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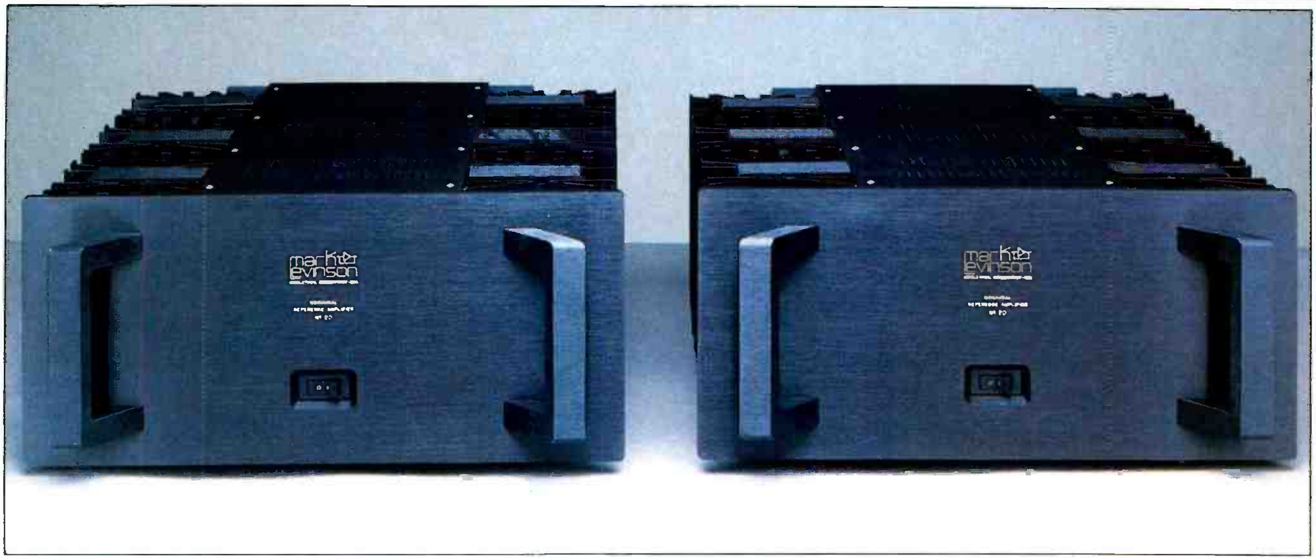

Mark Levinson Amp, page 62

FEATURES

PLANE FACTS ABOUT FLAT SPEAKERS ..... Kenneth L. Kantor 40
THE LEDE CONCEPT ..... Don Davis 48

EQUIPMENT PROFILES

MARK LEVINSON NO. 20 MONO AMP ..... L. L. Greenhill and D. L. Clark 62
MISSION PCM-7000 COMPACT DISC PLAYER ..... Leonard Feldman 80

MUSIC REVIEWS

ROCK/POP RECORDINGS ..... M. Tearson, J. and S. Tiven 88
COMPACT DISCS 94

DEPARTMENTS

SIGNALS & NOISE 4
AUDIOCLINIC ..... Joseph Giovanelli 6
TAPE GUIDE ..... Herman Burstein 10
SPECTRUM ..... Ivan Berger 12
AUDIO ETC ..... Edward Tatnall Canby 18
BEHIND THE SCENES ..... Bert Whyte 24
FORUM ..... Leonard Feldman 28

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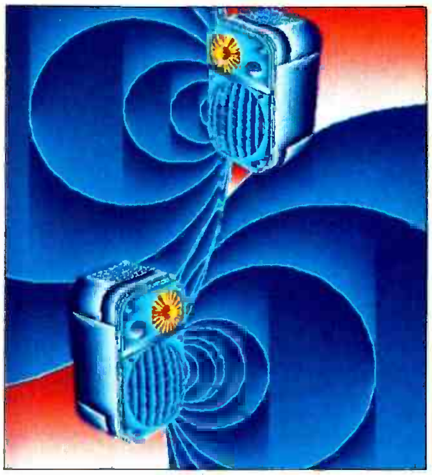

LEDE, page 48

Flat Speakers, page 40

SIGNALS & NOISE

At Your Service

Dear Editor:

Having read innumerable words of praise and damnation in the pages of *Audio*, I find that one particular subject has, unfortunately, been pushed aside in favor of disposable audio and mass merchandising.

In that today's technology, regardless of price, virtually ensures respectable performance, what might resurrect itself as a tangible consideration when contemplating the purchase of audio equipment?

The subject of service to the customer, not only during the sale but, more important, after, has faded into oblivion for many audio buffs. Increasingly, service after the sale is encompassed by your local independent television, radio and bicycle repairman who, through years of experience, knows all there is to know about your just-released equipment.

I wish *Audio* would look at "State of the Art" service, such as that rendered by one of the last great names in American audio, our own McIntosh Laboratory. Often exposed to the incessant banter of "new and improved," I will contentedly remain a member of the McIntosh family. Their concern for the customer is, like their equipment, absolutely first rate.

Michael J. Rodney
Pineville, N.C.

Editor's Note: Nominations are now open for more such recommendations.—*E.P.*

Defending Auto Coverage

Dear Editor:

In a past "Signals & Noise" column, reader Robert T. Shaw wrote to object that an entire issue devoted to auto sound was a step toward low fidelity. He also objected to your inclusion of Lirpa products.

I believe that high fidelity should not be limited to the home but be extended to the car as well. Since I spend a lot of time in my automobile, I appreciate good sound to make trips more enjoyable. With some of today's high-quality mobile components and with careful selection and placement of speakers, I can produce a level of fidelity in my sedan that can rival many of the better home systems. I am also looking for ways to upgrade my car system and thus appreciate any literature that can keep me informed of the latest equipment available.

For those audiophiles who don't want your publication filled with "wasteful" material, let them drive to their office with a Tchaikovsky overture trying to squeeze out of 3½-inch factory dash units or cruise down the interstate with a 4W Montgomery Ward cassette radio grossly distorting a Beethoven symphony.

As for products from Professor I. Lirpa, I find nothing wrong with a little sense of humor, which obviously some readers seem to lack. Lirpa makes for a refreshing pause in a highly sophisticated publication.

I commend *Audio* for its excellent coverage of the entire spectrum of the hi-fi world as well as a little humor. Keep up the good work!

Lonnie Wong
Denver, Colo.

It's a Must

Dear Editor:

I do agree somewhat with reader David Lansdown's point that you could review more affordable audio gear ("Signals & Noise," February 1987). I must say, though, that *Audio*'s features and columns, along with such indispensable articles as the blank cassette comparison you ran in June 1986 (which I still refer to), make your magazine "must" reading each month.

Tom Quarles
Production Director, KILO 94
Colorado Springs, Colo.

Tchaikovsky Found

Dear Editor:

In "Behind the Scenes" (January 1987), Bert Whyte says that neither Tchaikovsky's Symphony No. 3 nor his "Manfred Symphony" is available on Compact Disc. I have both works on CD: Symphony No. 3 (Chandos 8463) by the Oslo Philharmonic under Mariss Jansons, and the "Manfred" (Angel CDC-747412-2) by the Philharmonia Orchestra conducted by Riccardo Muti. The Symphony No. 3 is also available on DG with Herbert von Karajan conducting the Berlin Philharmonic, a fairly recent release.

Jack Bowers
Wilmette, Ill.

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AUDIOCLINIC

JOSEPH GIOVANELLI

Faint Noise

Q. I recently discovered that my sound system produces a small amount of hum even when there is no signal source connected. The hum can be heard only when the ear is brought close to the loudspeaker and only when the surroundings are quiet. Is this normal?—W. T. Lim, Republic of Singapore

A. Any piece of electronic equipment produces hum and noise, and you can often hear it if your speakers are efficient enough and you are close enough to them. It is only when this noise intrudes upon the music that you have a real concern.

Dealing with Dust

Like David Coup, whose problem was described in the November 1986 "Audioclinic," I have had problems with rotary controls becoming scratchy and jacks and plugs losing contact in a dry climate. I did not have this problem during the two years I lived in Florida despite the high concentration of salt in the South Florida air.

I have come to the conclusion that these scratchy control problems in dry climates are caused not by corrosion—as you speculated—but by dust. Here in Phoenix, everything tends to get covered with fine dust. Probably because of electrostatic forces, adherence of this fine dust layer is very strong—enough so that it does not blow off my car when I drive it at 70 mph! Dust does not accumulate as much in Florida because of the high humidity and frequent rain, which tend to purify the air and keep the dust down.

(Incidentally, your premise that corrosion is "water combining with oxygen" is close but not correct. Corrosion, as most laymen know it, is really a process where elemental oxygen combines with a metal to form a metal oxide, which sometimes reduces electrical conductivity to zero. Water or high humidity will increase the rate of oxidation because there is more oxygen in moist air than in dry air.)

To reduce dust buildup on electrical contacts (and to reduce or eliminate salt ingestion by components located near a beach), I recommend keeping the environs of any audio equipment very clean. At an extreme, this may mean never opening the windows; at a minimum, it will entail housing the equipment in a cabinet with few openings. (Remember, dust and salt can enter through vent openings.) Ventilation fans installed to cool components should have fine-particulate filters attached to catch dust before it enters the cabinet. This procedure has virtually eliminated my problem.

In closing, your recommendation of using WD40 to clean contacts is good. The oily residue reduces the adherence of dust by forming a low shear-strength film on contact surfaces, allowing the contacts to plow through the dust as switches, relays, or plugs are operated. Periodic removal of the residue with a solvent (possibly Freon) is recommended because the oily WD40 will allow a buildup to occur. After Freon cleaning, recoat sparingly with WD40 or any light machine oil.—Barry S. Draskovich, Phoenix, Ariz.

