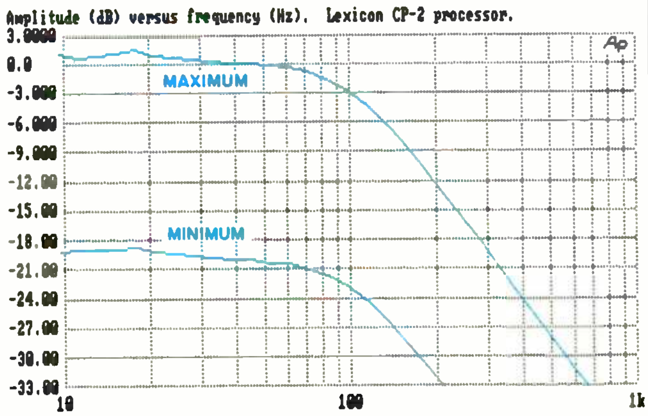

Fig. 2—Subwoofer-channel frequency response at minimum and maximum output trim settings.

ment. All are labelled in white and very easily seen on the black panel. White lines connect the output jacks' labels to the output trimmer labels, minimizing the possibility of adjusting the wrong pot.

Removal of the top and side cover reveals a neat layout of about 40 ICs and various sections of high-quality discrete components. All are mounted on two high-quality p.c. boards, each occupying nearly half the chassis and having many jumpers. My eye was caught by the Lexicon Lexichip-1 VLSI and CP-2 V1.0 ICs, a Zilog Z80 CPU, and two Burr-Brown PCM ICs. All of these are in sockets, which is helpful if replacement is needed or, in the case of the CP-2 program IC, for updating. With one exception, all other ICs are soldered in place. The boards are well supported, and there is little springiness. Interconnections among boards and the back of the front-panel electronics are made using multi-conductor plugs. Three side-panel-height rails connect the front and back panels, giving the assembly excellent rigidity. The power cable from the back panel to the power transformer loops through a ferrite core, which prevents high-frequency energy from getting out of the unit and radiating. The power transformer, mounted on the middle rail, was just warm after hours of equipment use. The two fuses are in clips. The CP-2 would be a good candidate for rack mounting, and Lexicon has adaptors available.

Measurements

As has been my practice, I made the measurements after all of the listening and viewing. Because of the dynamic processing of many surround units, normal input/output measurements can be misleading unless the processing is defeated. Therefore, Lexicon supplied a CP-2 service manual for guidance in putting the processor into test mode for some of the measurements.

Figure 1 shows the main-channel frequency response at three different input levels. The reference (0-dB) level was 0.25 V, and the input level was set just below the point where a 1-kHz signal would turn on the meter's red LED. (The turn-on voltage was lower at higher frequencies.) Responses were also run at 0.5 V (+6 dB) and 0.125 V (−6 dB). The response drooped at the higher frequencies at 0.25 V, more so at 0.5 V. The red LED turned on reliably at these two levels whenever the frequency approached the respective points of dropping response. The roll-off was normal and to specification at 0.125 V input level, and the −3 dB points were at 3.2 Hz and 16.3 kHz.

The subwoofer channel's response (Fig. 2) rolled off above 100 Hz at 12 dB/octave. The top curve was made with the output trim set for maximum, and the bottom curve, 20 dB lower, was made with the trim set for minimum. The main-, center-, and surround-channel trims all had the same range of attenuation. Without processing, the center- and rear-channel responses were the same as the main-channel response. The crosstalk in the right and surround channels from a left-channel input was measured with normal Dolby Pro-Logic processing (Fig. 3). The CP-2 does not have or need an input balance control because it incorporates Lexicon's Auto Azimuth circuit. The output level from the right channel was down more than 70 dB across most of the band. The lowest frequencies showed loss of separation, but the unwanted signal was down 25 dB or more at frequencies from 30 Hz up. When I first tried to measure the rear/surround output, I thought I might have made the wrong connection because there was no signal, even at −90 dB. Figure 3 demonstrates how low the crosstalk was in this particular test, over 95 dB down across the band.

The signal-to-noise ratio in "Pro-Logic" mode was 83.4 dBA for the main channels, 82.9 dBA for the surround

In Dolby Pro-Logic mode, S/N was greater than 80 dBA over a wide range of input and output levels, which is excellent performance.

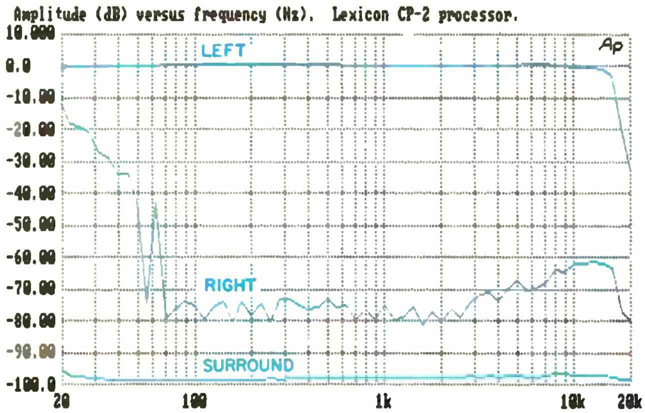

Fig. 3—Output of left, right, and surround channels in Dolby Pro-Logic mode with signal applied only to left channel.

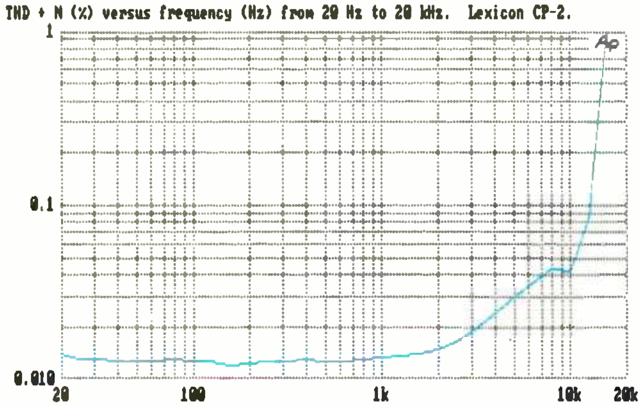

Fig. 4—THD + N of left channel; see text.

channels, and 85.1 dBA for the center channel. I got these results with 188 mV at the input and 4.4 V out. The ratios remained very close to these figures over a range of input and output levels—excellent performance.

Figure 4 displays THD + N across the band for the left main channel at 150 mV input and 2.36 V output. (The right channel was substantially the same.) The red LED turned on near 20 kHz, and the rising distortion confirms that indication of approaching overload. At lower voltages, distortion was lower at high frequencies, but the higher relative noise level raised the THD + N readings at low frequencies. Distortion would be low across the band with normal music, which has less energy at the higher frequencies.

When the input level control was at maximum, sensitivity was 185 mV for the maximum acceptable input level, and the meter red LED was just barely on. Input clipping appeared at 240 mV. Input overload (with input volume reduced) was more than 31 V, and the output clipped at 5.1 V. The input level meter's LEDs turned on at −22.1, −16.8, −9.8, and −4.5 dB relative to 0 dB for the red LED. This top-most indicator turned on with a 0.8-mS, 5-kHz tone burst having a continuous level 1 dB above indicator turn-on. The lower thresholds are good choices, and the very fast, red-LED turn-on would certainly show any normal transients. The decay time for the −22.1 dB LED to just turn-off was 250 mS, a bit short. The output polarities were reversed compared to the inputs. The main channel's input-to-output level change in the Dolby Pro-Logic program was +6.5 dB when the input and output volume controls were at maximum. Input impedance was 43 kilohms; output impedances were all a nice, low 485 ohms.

The two sections of the input level pot tracked within 1 dB from wide open down to below −80 dB. The volume control's sections tracked within a fraction of a dB for 1-dB steps down to −50 dB. Steps were then larger from −50 to −65 dB, followed by a 20-dB jump down to −85 dB. The total attenuation was covered in about 5 S if the button was held in. "Mute" reduced a 3-V output signal level by 105 dB, to 17 μV. The front/back and left/right balance attenuators have fractional-dB steps around the center points, facilitating smooth and accurate balance settings. All channels, including main, are processed digitally, and to allow time for dynamic steering, all channels have 22 mS of delay relative to the input. The rear channels have added delay, adjustable in accurate 2-mS steps, from 0 to 32 mS in "Music" and from 16 to 32 mS in "Pro-Logic" mode. The "Mono" mode has no added rear-channel delay.

If there was any sampling-rate residual in the outputs at 37.5 kHz ("Music" and "Pro-Logic" programs) or at 31.25 kHz ("Mono"), it was down more than 85 dB. The calibration test signal is shaped pink noise, rolled off above and below 800 Hz. The −3 dB points were at 400 Hz and 1.6 kHz. The remote control was reliable out to at least 25 feet on the sensor's axis and could be pointed as much as ±15° off at this distance. At normal viewing/listening distances, the control could be positioned up to ±60° off the sensor's axis as long as it was aimed at the unit, and the remote could be pointed as much as ±45° off when it was located on the sensor's axis.

Use and Listening Tests

The associated evaluation system was the same as described in previous profiles. I connected a two-channel oscilloscope across the left and right inputs and operated it in X-Y mode to show the existence or lack of stereo and surround information. (The reference was a combination of the Yamaha DSP-1 processor and DSR-100PRO Dolby Pro-

The illusion of wind in the desert that the CP-2 achieved when I watched *Lawrence of Arabia* was far superior to plain stereo.

Logic decoder.) When I first set up the CP-2 for preliminary listening tests, the right rear/surround channel was dead. Switching cables proved there was no signal coming from the back-panel jack. By removing top and bottom covers, I was able to pick out the point on the p.c. board run where the metal finger from the jack connected. A meter check showed that although there was continuity to its solder pad, there was no connection to the associated foil run. I wondered if the insertion of the plug had caused the pad to pull loose from the run. I noticed the subwoofer pad was also loose, moving back and forth as I moved the plug connected to its back-panel jack. A second CP-2 supplied by Lexicon did not have any loose pads, and I did not break any loose by making and breaking connections vigorously several times. The manufacturer stated the first unit had come from the first production run.

The CP-2 owner's manual provides a very good combination of text and illustrations on making connections and setting up and balancing the surround system. The page layout, headings, and use of different typefaces help to convey information clearly. A page on speaker placement includes desirable detail and is succinct at the same time. A theory and design section covers various facets of the three surround modes and gives helpful guidelines on what to do with different sources. More manufacturers should give such information on their decoders.

I connected the CP-2 to the required evaluation components. I did not use the subwoofer output because my subwoofer is connected across the main outputs. The center output was used, as well as the normal main and surround channels. I followed Lexicon's instructions on setting levels and balancing the system. I started with rear delay at 22 mS, which was a good choice for movies. I set the "Mono" mode "Enhance" parameter to get good dialog presence from the center speaker. For movies, I tried different settings of the "Music" program's "Steering" parameter. Most of the time I used either the 7-kHz cutoff or full bandwidth for the rear channels. I kept the "Pro-Logic" mode's "LF Spread" parameter at a low value to keep the bass in the center channel. For a surround system using a small center speaker, "LF Spread" should be used to shift bass energy to the main channels.

Dolby Pro-Logic was the best choice for movies unless I specifically note otherwise. The first movie I tried was *Lawrence of Arabia*, with Peter O'Toole, Omar Sharif, and Alec Guinness, in the Columbia Pictures Home Video VHS tape version. The overture at the beginning was most exciting with Dolby Pro-Logic, better than in "Music" mode and much better than the "Mono" result. The letterboxing of the picture was rather severe, but making it less so would have eliminated important action at the very left and right. Surround sound from rifle shots was certainly impressive, although flat desert landscapes do not really cause echoes and reverberation. The CP-2 created a good illusion of the wind in the desert, far superior to just stereo. I heard a couple of spots of sibilance on dialog, but the oscilloscope's X-Y display showed that the source had a non-monaural character at that time. The music surround was thrilling during the desert rescue scene, and my subwoofer demonstrated its value in the horse and camel charges. Because of the letterboxing, I thought placement and movement of effects was correlated best to the visual image when I sat closer than normal to the TV set. I decreased the CP-2's delay to compensate for the increased distance from the rear speakers to the listening/viewing position.

The Untouchables, on a Paramount Pictures VHS tape, with Kevin Costner and Sean Connery, demonstrated what is possible using a good source and a good decoder. On-screen dialog was kept centered, and off-screen voices were positioned correctly and effectively around the room. Background music had specific localization at times, adding to the suspense of a scene. During the gun fight in the railroad station, the music built up dramatically to a reverberating shotgun blast. A slow-motion sequence was effective, both visually and sonically, with the slow clock chime at the corresponding lower pitch.

Singin' in the Rain, an MGM/UA Home Video VHS tape, with Gene Kelly, Donald O'Connor, and Debbie Reynolds, was a major disappointment. I love the musical, but I hated the distorted dialog on this tape. The quality was not even mediocre, and the voice level and localization were continually jumping. The X-Y display confirmed the non-monaural character of the dialog sound and the presence of many artifacts causing the very poor result—"Digitally enhanced for stereo" indeed! I gained some improvement by switching the center to "Phantom" mode. Dialog was also improved by switching the VCR out of Hi-Fi mode, although musical numbers were better using Hi-Fi. The "Music" mode helped the music quality many times, but I was continually pushing buttons to make the dialog sound better. The Lexicon processor could not make the main or the surround sound a silk purse because the source was a sow's ear.

Goin' South, with Jack Nicholson (Paramount Home Video VHS tape), was strictly a mono source, and most of those watching it did prefer "Mono" mode. I actually liked Dolby Pro-Logic better at first but switched my choice to "Mono" after lowering the surround level and increasing the center level. *Flyers*, a Philips CD Video demonstration videodisc, came across best with Dolby Pro-Logic. Background music and effects created very good surround in this mode, and aircraft flybys were impressive in the character of the sound and exciting in the sweep across the room. Much of the on-screen dialog had too much presence for the location of the actors in the scene, but that was a fault in the source. The subwoofer proved its value in the scenes with jet aircraft.

Jekyll & Hyde, an ABC TV movie with Michael Caine and Cheryl Ladd, gave me encouragement on the future of MTS stereo in the home. Dolby Pro-Logic extracted excellent monaural, centered dialog as well as good music and effects in stereo and surround, including the use of localization to heighten suspense. Panning was used for passing carts and carriages, adding to the overall realism of the presentation. Although I noticed a few minor oddities in the source localization, they were unimportant distractions in comparison to the good use of stereo and surround throughout this movie.

I wanted to assess the effects of parameter changes on music while using "Music" mode, so I tried several FM stations to find a variety of music types. I tried "Steering" with both 7-kHz and full bandwidth for the surround chan-

Even with material that was primarily mono, with little surround information, this processor added realism to the room sound.

Photograph: © John Wilkes

nels. I reduced the level of the center speaker, but its contribution was still worthwhile for any talking. I increased "LF Spread" (accessed in "Pro-Logic" program) to shift more of the bass to the main speakers. I liked the music results best when front and back were in balance and delay was 22 mS. With all of the stations, "Music" mode was the best program for realistic music surround. Announcements were reasonably natural, much better than with the music modes on some other decoders.

My final listening evaluation involved a number of CDs in several music categories. Throughout this part of the evaluation, I tried changes in mode, front/back balance, rear delay, center-speaker level, and the mode parameters if I sensed the possibility of improvement. Most of the time, I got what I wanted by shifting front/back balance. "Music" mode was my preferred choice except where I state otherwise. First I tried Mozart's "Posthorn" serenade, performed by Sir Charles Mackerras and the Prague Chamber Orchestra (Telarc CD-80108). This CD evidenced considerable liveness in the recording. I could pick a range of front/back balances with good musical illusions and no localization to the surround speakers. Vivaldi's *The Four Seasons*, by Seiji Ozawa and the Boston Symphony Orchestra (Telarc CD-80070), benefited from my turning the center speaker up to get more presence from the violin solo. Even when the balance was well to the front, muting the surround caused an obvious and undesirable loss of room sound.

A CD of Debussy's works, *Danses Sacrée et Profane*, played by Leonard Slatkin and the St. Louis Symphony Orchestra (Telarc CD-80071), was very satisfying with the Lexicon processor. I lowered the center level during "La Mer" and shifted the balance to center it front/back. The detail in its quiet passages and the excitement of its spectacular parts was a most pleasurable combination. The quietness of the CP-2 was shown at various points in "Prélude à l'Après-Midi d'un Faune." The frontal localization of the flute, harp, and other individual voices was excellent. The Lexicon processing gave a very satisfying smoothness to "Danses Sacrée et Profane." Tchaikovsky's "1812" Overture, performed by Erich Kunzel and the Cincinnati Symphony Orchestra (Telarc CD-80041), required reduction in the source level; the cannon shots were well into the red until I lowered the input level. The sonic effects of the cannon, cymbals, and bass drum, and the sound of bells around the room, were emphatically better than stereo.

Scottish Overtures, by Sir Alexander Gibson and the Scottish National Orchestra (Chandos CHAN 8379), was generally best when I had the balance slightly toward the back. On the other hand, Arnold's "Tam O'Shanter" had too much surround until I shifted the balance to favor the front. For a musical, I tried Sondheim's *A Little Night Music*, with Glynis Johns, Hermione Gingold, and others (Columbia CK 32265). When I raised the center speaker level, the Dolby Pro-Logic program was preferred overall. One advantage of this choice was clearly demonstrated during a vocal trio with three different lines. Because of the good vocal presence and the excellent localization, I was able to follow each vocal line using minimum effort. Throughout this musical, the X-Y display confirmed that the localization I heard was exactly what was called for by the source.

I liked Dolby Pro-Logic but still had a slight preference for "Music" mode on Puccini's *Tosca* with Zinka Milanov, Jussi Bjoerling, and Erich Leinsdorf and the Rome Opera House Orchestra and Chorus (RCA 4514-2-RG). I raised the center speaker level slightly for more vocal presence with the soloists. After a period of listening, I shifted the balance just a little toward the back to generate the illusion of being farther away and in a larger hall. *Bach: The Organs at First Congregational Church, Los Angeles*, featuring Michael Murray (Telarc CD-80088), was improved by shifting the balance even further to the back and increasing the rear delay. "Music" mode was my definite preference for this CD, and a lower center level produced a more realistic frontal soundstage. The subwoofer's value was apparent and very welcome during low pedal notes in the Toccata and Fugue in D Minor. The reverberation in the recording itself was apparent in the sound and was shown in the collapsing patterns of surround in the X-Y display.

Beethoven's Piano Concerto No. 3, performed by Rudolph Serkin, Seiji Ozawa, and the Boston Symphony Orchestra (Telarc CD-80063), required a decrease in the delay I had used for the organ works. I also shifted the balance more to the front and raised the center level very slightly. The piano sound included some surround information (reverberation), but the CP-2 kept the localization very steady, very slightly left of center. Handel's "Dettingen Te Deum," with the English Consort conducted by Trevor Pinnock, the Choir of Westminster Abbey, and with overall direction by Simon Preston (Archiv 410 647-2), had a different sonic

The CP-2 always provided accurate, firm localization whenever the signal source included spatial clues.

character. This large-church music sounded very natural with the considerable liveness in the recording. For short periods of listening, many combinations of rear delay and front/back balance were all very pleasing. Over time I came to prefer less than maximum delay and identical front and back levels.