Hum Interference from TV Sets

Q. I have a humming noise caused by my power amplifier. The noise does not change even if all components other than the power amplifier are turned off. When my neighbor turns his television set off, however, the humming stops! Why does his TV affect my audio equipment? How can it be dealt with?—Jonas Hillergren, Stockholm, Sweden

A. TV sets often radiate electromagnetic interference from their horizontal sync circuits, and sometimes this interference is introduced into the a.c. mains. I believe that this is producing the hum in your power amplifier.

Some equipment tends to be particularly sensitive to undesired signals on the power line. Narrowing the overall bandwidth of the amplifier can sometimes make these undesired signals inaudible. I realize that this is not a "purist" solution, although it is often the most practical one.

An alternate solution (which does not always produce good results) is to place a suitable LC filter between the wall plug and the power cord of the offending TV set. You may also need to place a similar filter between the a.c. outlet and the wall plug of your power amplifier. Be sure that the filters can handle the wattage drawn by the equipment connected to them.

Mismatched Sound in Speakers

Q. I recently purchased a pair of loudspeaker systems. I discovered that one speaker had a sloppier, more pronounced bass response and sounded louder than the other speaker. I notified the dealer, who immediately replaced the pair. Unfortunately, I am experiencing the same problem with these replacements.

I had my receiver checked, and it was found to be functioning properly. I have switched the cables around and even have used the "B" output terminals on my receiver; the problem persists. I don't want to face the dealer again! What do I do now?—Joe Paolucci, Jr., Albany, N.Y.

A. This difference in sound between two supposedly identical loudspeakers may actually be not a speaker problem but one of room acoustics. The acoustical properties of a listening room can vary tremendously from one loudspeaker location to another. Physically switch the positions of your two loudspeakers. If I'm right, you will find that there are areas of your listening room in which a loudspeaker—any loudspeaker—will always produce more bass and appear to be louder than the other speaker.

There is also a possible electrical explanation, not related to defective loudspeakers. If one speaker is placed very near to your sound system and the other one is located at a considerable distance, differences in the lengths of the interconnecting speaker cables could be responsible for the change. This is very likely in instances where one cable must be made excessively long. The problem can be aggravated if you are using a small-gauge wire, such as No. 22 (which is sometimes sold as "speaker wire"). The resistance in long, small-gauge wires can reduce the damping; if your loudspeaker system is subject to wild cone excursions when damping is too low, this could be the cause of your problem. You should replace this cable with something considerably heavier, such as No. 16 or No. 14.

If you have a problem or question about audio, write to Mr. Joseph Giovanelli at AUDIO Magazine, 1515 Broadway, New York, N.Y. 10036. All letters are answered. Please enclose a stamped, self-addressed envelope.

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RX-7	5.73 secs.	141.04 ft.	6.20 secs.	.852g's
CONQUEST TSi	5.53 secs.	142.25 ft.	6.14 secs.	.875g's

*Overall official U.S.A.C. test results of standard equipped TSi, 300ZX with V-6 and RX-7 with rotary engine.

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Where to buy Polk Speakers? For your nearest dealer, see page 102

TAPE GUIDE

HERMAN BURSTEIN

Riding Gain

Q. What is "riding gain"?—Anthony Mauldin, Lewisville, Tex.

A. Riding gain means varying the record level while making a recording, to keep the signal level high enough to be clearly heard above the tape noise while ensuring that high-amplitude signals do not overload the tape. Such overload would cause distortion and possible treble loss as well.

Before the recording art developed to the point where cassette decks with signal-to-noise ratios well over 60 dB became common, it was very important to record at as high a level as possible, in order to maximize S/N. It was frequent practice to record at levels that would cause tape saturation on signal peaks unless gain (record level) were momentarily reduced during those peaks. This reduction could be done automatically by electronic devices, such as limiters, or manually, by riding gain. The latter practice requires accurate knowledge of the music, preferably by having its score before one's eyes, so that gain can be reduced and restored at just the right moments.

However, with signal-to-noise ratios of 70 dB or greater now common on tape decks, riding gain seems both unnecessary and undesirable. (*Editor's Note:* If you must ride gain, ride against the music—that is, slowly lower the gain while the music is getting louder, and raise it while the music is getting softer. If done properly, this enables you to maintain an only slightly diminished sense of the music's dynamics while ensuring that the signal will never fall into the noise floor or reach the overload level. Don't wait until the signal gets too high or low and *then* give the gain control a too-late jerk.—*I.B.*)

Speed Adjustment

Q. I am thinking of synchronizing the speeds of the two transports in my dubbing deck, with each other and with the deck in my car. At present their speeds are ever so slightly different. They are probably within specifications, but the difference is noticeable to me. Is there a way to adjust the speed of a cassette deck?—T. Veitch, address withheld

A. Some decks provide an internal speed adjustment, but many, regrettably, do not. Often there are other means of adjusting speed, such as changing a rotating part in the drive mechanism for one of slightly greater or smaller diameter. I have no way of knowing whether speed adjustment is readily feasible for your particular decks. Query the decks' manufacturers, or ask at the service shops in your area.

Dubbing via Videocassette

Q. I would like to copy some cassettes that were recorded with Dolby noise reduction. Since I do not own a second cassette deck, I would like to use my Hi-Fi VCR and then dub back to my cassette deck. Would this yield acceptable results? In what position should I set the Dolby switch on my cassette deck to make the final recording?—Rod Davidson, Alliance, Neb.

A. Your dubbing project is entirely feasible and should yield excellent results. Play the original tape with Dolby decoding on as you record onto videotape. Then play the videotape and record onto cassette with Dolby encoding on, using Dolby B or C NR, as you prefer. Best results in terms of low noise and extended treble response are usually obtained with Dolby C NR.

Audibility of Distortion

Q. I am planning to purchase an outboard noise-reduction system to be used with a very high-quality cassette deck. The specifications for the NR unit state that its total harmonic distortion is 0.1%. Is this amount of distortion significant? More important, will it be audible?—Keith B. Dant, Saginaw, Mich.

A. On a single tone, a listener with a highly trained ear might be able to detect distortion of 0.1%; on program material, it is very unlikely that he would be able to do so. Tests have indicated that distortion must reach about 5% on program material before listeners become aware of it. In sum, for all practical purposes, unless one confines listening to test tones, distortion of 0.1% is inaudible and therefore insignificant.

Bias Basics

Q. How are audio and bias signals processed to make recording possible? Is the bias frequency standardized, or does the deck manufacturer optimize it for each deck model? In terms of bias, what is the purpose of the HX Pro recording process, and how does it work?—Joseph J. Ferrier, Brooklyn, N.Y.

A. In tape recording, the relationship between the signal fed to the recording head and the magnetization level produced on the tape is not linear. In other words, changes in the magnetization level do not accurately reflect changes in the signal when that signal is very small or very large, creating distortion at those points. There is, however, a range of signal levels for which the relationship is linear. The addition of a bias signal, in proper proportions, shifts the audio signal up into this linear area. (This is explained more fully in a feature article on HX Pro in the August 1984 issue.)

The only "processing" involved in recording is the mixing of the audio and bias signals. This usually occurs just before they are fed to the recording head, though some decks have used a separate bias head located just across the tape from the recording head.

The bias frequency is not standardized and is left to the manufacturer; the choice will depend in part on the characteristics of the record head. It is universally recognized that the bias frequency should be at least five times the highest audio frequency to be reproduced, in order to avoid audible beats between the audio and bias signals. Therefore, the bias frequency is at least 75 kHz, and often 100 kHz or higher.

It has been found that the high-frequency portion of audio signals tends to behave in the same manner as bias generated by the bias oscillator. Hence, if there is considerable high-frequency content in the audio signal, the tape may be overbiased and cause treble loss in the signal recorded on the tape. HX Pro senses the amount of high-frequency content in the audio signal and correspondingly adjusts the bias current fed to the record head. Thus, the tape is better protected against treble saturation, and headroom is increased.

If you have a problem or question on tape recording, write to Mr. Herman Burstein at AUDIO, 1515 Broadway, New York, N.Y. 10036. All letters are answered. Please enclose a stamped, self-addressed envelope.

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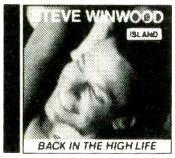

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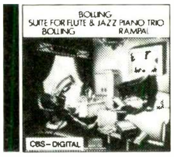

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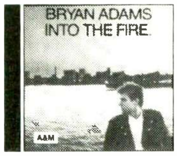

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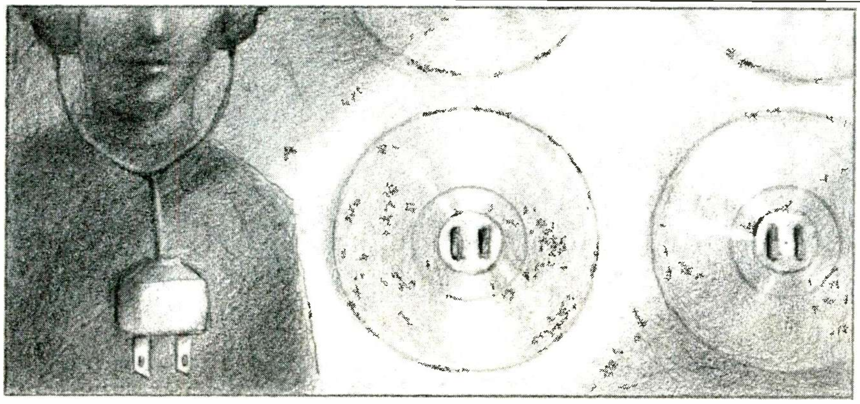

Illustration: Steve Dininno

Risks and Records

When I was a kid, choosing a record was less agonizing than it is today. You could walk into a record store, pick out a disc, and audition it in a little booth before buying. By the time I got an allowance, though, the listening booths had disappeared. The then-new LPs and 45s scratched easily, and buyers wanted factory-fresh records in sealed jackets.

This didn't deter me too much. The prices of the new vinyl discs were considerably less than those of the 78s they replaced, low enough so that I didn't mind taking an occasional flyer on a record I hadn't heard but which looked interesting.