For *Chicago XVII* (Full Moon/Asylum 9 25060-2), I preferred "Pro-Logic" slightly over "Music." I decided a fairly high center level was best, particularly for vocals. A high surround level also sounded good for some instruments and group vocals. I liked a high center level and the balance to the back for some tracks even though the sound was somewhat unrealistic. The sound of Billy Joel's *The Bridge* (Columbia CK 40402) was primarily mono, but I liked "Music" and "Pro-Logic" modes much better than "Mono" most of the time. Even when the surround energy was low in level, it added much realism to the room sound. The trumpet of Wynton Marsalis on *Hot House Flowers* (Columbia CK 39530) was close to monaural much of the time, but the rhythm accompaniment had quite a bit of surround information. "Music" mode created a better illusion for me than did "Pro-Logic." The overall results were best when I adjusted the center level for good presence with the trumpet and other solo instruments.

The Lexicon unit was substantially the same in overall performance as my reference processor for movies, videos, and stereo TV, with the exception that I judged the reference processor slightly better for *Lawrence of Arabia*. The remotely adjustable rear delay and front/back balance allowed me to maximize the sonic illusions created by the CP-2 with Compact Discs. Liveness in the recordings themselves helped in a number of cases. The reference processor was more flexible and successful in generating specific illusions I wanted, but the sound from the Lexicon usually was moderately smoother in character.

The CP-2 always provided accurate and steady localization whenever the signal source included suitable clues. Unwanted artifacts in the surround channels were never created by the CP-2's processing, and the levels at the rear speakers could be fairly high without my noticing specifically that the sound was coming from them. Noise and distortion were always low, contributing to the smoothness of the sound. I did have to get up to change the center speaker level at times, but the remote gave me control of everything else I wanted from the listening position. The adjustable parameters for the three programs can be tailored to match personal preferences and the particular equipment used. The Lexicon CP-2 is an easy unit to set up, use, and live with. This processor is excellent for movies and can generate very good illusions with particular music sources. It is worthy of comparison to many other units, some at much higher prices.

Howard A. Roberson

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Today people have become more and more space conscious. Many apartment dwellers don't want to give up valuable floor space for large speaker systems. Others who are planning a surround sound or home theatre system simply don't have the room for more speakers in their listening rooms or hesitate to commit the floor or wall space to a good sounding pair of speakers.

Until now, serious music lovers have had little, if anything, to choose from that would produce a large, bigger-than-life sound in a small, compact size. Systems that fit one's space requirements have been woefully disappointing in sound quality.

The RM 3000's satellites measure 7"H x 4 1/4"W "x 5 3/8"D and are available in black matrix, gloss black piano or paintable white. The subwoofer is 12 1/2"H x 20"W x 12 1/2"D and is available with black wood grain sides and a black, mar-resistant top.

The RM 3000 Three Piece System

Polk's engineers had determined long ago that there were indeed certain technical advantages in small speaker systems. Both high and mid frequencies could be faithfully reproduced with superior transient response and dispersion characteristics, and the convenient, more flexible placement of small enclosures within the listening area could create an ideal sound stage. Unfortunately, reproducing the life-like, full body of the lower frequencies could not be achieved in a truly compact enclosure.

Polk's RM 3000 replaces the traditional pair of speakers with three elements, two compact midrange/tweeter satellites and one low frequency subwoofer system. This configuration makes it easy to properly and inconspicuously place the system within your listening room while offering superior sonic performance.

The small satellites can be located on shelves, mounted on a wall or placed on their own floor stands. They are very attractive and yet small enough to be hidden from view if desired.

The RM 3000 subwoofer is also small enough to sit behind your furniture and can be used on its side to fit into tight spaces. And since it is beautifully finished, it can be used as a piece of furniture.

The Legendary Sound of Polk

In the tradition of Polk Audio, Matthew Polk and his team of engineers were determined to make the RM 3000 sound better than any other speaker of its type.

Initial reactions have been filled with superlatives including Julian Hirsch of *Stereo Review* magazine who says, "...they sound excellent...spectral balance was excellent—smooth and seamless."

Sound as big as life from speakers

Behind these accolades is an impressive technical story.

The Technical Side

The big sound of the RM 3000 is due, in part, to the unique arrangement of the tweeter and midrange elements. This "time aligned system" delivers the high and mid frequencies at precisely the same instant. The result is a clear, lifelike and expansive presentation.

The cabinet materials selected for the satellites are over four times as dense as typical enclosures. The black matrix finish is a non-resonant polymer aggregate (FOUNTAINHEAD®). The gloss black piano and paintable white finishes are rigid ABS

Where to buy Polk Speakers? For your nearest dealer, see page 96

small enough to live with.

surrounding a mineral filled polypropylene inner cabinet. Polk engineers have all but eliminated any "singing" or resonating of the satellite enclosure. You hear the effortless, free sound of a much larger system.

Most subwoofer systems look alike on the outside, but the Polk is worlds apart on the inside. Utilizing twin 6 1/2" drivers coupled to a 10 inch sub-bass radiator, the bass is tight and well defined. There is no tuned port to create "whistling" or "boominess" of the bass frequencies.

For deep, well defined bass, Polk uses twin drivers coupled to a sub-bass radiator. Normally, one sub-woofer system is used for both channels. For those desiring even greater low frequency performance, a second subwoofer can be added, one fed by the left channel, the other by the right channel.

You Have To Hear It To Believe It

You really won't believe how good the RM 3000 sounds until you hear it. We invite you to your nearest authorized Polk dealer for a demonstration. You'll hear sound as big as life...from a speaker you can live with.

You'll hear the next generation of loudspeakers.

polk audio

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2

MERIDIAN D600B SPEAKER

Manufacturer's Specifications

System Type: Active, three-way, vented-box system with three 70-watt power amplifiers, electronic crossover, digital control unit, and bitstream D/A converter.

Drivers: 6½-in. (16.5-cm) cone woofer, 6½-in. (16.5-cm) cone woofer/midrange, and 1-in. (2.54-cm) aluminum dome tweeter.

Frequency Range: 36 Hz to 20 kHz.

Sensitivity: Line level, 775 mV nominal.

Maximum Output: Maximum, 110 dB SPL on musical peaks.

Crossover Frequencies: 500 Hz and 2.5 kHz.

Input Impedance: Analog, 11 kilohms; digital, 75 ohms.

Recommended Amplifier Power: Not applicable.

Dimensions: 35½ in. H × 8¼ in. W × 11⅝ in. D (90.2 cm × 21 cm × 29.5 cm).

Weight: 70 lbs. (32 kg).

Price: $5,490 per pair, including Model 609 remote control.

Company Address: 14120-K Sullyfield Circle, Chantilly, Va. 22021.

For literature, circle No. 91

The D600B is the second generation of Meridian's Digital Active loudspeaker, the Model D600. The D600B employs a version of the widely acclaimed bitstream D/A converter used in Meridian's Model 206B and 208 CD players, and the new Model 203 D/A converter, instead of the earlier, 16-bit converters with four-times oversampling. The D600B is just one unit from Meridian's extensive, ambitious line of "intelligent" high-fidelity components that allow multi-room control and full remote operation of multiple listening zones in the home. Meridian's line of components includes CD players, preamplifiers, power amplifiers, remote-control units, remote sensors, wall display panels, in-wall loudspeakers, and active loudspeakers, all of which are designed to be a part of a total multi-room system.

Meridian is the marketing arm of a relatively small British company, Boothroyd Stuart Ltd., founded by electronics designer Robert Stuart and industrial designer Allen Boothroyd in 1977. Stuart is the technical brain behind most of the

ANNOUNCING THE BRYSTON TWENTY YEAR WARRANTY

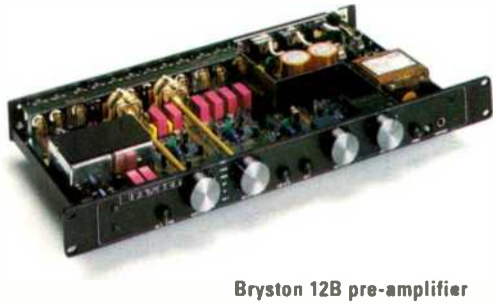
For over a quarter-century Bryston has been committed to designing and producing audio products with musical accuracy, reliability and value as our primary focus. It is widely known that Bryston's policy on the warranty of our products has always been extremely generous if ever required. To further enhance our long term commitment Bryston is instituting a 20 year warranty program as of January 1st, 1990. This, as far as we know, is a first in our industry and as such will further demonstrate our continuing dedication to our products and customers.

Musical accuracy is reflected throughout all Bryston power amplifiers. This includes the necessity for wide-band transient accuracy, open loop linearity ahead of closed loop

Bryston 10B electronic crossover

specifications, and power supply design as an integral part of the overall sonic and electrical performance of a power amplifier.

We have found that a simple carbon film resistor can contribute more static distortion to a signal than the entire circuitry of the amplifier.



Bryston 12B pre-amplifier

We discovered that some parameters of transistors must be controlled as much as 100 times more closely before their contribution to audible distortion is rendered negligible.

Each of the steps or stages in every Bryston amplifier, from the input section to the output section, without exception, are designed to optimize the musical experience. Bryston takes very seriously the correct functioning and long term reliability of its products.

This new twenty year warranty is also retroactive. It includes all audio products previously manufactured and sold under the Bryston name. This warranty is also fully transferable from first owner to any subsequent owners.

Bryston has always been dedicated to designing and producing audio power amplifiers, crossovers, and pre-amplifiers that deliver uncompromised performance, outstanding reliability and exceptional value. We believe our new 20 year warranty is one more example of our continuing commitment to this ideal.

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BRYSTON

The self-powered D600Bs can accept digital and analog signals, with remote input selection and control of tone and volume.

goods that the company sells, while Boothroyd provides most of the styling and industrial design. All of Meridian's products have a very distinctive, European avant-garde look that sets them apart from those of other manufacturers. Boothroyd Stuart is part of the British AGI group that, coincidentally, owns KEF; both Meridian and KEF are marketed by the same organization in the United States. In September of last year, I had the pleasure of touring the Meridian plant with a group of American journalists. I was quite impressed with their facility, and particularly with their computer-automated testing facility for CD players.

The D600B bears the "Digital" designation because it has a built-in, audiophile-grade D/A converter that accepts digital signals directly from a CD player. The D600B can accept both coax cable and fiber-optic digital inputs.

In addition to the digital circuitry, the system contains three 70-watt power amplifiers which individually drive the woofer, woofer/midrange, and tweeter from the outputs of the internal electronic crossover. The Meridian D600B also has two selectable line-level analog inputs which can be driven from conventional audio outputs from CD players or preamplifiers.

The D600B comes supplied with the Model 609 System Handset remote-control unit, which is the only way to control the system. (The remote also controls such aspects of a Meridian CD player as play, pause, stop, track selection, etc.) The top of the enclosure's front panel contains a red LED that indicates which speaker system is the master, a four-character green status display, and the infrared receiver for the remote. The display can show the status of various system settings, such as volume level, channel balance, active inputs, tone modifications, setup and programming information, and CD track number and time remaining.

Each D600B is controlled by an internal microprocessor that interprets the commands from the 609 remote control,

communicates with the other D600B and with Meridian 200-series components, operates the front-panel display, and supervises the digital audio process. The system I evaluated included the Meridian 206 CD player, the pair of speakers, the 609 remote, and various interconnects (including coax and fiber-optic cables). I did not use any other sources for listening evaluation of the D600B speakers.

The D600Bs are relatively small and compact for the amount of electronics and the drivers that they contain. The rear quarter of the cabinet, from top to bottom, is taken up by analog and digital electronic assemblies, including all system inputs and outputs. The base of the rear panel contains the substantial regulated power supply, which includes two large, 10,000-µF electrolytic capacitors. The mid portion is taken up by the three power amplifier assemblies, which use the metal rear panel as a heat radiator. Under normal operation, this panel just barely gets warm; however, during my high-power woofer excursion tests, reported on later, the rear panel got very warm and caused the amplifiers to thermally shut down. After simply waiting a few minutes for the amps to cool, I was able to continue. The power amplifiers are all constructed from discrete transistors operated from ±45 V supply rails.

The digital and control electronics, including the bitstream D/A converter, are mounted near the input connector panel at the top rear of the D600B's enclosure. The electronics of the D600B are internally shielded by aluminum foil which lines the rear cavity of the enclosure.

All the signal input and output connectors of the system are mounted on the upper rear of the enclosure. These include eight RCA phono jacks (for two digital inputs and two balanced analog line-level inputs, a digital output, and a signal ground), an EIAJ optical input, and separate DIN-style seven-pin connectors for system communication input and output. Both positive and negative analog inputs are provided, for balanced connections or polarity inversion. The simplest way to connect the speaker systems to the CD player, and to each other, is by the use of Meridian's "composite system cable," which uses the DIN connectors. Both digital audio and bidirectional system-control signals pass through this cable. Each speaker's on/off switch and a.c. power input are at the bottom rear of the enclosure. The on/off switch, curiously, turns the system on when the switch is in the downward position, which is the reverse of what I would have expected.

The two speakers come preprogrammed so the left speaker will be the master and the right speaker will be the slave, but they can be reprogrammed by the user. Once these settings are determined, only the master unit responds to the remote control's commands; the slave and other connected units follow the commands of the master. The input assignment scheme of the D600B is very versatile although a bit complicated to set up. Any of the digital and/or analog inputs can be assigned to any of the input selection keys on the remote control, which are labelled "CD," "Radio," "LP," "Video," "Tape 1," and "Tape 2."

The remote can be used to set volume in steps of approximately 1.25 dB, and the setting is indicated on the display by a number between 1 and 64. In addition to controlling volume and balance, the remote can set three tone-control

You wouldn't buy the drive train from a Ferrari, the gear box from a Porsche, the suspension from a Mercedes & assemble them in a pickup chassis . . .

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Frequency response was flat, within ±1.5 dB from 44 Hz to 20 kHz, using Meridian's recommended bass setting for the bass control.

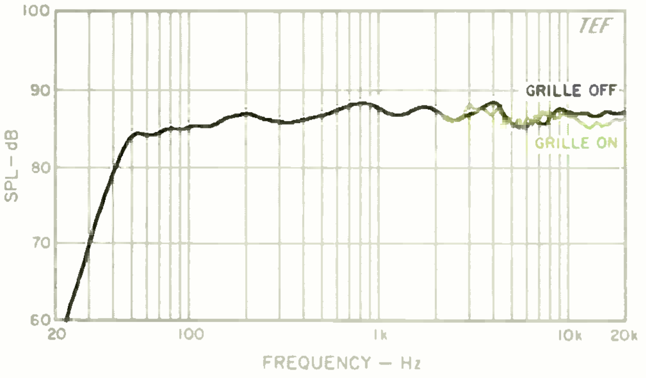


Fig. 1—On-axis frequency response with 1 V rms applied to an analog line input (see text). The system gain was set to the start-up value of "32" with all tone modifications off.

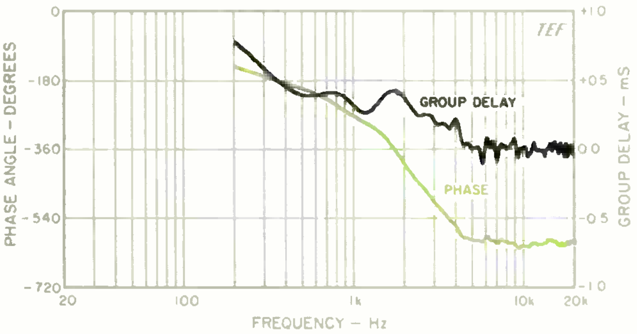


Fig. 2—On-axis phase response and group delay, corrected for tweeter arrival time.

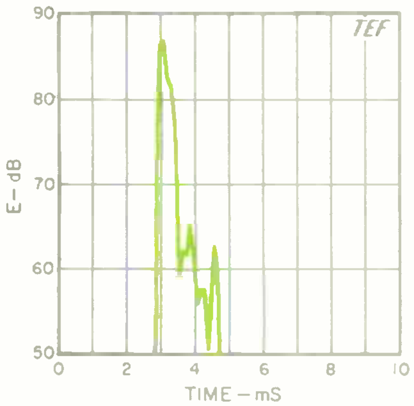


Fig. 3—One-meter on-axis energy/time curve, measured with grille off.

values: "Tilt," "Bass," and "Q." The tilt control varies the system's high/low frequency balance by gradually changing the response to favor either the upper or the lower frequencies. The adjustment range is approximately ±4 dB at the high frequencies. The bass control raises or lowers the low frequencies by about ±2 dB below 400 Hz. The Q control allows adjustments of the low-frequency response shape below about 80 Hz.

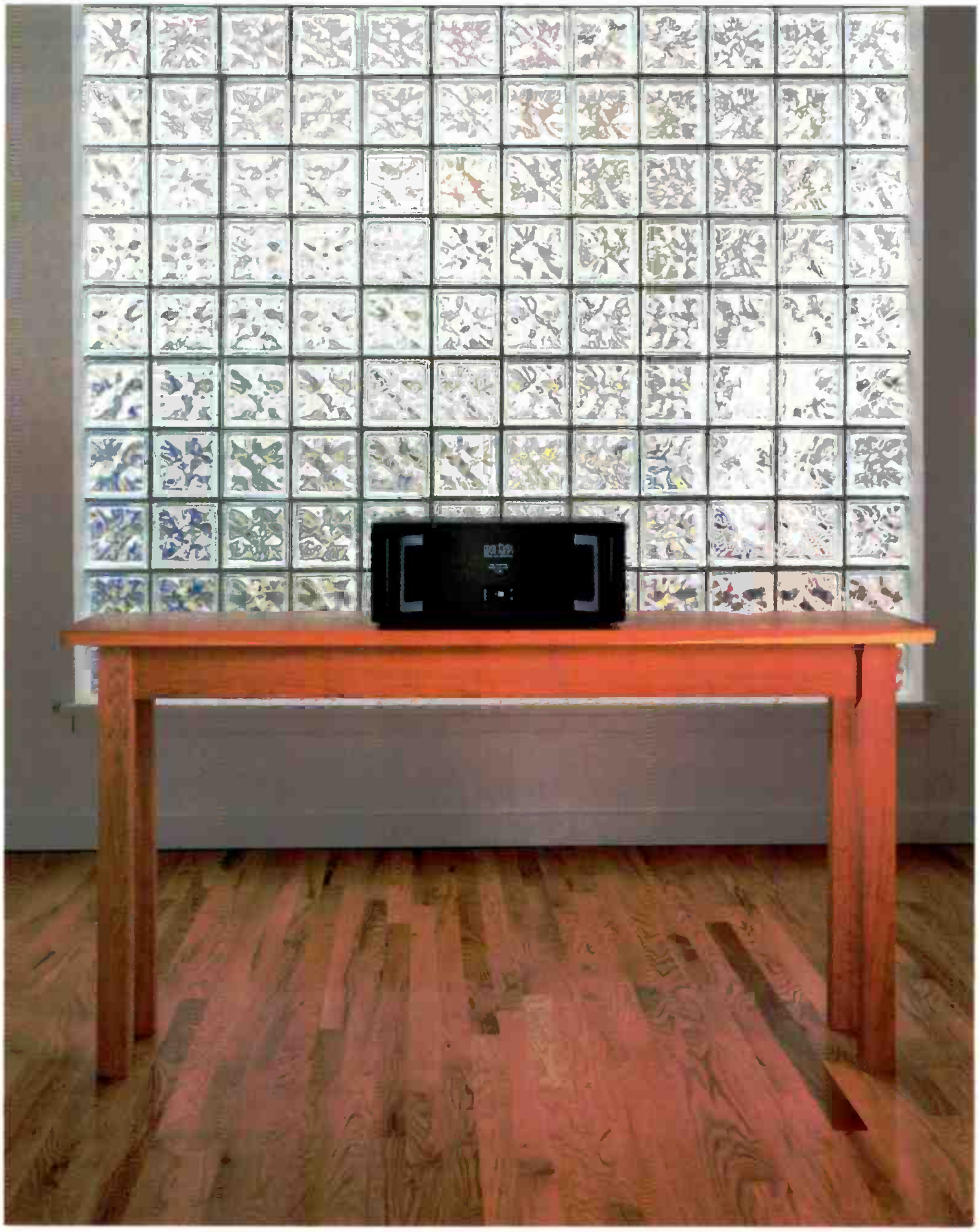
The three drivers of the D600B, made for Meridian by a Scandinavian manufacturer, include two long-throw 6½-inch woofers with polypropylene cones and a Ferrofluid-cooled, 1-inch aluminum dome tweeter. The upper woofer is used all the way up to the 2.5-kHz crossover, while the lower woofer is only used below 500 Hz and is rolled off at 6 dB/octave at higher frequencies. This roll-off decreases the effective vertical size of the radiator, thus minimizing vertical directivity effects and undesired vertical lobing.