With CDs, I'm more reluctant to take chances. Prices are beginning to drop, yet most of the CDs in the stores still cost about twice what LPs do. And I feel railroaded by the still-limited selections available. Much of what I want is not available on Compact Disc yet—either not at all, or not by performers I've learned to trust on that particular music.

Reviews are some help, but what I really want is the chance to hear at least some snatches from each disc before I buy. As a result, most of the CDs I do buy are reissues of LPs I've loved to death—and even some of these are sonic disappointments.

Buying CDs need not be such a gamble. Compact Discs don't wear down from use, and any audible damage will probably be visible as well. So a few record stores are once again letting customers listen to discs before buying. The old listening booths of my 78-rpm childhood have been done in by the high cost of commercial real estate and the high quality of modern headphones, which provide better listening in less space.

The stores with listening facilities I've heard of so far are Compact Disc Warehouse in Huntington Beach, Cal., and Waterloo Records in Austin, Tex. Each has its own approach. Compact Disc Warehouse has a battery of five, 60-disc jukebox-style players hooked up for headphone listening. The store also sells used CDs for $8.99 each, and that stock is available for listening as well. New CDs not in the 300-disc jukebox system cannot be auditioned, however, because of the difficulty of removing them from their theftproof packages and the near impossibility of restoring the packaging after play.

Waterloo Records takes a less limited approach. They'll not only open and play anything they have in stock but will even let customers audition CDs at home and exchange them if not satisfied. Because Waterloo keeps its CDs under glass, theftproof packages are not required. Therefore, repackaging is no problem.

"Our policy sells records," says co-owner Louis Karp. "About 60% to 70% of the people who listen in the store buy the discs they've auditioned. They're usually pretty close to deciding on a disc by the time they listen to it—they just want to make sure. And we get very few discs returned.

"We have a lot of music that people will never get to hear on the radio. Letting people hear before they buy encourages them to take chances on new material. I don't know why every record store doesn't do this."

Amen, Mr. Karp. Amen.

Sub System

Urbanites don't hold garage sales unless they're moving. Since I have no plans to move, I tend to squirrel away odd bits of unused audio equipment—power amps and gadgets, mostly—against the day I may have use for them again. My wife quietly wonders if such days will ever come, but just recently one did.

I wanted music in the bedroom I use as a home office, so I set up a first-generation CD player and a pair of small powered speakers back there. The system sounded fine (not as good as my main system, of course), but it lacked two useful features—a master volume control (each speaker has its own control) and a second input for my portable cassette player.

So I dug way back into my closet and came up with AR's SRC remote control system, which has both a tape monitor and a master volume control. I feel a little silly using a wireless remote to span the 2 feet between my chair and the equipment, but it does the job.

White Black Box

During a concert at New York's Weill (formerly Carnegie) Recital Hall, I noted something I hadn't seen at previous concerts: Two white, flat boxes were mounted on gimbals from pipe stands which projected from points high on the stage's side walls. Each box was about 12 inches high, 18 inches wide, and 3 inches thick. Ventilation slots were cut into the narrow sides of the box, and the large face, which was tilted down towards the audience, had a gridwork of holes about ⅜ inch in diameter. A black cable snaked from each box to a plug in the wall, hard by the base of one of the pipe stands.

It looked like a piece of audio equipment (perhaps the cable and plug tipped me off to that), but I had no idea just what it might be. The boxes were too small to be speakers and too thick to be backup plates for PZM or similar microphones. When the concert ended, I asked a stagehand. He told me they were infrared transmitters which allow the use of infrared-sensitive headphones by hard-of-hearing concertgoers.

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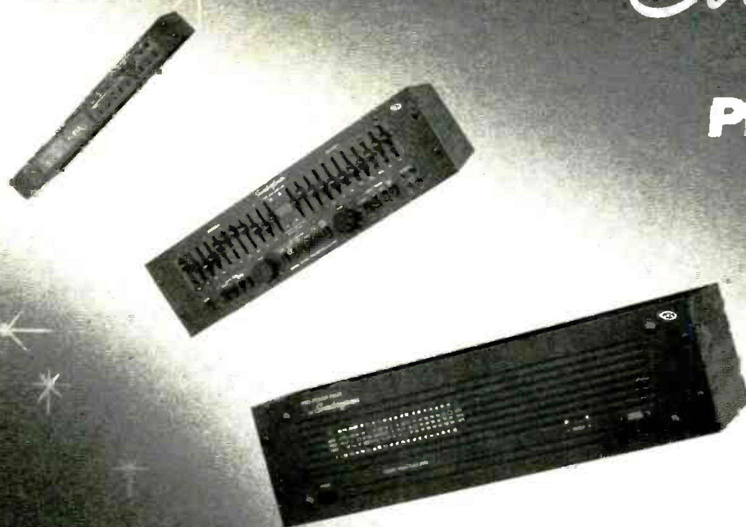

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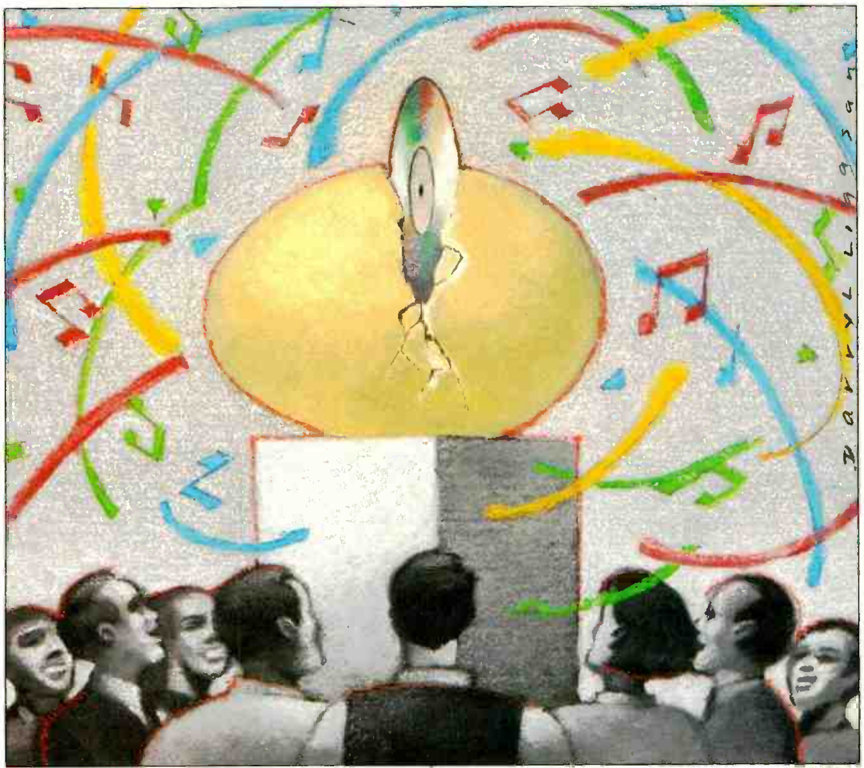

There's no great rush at the moment toward surround sound for music in the home—the kind of audio that doesn't have pictures and isn't on wheels. Still, all sorts of signs say that we will have it (in due time) when a few things ripen sufficiently. Notably, of course, the digital approach. Fortuitously, that gives me a chance to sketch in a bit of background (avoiding staggering amounts of technicalities) that might help the consumer to think ahead, and maybe even the manufacturer too.

My retrospective look at quadraphonic sound of the 1970s in the April and May issues of *Audio* was deliberately confined to the sound we then knew, minus even the thought of a video picture and mainly concentrated in the classical area, including the standard demo warhorses. Now things are different. Surround sound, returning to our homes, comes through the back door, en route from the movies. Where does it go? Not, you may be sure, to the music room. It heads straight for the nearest VCR, and what used to be the living room "concert hall" is now mostly a mini-theater. This is indeed a brave new world (sometimes), full of varied entertainment. Music listening, shall I say, tends to take a back seat. Or a front seat when it's on wheels.

Believe me, non-picture music—the standard living room audio that has sustained us through 40 years of hi-fi—is going to persist, video or no video. It still has huge resources to offer, as witness the extraordinary success of the still-expensive CD even before price levelling. (Not a video in a carload of CDs, if you remember the famous ad.) But at this moment the great Public is interested in what's new, which means anything with a picture attached, whatever the video format might be. It doesn't much matter whether it is Cultural Uplift or TV Wasteland, as long as you can look at it and hear the sound.

But surround sound is a catchy thing, and, as I have said before, we now know a lot more about the ways it can work for our ears. It will find its way back into classical and other music before too long, and we'll handle it far more knowledgeably than in quadraphonic days, both in the listening and in the technical know-how. So gather ye videos while ye may (with Dolby Surround Sound), and bide your time.

If you will think of things this way, you will understand a lot about the current discussions concerning surround sound, which, under the Dolby logo, clearly has the lead in the movie/video world of commercial entertainment and an enormous extension into the home market. As usual, Ray Dolby has his sensitive forefinger on the Public's beating pulse. The fact is that the present Dolby parameters are elegantly geared to things as I have just described them. To the best of my knowledge, there is no further intention. Dolby Surround is not for music—at least not for music that doesn't come with pictures.

The catch is that you *could* play your Beethoven and your Beatles records and lots more with genuine Dolby Surround Sound, and no pictures at all, if somebody would obligingly encode a few recordings for you. (This is assuming you have the extra gear for surround sound.) Who's to stop you? But the problem is that none of the three Bs or four, if you count The Beatles) comes under the Dolby guarantee. So yours is the risk—not legal, but merely that you may achieve something less than surround perfection in your classical music (or any other type). What more should you expect? We're in the movies now. We're into video. We take our surround from those sources. Dolby is impeccably right!

What we need—now—for music is *one* surround system, as a beginning, with no ifs or buts, no alternatives, no complications beyond the basics. Please—not another quadraphonic mess! One step at a time, and each an absolutely clear one.