The D600B's ow-frequency alignment is a standard, sixth-order vented-box design with a corner frequency at about 38 Hz. The enclosure is also tuned to about 38 Hz, with a rear-mounted duct 2½ inches in diameter and 7½ inches long. This alignment requires the use of a second-order high-pass driving filter with an underdamped response, which provides a boost of approximately 4 to 6 dB at the filter's corner frequency. In addition to providing boost, the filter provides a sharp roll-off for all lower frequencies, thus greatly improving the vented box's effective subsonic power-handling capability. This vented alignment has an excellent combination of extended response, controlled cone motion, and a relatively small enclosure. (The details of this alignment are described in one of my own papers, "A New Set of Sixth-Order Vented-Box Loudspeaker System Alignments," *Journal of the Audio Engineering Society*, June 1975.)

The enclosure is available in walnut, rosewood, or black ash finishes. It is quite well braced with internal transverse strengtheners and is constructed of mass-loaded, high-density ¾-inch particleboard to decrease vibration. The box was quite inert to my "knuckle knocking" test. The grille is a plastic space-frame assembly, covered with black cloth, with projections on the rear that match up with holes, filled by rubber grommets, in the enclosure's front panel.

Measurements

The D600B presented more of a measurement challenge than a typical unpowered speaker system. The system can only be controlled with its supplied 609 remote, and only if a specific unit of the pair is configured as the master. For testing, the unit had to be programmed with the line input active, and the system gain set appropriately, so that the test signal could be injected. All of my electroacoustic tests were done using an analog test signal driving one of the two line inputs. No digital measurements of the internal D/A converter were performed, except for listening tests reported later, using the Chesky CD's "bonger" tone. An inconvenience was the requirement of providing a.c. power to the speakers. One advantage of the systems was their relative small size and light weight, considering all the acoustic and electronic parts that are inside the cabinet. (They're actually smaller than, and weigh about the same as, the unpowered



The off-axis horizontal response curves show that the Meridians should image quite well over a broad listening area.

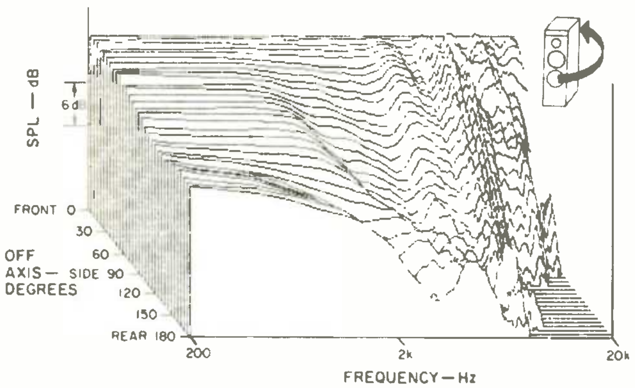


Fig. 4—Horizontal off-axis frequency responses, taken from the front, around the side, and to the rear of the speaker and normalized to the on-axis response.

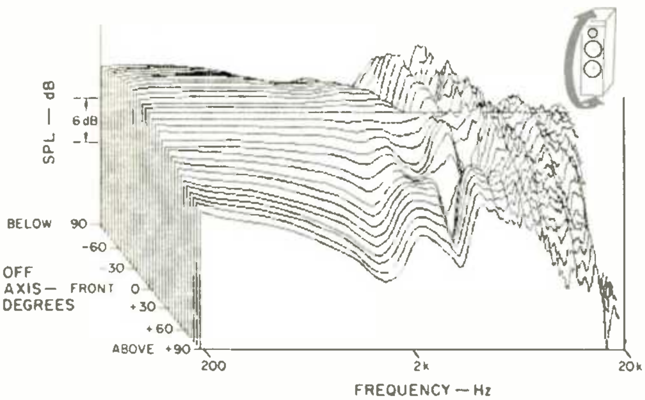


Fig. 5—Vertical off-axis responses taken from below, up the front, and to the top of the speaker and normalized to the on-axis response. Note that the above-axis response is at the front of the display.

Boston Acoustics T1030 systems reviewed in the January 1991 issue!)

The on-axis frequency response, with and without grille, is shown in Fig. 1. A signal of 1 V rms was used, driving the A1 positive line input, with a front-panel indicated gain of "32" (the start-up, or default, value). The digital control circuitry was in the reset state, which turns off all system tone corrections. The frequency response was taken at a distance of 2 meters, even with the top of the enclosure, at the manufacturer's recommended measuring point. This position lies along the same line as the ears of a listener seated 3 meters away. The angle is about 3.5° above a line originating from a point midway between the tweeter and upper woofer/midrange.

The curve is well behaved and fits within a window of ±2 dB from 49 Hz to 20 kHz. With the bass control set at "+1," which provides about 2 dB of lift below 200 Hz, the curve (not shown) was even flatter and more extended, fitting a window of ±1.5 dB from 44 Hz to 20 kHz. Meridian recommends that this bass lift be employed if the system is used away from reflective boundaries, as it was for this measurement. Just above the upper crossover point, the curve exhibits a mild peak at 4 kHz followed by a dip at 5.5 kHz. Between 8 and 20 kHz, the curve is very smooth and flat.

The grille mainly affects the response by adding some roughness between 3 and 8 kHz and lowering it by about 2 dB above 10 kHz. I suggest removing the grilles for most serious listening. To emphasize the grille's effect on the axial response, the "Grille On" curve was not subjected to the tenth-octave smoothing applied to the "Grille Off" curve. All of the following tests were made with the grille off.

Averaging the axial response over the range of 250 Hz to 4 kHz yielded a sensitivity of 87 dB SPL at 1 meter. This is the output that resulted from a 1 V rms signal applied to the line-level input with the system gain set to the default value of "32." The right/left matching of the systems was quite good, with no more than ±0.75 dB variation above 100 Hz.

Figure 2 displays the axial phase and group delay of the system, corrected for the tweeter signal's time of arrival. The phase response exhibits a total phase rotation of about 330° between 1 and 20 kHz. A separate measurement of offset revealed that the woofer/midrange trailed the tweeter by a fairly significant 0.27 mS, which corresponds to a distance of 3.6 inches. At the crossover of 2.5 kHz, this offset represents approximately 0.67 wavelength, or 240°. The above-axis measurement location contributed to this fairly large offset between the midrange and tweeter, because the woofer/midrange is physically farther away than the tweeter.

The excursion capability of the woofers was determined by energizing the system with a high-level swept sine wave covering the low frequency range. The maximum linear excursion capability of the woofers was a fairly large ±0.2 inch (0.4 inch, peak to peak). The effective piston diameter of a single woofer was about 5 inches, and thus two woofers have almost the same effective area as a single driver nominally 10 inches in diameter. The woofers exhibited no extraneous sounds when overloaded, other than the expected increase in low-order harmonic distortion.

The vented-box resonance significantly reduced cone motion between 27 and 50 Hz, with a minimum displacement at about 37 to 38 Hz. Most of the radiated sound in the latter region came from the vent. Some vent wind noise and air-turbulence sounds were noted at high levels. Fortunately, the more detectable higher frequency components of the vent noise were radiated to the rear, because of the back-mounted vent, and thus were less objectionable.

The effect of the high-pass filter used in the D600B's sixth-order, vented-box, low-frequency alignment was quite evident in these tests, in that the system did not make any distressful noises when the high-level test signal was swept below 35 Hz. The filter just reduced the input so that the

The lower harmonics of E_1 (41.2 Hz) reached only about 7%, impressively low for a speaker system this size.

woofers could not be easily overloaded below 35 Hz. Some dynamic offset of the woofers was noted during these high-level sine-wave tests. The enclosure side walls were quite rigid and displayed no significant resonances.

While running the woofer excursion tests, I decided to check the effect of the "Q" setting on the control unit. The Q adjustment has two settings, "Flat" and "Cut." According to the owner's manual, "The Q key controls the response shape for the deepest notes" and should be in the "Cut" setting "when the D600 is close to walls or in a smaller room." With the "Flat" Q setting, everything was normal and operated as expected. However, with Q in the "Cut" position, I noticed a *slight* amount of excursion reduction above 40 Hz but a *large* increase in excursion below 35 Hz, continuing down to subsonic frequencies below 10 Hz. The frequency response of the effect of Q, shown in the manual's appendix, implies that in the "Cut" position, the setting just acts as a single high-pass filter in reducing the amount of low frequencies. This was found not to be the case. Measurements revealed the control was reducing the level by about 2 dB between 40 and 80 Hz but increasing the level by nearly 9 dB below 35 Hz. Because of this, and to reduce the D600B's susceptibility to high-level energy in program material below 30 Hz (where the system's output is greatly attenuated and potentially distorted on high-level signals), I suggest that the Q control always be left in the "Flat" position.

The linearity of the system's volume adjustment was checked by running a series of frequency response curves at different volume settings. The manual states that the volume can be set in 64 steps, with each step being 1.25 dB. The measurements revealed error in the steps, some as small as 0.8 dB and others as large as 2 dB. The step error appeared to be cyclical, with every eighth volume step being large and those in between smaller. Fortunately, both systems of the pair were closely matched, with their steps tracking precisely. The audible difference between 0.8 and 2.0 dB is very slight, and what counts is that the right/left balance of the systems is not changed.

The crossover of the D600B is accomplished before the power amplifiers, using conventional IC op-amps and RC networks. There is a separate 70-watt amplifier for each of the system's three drivers. Measurement of the voltage-drive frequency response of each of the drivers revealed that the upper crossover occurred very close to the rated 2.5 kHz. It also revealed that the tweeter was rolled off at 24 dB/octave below crossover, while the woofers were rolled off at 18 dB/octave above crossover.

The upper crossover's acoustic phase relationships were investigated by reversing the tweeter connections and then noting the change in the frequency response in the crossover region. When reversed, the response at crossover dipped only about 10 dB, which indicates that the woofer/midrange and tweeter are somewhat out of phase in the region of the 2.5-kHz crossover and thus will exhibit some lobing. With the leads reversed, the response between 1 and 2 kHz actually rose by about 1 to 2 dB, which indicates an even greater amount of lobing in this region.

The 1-meter, on-axis, 1-watt energy/time curve (ETC) is shown in Fig. 3, for a test signal swept over the range of 200 Hz to 10 kHz. This ETC represents mostly the tweeter's response and emphasizes energy in the range of 2 to 9 kHz. The response is fairly tight, although somewhat broad below 80 dB, and is followed only by lower level arrivals which are more than 20 dB down from the main arrival. The increased width of the energy arrival below 80 dB is presumably due to the later contribution from the woofer/midrange.

The normalized, horizontal "3-D" off-axis curves of the D600B are shown in Fig. 4. The curves are quite well behaved but indicate some off-axis roughness above the upper crossover. The response holds up well to 16 kHz at

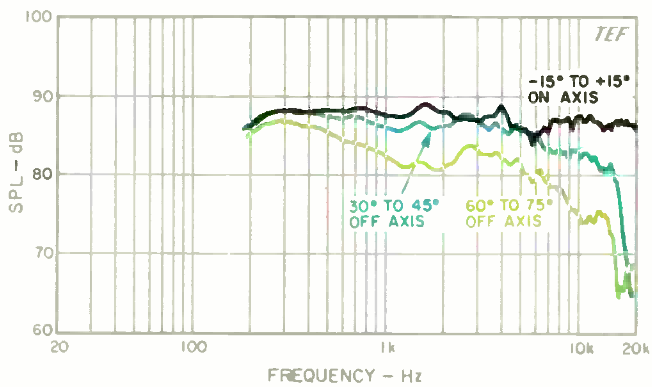


Fig. 6—Mean horizontal response derived from data of Fig. 4. The axial and 30° to 45° off-axis curves are well behaved and extended.

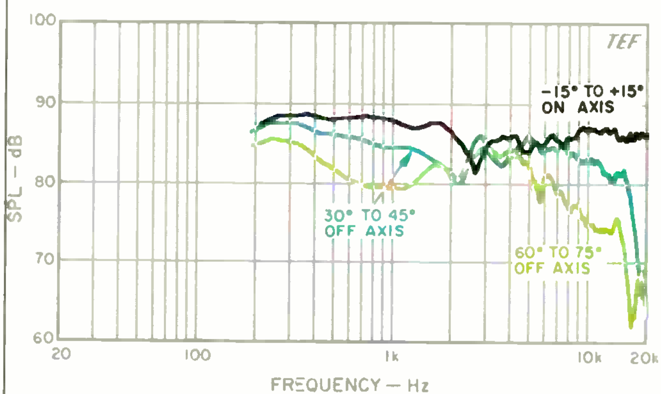


Fig. 7—Mean vertical response derived from data of Fig. 5. These curves show some of the effects of driver interference in the crossover region from 2 to 4 kHz.

On the "bonger" tone test for low-level nonlinearity, the D600Bs' D/A converters sounded very clean, with virtually no anomalies.

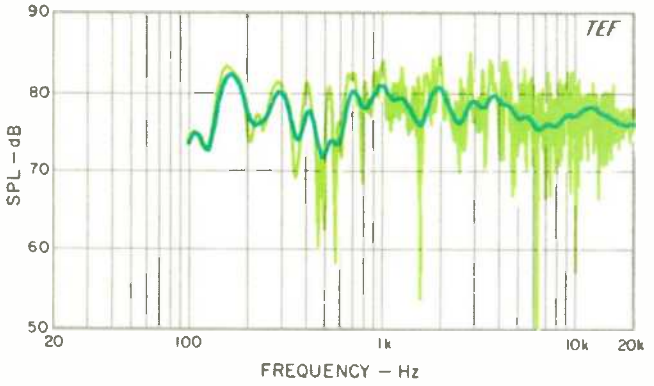


Fig. 8—Three-meter room response with test microphone at the height of a seated listener's ear, showing both raw and smoothed data. The curve is quite well behaved.

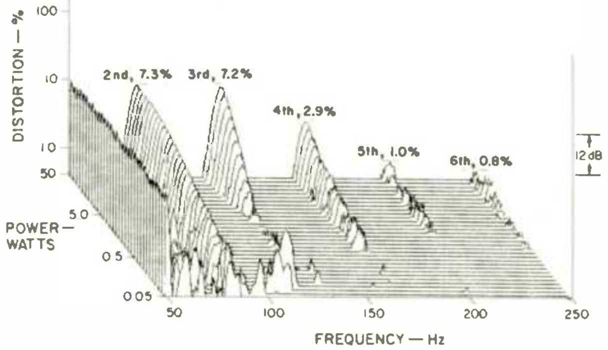


Fig. 9—Harmonic distortion products for the musical tone E_1 (41.2 Hz). At maximum power, the input level was set so that each woofer reached 50 watts at 41.2 Hz (100 watts total for both woofers). At this level, the distortion was commendably less than 10% for the second and third harmonics.

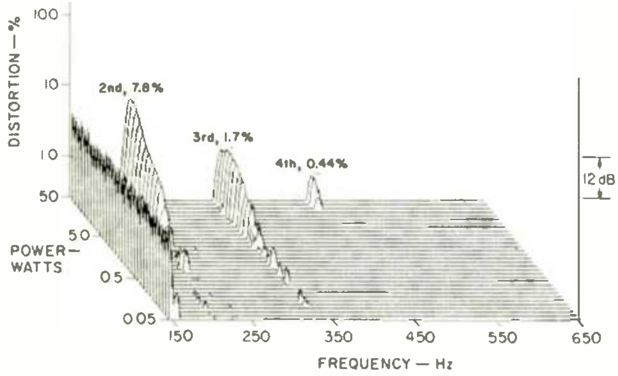


Fig. 10—Harmonic distortion products for the musical tone A_2 (110 Hz). At maximum power, the input level was set to the same value as in Fig. 9.

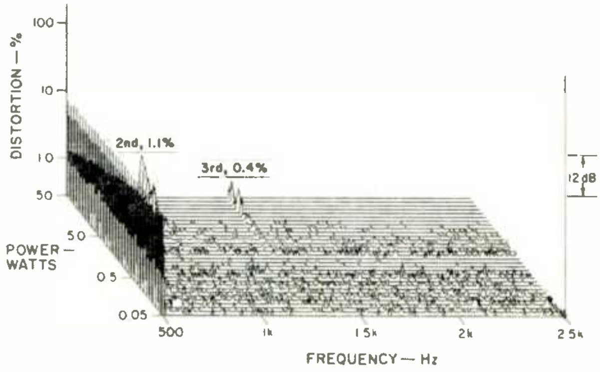
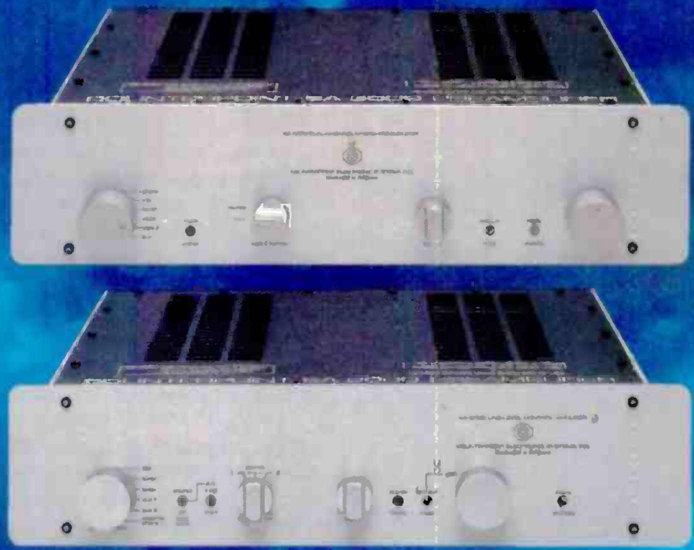


Fig. 11—Harmonic distortion products for the musical tone A_4 (440 Hz). At maximum power, the input level was set to the same value as in Fig. 9. The harmonic levels are quite low at this frequency.

angles out beyond 45° or so off axis. The vertical off-axis curves shown in Fig. 5 indicate significant roughness through the upper crossover region from 1.5 to 6 kHz. Not completely visible in this display is a significant drop in the response at the upper crossover, just below the axis, which indicates a moderate amount of lobing. Fortunately, the response through this frequency region is much smoother above axis than below.

The NRC-style mean horizontal and vertical on- and off-axis response curves of the system are shown in Figs. 6 and 7. The horizontal curves are shown in Fig. 6. The mean axial curve (–15° to +15°) is very well behaved except for the peak and dip at 4 and 6 kHz, respectively. (This curve represents the average frequency balance within ±15° of the axis horizontally but on axis vertically.) The 30° to 45° response is also quite smooth, with a gradual roll-off above 3 kHz. The 60° to 75° response exhibits a slump between 1 and 3 kHz and a moderate roll-off above 4 kHz. These measurements indicate that the D600Bs should image quite well over a wide horizontal listening area.

The vertical responses are shown in Fig. 7. The mean axial response has some roughness in the upper crossover region but is, in general, quite well behaved and flat. The below-axis curves that dip down in this crossover region are



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The overall sound was very neutral, and the systems brought out subtle sonic details exceptionally well.

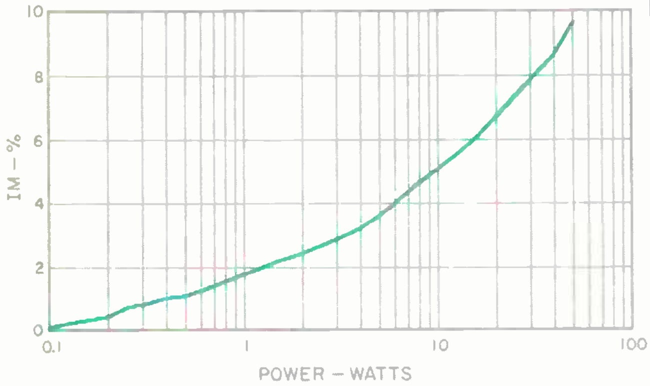

Fig. 12—IM distortion on 440 Hz (A_4) produced by 41.2 Hz (E_1) when mixed in one-to-one proportion (see text). The distortion is admirably low, less than 10% at full power.

averaged into the curves shown here. Fortunately, the above-axis curves are smoother than the below-axis curves, which is good news for a standing listener. The 30° to 45° averaged response is significantly less smooth because of off-axis directivity effects and lobing. The 30° to 45° response does extend beyond 16 kHz before falling rapidly at higher frequencies. The 60° to 75° averaged response displays low-frequency directivity effects of the dual woofers in the range from 400 to 1,500 Hz, where their response overlaps, along with high-frequency roll-off above 7 kHz.

Figure 8 shows the 3-meter room curve of the system for both raw and sixth-octave smoothed responses. The speaker was located in the right stereo position. with the test microphone placed at ear height (36 inches) on the sofa where the listener normally sits. The system was swept from 100 Hz to 20 kHz with a 1 V rms sine-wave signal applied to the A1 positive line input and the system gain set to "32." The sweep parameters were chosen so as to include the direct sound plus 13 mS of the room's reverberation; the resultant sound levels can be read directly off the graph. The curve is quite well behaved and extended except for a moderate dip in the response between 400 and 600 Hz and a slight depression between 5 and 9 kHz.

Harmonic and intermodulation distortion were measured and are displayed in four graphs. Figures 9, 10, and 11, respectively, show the spectra of single-frequency harmonic distortion versus power level for the musical notes of E_1 (41.2 Hz), A_2 (110 Hz), and A_4 (440 Hz). The indicated power levels (from 0.1 to 100 watts, –10 to +20 dBW, a 30-dB dynamic range) are only approximate in the case of the D600B, because the power amplifiers are built into the speaker and are not readily accessible. The line-level input voltage was set so that each woofer reached an approximate 50-watt level at 45 Hz, where the system's alignment filter provided maximum boost. This level, 7.1 V rms with the system gain set to "32," was maintained for all tested frequencies.

Figure 9 shows the E_1 (41.2-Hz) harmonic distortion data. Maximum power was 50 watts into each woofer, making a total of 100 watts. The nonharmonically related spikes at lower power levels are due to background noise in the measurement setup and were not generated by the loudspeaker. At lower power levels, the second and third harmonics predominate, while at higher power levels, the fourth, fifth, and sixth harmonics join the lower ones. The lower harmonics reach only about 7% at full power; this is impressively low considering the size of the system. The second and third harmonics are roughly the same level at higher power levels, which indicates that the one-sided and symmetrical nonlinear mechanisms are roughly equal. Note that the system was generating a fairly loud 99 to 100 dB SPL at 1 meter with full power at 41 Hz.

The A_2 (110-Hz) harmonic data is shown in Fig. 10. The graph indicates that only the second and third harmonics are significant over the tested power range, with the second harmonic predominating at higher power levels. The second harmonic increases with power, reaching a level of about 8% at full power; the significantly lower third harmonic reaches only 1.7% at full power.

The A_4 (440-Hz) harmonic measurements are shown in Fig. 11. The only noticeable distortion was a low amount of second harmonic, which peaks at about 1% at full power. All other distortion products are mostly below the noise floor of the display, about 0.2%!

The IM distortion on a 440-Hz (A_4) tone created by a 41.2-Hz (E_1) tone of equal input level is shown in Fig. 12. The IM distortion gradually rises with power, reaching only about 10% at full power The first-order ($f_2 \pm f_1$) and second-order ($f_2 \pm 2f_1$) side frequencies were the only significant ones in this power range. The vented-box design of the D600B, which coincidentally is tuned to roughly the lower test frequency, contributed to the relatively low IM distortion.

Figure 13 shows the short-term peak input and output capabilities of the D600B as a function of frequency. The tests were run by exercising the system with a shaped, 6½-cycle, sine-wave tone-burst test signal at all third-octave intervals from 20 Hz to 20 kHz. As before, the system was driven through the line input. The gain was set higher, at "42," so that the power amplifiers would reach their clipping limits before any earlier amplifying stage did.

The test sequence consisted of determining how much of the burst test signal could be handled by the system, at each frequency, before either the output sounded audibly distorted or the acoustic output waveform appeared distorted, whichever occurred first.

The maximum input capacity of the D600B is shown in the lower curve of Fig. 13. The peak input voltage is in decibels referenced to the peak of a 1 V rms signal, corrected for the added gain provided by the "42" setting as compared to the "32" setting (an actual gain increase of about 13 dB, or about 1.3 dB per step). Above 50 Hz, the peak input rises with frequency, reaching a plateau at about 28 dBV peak. Below 50 Hz, the input voltage also rises, due to the effect of the D600B's high-pass filter.

The D600Bs were always first-class in imaging, soundstaging and focus, and brought out the best in every recording.

The upper curve in Fig. 13 illustrates the maximum peak sound pressure levels the system can generate at a distance of 1 meter on axis for the input levels shown in the lower curve. Also shown in the upper curve is the maximum output with the "room gain" of a typical listening room added at low frequencies. This adds about 3 dB to the response at 80 Hz and 9 dB at 20 Hz. With room gain, a single system can generate peak levels in excess of 110 dB above 100 Hz, reaching respectable levels of 115 dB SPL at higher frequencies. At upper frequencies, peak output was limited by the internal 70-watt amplifiers; below 200 Hz, it was limited by driver excursion. A pair of these systems, operating with mono bass, will be able to generate higher levels by some 3 to 6 dB in the bass range.

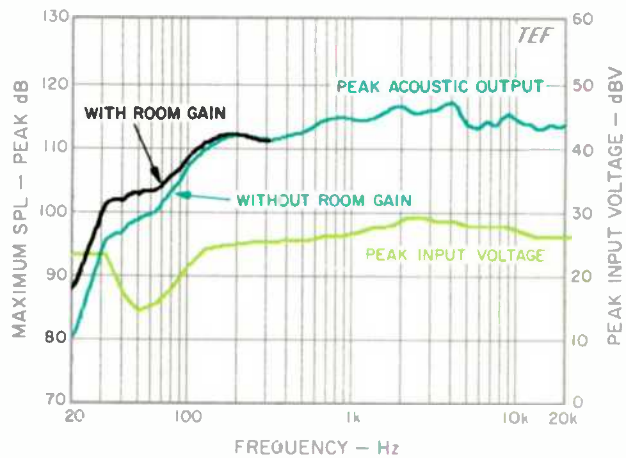

Fig. 13—Maximum peak sound output measured at 1 meter on axis, and corresponding maximum peak line input voltages (see text). The effect of low-frequency room gain on maximum output is also shown.

Use and Listening Tests

I have been fortunate in having the Meridian D600Bs in my possession for several months. Because I didn't have a decent system in my office to listen to while writing, I used the D600Bs. I set them up on either side of my desk, out from the wall, for some informal initial listening from fairly close in. My office is relatively large (13 × 16 feet), and the desk is centered on the long wall, in front of a window. Even in this atypical situation, I was quite impressed with the overall performance of the D600Bs and, in particular, with their bass and smooth upper mids and highs.

Getting the D600Bs set up and connected to the Model 206 CD player does require a significant amount of extra effort and study of the instruction manuals, as compared to setting up a passive speaker system. The Meridian speakers are supplied with two quite detailed manuals, an 11-page user manual and a 29-page(!) manual for setup. An initial examination of the manuals left me feeling apprehensive and somewhat confused on where to start because of the system's apparent complexity. But I then found a sheet, "Getting Going," that really helped move things along.

The D600B's extraordinary versatility, including its ability to link with Meridian's multi-room products, greatly increases the overall complexity of the system. The user manual states it quite well:

> Unlike other home electronics, the D600 is user-configurable. This means that you can program the D600 to interpret your commands in a convenient way. Whilst this power makes the D600 very simple to use on an everyday basis, the process of customizing—if you choose to do it—may be confusing if you do not read and understand the D600 Setup Manual.

The system can only be programmed via the 609 remote control, following a complex set of menus and submenus whose status is indicated on the multi-character displays on the front of the D600Bs. The programming is still confusing to me, even after I've lived with the system for a while and read the setup manual!

More serious auditioning was performed in my listening room, which measures 15½ × 27 × 8 feet and is furnished as a normal, carpeted living room. The listening equipment consisted primarily of the Meridian D600Bs and the company's 206 CD player, augmented with gear to drive my reference B & W 801 Matrix Series 2 speakers. For A/B comparisons, I fed the Meridian 206's analog outputs to a Krell KSP-7B preamp and KSA-200B power amplifier. Spiked feet were supplied for the bottom of the cabinets and used for a portion of the listening tests. They came with plastic covers that could be used if the sharp tips were not required.

As stated before, I made no electronic measurements of the bitstream D/A converters in the D600Bs but did do critical listening using the very demanding Chesky "bonger" test (tracks 25 and 26 of the *Jazz Sampler & Audiophile Test Compact Disc, Vol. 1*, Chesky JD37). This test, a series of sine-wave tone bursts with a sharp attack and slow decay, recorded at successively lower playback levels, is very revealing of low-level nonlinearities in D/A converters. The decay of the tone should sound very clean, with no extraneous sounds, and should fade smoothly into the dithered background noise. Fortunately, the disc has both good (track 25) and bad examples (track 26) of A/D converters, so listeners can train their ears by comparing the good and bad tracks. With gain turned up on the low-level bursts, it is very easy to hear what a poor converter does to the tone; the effects are not subtle at all! The D600B reproduced the good track very cleanly, with hardly any detectable anomalies. Its converter's performance exceeded that of my Rotel RCD-855 CD player and was significantly better than that of my Onkyo Grand Integra DX-G10.

Most of the serious listening was done with the D600Bs placed in my regular evaluation position, about 6 feet away from the short rear wall, and separated by 8 feet. This left a spacing of about 4 feet from the side walls. The systems were canted-in laterally so that I was on each system's axis. Listening took place on the sofa, about 10 feet away, with my ears roughly even with the top of the enclosure. Most listening was done using digital coax cable rather than fiber-

A Meridian preamp/CD player atop the D600B loudspeaker system

optic cable. In informal listening tests, I could hear no difference between the coax and fiber-optic cables.

An initial comparison with my reference systems revealed a compelling sound that was quite comparable, except for very low bass. The Meridians could be played cleanly at as high a level as my reference systems, and delivered quite even horizontal coverage and a very open, revealing sound. They passed nicely the stand-up/sit-down test of vertical coverage (using pink noise) with only minor changes in upper midrange timbre.

Most of my listening was done with the Meridians in their reset state, which defeats the tone corrections. Even though the manual recommends a bass setting of "+1" for systems placed well away from the walls, as they are in my setup, I did not find that the additional bass was required. However, it was quite nice to have the additional flexibility that the bass and tilt controls provided, although most of the time the corrections were not needed.

It was quite hard to break the habit of aiming the remote control at the source equipment, which is over to the left in my setup, instead of forward towards the speakers! Also, there was a bothersome lag of about 0.6 to 0.7 S before commands issued from the 609 remote to the CD player (but not to the speaker) took effect, and any command given in the interim was ignored. This was a continuous annoyance. Fortunately, the remote's mute command usually took effect immediately.

I also noted a software bug in the interaction of the "Bass" control and the "Reset" key. When a command was issued to increase the bass setting by one step, overall gain was increased by two steps, which resulted in a net bass gain. If I then decreased the bass, the gain was appropriately reduced by two steps. However, if the "Reset" key was used to cancel all tone settings after a command to increase the bass was issued, the gain was left in the higher setting (or lower setting if the original command was a bass decrease), which resulted in an audible jump in level.

On the new piano CD of Earl Wild playing Chopin (*Earl Wild/Chopin: 4 Ballades—4 Scherzi*, Chesky CD44—a super piano disc!), the D600Bs exhibited a very smooth midrange coupled with impressive dynamics and a very realistic portrayal of the hall's reverberation. The bass solo of Figaro's aria, "Non più andrai," from *The Marriage of Figaro* (*Mozart: Opera Highlights*, Laserlight 15 655, part of a 10-CD Mozart set I purchased at a local warehouse club for $29.95!) was rendered very cleanly, without any harshness or tubbiness. (I normally don't go out of my way for opera, but this is great stuff!)

The overall sound of the D600Bs is very neutral, with hardly any emphasis or de-emphasis of any part of the audible range. These speakers do an exceptional job of bringing out the fine, subtle details in source material that you often miss with other speaker systems. The D600B's triamped internal configuration contributes to its effortless peak-reproduction capability and cleanliness when executing such difficult source material as high-level jazz trumpet and trombone.

The bass response is quite outstanding considering the overall size of the enclosure. Down to about 32 Hz, these systems can compete with much larger ones. In the region from 20 to 25 Hz, however, the system's output is gone. Yet unlike most other speakers, no distortion or bad extraneous sounds are heard from the D600B if any high-level energy exists in the program material in this range. This is due to the high-pass action of the sixth-order alignment filter. The kick drum on Makoto Ozone's *Starlight* disc (JVC JD-3323) was dealt with very effectively, although the string bass on track 7 was a little heavy and required the bass to be set at "−1" for best results.

The D600Bs were always first-class in stereo imaging, soundstaging and focus, and always brought out the best in every recording that was appropriately miked. The systems also ranked very high in clarity and dynamics and in the ability to be played loud and clean, considering their relatively small size. In addition, I was quite impressed by the D600Bs' ability to act as a neutral sonic arbiter of whatever I listened to. These speakers nicely emphasized the best (or the worst) of recordings I heard and allowed sonic judgments to be made easily.

Is the D600B for you? It depends on whether you basically look at it as a small, two-way loudspeaker with a 6-inch woofer and with some very expensive high-tech gadgets thrown in—or as a complete, fine-tuned audiophile system with self-contained amplifiers and an excellent built-in D/A converter that can compete with the best outboard converters. What $5,500 buys you is a well-designed system, already set up, that has high audiophile performance. A pair of D600Bs competes very well with other high-end products but doesn't put you through such hassles as having to choose and select separate components and interconnects or worrying about interface considerations.

The D600B is truly much greater than the sum of its parts; it is a well-executed, all-in-one system that provides serious high-end performance. And the fact that it is specifically designed to work in a remotely controlled, multi-component, multi-room setup will enhance its value to anyone for whom this aspect is important. *D. B. Keele, Jr.*


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SSI SYSTEM 4000 II DOLBY SURROUND DECODER

Manufacturer's Specifications

Separation: Front center to surround, 65 dB; left to right, 35 dB.

Frequency Response: Front channels, 18 Hz to 50 kHz, +0.5, −0 dB; surround channels in "Music" mode, 18 Hz to 50 kHz, +0.5, −0 dB; surround channels in "Dolby" mode, per Dolby Surround specifications, +0.5, −0 dB.

Distortion: Front channels, 0.03%; surround channels, 0.25%.

A-Weighted Output Noise: Front channels, −85 dB at 1 V rms; surround channels in "Music" mode, −75 dB at 1 V rms; surround channels in "Dolby" mode, −68 dB at 1 V rms.

Dynamic Logic Steering Factor: −3.

Delay Range: 10 to 30 mS, adjustable.

Input Balance Range: 0 to 6 dB of correction.

Input Impedance: Audio, 47 kilohms; video, 75 ohms.

Power Amplifier Output: 45 watts total continuous power into 8 ohms.

Power Requirements: 120 V a.c., 60 Hz, 120 watts.

Dimensions: 17 in. W × 3¼ in. H × 13 in. D (43.2 cm × 8.3 cm × 33 cm).

Weight: 14.2 lbs. (6.5 kg).

Price: $549.

Company Address: 400 South Date Ave., Alhambra, Cal. 91803.

For literature, circle No. 92

The SSI System 4000 II decoder is somewhat larger than some processors, but it includes a two-channel power amplifier for driving the surround speakers. Its five operating modes are "Dynamic Logic," "Dolby" Surround, "Music," monaural enhancement, and bypass. SSI's exclusive Dynamic Logic steering circuit keeps residual sound in each channel to prevent sonic voids that can appear in other steering systems. Three modes of center-channel operation give the user flexibility in matching the surround to his particular listening environment. The switching arrangement and jacks provide for playing or dubbing up to four audio or audio/video sources. Delay times range from 10 to 30 mS in 5-mS steps, usable with "Dynamic Logic," "Dolby" Surround, and monaural enhancement modes. The front panel includes front/rear balance and up/down volume controls. The remote control handles these as well as many other useful functions.

Control Layout

The large, rectangular "Power" button is at the lower left of the front panel, just below the remote control sensor. To the right are the "Balance," "Null," and "Amp" controls, each having a relatively small knob with excellent knurling. The multiple detents of "Balance" and "Amp" give a feel somewhat like that of a professional attenuator, but I would prefer the finer resolution available without detents. "Balance" controls the relative output levels of the built-in two-channel amplifier, "Null" is the input balance pot for Dolby Surround, and "Amp" is the volume control for the built-in amplifier. Located at the extremes of rotation are "L" and "R" for the "Balance" knob and "Min" and "Max" for the "Amp" control.