Beyond my somewhat simplified language is an ocean of complication. Over the years, as some know, the earlier matrix way of encoding numerous sound channels into our basic two has been busily developed in a dozen directions, Dolby being only one—if the first to emerge at top level. But there are also other possibilities, much more advanced and much more versatile, in the digital area. They could compete very meanly with Dolby for a general music surround—that is, if the present Dolby Surround were to be promoted as all-purpose. So Ray Dolby, I would say, is extremely wise to stay out of those potentially larger mar-

Illustration: Darryl Ligasan

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Should Dolby improve his analog surround for home listening, with digital surround only inches away? No reason to do so.

kets. He is into *home video* surround, licensing decoding circuitry for equipment used in playing videocassettes whose soundtracks carry Dolby encoding. *Home video*, period. I think that's plenty. You could run a dozen conglomerates on this much business potential alone.

Digital surround does indeed loom and may arrive very soon. I've had material on hand for some time, for example, concerning a system rather bravely named Colossus, perhaps to match the clout of that hallowed name Dolby. It looks good. This system is already projected in numerous formats for pro and consumer four-channel surround recording. No details here, but not only is it all-digital, it (a) is video based; (b) has discrete channels, four for consumer use and as many as 32 for the pros, and (c) seems to be infinitely compatible with everything—via the usual no-loss transference from one digital format to another.

The first recording for the Colossus system (the consumer version) was made at a championship air race—not exactly classical music. But this may have been because Colossus was associated for a time with that familiar audio outfit, Mobile Fidelity Sound Lab, which began, many years ago, with superb LP recordings of railroad and trolley sound effects. Sound effects, you'll note, are very useful in movies and video. But, aside from the "1812 Overture," they don't occupy much space in home music.

Ah, but wait. Being digital, the Colossus system is easily adaptable to the type of digital data stream used for Compact Discs. So can we have CDs with digital surround sound via the Colossus system? Definitely. And discretely. DATs (Digital Audio Tapes) too, if and when.

Look a bit further and you will see why Ray Dolby is playing his potent cards with extreme finesse. Other news is that Telarc, that familiar supernova of the record biz—the first in the States to record all-digital and the ardent promoter of the classical spectacular—has already acquired a Colossus unit, with its discrete four-channel format, for recording on CD. No recordings as yet announced, but you can be sure they won't be of jet planes. More likely the "1812 Overture." But keep in mind that there *might* be Beethoven, or a Brandenburg Concerto, or even a string quartet. All this, if we have patience. It'll be a while.

I could go on and on about the enormous advantages of a digital approach to surround sound, given enough time for careful development toward the end, or ends, that are envisioned. Let's say only that, aside from noiseless sound quality, there is that near-infinite capacity for transference (what used to be called copying), but now without loss. Digital audio transfers itself in any direction as new systems may require; it does not become obsolete, it just adapts and lives on. There is also digital's enormous capacity for information, its extra room for even more info than we will need. That in itself is a mortal challenge to any analog surround-sound system for the consumer.

These implications, and plenty more, are certainly understood by Dolby, whose present Surround Sound is not digital, just a typically ingenious and precise version of the long-time matrix approach. Precise, again, for its present use. But not for a wider purpose, in competition with digital.

The genius of Ray Dolby is his dazzling ability to choose the right parameters, not only at the exact right moment but for a future longer than anyone might believe. Dolby has provided the very best bandages for the disabilities inherent in analog audio, which over the years has surely been more triumphant because of him. Dolby bandages—signal processings—persist where others fade, not always for reasons of profit and loss. The others may work even better than Dolby, but they don't hit the nail on the nose. Who but Dolby could have set down, in the early 1960s, the Dolby A noise-suppression parameters that have survived through nearly a quarter-century right up to the digital present? The same for Dolby B when NR moved into the home area, and later for the Dolby C extension of the B.

Now, Dolby SR is probably the final segment in this line, almost a stunt in the face of digital, with professional specifications that can exceed those of present digital sound. This system may be analog, but I'll bet it will sell. Besides, it's beautiful.

Ray Dolby's contributions have an elegance of design like that of the Parthenon and the Taj Mahal, without the weight. This includes Dolby Surround despite that system's curiously negative quality: Its precise tailoring for one immediate purpose and no other.

Yes, there is considerable protest now from those who think that Dolby for home video is not quite the thing for home Beethoven; they are urging a Dolby modification or alternative, for better results. Yes, it could be done. We have that from Peter Scheiber himself, who holds the basic matrix patents from which Dolby operates. There is the leeway. You will find the Scheiber reasoning in the final issue (October/November 1986) of a feisty little mag called *MultiChannelSound* (or *MCS Review*), which had been coming from one Larry Clifton (Box 19, Capron, Va. 23829) ever since quadraphony waned. In that excellent issue there is also a spirited technical report on Dolby's inadequacies for music surround both in the theater and the home, among them the notorious mono that goes to the rear speakers. I agree with both accounts. I could imagine a simple alternative built into the Dolby system, with a switch marked "Video" and "Music," like the pushbutton choices between competing matrix systems we used to have. It really would be very simple to design—and to manufacture.

If you have followed me this far, I think you can see that this will not happen—and for good reason. Should Dolby set himself up at this late date with an essentially short-lived *analog* surround for the special demands of home listening, with digital—like Colossus—hovering only inches away and possessing a far greater potential? Not likely! Dolby is right.

If and when the Dolby people get into general music surround sound, you may guess, it will be on a much grander scale and will have the typical Dolby permanence and all-over usefulness. A new digital dynasty? That would require, of course, a whole new Dolby designation. It could well affect audio, *our* audio, as greatly as all the earlier Dolbys put together. We shall see.

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BERT WHYTE

THE GENRE GAP

Illustration: Debra White

The 1987 Summer Consumer Electronics Show in Chicago will be history by the time you read this. As usual, thousands of audio/video dealers will have trudged through the endless aisles of the main exhibit hall, cavernous McCormick Place, to view the glittering new components produced by hundreds of manufacturers. For the most part, the products on display in McCormick Place are mass-market oriented, designed to sell at price points palatable to the average consumer. Generally, the music which these manufacturers play to demonstrate their products is of the pop/rock variety.

In marked contrast to this scene is the activity at the Americana Congress Hotel, where a much smaller group of dealers will have auditioned the newest state-of-the-art audio components from high-end manufacturers. In this milieu, most manufacturers use classical music to emphasize the performance capabilities of their pedigreed products.

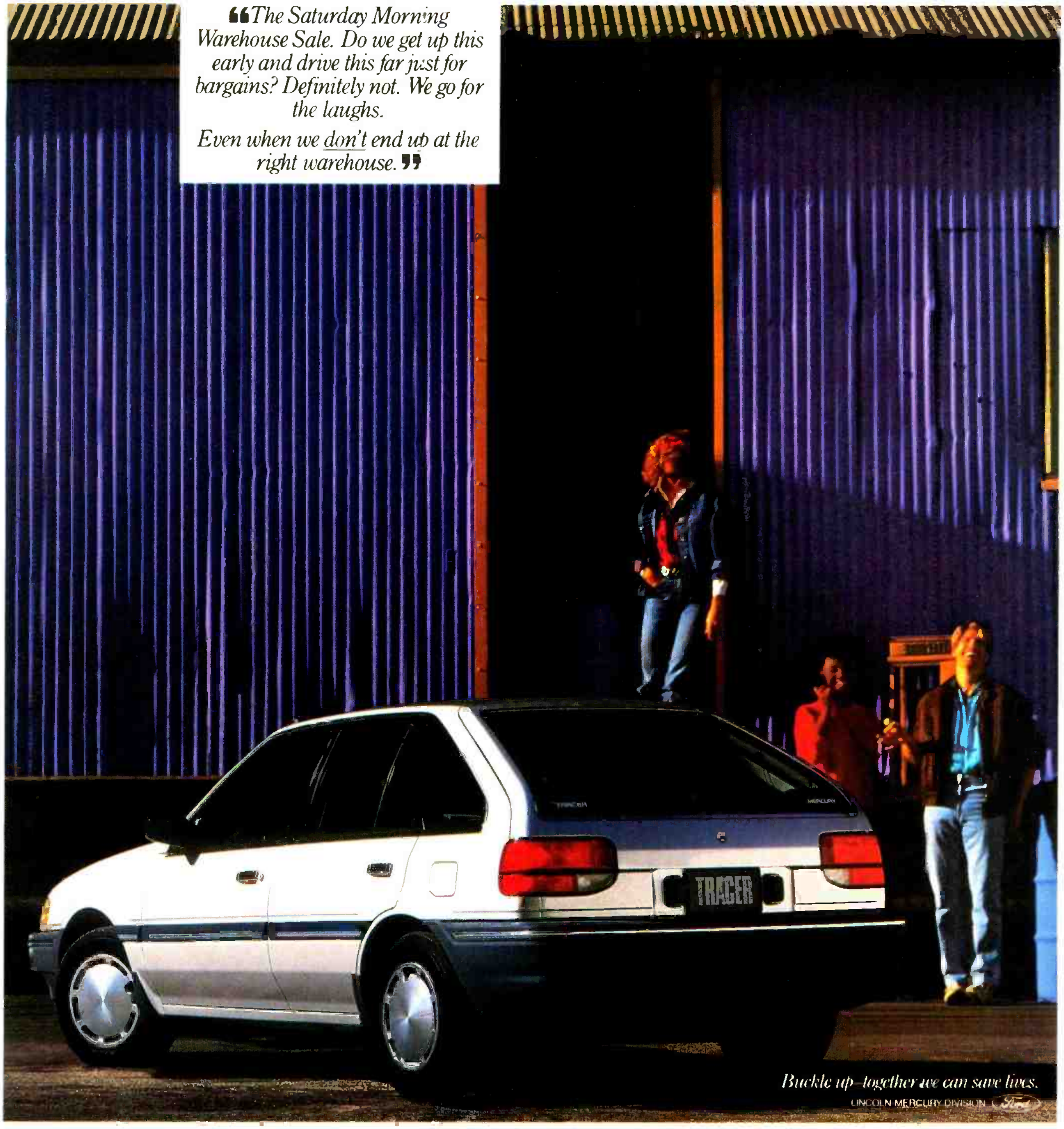
One might well ponder why this situation exists. Does the preponderance of classical music in demonstrating high-priced, high-end audio equipment connote some sort of music snobbery or elitism? Most likely there are experts who would have us consider sociological, environmental, economic, and cultural factors. However, I don't think the makers of high-end equipment harbor any sinister motives, nor do I believe any attempt is being made on their part to denigrate the average consumer's musical tastes. Quite simply, high-quality recordings of classical music have historically been the programs of choice for evaluating progress in audio technology.

Why classical music predominates in the demonstration of high-end audio equipment is easier to understand by considering state-of-the-art recording technology in pop and classical music. First off, let me say that I have the highest regard for some of the brilliant engineers who are masters of the art of recording pop music. They create marvelous and even astonishing sounds. But the key word is "create," for most of their recordings are cleverly contrived, made in a totally controllable studio environment, and they have no existence in real time!

The typical pop/rock recording has a lead vocalist, accompanying vocal group, guitars, electric bass, synthesizers, drum set and assorted other percussion, and possibly some brass and reed instruments, plus an acoustic or electric piano—all acoustically isolated from each other. As many as 60 or more microphones of various types may be used in a recording: some engineers use as many as 17 mikes on the drum set alone to capture its proper impact and tonal nuances and characteristics. (Incidentally, even in a studio with conscientious personnel, the chance that all microphones will have the same polarity is pretty slim; this explains why people who own preamps with polarity-reversal switches are so often frustrated when they attempt to perceive sonic differences between the two switch positions. The same thing holds true, of course, for multi-miked classical recordings.) Typically, all these mikes are fed into a huge, multi-input/output mixing console that has myriad faders, knobs, and switches. Very often, two 24- to 32-track analog or digital recorders will be interlinked to accept a greater multiplicity of microphones.

The engineer may have at his disposal up to six acoustic echo chambers, plus another half-dozen channels of digital reverberation. All these permit him to employ selective reverberation for the various instruments and vocals, as well as control the nature and character and time period of the reverb. In his console, the engineer has a vast armamentarium of controls allowing him to process and manipulate and tailor the sound and to create special effects. At his fingertips he has graphic and parametric equalizers, devices for phasing and flanging effects, overdubbing facilities, and a great deal more.

The very highest quality pop/rock recordings can offer exciting—even spectacular—and most certainly entertaining sound. In terms of sound for the sheer sake of sound, some pop recordings are awesome in their complexity and in their impact. Despite the fact that a loudspeaker may reproduce the full frequency response of a pop recording, and handle its dynamic range and cleanly present its spiky transients, nonetheless I feel most pop recordings are of limited value in testing loudspeakers. Since most pop re-



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cordings do not exist in real time, the ear/brain combination has no point of reference; the recorded sound of a given group will be considerably different from how it sounds in a nightclub or at a concert. Shorn of most of its acoustic and electronic processing and trickery, the live music cannot be referenced to the recording. Obviously, it is for this reason that pop recordings have limitations if used for evaluating loudspeakers. (Just as obviously, judging from the fact that pop and rock account for 95% of the total record market, these limitations are of little concern to most listeners; for them, the music and the melody matter most.)

While most pop recordings are made under controlled studio conditions, this is rarely the case with classical recordings. Small-scale and chamber-music recordings may be made in studios, but large-scale symphonic works, operas, oratorios, etc. are almost always recorded on location in concert halls or in other large acoustic spaces such as churches, ballrooms, and multi-purpose municipal halls like Walthamstow or Watford in surburban London. It is true that a number of classical-record companies utilize multi-mike, multi-track digital recording techniques and a certain amount of equalization. But more and more are using simpler M/S, Blumlein, ORTF, and spaced-array mike techniques, and for the most part they are using very little equalization. A few companies, like Telarc, use no equalization, compression, or limiting whatsoever (as was my own practice with Everest and Crystal Clear recordings).

A well-recorded classical work, made with "purist" minimal mike techniques, is an invaluable aid in loudspeaker evaluation: It strives to reproduce the live, real-time listening experience, unsullied by any kind of electronic processing or manipulation. A delay system would help to heighten the illusion of being in a concert hall, but the important thing is that the ear/brain has a point of reference, and this can help one assess the accuracy of loudspeaker reproduction.

Although there may be less processing involved in a classical music recording, the totally trouble-free session is a rare bird indeed! Quite often, the challenges of recording a symphony orchestra in certain halls are hugely formidable. Of course, the worst situation is when you are going to record in a hall you've never been in, and have no knowledge of its acoustics. Classical recording sessions can be very frustrating and off-putting, and I have had my share of them!

Some years ago, I was recording in London. A fairly large Ford van was rigged to transport all of the tape recorders, mikes, booms, cables, amplifiers, monitor speakers, etc. This van accompanied me on the S.S. United States to Southampton, England. After clearing Customs, I continued on to the

Walthamstow Assembly Hall, where I spent several weeks recording the London Symphony and London Philharmonic orchestras. I then had a free week for R and R, before going on to Paris to record the Lamoureux Orchestra, conducted by temperamental Igor Markevitch.

So there I was in mid-December, enjoying the view of the blue Mediterranean from a hotel room in Monte Carlo, when the phone rang. I was informed that a terrible accident had occurred with the recording van. It seems the van had been ferried across the English Channel to Calais, where the inimitable French bureaucracy asserted itself. The officials insisted that a French driver deliver the van to Paris. Now, the van was equipped with a standard miles-per-hour speedometer, but apparently the driver assumed it was marked in kilometers. When the driver thought he was doing a relatively safe 60 kilometers per hour, he was really doing 60 miles per hour (about 100 kilometers per hour). The roads were icy, and the van skidded off the road and turned over. The poor driver suffered a concussion and lost his right arm. The van was torn open by the impact, and a large amount of recording gear was battered and scattered all over a field.

The equipment was put onto a truck and delivered to the Salle Pleyel, my recording venue in Paris. I arrived at the hall to find my trusty technician Ted Gosman feverishly trying to sort things out, repair what was broken, and do a lot of testing. Miraculously, although the cases for the special three-channel Ampexes were cracked and some of the recording amplifiers had several bent corners, they still worked. The KLH monitor speakers were splintered and their grilles were torn, but they too worked! We had a few bent mike booms, and a test oscillator was totally out of commission. But we could record!

The next day, recording sessions were to begin at 9 a.m., but the first cellist wandered in almost an hour late and dismissed his tardiness with a typical Gallic shrug of his shoulders. We were recording several large-scale choral works of Lili Boulanger, deceased sister of the redoubtable Nadia Boulanger, the famous teacher and mentor of Aaron Copland, Leonard Bernstein, and many other American composers and conductors. Nadia, who was then in her seventies, attended the sessions. A rather prim, no-nonsense lady, she just lifted a quizzical eyebrow when she saw the battered recording equipment, but she was all smiles when she heard the thrilling playback of her sister's "Descent into the Abyss."

Ironically, after all the trouble with the accident and assorted other problems, that recording of the Lili Boulanger works won the Grand Prix du Disque of the Academie Française!

LEONARD FELDMAN

UNBALANCING ACT

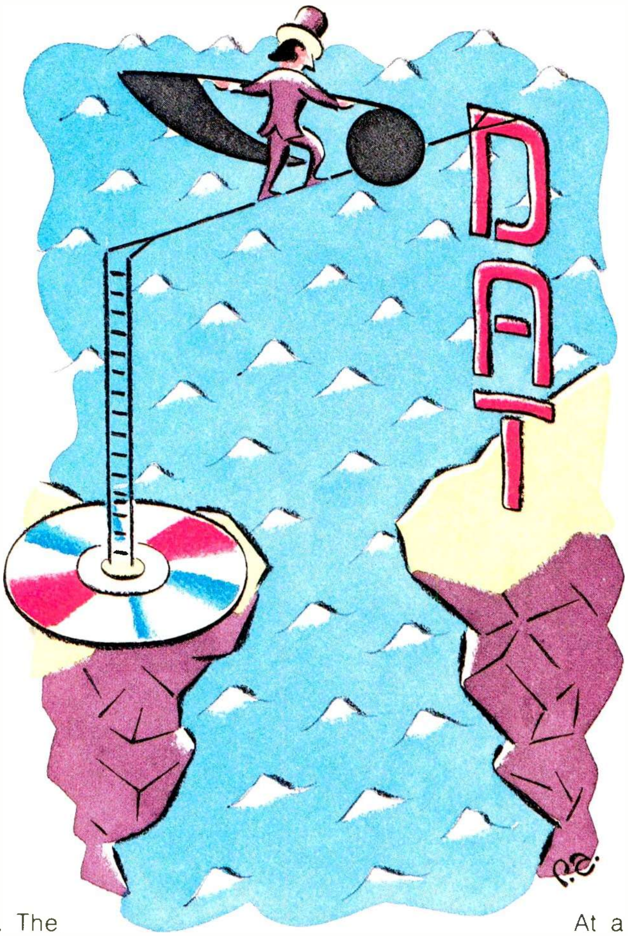

Illustration: Philip Anderson

By now, you've probably heard about the battle going on between makers of audio equipment and many (but not all) producers of recorded music. Although most of us have been freely making tape recordings of radio programs, video programs, and, yes, analog discs for several decades, suddenly a new effort has been launched to deprive us of that right. Record companies claim that we are cheating them out of "billions of dollars" of sales because of the widespread tape copying that we do.