Next on the right is the "Delay" change button, with a display above it. The selected delay is shown by an LED array, with a yellow LED for 10 mS at the left, a red LED for 30 mS at the right, and three green LEDs between them. The leftmost indicator is always on in the "Dolby" Surround or "Mono Enhance" mode. Each push of "Delay" adds 5 mS and illuminates another LED; when all five are illuminated (30 mS), another push returns the delay to 10 mS. Any delay selected remains in memory when power is turned off.

The "Audio Video Selector" to the right has four buttons ("A" to "D"), each with a red indicator confirming the choice made. A green LED "Surround" indicator is above and between the "B" and "C" LEDs. The level of surround energy in an incoming signal is shown by the brightness of the indicator. Next on the right is the "Surround Mode" button, which steps the mode from "Dynamic Logic" to "Dolby" to "Music" to "Mono Enhance" to "By-pass" and finally back to "Dynamic Logic." Indicator LEDs are green for all choices except "By-pass," which has a yellow LED to remind the user that there is no processing in this mode.

At the extreme right are the "Balance" ("Front" and "Rear") and the "Volume" ("Up" and "Down") buttons. "Front" and "Up" are above the "Rear" and "Down" buttons, which seems very logical to me. Arrows above the top buttons' labels and below those of the bottom ones help convey the functions immediately. The "Balance" arrows are double, helping to differentiate them from the single arrows on the "Volume" buttons.

The labels on the panel, the labels and arrows on the buttons, and the indices on the knobs are all gold and are easily seen against the black panel over a wide range of lighting.

At the back panel's extreme left are the audio ("Left" and "Right") and video phono jack inputs. From left to right, they are "D," "C," "B," and "A," with the video jacks above the audio. Next on the right, near the bottom of the panel, is the three-position slide switch for center-channel mode. In position "1," left plus right is fed to the left, center, and right channels, spreading monaural signals across the whole frontal stage; this mode would be useful for a wide listening area. In position "2," left plus right is fed only to the center channel, putting monaural sources in the center; individual left and right signals maintain their stereo position. In "3," the center channel is off and left plus right is mixed into both the left and right channels, generating a phantom center. The numbers labelling the center-channel switch positions are farther apart than the actual positions of the switch, which leads to a little confusion when it is first used.

Next on the right are stereo phono jack pairs for "Dub Out" and "Front" (both with video output jacks above them) and for "Amp Input." There are paralleled mono output jack pairs for "Center," "Surround," and "Subwoofer."

The System 4000 II does not have a tape monitor function as such, but one of its inputs and the "Dub Out" jack can serve this purpose. The unit also provides the advantage, to some users, of switching any associated video source. The 4000 II is supplied with U-shaped wire links connecting the two "Surround" outputs to the amplifier inputs. The links can

Sibilance on a news show was caused by the station's twisting the mono signal's phase until it looked like a pretzel on my 'scope.

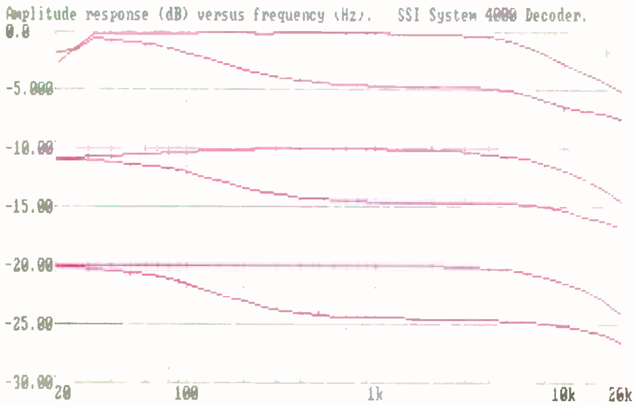

Fig. 1—Frequency response of main channel at three signal levels. The flatter curve of each pair is with the center-channel switch in position "3," while the curves that plateau at 600 Hz were made in switch position "1." See text.

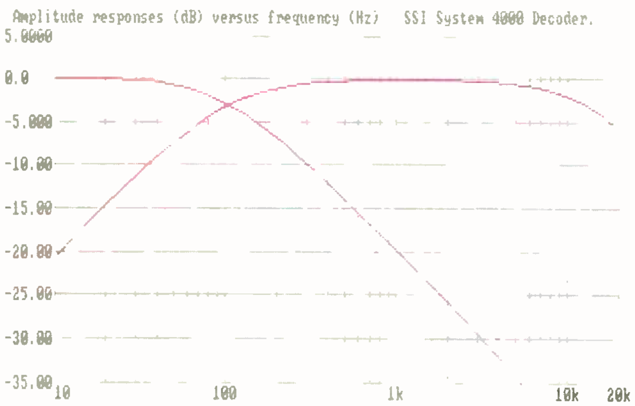

Fig. 2—Frequency response of subwoofer and center channels in switch position "1."

be moved to obtain two other configurations: Both amplifier channels driven by "Center," or one channel driven by "Center" and one by "Surround." This is a simple arrangement and well thought out by SSI. Further to the right are "Left" and "Right" spring-loaded speaker terminals. Finally, at the upper right is a post-type fuse-holder—a worthwhile convenience, in my view. The labels are white and very easy to read against the black panel.

When I took off the unit's top/side cover to examine its interior, I noted a number of impressive things: The very large heat-sinks for the power amplifier; the half-chassis-size, high-quality main p.c. board, and the many components on the board and their neat arrangement. Superior-quality components were in evidence, and all parts were labelled. Three other boards are used, for the power supply and power amplifier, the back-panel video in/out circuitry, and the circuitry behind the front panel. Soldering was excellent, for the most part, and the hand-soldered points had relatively little flux remaining. Interconnections between boards were made with multi-conductor cable and plugs. The boards were well supported, in general, but there was some springiness. The front panel could be bent back and forth rather easily, while the back panel was more rigid. (Replacing the cover did make everything much more rigid.) The large power transformer was quite warm after driving the amplifier at full power for some time. Without the power amplifier driven, the transformer remained cool to the touch.

The remote control is a convenient size to hold in one hand and operate the buttons with the thumb. "Power On/Off" is the button nearest the emitter end. Below it are the side-by-side "Mode" and "Delay" buttons. Below these are the "Balance" ("Front" and "Rear") and "Volume" ("Up" and "Down") buttons; the positioning of these four controls corresponds to their positioning on the unit's front panel. Last comes the "Mute" button—a most logical place for it to be. Except for the red "Power On/Off," all of the labels are gold, easily seen against the black background. The light gray buttons stand out clearly, even in dim light.

Measurements

All of the measurements were made after the listening and viewing. Figure 1 shows the main-channel frequency response at three different levels for two positions of the center-channel switch on the rear panel. In each case, the response where the level drops off above 20 or 30 Hz and reaches a plateau at 600 Hz is obtained with the switch in position "1," and with the same signal fed to both inputs. In this position, a left-plus-right sum signal is fed to the left, center, and right channels. When just one input channel is driven, the response is basically flat. In other words, in position "1," the bass frequencies of a monaural signal are more prominent in the left and right speakers than are the higher frequencies. The other response curves shown were obtained with position "3," in which center is off and a phantom center channel is made by feeding a left-plus-right sum signal to the left and right channels. As the level is reduced, the responses for these two switch positions become flatter at the frequency extremes. In position "2" (not shown), left plus right is fed to the center channel, and left and right individually are fed to their respective channels. The main-channel response in this position was close to the low-frequency characteristic of position "3" and the gentle, high-frequency roll-off of position "1." In position "2," the response was down 0.29 dB at 20 Hz and −1.9 dB at 20 kHz. The −3 dB points were at 4.4 Hz and 25 kHz. At the frequency extremes, all of the responses show some effects of the level-sensing circuitry.

Figure 2 shows the subwoofer and center-channel responses. The subwoofer roll-off above 100 Hz is at 6 dB/octave. In switch position "1," the center-channel response is rolled off below 100 Hz at 6 dB/octave. The response

The Krell MDA-300 Mono Amplifier

The MDA-300 represents a new generation of monaural amplifier design. The designation MDA, which stands for "Mono Differential Amplifier", only begins to describe the innovative design concept of the MDA-300.

The MDA-300's circuit topology is unique from any previous amplifier intended for audio use. Two discrete hemispheres are used to amplify the non-inverted and inverted portions of the input signal. This technique allows independent amplification of both halves of the balanced signal, eliminating the possibility of degradation or contamination of one half by the other.

Another unique design feature is the absence of feedback from output to input. Front-end circuits operate as pure, uncompromised gain stages, as opposed to designs employing global feedback. This creates an inherent stability not otherwise possible.

The MDA-300 completes the third series of Krell convertible amplifiers. Our KSA-150 stereo amplifier can be remanufactured into an MDA-300. This allows the KSA-150 owner to upgrade to a pair of MDA-300's without selling or trading-in the stereo unit.

The MDA-300 technology yields great advancements in speed and power delivery. The resulting sonic quality is easily perceived and must be auditioned to be appreciated. Please contact your local Krell dealer to arrange a personal listening session.

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The SSI decoder was totally reliable throughout my tests. Changing settings was a snap, and the remote control was easy to use.

crossover was 2.8 dB down, very close to the −3 dB (half-power) point. In this position, the main speakers are boosted in the bass region, relatively speaking, as was shown in Fig. 1. With the switch in position "2," the response would be close to that of the main channels for this switch position. The center channel is off in position "3."

Figure 3 shows frequency response of the surround channels in "Dolby" and "Music" modes, with those for "Music" obviously flatter than those in "Dolby." The "Dolby" mode responses are in basic agreement with Dolby Surround standards.

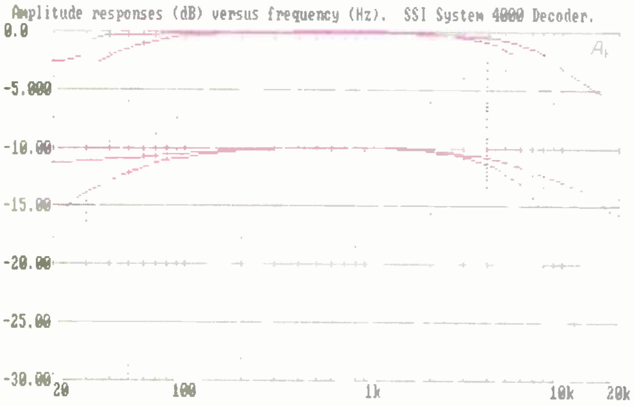


Fig. 3—Frequency response, at two signal levels, of surround channel in "Music" mode (top curve of each pair) and "Dolby" mode (bottom curve of each pair). The Dolby Surround standard mandates the bass and steep treble roll-offs shown.

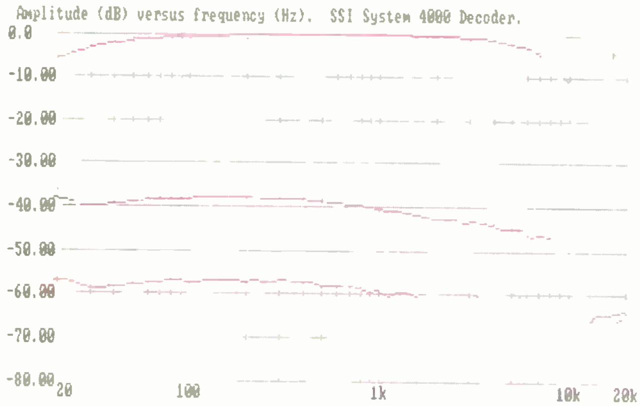


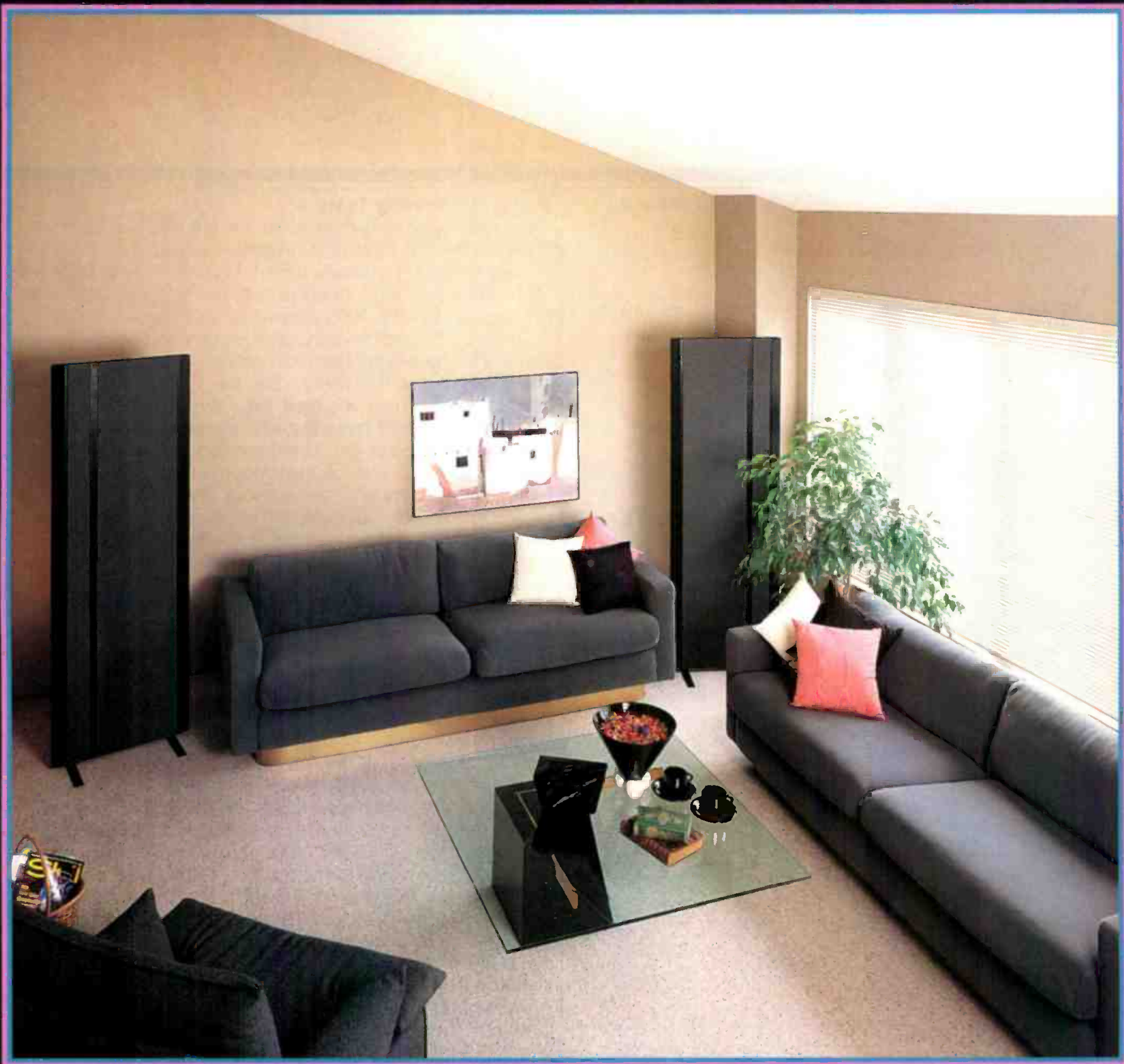
Fig. 4—Output from surround channels in "Dolby" mode with mono signal fed to left and right channels. Top curve is with "Null" control at one extreme, middle curve is with control at 12 o'clock, and bottom curve is with knob trimmed to about 12:15 for greater separation. See text.

The output in the surround channels in "Dynamic Logic," with a mono input (Fig. 4), was measured with the "Null" control in three different positions. The top curve was obtained with the null control to one extreme, the middle curve resulted when the knob was centered at 12 o'clock, and the bottom curve was run after trimming the knob position (to about 12:15) for more separation. Both of the latter two curves are excellent, and it was possible to get even better separation (more than 70 dB) by very careful trimming. The signal-to-noise ratio, in "Dynamic Logic" mode with a 1-V reference, was 91.0 dBA for the main channels and 81.2 dBA for the surround channels.

Figure 5 shows THD + N across the band for the main channels at 2 V input and output. The higher THD + N curve was obtained with the center-channel switch in position "1." The output in this position was 2 V at only the lowest frequencies, before the response roll-off shown in Fig. 1. The bottom curve was made in position "3." These results are quite acceptable but not overly impressive. The maximum input level before waveform distortion began to appear at the main outputs was 2.8 V with both inputs driven. The main outputs did not clip at any setting of the master volume control up to maximum. At the point where the front and rear output levels were equal, the level in each channel was about 9 dB below its maximum. A little checking revealed that waveform distortion appeared in the main outputs only when there was clipping in the surround outputs. An input level of 1.0 V at 1 kHz was the maximum that would ensure against any type of waveform distortion in the surround outputs in any surround mode. This somewhat low maximum might be limiting in particular cases, but I did not hear any distortion I would attribute to it. In "Music" surround mode, the input level could be at least 3 V without any waveform distortion.

The input impedance was 18.2 kilohms. The main channels' output impedance was a nice, low 510 ohms. Output polarity was reversed in the main and center channels. As Fig. 6 shows, distortion in the amplifier's output, at the 20-watt power level, was low over most of the frequency range but rose at higher frequencies.

The main channel's input-to-output level change in "Bypass" mode was + 1.1 dB on both channels with the master volume control at maximum. The master volume control covered a range of 56 dB in 31 steps, and its sections tracked within a fraction of a decibel over that entire range. The first steps from zero attenuation averaged about 1 dB each, increasing to about 2 dB each by −9 dB. If the "Down" volume button was held in, it took 5 S to cover the attenuation range from 0 to 56 dB (which is also the muting level). The "Front/Rear" balance control operated over 15 steps, to yield a maximum attenuation of 19 dB at either front or rear. The number of decibels per step varied with the setting of the volume control, which had to be at least 11 dB below its maximum setting for the full balance range to be available. The Dolby Surround input balance control ("Null") could reduce the level of either channel up to 6.7 dB from the center position.



The system provided good sonic illusions from many CDs, and did nearly as well as my reference processor on stereo TV and movies.

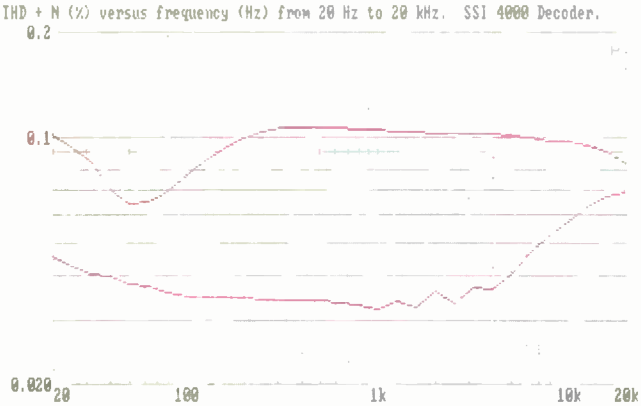


Fig. 5—Main-channel THD + N at 2 V in and out in "Dolby" mode, with center-channel switch in positions "1" (top) and "3" (bottom).