To solve this "problem," the record companies have launched a drive to have Congress pass a law that would make it mandatory for any Digital Audio Tape (DAT) recorders brought into this country (none have been introduced so far) to include a so-called anti-copying chip. This chip, in combination with specially encoded program material, would shut down the DAT recorder when anyone attempted to make a copy of such encoded programming. The technology involved in this scheme, by the way, has been around for several years. It was first discussed during the proposals to levy a royalty tax on blank tape as well as on cassette tape decks. Fortunately, that idea never got much beyond the talking stages. So why have the record makers decided to revive the anti-copy chip now? The new push is on because these companies see the DAT recorder as a machine that can literally make endless numbers of "clones" that will sound every bit as good as the original recordings. In fact, that's not the case at all. The DAT standard already prevents such cloning in two ways, as I will discuss later.

For the moment, let's skip the arguments concerning whether or not we have a right to copy *any* music from *any* paid-for source (including radio and TV programming, which is paid for by sponsors before it enters our homes). Instead, I'd like to talk about the degradation of sound quality that will occur if the anti-copy chip and associated encoded program sources become the norm in the future. First, a summary of how the chip works:

This copy-prevention scheme requires encoding of records or other program material, as shown in Fig. 1. The pattern of frequency distribution at the left shows the average energy content of music over the recognized audio spectrum from 20 Hz to 20 kHz. The pattern at the right shows that an encoded record would notch out a narrow band of frequencies centered at 3,840 Hz. If you have any doubts as to the musical significance of this region of frequencies, or if you don't believe that energy content at or around that frequency is not all that much lower than it is at mid-band, consider the spectrum analysis 'scope photo of Fig. 2. To obtain this pattern of energy distribution, I simply played a CD and fed the player's output to a spectrum analyzer as it swept repeatedly from 20 Hz to 20 kHz. The sweep in this case was logarithmic so that the horizontal scale would correspond to the scales used in Fig. 1. It took only a minute or so to produce the pattern shown, and you'll notice that it corresponds almost exactly to the patterns of Fig. 1.

Now let's return to the system and how it works (Fig. 3). If you try to record the content of an encoded record using a tape deck that's got the "spoiler" chip inside, the chip checks to see if frequencies in the vicinity of 3,840 Hz are missing. However, since it is possible that the music is "low-fi" to begin with or that there are long, silent pauses in it, there is a second requirement: The chip must sense the presence of frequencies on either side of the missing frequencies. If both conditions are met, the chip shuts down the recorder. It takes about 15 to 18 seconds for the chip to complete its analysis. The three possible cases are shown in Fig. 4.

At a meeting held several months ago in Washington, D.C., Hiroshi Kosaka, Senior Manager, International Business Environment Office of Toshiba; Masahiro Kosaka, General Manager and member of the R&D Steering Committee of Matsushita Electric Industrial Company, and I. Iwashita, a Pioneer research engineer, presented their views concerning the impact of the anti-copy chip on recorded sound. The meeting was confined to technical considerations; legal and moral issues were not addressed.

When I was first introduced to this anti-copy scheme nearly two years ago, I was told by its promoters that the narrow band of frequencies which it sucks out of the music is above the fundamental tones produced by any musical instrument. I was also told that the frequency band is so narrow that one would never notice that it was missing. It seems clear now that the promoters of the chip are unfamiliar with a piano keyboard.

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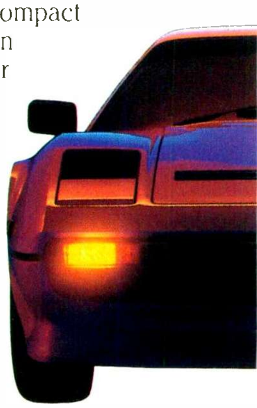

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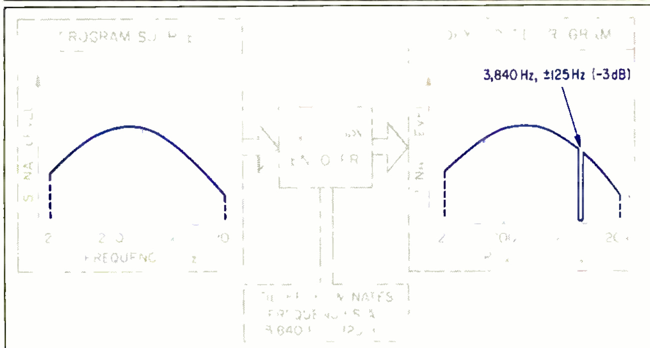

Fig. 1—Basic encoding scheme for the anti-copy chip.

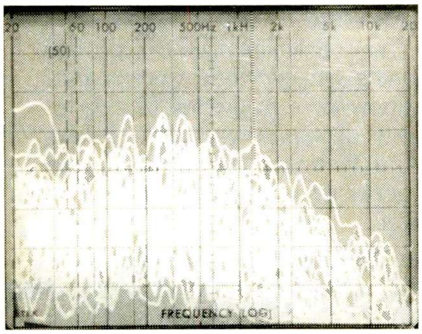

Fig. 2—Energy distribution of an actual music program. Note the close match to the curves in Fig. 1. Sweep is logarithmic, from 20 Hz to 20 kHz.

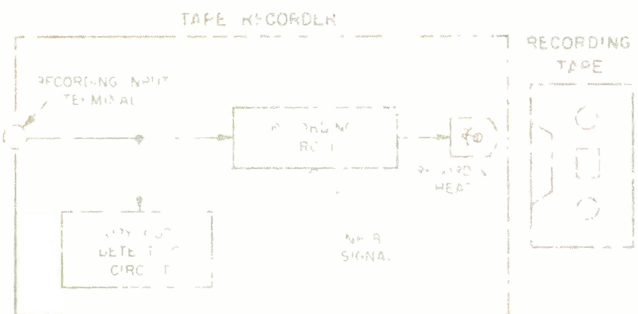

Fig. 3—Block diagram of the copy-code and record-inhibit systems in a tape recorder.

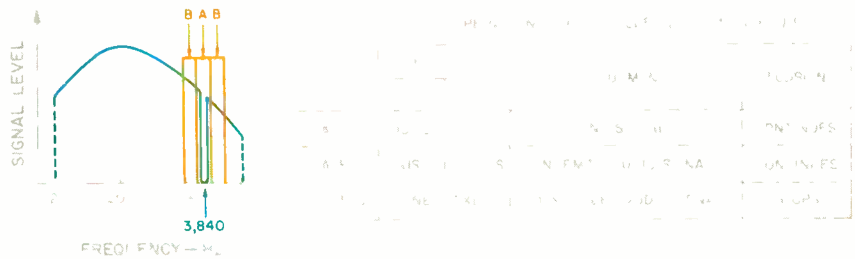

Fig. 4—How the copy-code circuit interprets the presence or absence of signal energy at and around the notch frequency.

Figures 5 and 6, presented by Mr. Kosaka during the meeting in Washington, clearly refute the statement that the missing frequencies are above fundamental tones of musical instruments. Figure 5A shows the frequency range that would be affected by the introduction of the notch filter. The −3 dB points occur at 3,715 and 3,965 Hz, while the frequency of greatest attenuation occurs at 3,840 Hz. As is evident from Fig. 6, the pitches of the second and third notes from the top of a standard 88-note piano keyboard ($A^{\#}_7$ and B_7) fall squarely in the region of the notch. These notes have fundamental frequencies of 3,720 and 3,951 Hz, respectively. It became clear, too, from Mr. Kosaka's presentation that *many other notes of the piano (or any other musical instrument that is rich in harmonics) would also suffer*, though to a lesser degree. The lower portion of Fig. 6 shows the relative effect upon these lower tones. For example, the A-sharp and B-natural notes a full octave below the ones most affected would also undergo serious degradation. Although their fundamental tones would not be attenuated, the second harmonics of these lower notes fall right in the region of the notch and would therefore be severely attenuated. A piano, like most musical instruments, produces sounds that are rich in harmonic content. By removing the harmonics, you are also removing the qualities which make a piano sound like a piano, a violin sound like a violin, and so forth.

Figure 5B shows the extreme phase distortion that occurs at or near the center frequency of the notch. It's interesting that audio purists condemned early CD players for exhibiting a slight phase error at the extreme high end of the audio band. Objections were so great that most makers of CD players now employ oversampling and digital filtering to overcome such phase distortion. Yet here is a proposal for a filter that would put much more severe phase distortion near the middle of the audio spectrum!

The representatives of the Japanese firms pointed out several other harmful effects on program sources that would occur if the chip finds its way into DAT recorders. And don't overlook the possibility that once it gets into DATs, it will

UPDATE UPDATE UPDATE UPDATE UPDATE UPDATE

Since I wrote the accompanying article about the anti-copy scheme, I have been in the thick of the controversy, having been asked to testify on several occasions before various Congressional subcommittees. I have appeared as a technical witness for the Home Recording Rights Coalition, an association of audio hardware makers, blank tape manufacturers, and audio retailers. In the course of preparing that testimony, I have learned some additional facts concerning the anti-copy system which I'd like to mention.

Each time I demonstrated the audible effect of the "notch" during my testimony, proponents of the notch claimed that my experiments were flawed; they said my demonstrations showed audible differences because I did not really know the parameters of the latest version of the notch. Proponents maintained that the "actual" notch now proposed would not be audible. It is true that the parameters used in my demonstration are those I learned of nearly two years ago, but they were provided to me directly by the people who were in charge of the project at the CBS Technology Center. I am certainly willing to concede that the parameters may have been changed. However, despite the fact that I have repeatedly asked for the new parameters, David Stebbings, Director of Recording Technology at CBS Records, has not been willing to provide them.

About the only difference that I have been able to learn of, between the early version of the system and the present or "revised" version, concerns the notch's center frequency: It is 3,838 Hz instead of 3,840 Hz. This 2-Hz difference is hardly enough to change the overall results or the degree of audibility when the notch is inserted in music.

Stebbings has suggested that the bandwidth of the notch that I used in my demonstrations is far wider than the final version being proposed. (In my experiments, the notch was set to have a width of ±125 Hz about the center frequency.) Perhaps the notch has been narrowed, but if it has been, no fewer than three problems arise from such further narrowing, say technical experts who were involved in the early stages of the system's development.

First, narrowing the notch will cause the kind of "ringing" associated with ultra-narrow band elimination filters, making the notch even more audible until it becomes very narrow indeed. Second, the narrower the notch, the longer it will take the scanner circuit to analyze the program material. As the notch width approaches inaudibility, the time it will take for the scanner to identify the presence of the notch will approach infinity. In simpler terms, if the notch is made so narrow that its presence becomes inaudible, the scanner won't ever shut down the recorder, and the system won't be practical for its intended purpose.

Third, I have already mentioned that the system, as devised, is subject to "false positive" errors—it can shut down erroneously when analyzing program material that was not even encoded with the notch. I am informed by several former employees of the CBS Technology Center who were involved in the copy-code system's development that, out of 100 *unencoded* LPs played through the system (as configured in my demonstrations), unintended shutdown occurred on two of those discs. Making the notch still narrower would, in all likelihood, increase the probability of unintended shutdowns.

It is interesting to note that a growing number of people in the professional audio community (including recording engineers, broadcast engineers, mixing technicians, and the like), upon hearing demonstrations of the system, have been able to detect the presence of the notch in a variety of program material *selected by the proponents of the system and using their circuitry*.

If you'd like additional information concerning this controversy, you can contact the Home Recording Rights Coalition at (202) 663-8452 or write to them at 2300 N Street N.W., Washington, D.C. 20037.—*L.F.*

Editor's Note: In an effort to learn more about the copy-code system, I went to the CBS Records R&D Center in Milford, Conn. in late May. Accompanying me were *Audio* magazine's Technical Editor and two independent recording engineers who are owners of their own small recording companies. Our hosts were David Stebbings and Howard Schwartz. There was a good deal of discussion about recent events surrounding the copy-code legislation. The most important items are these: Congress has asked the Office of Technology Assessment to report on how the introduction into this country of DAT recorders would affect the record industry, and both Congress and the Recording Industry Association of America (RIAA) have asked the National Bureau of Standards to perform tests on the audibility of the copy-code system.

Very few technical details concerning the system have been released, though we were able to pry loose a couple of new facts—specifically, that the center frequency of the notch is 3,838 Hz and that the filters are multi-section ellipticals. As might be imagined, there have been quite a few articles about the copy-code system and its effect on DAT recorders, but most have focused on the legislative process. Perhaps the best technical article we've seen was in the July 1987 issue of *High Fidelity*, though the author of that piece, David Ranada, was not able to get the system's specifications confirmed.

David Stebbings says that full technical details on the system have not been released because its developers intend to maintain control over the performance parameters, just as Dolby Labs has done with its licensees, for example. Unlike Dolby Labs, however, they do not intend to charge a royalty. Stebbings says further that "at the request of the Senate and House Congressional Subcommittees of the Judiciary, we are submitting the CBS Copy-Code System and specifications to independent testing at the National Bureau of Standards. The N.B.S. is widely recognized as the most prestigious independent testing laboratory in the United States, and we eagerly await the results of their evaluation of the CBS system."

We four visitors concluded our stay by participating in a double-blind A/B listening test in the R&D Center's listening room. We used a wide variety of CDs, playing them on a good (but not state-of-the-art) system. The object of a test set up in this manner is to judge whether there is a difference between the A and the B circuits (or whatever is being tested) and then follow that difference as it is randomly switched between the two presentation positions. One of the four visitors was able to accurately follow a difference he heard on nine of 11 trials. While this is a small number of trials, I believe that it is statistically significant, so I conclude that the system is audible with music.—*E.P.*

This scheme could severely attenuate harmonic tones. Remove them, and you lose what gives instruments their special characters.

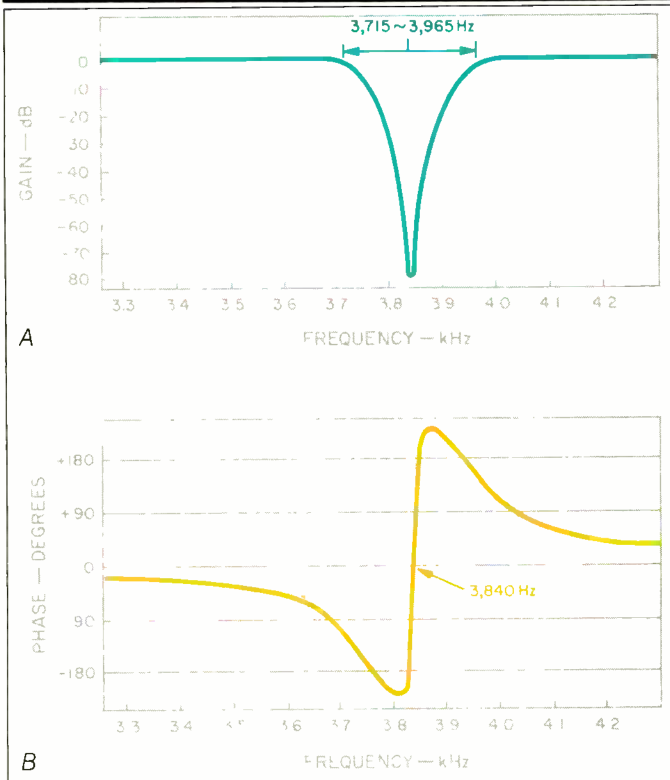

Fig. 5—The effect of the proposed anti-copy encoding scheme on a recording's frequency response (A) and phase characteristics (B).

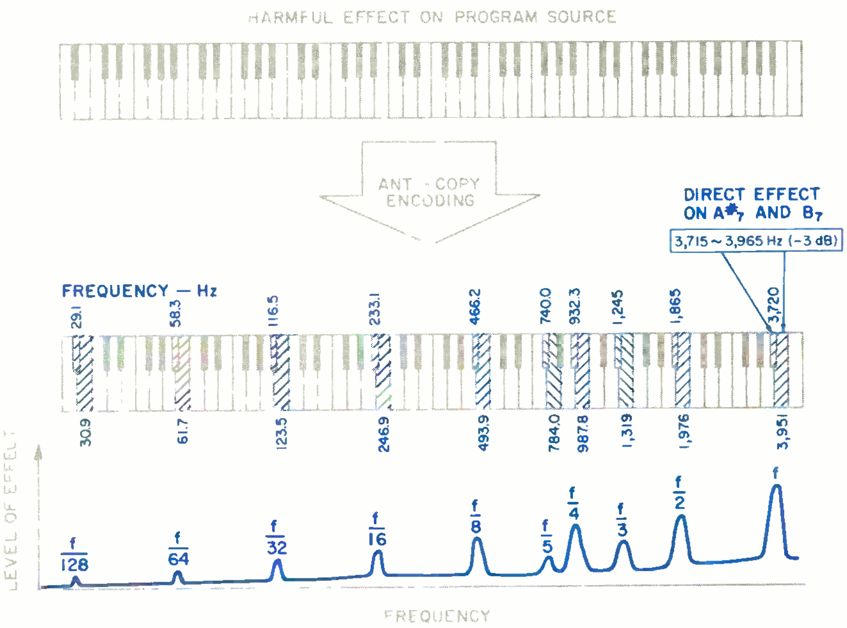

Fig. 6—How the anti-copy scheme's effects relate to the notes on a piano. The notch would directly affect two notes and change the timbre of 18 others. The degree of this effect would vary with the note, as shown at the bottom.

also creep into analog recorders, the sound-recording portion of video recorders, audio and video broadcasts, and who knows what else—where it will have the same deleterious effects.

An interesting sidelight concerning the anti-copy chip was brought up during the meeting with these engineers. Under certain conditions, the chip could actually shut down a recorder *even when that recorder was being employed to record unprotected software or original audio programming created by a user.* How is that possible? As I mentioned earlier, the chip looks for two conditions: An *absence* of signal content in the narrow band of frequencies that have been filtered out and the *presence* of frequencies on either side of the missing band of frequencies.

Now consider the top illustration in Fig. 7. A violin's output waveform is not unlike that of a sawtooth wave; it contains a fundamental tone and many harmonics above that fundamental. Suppose a violin produced a note having a pitch somewhat lower than one-sixth that of the notch frequency. The sixth and seventh harmonics of the note would fall on either side of the notch frequency, meeting the second condition for recorder shutdown. At the same time, there would be *no* signal content at the notch frequency itself, meeting the first condition. Under such circumstances, the recorder would be shut down by the chip *even though a user was trying to record material that was not copy encoded!* A second example of such a possible chip malfunction is shown in the lower half of Fig. 7: The sound of a wind instrument, such as a clarinet, can produce a waveform very similar to a square wave. Now, a square wave produces a fundamental frequency plus all the *odd* harmonics (third, fifth, etc.) of that frequency. Again, both conditions for recorder shutdown could be met: Absence of signal content at the notch frequency itself and presence of a harmonic to one side of the notch frequency. This, too, would cause shutdown of a recorder even though unencoded program material was being recorded. Admittedly, the statistical chances of an improper shutdown are small, but such an occurrence is quite possible.

Speaking of square waves and trian-


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Under certain conditions, the anti-copy chip could shut down a DAT recorder even in the presence of unprotected software.