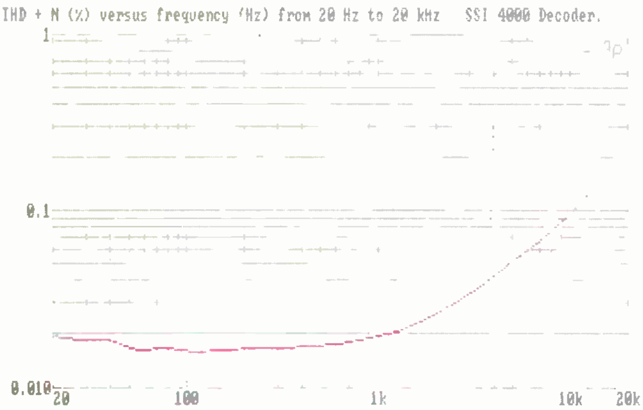


Fig. 6—THD + N of power amplifier at 20 watts per channel into 8 ohms, both inputs driven.

The delay times were 8.6, 12.5, 18.7, 22.2, and 29.4 mS, which are at some slight variance with the specified range of 10 to 30 mS. As a practical matter, this discrepancy is not important; the measured delay times are good for matching the great majority of listening rooms.

The remote control was reliable out to at least 25 feet on the sensor's axis and could be pointed just ± 15° off axis at this distance. At normal viewing/listening distances, the remote could be positioned up to ±60° off the sensor's axis as long as it was aimed at the System 4000 II, and could be pointed as much as ±30° off axis when it was located on the sensor's axis.

Use and Listening Tests

My evaluation and monitoring system was the same as I have used in the past. The reference surround unit was the combination of Yamaha's DSP-1 processor and DSR-100 PRO Dolby Pro-Logic decoder. For the listening tests, I did not use the System 4000 II's built-in amplifier.

The SSI's instruction manual provides good guidelines for setup and operation. The instructions on setting delay are correct in a general sense, but the manual is wrong in stating that the user will hear definite echoes as a guide. The manual should have stated that too short a delay can cause localization to shift to the surround speakers, and too long a delay can reduce the smoothness of the surround. Although the manual's text is lucid, the first line of each paragraph is not indented, which makes reading a little more difficult. On the plus side, a number of large connection diagrams cover a wide variety of hookups and show clearly what to do.

On Showtime, I watched *Dancers*, with Mikhail Baryshnikov and Alessandra Ferri. I thought "Music" mode was best overall, but "Dynamic Logic" and "Dolby" Surround were also good; "Mono Enhance" was not a good choice. "Bypass" (regular stereo) provided good detail but had a collapsed sound field. At one point I thought I noticed slight sibilance in the surround channels in "Music," but then I discovered it was in the source. On another station, *The Oprah Winfrey Show* had stereo synthesis and some sibilance; the latter was lowest with "Mono Enhance" or "Bypass." On the same station, the sibilance was very high during two remote news broadcasts. The display on my oscilloscope revealed that a monaural signal was causing a very distorted, convoluted X-Y pattern, apparently because of stereo synthesis. A number of stereo stations and programs do show a narrow ellipse on mono signals, evidencing some phase shift, but not the twisted pretzel I saw in these cases.

Unless noted otherwise, I used "Dynamic Logic" for regular movies and music videos. *The Witches of Eastwick*, the Warner Home Video VHS tape with Jack Nicholson, Cher, Susan Sarandon, and Michelle Pfeiffer, has a good storm sequence at the beginning. The System 4000 II provided excellent surround sound, and using a subwoofer with it proved valuable. I felt overall bass was a bit excessive with the center-channel switch at position "1," so I used "2" after some adjustment to center level. With few exceptions, the dialog was always exactly centered as it was in the source—even when the actor was off screen. I heard one spot of sibilance, but I did not detect it in surround. The Paramount Home Video videodisc of *Beverly Hills Cop*, with Eddie Murphy, has a good opening music track. Quite a bit of the sound is mono, although some stereo and surround is used, including good effects in a chase sequence and a gunfight near the end. The SSI decoder did well with the limited surround in the source.

Little Shop of Horrors, the Warner Home Video videodisc with Rick Moranis and Ellen Greene, had good surround; music and effects were well placed. During vocals, I detected a couple of small jumps in sound localization to center. I wasn't certain about their cause, but I did pin down at least one sudden jump in vocal presence to the source. *Stevie*

The SSI 4000 II performed well, especially with films. Much lower in cost than several other decoders, it is definitely a good value.

Nicks—In Concert, a Pioneer Artists videodisc, benefited from my raising the center speaker level. The music had relatively little stereo or surround—perhaps necessary for a concert illusion. The crowd noise and applause, however, generated good surround. I had a slight preference for "Dynamic Logic" or "Dolby" mode over "Music" and "Mono Enhance." The overall results provided by the System 4000 II were noticeably better than those I had obtained previously with the same videodisc using another, more expensive surround decoder.

The first CDs I tried were Bach's *Brandenburg Concertos* performed by I Musici (Philips 412 790-2). I used center-channel position "3," which has a phantom center image. In general, "Dynamic Logic" mode provided more spaciousness but "Music" had more detail. I noted that with Concerto No. 4, I liked the liveness with "Music" mode but wanted it to surround me more. The results with Concerto No. 5 were pretty much the same. I did notice occasional jogs in localization in "Music" at first, so I shifted the balance to the front to reduce them. The next selection was Schubert's "Death and the Maiden" string quartet, with the Amadeus Quartet (Deutsche Grammophon 410 024-2). The string tone was a bit pointed in center-channel position "3," and I liked the result better after a switch to "2" but with the center channel turned off. To me, "Dynamic Logic" and "Dolby" modes were more solid, but "Music" was more detailed. I shifted balance somewhat to the rear for more liveness.

Mozart's *Eine Kleine Nachtmusik*, performed by Mackerras and the Prague Chamber Orchestra (Telarc CD-80108), sounded best with the same basic settings used for the Schubert work. This CD has more liveness, however, and I shifted the balance slightly back toward the front. I definitely preferred "Music" mode for the Berlioz *Symphonie Fantastique*, with Dutoit and the Montreal Symphony Orchestra (London 414 203-2). I wanted more liveness, and the challenging "March to the Scaffold" seemed constrained very slightly. The value of using the subwoofer was demonstrated a number of times. Borodin's "Music from Prince Igor," performed by Shaw and the Atlanta Symphony Orchestra (Telarc CD-80039), was somewhat better in "Music" than in "Dynamic Logic" and "Dolby" modes. During the dance music, the bass drum was very impressive. *William Tell & Other Favorite Overtures*, with Kunzel and the Cincinnati Pops Orchestra (Telarc CD-80116), seemed better to me in "Music" mode. In some respects, parts of Offenbach's "Orpheus in the Underworld" seemed closed-in sonically, but there certainly was no doubt about the *big* bass drum.

The System 4000 II produced quite a good result in "Music" mode when I played Brahms' *Piano Concerto No. 2*, performed by Ashkenazy with Haitink and the Vienna Philharmonic (London 410 199-2). With Michael Murray's *Bach: The Organs at First Congregational Church, Los Angeles* (Telarc CD-80088), I wanted much more liveness than I could get for the large-church illusion, and bass seemed to be hanging on, somehow, after some of the pedal notes. Next I tried Beethoven's "Choral" Fantasy, with Rudolf Serkin, Ozawa, the Boston Symphony Orchestra, and the Tanglewood Festival Chorus (Telarc CD-80063). I preferred "Music" mode with the piano and orchestra, but when the chorus was added my preference switched to "Dynamic Logic." Localization of the piano shifted from slightly left toward the center a couple of times. For Puccini's *La Bohème*, sung by Moffo and Tucker with Leinsdorf and the Rome Opera House Orchestra and Chorus (RCA 3969-2-RG), I shifted balance slightly to the right to obtain better placement of voices. "Dynamic Logic" was preferred over "Music" mode, and vocal presence was fine without the center loudspeaker.

Creedence Clearwater Revival's *Chronicle, Vol. 1* (Fantasy FCD-623-CCR2) needed the center speaker on. I set it at a lower level than I did for movies, but the center localization was important for vocals. This CD is mostly mono, with some left/right positioning. I switched among all the surround modes, the choice depending on the track. "Proud Mary" and "Down on the Corner" came across particularly well with the SSI decoder surround. *Star Tracks*, with Kunzel and the Cincinnati Pops (Telarc CD-80094), has a lot of good surround sound. I left the center speaker on but set its level fairly low. The sounds of bass drum and cymbal crashes were handled well, and the music in general was a good match for the System 4000 II. I switched back and forth between "Dynamic Logic" and "Music" modes to get the best results for each track. Jennifer Warnes' *Famous Blue Raincoat* (Cypress 661 111-2) is primarily monaural because of the vocals, but it does have important surround sound. For most of the tracks, it sounded best in "Dynamic Logic" or "Music" mode with the center level up. I liked the surrealistic character of "First We Take Manhattan," obtained effectively from "Music" mode with the center level down. Handel's *Water Music*, a recording by Stokowski and the RCA Victor Symphony that I heard on FM, had good surround sound, and the "Music" mode delivered good listening from it. In center-channel position "2," station announcements were fine and had good presence, even if the center level was low.

The SSI decoder and its controls were completely reliable throughout the testing. The indicators clearly showed how the controls were set, and the "Surround" LED was nice to have. The remote control was very easy to use; I used it to change modes, delays, levels, and balances without any confusion. For stereo TV and movies, the performance of the System 4000 II was close to that of the much more expensive reference processor. When a source was poor in some way, especially as a result of stereo synthesis, the SSI decoder did generate occasional sonic artifacts not heard with the reference unit. The System 4000 II provided good sonic illusions from a number of Compact Discs, but the processing of the reference decoder was needed if I wanted to change liveness or another room parameter. Several times, the SSI unit provided accentuated bass that would be appealing to many users. In a couple of cases, I concluded that the bass was better articulated by the reference processor.

The SSI System 4000 II surround decoder performs well, particularly with movies. Its flexible input switching of video and audio will be very helpful, perhaps essential, to some users, and the built-in stereo amplifier offers a convenient way to drive surround speakers. The System 4000 II, much lower in cost than several other decoders, is a good value.

Howard A. Roberson

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Threshold founders Nelson Pass (right) and René Besné with the first Threshold preamplifier; the Model NS 10. The NS 10 contained advanced single-ended ultra class A and non-feedback technology which predated the present popularity of these techniques. Typically for Threshold, the 1977 introduction of this preamplifier set state-of-the-art standards that are still valid today.

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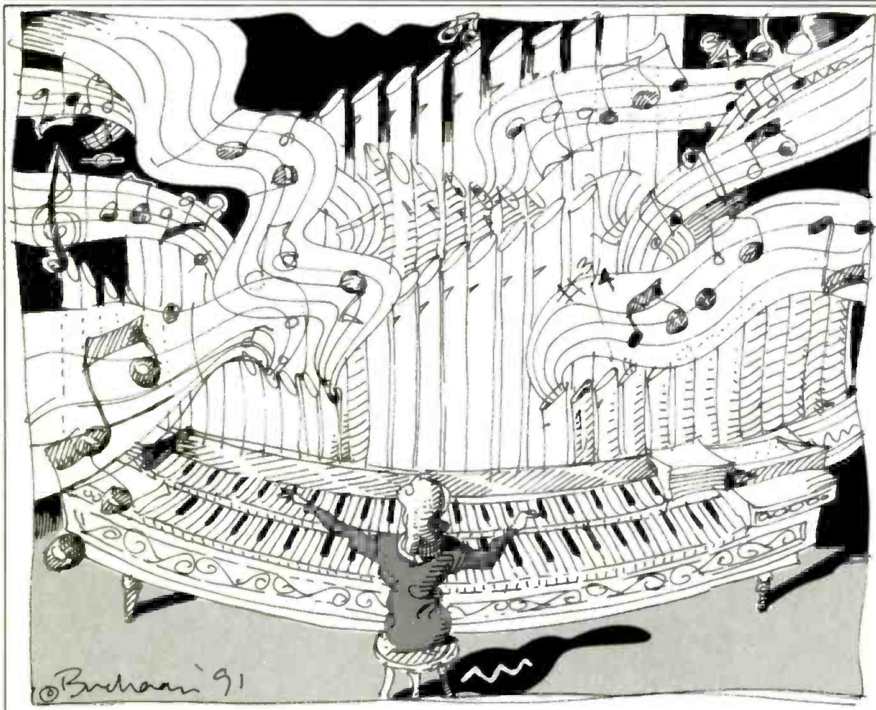

Illustration: Yvonne Buchanan

Couperin: Messe pour les Paroisses; Messe pour les Couvents; Clerambault: Suite du Deuxieme Ton. Marie-Claire Alain, Moucherel-Formentelli grands orgues historiques, Eglise Ste. Cecile d'Albi.
Erato 2292-45460-2, two CDs; DDD; 1:36:22.

In spite of all the French obscurities above, this is a terrific, maybe sensational, recording of its type—music for organ. Anyone with a bit of patience (and plenty of time) who has thrilled to *any* sort of organ music should have this two-CD album, two organ Masses by Couperin the Great, one for parish use, the other for convents. (Curiously, the parish work is the more serious and disciplined; the nuns got a more relaxed and songful opus.)

So many good points. The cryptic plural "les orgues" refers to one built in 1736, another in 1981! The lady organist appears to play both at once; there is no further distinction. My guess is that the old organ was modernized and expanded by the later builder, the two, clearly, in the same manner of construction, now combined as one at a single console. This is pretty much normal practice when an old organ is being renovated. Yes, this combined organ is a splendid example of the French baroque, quite different from the Bach type, the many organs of the north, much brassier, brighter, with very strong tonal colors. Indeed, it practically snarls at you much of the time, a gutsy sound that offers superb contrast to the stringy and flutey sounds of other pipes. The rationale for this sound, moreover, was never so beautifully displayed. This cathedral at Albi, in the mountains of south-middle France, has a reverb time of 6 or 7 *seconds*. And yet, without undue close-up miking, every complex detail is easily audible, inner parts and all. The sharp colors do the trick.

As for the music, it is an unfamiliar format for most of us, but the many short segments, a couple of minutes each (except for a few longer introduction and collection works), each to a specified set of pipes and/or a type of musical form, are perhaps familiar in other old French music, including the harpsichord suites of Couperin, Rameau, and others. It is easy music to listen to, and becomes easier as time passes. Immense dignity, intrinsic elegance, but not monumentality.

As for the Mass aspect (Catholic), it was intricately understandable to the worshippers of that day, each little piece having to do with a portion of Mass text, substituting for that text in an actual service. In the first Mass, for the parishes, there is much Gregorian chant as a basis, long sections that were familiar to the participants, both melody and text. All this we can ignore, with much to listen to.

The most interesting aspect of French baroque, sharply differing from the German organ school, is the precise detailing of the stops, the pipes, to be used for each piece. The Germans, including Bach, rarely indicated any particular sound, though for the good organist there were indirect suggestions. Since the French organs sound, when kept up or restored, much as they were heard more than 200 years ago, and the specific pipes are indicated, we have perhaps the most literally "authentic" sound of old music to be heard anywhere.

Marie-Claire Alain is a sturdy, immensely competent organist, no showoff but a master (mistress) of the long-span drama, built up segment by segment. When you have heard her through, reflect that all this towering music was composed when Couperin was 21.

Edward Tatnall Canby

Glazunov: Symphony No. 6; Serenades Nos. 1 and 2; Triumphal March. London Symphony, Royal Philharmonic, Yondani Butt.
ASV DCA 699, CD; DDD; 51:08.

Here the CD, so typically, gives us an unusual insight at length into "the last of the Russian Nationalists" of the late Romantic period, a man who could play with the big, lush 19th-century orchestra alongside the best of them, though for reasons not ever to be explained, he is generally as un-profound as he is skillful. A curious twist—Glazunov (to use this recording's spelling) lived on far beyond his time, until 1936, leaving Russia for Paris only in 1928, long after the revolution. But his musical voice effectively ceased before WWI. And even then it was untouched by the familiar modernisms of the early century—from Debussy's impressionism to Scriabin's mysticism and from the operatic terrors of Richard Strauss to Stravinsky's sensational rites of a pagan spring. At *that* moment, Glazunov was not yet out of his 40s.


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RIPPINGTONS Featuring Russ Freeman
"Welcome to the St. James' Club"
NELSON RANGELL
"Nelson Rangell"
MICHAEL PAULO
"Fusebox"
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Although Glazunov absorbed all the music of his day and brilliantly laid it forth, he gave back very little originality.

Listening here, first to a full-size Romantic symphony of 1896, then to two quite lovely little serenades composed at 18 and 19, and finally to a bombastic celebration march composed in 1893, I felt strongly that this was not a very original mind, though born an all-out musical genius and in spite of his sensational childhood exploits, to astonish all, notably his Russian music teachers. Glazunov effortlessly absorbed everything of his day but gave back less, however brilliantly laid forth.

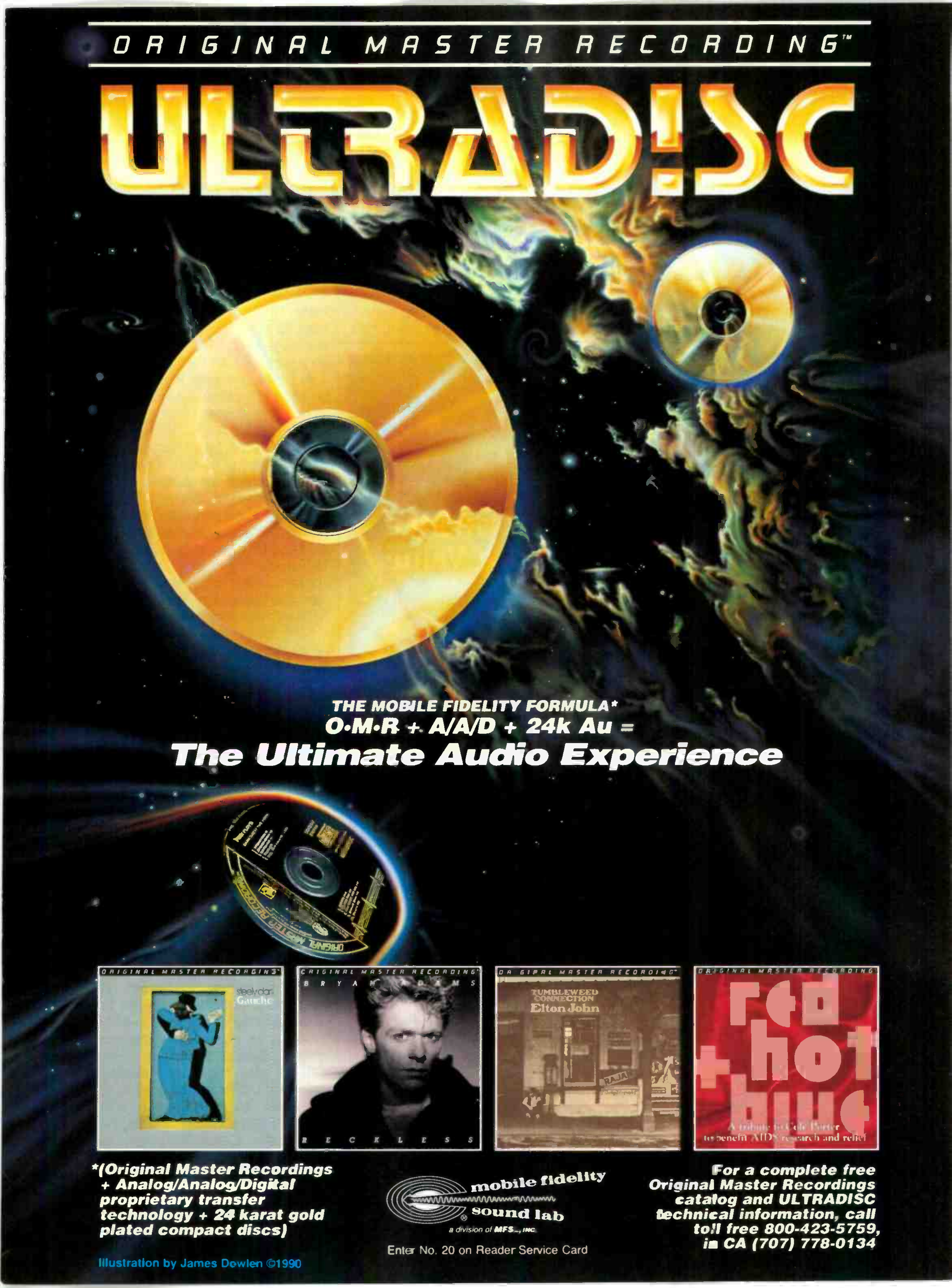
I kept hearing others of that time: The great Borodin, still a bewitching writer of lilting tunes for our ears; a much milder and sunnier Sibelius (born the same year, and another long-lived Romantic composer whose voice ceased early). In the two early serenades, there was even a touch of the sound of Dvořák and Brahms. But oddly, the man who most came to my mind was Sir Edward Elgar (still another of the above) who was eight years older but flourished in close parallel with Glazunov, though one might think them worlds apart, as between Victorian/Edwardian England and imperial Russia. The second movement of the Glazunov Sixth is a theme and variations that is sure to bring to mind the well-known "Enigma" Variations of Elgar. Not nearly as "icky" in the harmony as that earlyish Elgar, his most saccharine (should I say NutraSweetian?), nor as concentrated in thought as "Enigma," but of a similar nature emphatically.

The London Symphony deals manfully with what must have been an unknown score, audibly not quite enough rehearsed. Nothing drastic and the spirit is okay, the music gets over. The Royal, which plays the shorter works, is more self-assured—but these were easier and brief, perhaps allowing the greater polish. *Edward Tatnall Canby*

Sofia Gubaïdulina: Chamber Pieces.
Vladimir Tonkha, cello; Friedrich Lips, bayan; T. Sergeyeva, organ; Collegium Musicum Ensemble; T. Mynbayev, conductor.
MCA Classics AED-68005, CD; DDD; 74:04.

SO-fi-a GU-ba-i-DU-li-na—the dactyls of her Tartar name fall trippingly off the tongue. This extraordinary Soviet citizen has overcome massive odds to become one of the most interesting composers on the contemporary scene.

Born in 1931, she grew up in Kazan; she didn't move to Moscow until the age of 32. Her teachers have included Vissarion Shebalin and Nikolai Peïko. (An unsung hero, Peïko also exerted crucial formative influence on Edison Denisov, Alfred Schnittke, and other Soviet composers formerly classified almost as dissidents.) Gubaïdulina's exotic origins, her gender, and her religious convictions gave her a triplex minority status. Trailblazing performances in recent years, by the great violinist Gidon Kremer and a few other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Gubaïdulina definitely belongs to the musical avant-garde but in a manner all her own.

champions of the avant-garde, have made Gubaïdulina world famous, but at home she remains a prophet largely without official honor.

In two of these works, Gubaïdulina has composed for the *bayan*, a Russian folk version of Western Europe's accordion. This sort of artful camouflage—using a folkish veneer to mask otherwise impermissible techniques and materials—has cropped up repeatedly in the history of the beleaguered arts of the pre-glasnost USSR.

Gubaïdulina's musical materials here remain largely tonal, even diatonic, but her employment of them gets adventurous. The cross dominates all three works. Christ made those seven last utterances from the cross; *Et exspecto* (here misspelled *expecto*) abbreviates *Et exspecto resurrectionem mortuorum* (a title used by Olivier Messiaen, incidentally); *In croce*, aside from its title, has a cruciform musical structure. Gubaïdulina's devout spirituality pervades all this music.

In croce presents the unusual combination of cello and organ; the organist noodles around, ringing changes on one unaltered major chord, providing a tapestry against which the cello bares the recesses of its soul. *Et exspecto*, a kind of sonata for solo bayan in five brief movements, shows off the capabilities of that instrument in its timbre, both commonplace and exotic, by exploiting its every conceivable facility for producing sound; that includes some virtuoso bellows work and even the ventilating key, which produces nothing more than rushing air.

"The Seven Last Words" (another title already used by more than one of Gubaïdulina's predecessors) brings together cello, bayan, and string orchestra in a seven-movement cycle. Gubaïdulina here acknowledges her indebtedness by including a musical quotation from Heinrich Schütz (1585-1672). At the end, so *pianississimo* it must have caused the engineer to tear his hair out, the music doesn't really end, in any conventional way, so much as it simply winds down, dwindles away, receding into primeval silence.

In Sofia Gubaïdulina's quiet sort of way, she definitely belongs to the musical avant-garde but in a manner all her own. She displays extraordinary inventiveness in her exploratory knowledge of the instruments she employs and in her exploitation of their least familiar resources. She herself, and her performers here, do countless unconventional things but in a manner always gentle, always compassionate, in striking contrast to so many of her colleagues who might take these same materials and cast them in a form bristling with bravado and aggressiveness. This CD offers a fine opportunity to become acquainted with at least one facet of her remarkable personality. She could hardly have wished for better performances or better recording techniques than these. *Paul Moor*

SO YOU STILL WANNA BE A ROCK 'N' ROLL STAR?

Back from Rio: Roger McGuinn
Arista APCD-8648, CD; DDD; 41:55.

Sound: A– Performance: A

With Roger McGuinn's place in rock 'n' roll history reaffirmed courtesy of Columbia/Legacy's boxed-set retrospective, *The Byrds* (reviewed in this issue), it makes sense for him to release a new album. McGuinn, having been responsible (along with his Byrd cohorts) for such an influential and infectious sound (jangly Rickenbacker guitars), should intrigue those who caught and appreciated his act the first time around. The question is, what is the Roger McGuinn sound of the '90s?

It should be no surprise that McGuinn collaborates with Tom Petty and his Heartbreakers, for he did that successfully once before. There are songwriting efforts with Petty ("King of the Hill") and Heartbreaker guitarist Mike Campbell ("Car Phone"). Every track has at least one Heartbreaker as a player and/or songwriting partner.

The other cameos of note are from Michael Penn, David Crosby, Chris Hillman, Timothy B. Schmit, and Elvis Costello, all providing background vocals. Jeff Lynne and Dave Stewart each co-wrote a song with McGuinn, but neither performed on the album.

So what does it sound like? To the same extent that Tom Petty and The Heartbreakers tend to sound like The Byrds, Roger McGuinn seems to have edged toward the territory claimed by Petty. "Car Phone" quotes The Beatles' "A Day in the Life" and The Byrds' "Eight Miles High" while bearing no small resemblance to Dwight Twilley. An Elvis Costello song, "You Bowed Down," starts off as a rewrite of "Positively Fourth Street," the great Dylan song recorded by The Byrds.

This is an extremely well-crafted job of contemporizing McGuinn. He co-wrote most of the songs, and there's plenty of that jangly 12-string electric guitar associated with him.

As a whole, this is not a record that tugs the heartstrings all the way through. Hey, those of us who were there the first time remember Roger as the scientist as much as the artist, but there are moments—on songs like "Suddenly Blue" and "Someone to Love"—when it seems impossible that any time has passed since "Mr. Spaceman" and "Chestnut Mare" were staples on radio. One hopes that '90s radio will embrace *Back from Rio* and ignore its warts.

Time has been very kind to the guitar sparkle and vocal tremolo that are trademarks of the McGuinn sound. The cleanliness of digital deals well with these kinds of toppy instruments, and co-producer David Cole has made a polished record without making a piece of glossy dross.

McGuinn's legacy has inspired contemporary artists from R.E.M. to Elvis Costello. After the mediocrity of his last few solo efforts, McGuinn will hopefully be taken seriously as an elder statesman of rock—not a dinosaur or has-been. No matter how much we may be attached to his back pages, these new songs speak volumes. Roger McGuinn is not just *Back from Rio*, he's back.

Jon & Sally Tiven

The Byrds
Columbia/Legacy C4K 46773, four CDs; AAD or ADD; 63:34, 63:35, 68:08, and 70:30.

Sound: A Performance: A+

Boxed-set retrospectives have gotten to be pretty regular. Some have been very good, while others appear to have been hastily assembled and slapped out for a quick buck. Happily, *The Byrds* is a textbook case of how it should be done.

There are 90 selections chronologically sequenced over four CDs. Of these, eight are alternate versions to the released takes, and another nine have never been released before. Gram Parson's vocals are featured on five of these gems, long thought permanently lost after legal hassles forced them off *Sweethearts of the Rodeo*, which arguably was the very first country-rock album. Four more songs were recorded by Roger McGuinn, David Crosby, and Chris Hillman in Nashville in August 1990 especially for this release. Two others come from the Roy Orbison Tribute concert in February 1990: An incendiary take of "Turn! Turn! Turn!" and a thrilling version of "Mr. Tambourine Man" (all verses included), during which Bob Dylan himself saunters out to join in on the fun.

Throughout the collection, the sound is superb, as all the old tracks were remastered for this release. Sometimes the extra clarity lets you hear bits that you never quite heard before.

The 56-page booklet contains fully annotated track listings—including recording dates, sidemen, prior ap-

The Byrds is a textbook case of how boxed-set retrospectives should be done.

pearances—and extra notes about remixing, remastering, and historical peculiarities. McGuinn and Crosby contribute some thoughts, and there is a Chris Hillman interview as well as an excellent essay by David Fricke. A Byrds family tree, discography listings, lyrics to the four new recordings, and a closing note from Byrds fanatic Tom Petty are also included.

Boxed sets are not for the casual fan; by design and by price they are intended for the hard-core. For such Byrds fans, this set will prove indispensable, an absolutely riveting orgy of sounds. Don't mind the price of admission. You won't be sorry. Columbia's new Legacy imprint for historical reissues is off to (excuse the expression) a flying start. *Michael Tearson*

Invisible Means: French, Frith, Kaiser, and Thompson
Windham Hill WD-1094, CD; AAD; 68:56.

Sound: A Performance: B+

When you combine talents that have staked their names and reputations with people and projects such as Captain Beefheart (John French); Brian Eno, Henry Cow, John Zorn, and composer John Cage (Fred Frith); La Perversita (Henry Kaiser), and Fairport Convention and John Cale (Richard Thompson), pop is a long shot. Not that *Invisible Means* isn't accessible, it's just a bit too close to the edge to make the Top 40.

As you also might guess, if there's an overriding characteristic of this recording, it's a sense of humor. Most of the music for this odd session was composed by the principals and includes everything from Thompson's neo-'60s "Peppermint Rock" to an operetta ("March of the Cosmetic Surgeons," with guest mezzo-soprano Catherine Keen). In between are exotic atmospheres (Frith's "Hunting Sunsets"), blues rock (the title cut by French and Bob Adams), a rousing traditional folk song ("Loch Lomond"), a rendition—with narrative—of the theme to the daytime soap opera "Days of Our Lives," and an absolute hooter, "Now That I Am Dead," which is told from the perspective of a dead rock star. Contrasting this lightness is "Killing Jar," the dark closing number. Perhaps the record's highlight, it is nearly eight minutes of starkly depressive sentiment.

Thompson handles most of the singing on an album that is delivered in offbeat, loping rhythms with Thompson's own signature shimmering, angular guitar lines seconded by Kaiser's slide-guitar textures.

If you're familiar with any of these artists' aforementioned bands and solo works, you'll have fun picking out their contributions here. If you're just tired of the usual rock fare, then you'll be amused, if not inspired, by *Invisible Means*. *Michael Wright*

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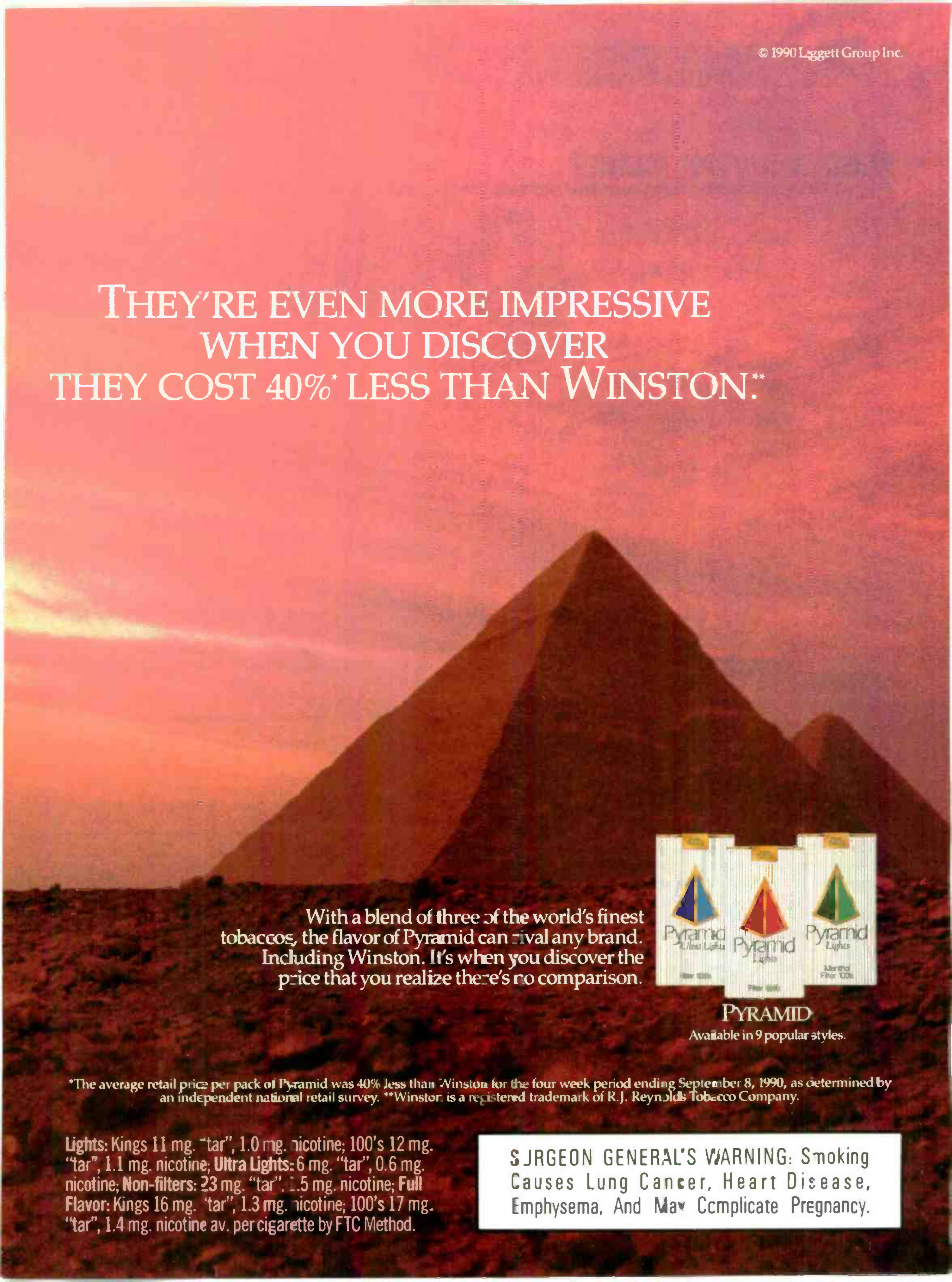
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ELECTRIFYIN' BLUES

Photograph: Frank Driggs Collection

The Complete Recordings of T-Bone Walker, 1940-1954
Mosaic MD6-130, six CDs; AAD; 70:25, 69:51, 69:58, 67:20, 63:12, and 63:17.

Sound: A Performance: A

I feel like shouting, and I sure have something to shout about with Mosaic's compilation of Aaron Thibeaux Walker's complete recordings from 1940 to 1954. The 144 songs in this boxed set represent the bulk, and certainly most of the best, of the work of the blues guitarist who, along with Charlie Christian, ushered in the modern age by plugging in the guitar. Admittedly, nearly seven hours of songs that rarely clock in at over three minutes could approach information overload, especially since T-Bone's releases were tailored and time-released to reach a specific 78-rpm-buying audience. And with the alternate takes, some of which are deservedly alternates, there's a degree of repetition that may be off-putting to those predisposed to finding sameness in the blues. What's remarkable about this compilation is that in repetition, Walker's skills are brightened, not tarnished.

Walker, a compatriot of and fellow student with Christian, undeniably provided one of the blues world's most durable standards in "Call It Stormy Monday," but noting that and hearing the original and its weird reverbed alternate don't do him justice. Even his earliest recordings, show-biz big band arrangements where Walker is merely the featured vocalist, display a smooth warmth that's reassuring and elevates the fussy and maudlin (as do Louis Armstrong, Billie Holiday, and Hot Lips Page). By the mid-'40s, Walker had collected a group of like-minded musicians in Los Angeles to record a series of seminal singles where he corralled the dramatic imagery and energy of the blues into the sophisticated confines of jazz. Yet Walker's recordings are those of a bluesman appropriating jazz trappings, not those of a jazz player using blues for comic relief.

Walker's vocal phrasing is impeccable both in his interplay with his own guitar obbligatos as well as those of the trumpet and tenor. His singing is insouciant and sly, with a hint of the sinister. And there's a subtlety in the snappy arrangements that allows them to swing with the momentum of a Kansas City orchestra, whether on tense, galloping shuffles or falling-off-the-edge-of-the-world slow blues. Within this slick jazz combo exterior, however is contained some stunning guitar and piano duets that belie Walker's debt to Leroy Carr and Scrapper Blackwell. On more than 2½ discs, on songs like "I'm in an Awful Mood," "Triflin' Woman Blues," "T-Bone Shuffle," "So Blue Blues," and "Inspiration Blues," Walker's clear single-note runs, marrow-tingling chords, and sometimes rushed figures of triplets combine the fluidity of Lonnie Johnson with the jaggedness of Blind Lemon Jefferson. In addition, the multiple takes offer an opportunity to appreciate the modifications in tempo that give each tale a life of its own, not to mention the opportunity to hear some scorching tenor saxophone solos by Hubert Maxwell "Bumps" Myers and Thomas Maxwell Davis.

The set occasionally gets bogged down when Walker abandons his own highly stylized orchestrations and singing for covers of Nat King Cole, Louis Jordan, and even Joe Turner-type tunes, but this is a minor quibble. Overall, the music is somehow urbane and hip yet dark and sincere. And its elegiac ease should calm any troubled soul. *Don Palmer*

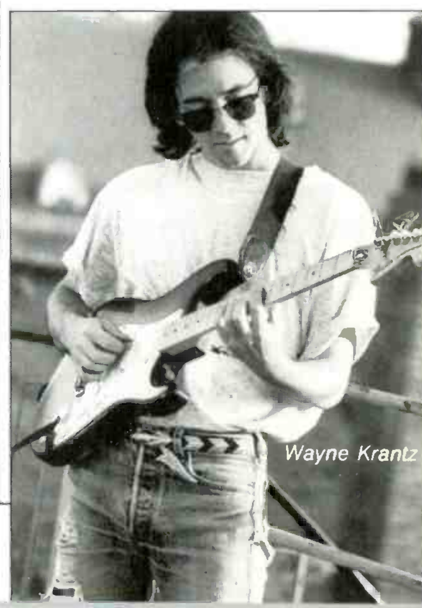
Signals: Wayne Krantz
Enja R2 79642, CD; ADD; 41:49.

Sound: A Performance: A

The Marksman: Mark Whitfield
Warner Bros. 9 26321-2, CD; AAD; 60:51.

Sound: A Performance: A

In case you haven't noticed, there's a new generation of jazz musicians.



Wayne Krantz

[redacted]

These artists are putting a fresh face on both standards and new tunes, using a vocabulary that draws on time-tested theory and modern technique. A disproportionate number come from Boston's Berklee College of Music, which is doing something right when it comes to passing the baton. Two examples are new recordings by guitarists Wayne Krantz and Mark Whitfield, Berklee grads both, reflecting quite different approaches.

Signals is Wayne Krantz' solo debut, and on the surface it might be considered a fusion or electric jazz album. Certainly the music (all but one cut was composed by Krantz) has a contemporary sound, but a closer listen reveals a remarkable complexity of rhythms and intelligent, melodic shapes. Krantz favors a guitar sound that puts his Stratocaster through a slight chorus effect with a touch of reverb. This gives him a very distinct, crisp, and funky tone reminiscent of early Larry Carlton. Krantz has an excellent ear for hooks, so you'll encounter many hummable melodies ("Alliance" and "Music Room" are good examples). His solos always serve his tunes, but he does blaze through improvisations on occasion with angular lines that remind one of John Scofield (check out "Sossity; You're a Woman" and "Two of Two") and even throws in some hot rock licks ("Don't Tell Me").

Krantz is backed by some of New York's top sidemen, making a very tight ensemble that's the perfect accompaniment for the guitarist's talents. By the way, if you like *Signals*, you might want to check out Krantz' axework on bassist Michael Formanek's new release, *Wide Open Spaces* (Enja R2 79648).

In a more conservative vein is *The Marksman*, the debut solo outing for Mark Whitfield, a young man who has received the support and encouragement of George Benson. Produced by veteran Tommy LiPuma, this is a classic jazz combo consisting of Whitfield on guitar, Marcus Roberts on piano, Reginald Veal on acoustic bass, and drummers Troy Davis and Herlin Riley. Whitfield takes us through a very tasty set of originals and standards including "In a Sentimental Mood," "The Very Thought of You," and "There Is No Greater Love." Whitfield's playing is

Mark Whitfield's command of technique is amazing; especially on his own tunes; there's no mistaking who's the star here.

expressive, fluid, and flawless as he moves smoothly from rapid-fire runs with ornamental turns to lush chordal comping. The sound is thick and mellow, like vintage Wes Montgomery, Kenny Burrell, or the young Benson himself. Whitfield's command of technique is quite amazing—especially on his own tunes, like the title cut with its elaborate melodic variations, the sophisticated changes of "Medgar Evers' Blues," and the fancy chord and scale riffing on the solo "Namu." Whitfield's companions get their chances to solo, particularly Roberts, but there's no mistaking who's the star here.

Both Wayne Krantz' *Signals* and Mark Whitfield's *The Marksman* hit their respective marks as impressive debuts and are signs that jazz is indeed alive and well, with a very bright future if musicians like these stay on course.

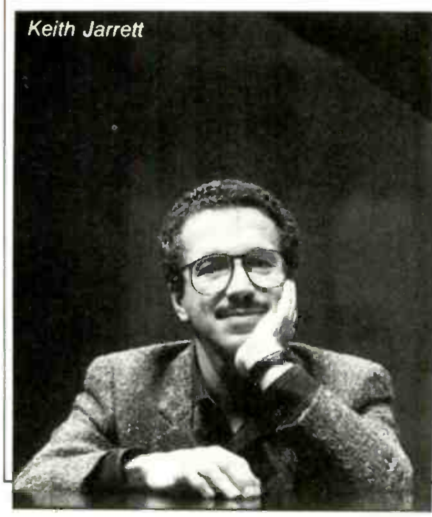
Michael Wright

Paris Concert: Keith Jarrett
ECM 839 173-4, CD; DDD; 50:24.

Sound: A — Performance: A–

Keith Jarrett is a musician in constant search, trying to resolve the struggle between the cerebral and the intuitive, the complex and the primitive. Within these matrices he seeks unity in the music he loves: Baroque and 20th-century classical, ancient folk forms and free improvisation, jazz standards and Asian nuance.

These themes are explored not only on each of Jarrett's records but also within any given song and even within a solo on "October 17, 1988" from *Paris Concert*. On this album he's in solo piano mode, an increasing rarity since the flood of solo recordings that established him and the genre in the '70s. While Jarrett wandered off into orchestral works, intuitive folk music, baroque repertoire and harpsichords, a host of pianists from George Winston on down to your corner lounge act have polluted the solo piano horizon like a belching smokestack.


Keith Jarrett

With the nearly 40-minute improvisation on "October 17, 1988," Jarrett reestablishes his preeminence as a solo pianist. He brings the work almost painfully out of silence with stark, contrapuntal lines that trail each other in arid slow-motion. With seemingly effortless grace, Jarrett evolves these sparse beginnings into angular structures. A simple ostinato anchors melodies that stack in increasingly complex configurations, building in dense layers until he suddenly pulls the rug out. You're left suspended in air, looking down in space through the skeletal structure from which he began. In the second half, Jarrett creates his unique sonic effects, turning the piano into an orchestral hammered dulcimer as he strikes the keys with sharp, percussive intensity.

Two more pieces round out *Paris Concert*. "The Wind" is a soft, languid reading of the Russ Freeman and Jerry Gladstone standard. But it's on "Blues" that the paradox of Jarrett's search is again revealed. It's a slow boogie-woogie, but Jarrett can't quite get down with it. He's thought about it so much that his playing is unusually clinical. This is not a flaw in *Paris Concert* but an insight into what makes Jarrett vital as a musician, the constant effort to reach a unity in his music, to reduce the dualism.

John Diliberto

Rootless Cosmopolitans: Marc Ribot
Island 422-842 577-2, CD; AAD; 47:06.

Sound: A — Performance: A

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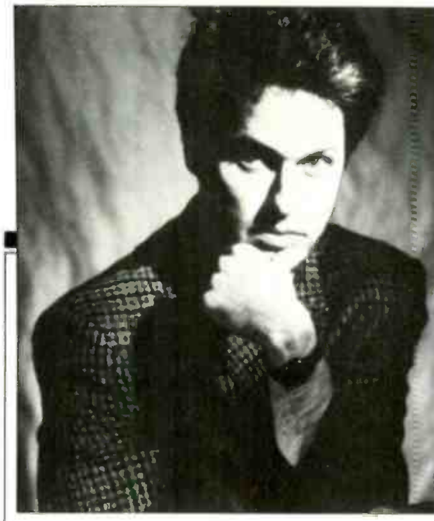

Guitarist Marc Ribot and his band of noisy merrymakers, The Rootless Cosmopolitans, are like gate crashers at the style council.

but album is that it's not everyday music. I've played it and cringed as the notes caromed off my cranium before reverting to music more soothing to my battered soul. However, at other times, their sardonic, clattering chatter seems the perfect aural salve to a chaotic world. See, The Rootless Cosmopolitans are not mere clever eclecticians manipulating the market with ready-mades from different genres. Instead, guitarist Ribot and his band of noisy merrymakers are like gate crashers at the style council, blending Tin Pan Alley sensibility with the raucous tone of rockin' blues and the tumultuous melodic and harmonic distortions of avant-garde jazz. Yet there's an orchestral sense and goofy indigo mood that prevents The Rootless Cosmopolitans from sounding like a fusion band hurtling through an abyss of overworked vamps.

With the help of free-bop klezmer clarinetist Don Byron and atmospheric keyboardist Anthony Coleman, Ribot—sometimes sideman for Tom Waits, The Lounge Lizards, Elvis Costello, and Marianne Faithfull—dovetails and layers R&B, blues, Afro-Caribbean, twangy surf guitar, and funky grooves. Songs like "Nature Abhors a Vacuum Cleaner" and the piercing "Friendly Ghosts" occasionally erupt into the soulful swing of an organ/guitar combo, whereas the metallic, erector-set versions of "I Should Care" and "While My Guitar Gently Weeps" read like questions.

There are moments, such as the ensemble bridges of the barnstorming "Shortly After Takeoff," where The Rootless Cosmopolitans evoke Ronald Shannon Jackson's Decoding Society—as much to the credit of bassist Melvin Gibbs, whose full tone anchored the Decoding Society for years, as to design. Byron, who adds wild whale screams on "Takeoff," sizzles on most cuts, whereas Coleman's slabs of sound add intriguing orchestral coloration on tunes like the eerie "Friendly Ghosts" and the lithe but funky "Cocktail Party." But even as Ribot, Byron, and Coleman slash, clank, and wander through startling changes of tempo and mood, bassist Brad Jones (Gibbs appears on "Shortly After Takeoff" only) and drumer Richie Schwarz keep The Rootless Cosmopolitans rooted in their fluid swing. *Don Palmer*

Dreams Come True: Marcia Ball, Angela Strehli, and Lou Ann Barton
Antone's ANT0014, CD; AAD; 40:22.

Sound: B+ Performance: A−

Labors of love are as rare in the blues world as in any other. *Dreams Come True* is a success precisely because its performers sing more for the exhilaration of working together than as a calculated career move. Nothing else explains their willingness to venture into each other's territory, with sometimes curious results. While they've sporadically performed togeth-

Joachim Kühn never loses control, flying out rippling melodies, fluid chordal changes and scattershot phrases.

er over the years at Antone's and elsewhere, recording their jams for posterity took a certain courage.

"Something's Got a Hold on Me" highlights the contrasts of these women, as each takes a verse. Angela Strehli's studied Etta James growls give her the edge on power, but Lou Ann Barton and Marcia Ball take the prize for originality.

Few singers can match Barton for sheer velocity. When she yells "Go" at the beginning of "Good Rockin Daddy," she might as well be challenging the band to a race. Her confidently reckless vocals and swaggering sexuality embody the distinction between R&B and basic rock 'n' roll. "Bad Thing" realizes her potential more fully than anything on her previous solo album.

The album's best moments are the casual interactions rare among established performers. "Love Sweet Love" is the latest in the series of brokenheart ballads from Marcia Ball in which the limits of her voice convey an aching vulnerability. For the first time, however, Barton's overlapping vocals add beer-bottle optimism. "It Hurts To Be in Love" features a roaring Strehli-Ball duet in a thick slice of classic New Orleans R&B built around a dense, full-bodied brass arrangement, a honky-tonk piano break, and gutsy sax playing from Mark Kazanoff.

Producer Mac "Dr. John" Rebennack brings a sideman's sensibilities to *Dreams Come True*. Under his guidance, the tightly knit studio band isn't a lauching pad for potential solo careers. Compact breaks and crack ensemble playing don't dominate arrangements that spotlight the singers. The polished tracks magically preserve the crucial illusion of spontaneity.

Whatever they're feeding these ladies down in Austin, Texas at Antone's should be packaged and sold to the rest of us. *Roy Greenberg*

Live 1989: Joachim Kühn, Daniel Humair, and J-F Jenny-Clark
CMP CD 43, CD; DDD; 57:14.

Sound: A | Performance: A

Joachim Kühn is one of the most underrated pianists of the last decade. After a journeyman career in the '60s and '70s, playing everything from free-form jazz to tepid fusion, Kühn finally emerged in the '80s as a gifted and virtuosic improviser.

On *Live 1989*, with his trio of bassist J-F Jenny-Clark and drummer Daniel Humair, Kühn and his collective ensemble have attained a remarkable

degree of intuitive interplay. An excellent example is the album opener, a Kühn barn-burner called "Changement." It's powered by Humair's drums, a waterfall of rhythmic variation and colors that almost threatens to wash away his bandmates, but they're more than up to the task. Kühn never loses control, flying out rippling melodies, fluid orchestral chordal changes, and scattershot phrases that match Humair's own turbulent cymbal crashes and delicate bell accents. Jenny-Clark, who cut his teeth in the '60s avant-garde with Don Cherry and Gato Barbieri, is no stranger to music that seems to ebb and flow at will. He navigates a winding course through the shifting textures of Humair and Kühn. The ensemble maintains this pace throughout *Live 1989*, whether turning Gato Barbieri's "Last Tango in Paris" into a smoldering odyssey of sensuality or fragmenting the Jerome Kern standard, "Yesterdays."

Although it's a live recording from the Théâtre de la Ville in Paris, *Live 1989* has a clarity and definition that should be a model for jazz recordists. CMP's Walter Quintus and Kurt Renker open up the instruments, spreading the piano and drums across the stereo field so that the instruments actually seem to move with their music. This adds to the music's already enveloping sound.

The Kühn/Humair/Jenny-Clark trio is clearly one of the most energized and intense ensembles of the '90s, rivalling such trios as Air or the powerful Sam Rivers ensembles of the '70s. And that is heady company. *John Diliberto*

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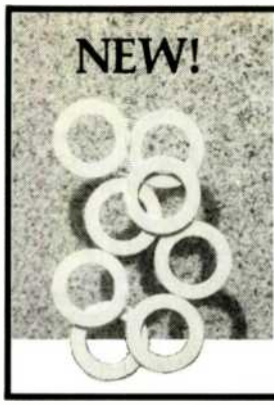

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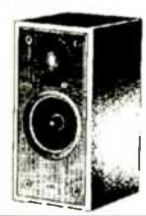

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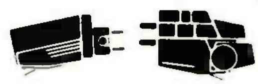

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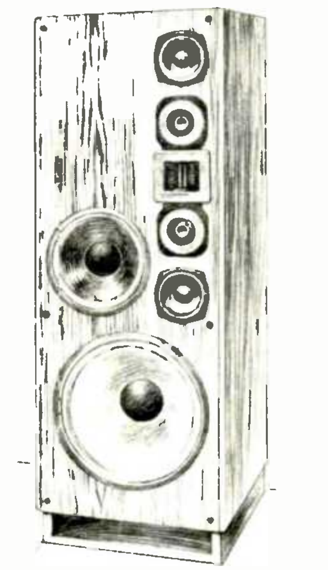

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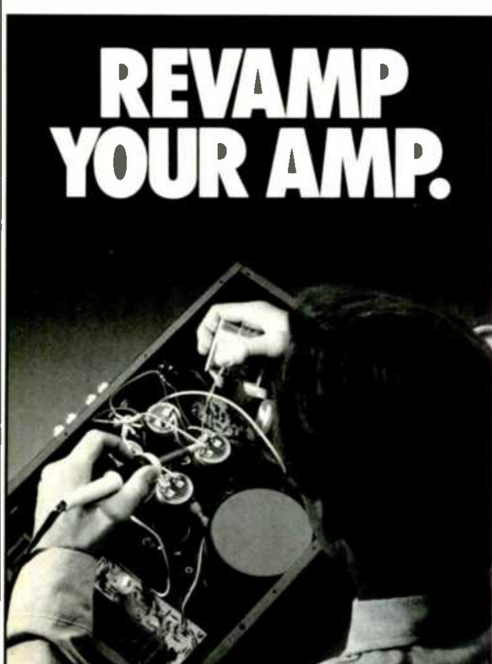

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AD INDEX

Class A amplifiers ain't what they used to be.

For the sake of signal purity, audio buffs have long put up with Class A amplifiers—powerful, pricey amplifiers the size and weight of cinder blocks.

Amplifiers that give off so much heat, you wouldn't want to touch them without oven mitts. Well not anymore.

Yamaha's new UL-approved MX-830 is the first Class A amplifier (with a patent to prove it) to defy the aforementioned drawbacks of Class A amplification.

The key is something we call Hyperbolic Conversion Amplification. HCA for short.

A mouthful which ensures operation won't degrade to Class AB even at extremely high levels of output.

The result is one of the world's most powerful Class A amplifiers for its size—170 Watts RMS/channel.* Enough to drive three pairs of speakers in any combination.

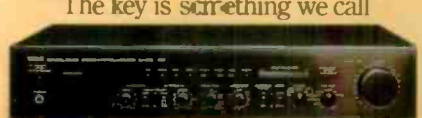
As one might expect, the MX-830 boasts tremendously high dynamic power (600 Watts, 1ohm, 1kHz). More than enough to prevent distortion during the most demanding passages.

And Yamaha's Advanced Power Supply (APS) assures full output power is supplied even when driving a low-impedance load.

The perfect companion to all this performance is the CX-830 preamplifier with five audio and three video inputs. Four audio and two video record outputs. And audio/video switching. Plus a learning capable remote control that provides a degree of convenience not usually found on such sophisticated equipment.

And there's more. Much too much to describe in detail here.

Drop by your nearest Yamaha dealer for a demonstration of the new MX-830. The first Class A amplifier it doesn't take a fire permit to operate.



The CX-830 preamplifier. The perfect companion to the affordable MX-830 amplifier.

YAMAHA®

YOU CAN HEAR THE DIFFERENCE!

"*It's amazing*", most people say, "*how much better my system sounds with AudioQuest® cables. I can't believe what I've been missing!*"

AudioQuest makes a full line of cables; speaker, audio-interconnect, video, S-video, fiber-optic and installation cables. All are engineered to bring you maximum performance.

AudioQuest has spent 12 years continually improving and fine tuning its cable designs to reduce all types of cable-induced distortion — and, to do it cost-effectively. Many different constructions and grades of copper and silver are used depending on the budget.

AudioQuest *F-18* speaker cable is one of three very flat cables which use multiple-solid conductors. The sound is sweet and clean because strand interaction is eliminated, while skin-effect and resistance are kept to a minimum.

*F-18**

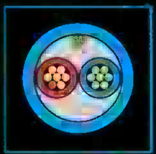
AudioQuest *Indigo Hyperlitz®* speaker cable uses geometry similar to our most expensive cables, yet is very affordable. The spiraled solid conductors maintain an absolutely consistent position and are far enough apart to prevent magnetic interaction. The clarity, dynamics and sense of acoustic space are incredible.

AudioQuest *Lapis Hyperlitz®* interconnect cable uses a patented construction which eliminates strand interaction and minimizes distortion caused by insulating materials. Teflon insulation, FPC-6™ copper (99.99997% pure), and resistance-welded, direct-gold plated, FPC™ plugs make this cable sound incredible. The aural invisibility of this cable is something you will have to experience for yourself.

AudioQuest's absolute commitment to value doesn't mean that all AudioQuest products are inexpensive. It does mean that the expensive products are a very good value when used with better systems.

No matter what type of equipment you have, you can maximize your system's performance with AudioQuest cables! Contact your local AudioQuest dealer and listen for yourself. You can hear the difference!

*Indigo Hyperlitz**



*Lapis Hyperlitz**

**All diagrams are 1½ times actual size.*

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