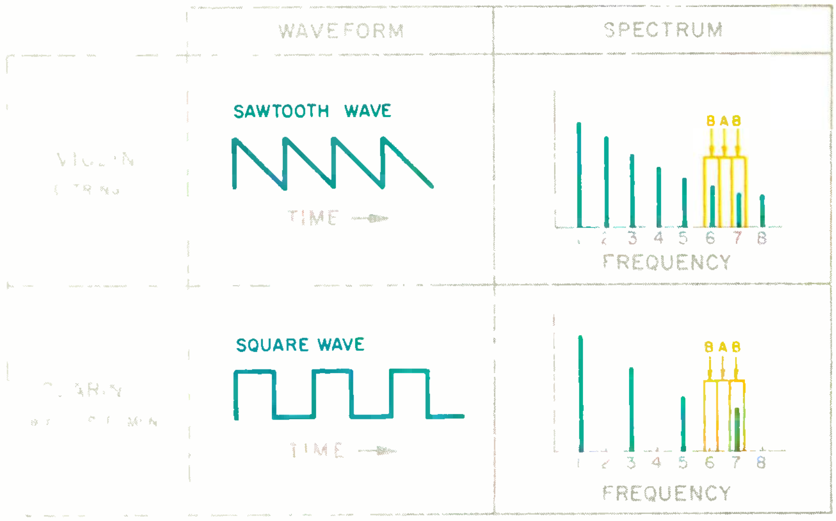
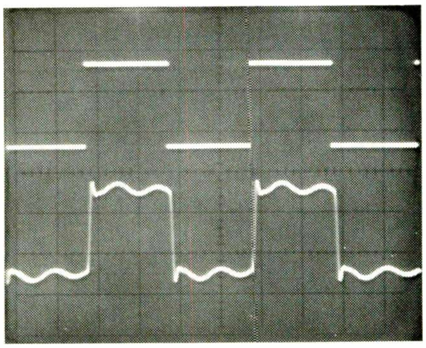


Fig. 7—The waveforms of instruments such as the violin and clarinet could be mistaken for anti-copy encoding, causing a recorder to shut down even when taping material that was not copy protected.



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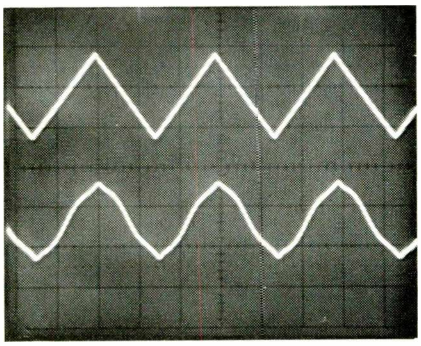
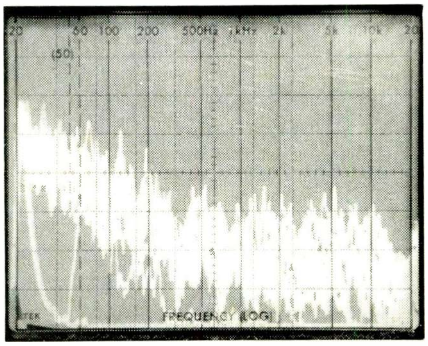


B

Fig. 8—Effect of the anti-copy notch filter on a 1-kHz square wave (A) and a 1.4-kHz sawtooth wave (B). Upper traces are input signals, lower traces show signals after filtering.



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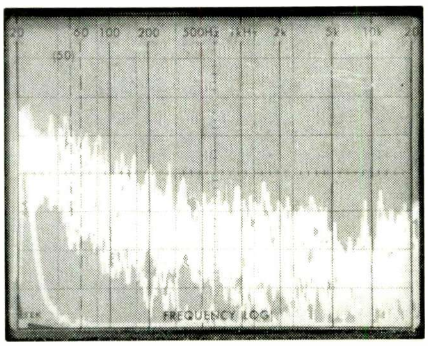

B

Fig. 9—Spectrum analysis of 1 minute of music with notch filter (A) and without (B). Note notch in response of filtered signal. Sweep is linear, from 0 Hz to 10 kHz.

gular waves, you might be interested to see how wave shapes would be distorted by a notch such as the one that the anti-copy scheme would incorporate. The upper waveform in Fig. 8A is a 1-kHz square wave—not a particularly high-frequency waveform, but one that's right in the center of the audio band. The lower waveform of Fig. 8A shows what this square wave would look like after passing through a notch filter of the type required in the anti-copy chip scheme. I repeated the same experiment for a triangular wave shape; results are shown in Fig. 8B.

It might be argued that repetitive wave shapes are one thing and music signals quite another, and indeed that's true. The company representatives with whom I met were ready for this argument as well. They had prepared a cassette tape containing not only swept tones generated by signal generators, but short musical selections recorded alternately without and with "spoiler" chip encoding. Particularly during the sequences involving solo piano and violin, the difference in sound quality between the unencoded and encoded versions was evident to everyone at the meeting.

Still, in fairness to all, I decided to check it out on my own with randomly selected music. My final experiment consisted of simply feeding the output of one channel of a CD player into a spectrum analyzer and letting the analyzer store successive sweeps for exactly 1 minute. I selected band 5 of a brand-new release entitled *Pomp and Pizazz* (Telarc CD-80122), featuring the Cincinnati Pops Orchestra under Erich Kunzel's direction. Band 5 is the "Coronation March" by Tchaikovsky. Figures 9A and 9B show the results. This time, the sweep is linear and from 0 Hz to 10 kHz. (If I had used a logarithmic sweep, the region around the 3,840-Hz notch would have been too compressed to see the difference between the two 'scope photos.)

Look carefully at the region about four *linear* divisions in from the left edge of Fig. 9A and you will see a distinct dip in the accumulated energy spectrum. Can you guess what it is? Of course! It's the missing musical content around 3,840 Hz that was sucked out by a notch filter that I had inserted in the signal path to simulate the anti-

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PLANE FACTS ABOUT FLAT SPEAKERS

Kenneth L. Kantor

Loudspeakers, like other sex symbols, have at certain times been considered most desirable when fleshy and substantial, and, at other times, when lithe and ethereal. Macho woofers had their days of glory, but flat panel speakers have remained the cat's meow since before most of us were born. I confess to getting a little bit lightheaded when listening to really good panel speakers. They look so incapable of filling a room the way they do, it's easy to forget they're around.

However, there is much more to the sound of the best flat speakers than the power of suggestion. Although a technologically diverse bunch, flat speakers share some important general characteristics that set them apart from more conventional box types. Properly applied, these characteristics can lend themselves to some of the best sound many of us have had the pleasure of hearing.

Kenneth L. Kantor is the president of Product Design and Evaluation Services, a consumer electronics consulting company located in San Francisco, Cal.

Photograph: ©1987, Bill Ashe

The Scoop on the Cone

The epitome of conventional loudspeaker design is the ubiquitous electrodynamic cone driver, a cross-section of which is shown in Fig. 1. Alternating electric current from a power amplifier flows through the driver's voice-coil, generating a magnetic field that interacts with the field of the permanent magnet, causing the coil to vibrate forward and back. The coil, in turn, is attached to a diaphragm in order to more efficiently couple its motion to the air. This diaphragm is formed in the shape of a cone to increase its ability to move as a rigid unit in response to voice-coil forces. This kind of uniform in-and-out cone movement is referred to as "pistonic motion," for obvious reasons. Electrodynamic cone speakers made their first strong appearance in radios of the 1930s, and rapidly came to outnumber

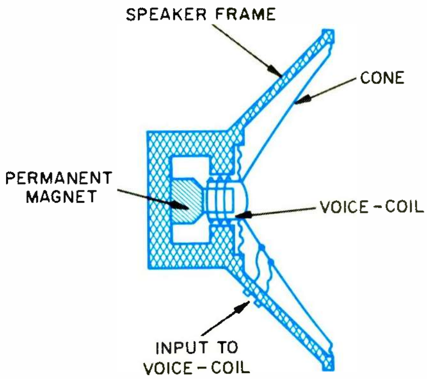


Fig. 1—Cross-section of a typical electrodynamic cone driver. (After Edgar Villchur.)

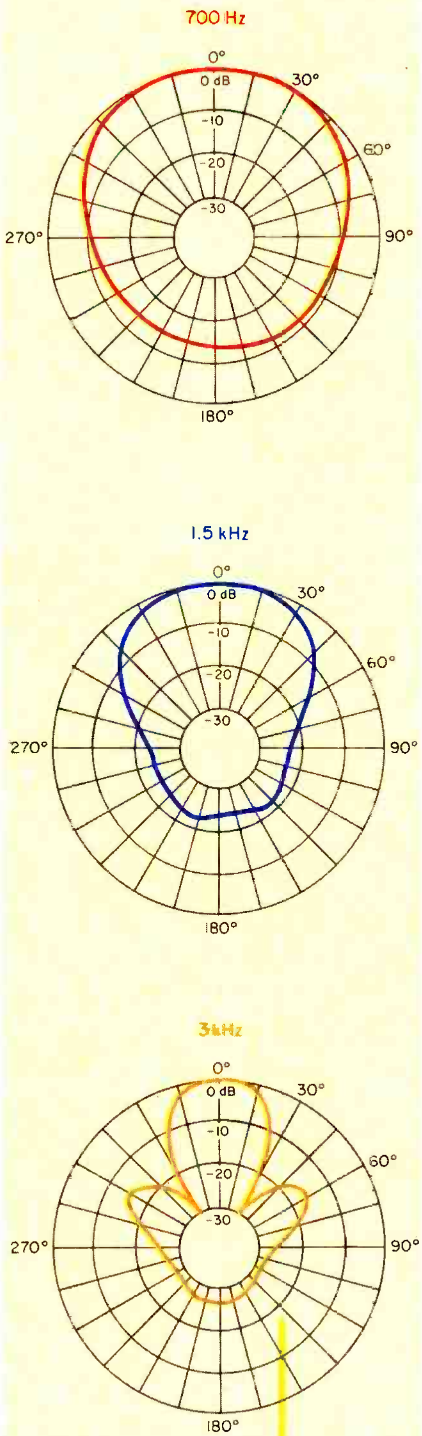


Fig. 2—Polar radiation patterns at three frequencies, for a piston speaker in a small cabinet. (After Leo Beranek.)

competitive electrostatic units due to their reliability and relative ease of manufacture.

While widely accepted, the cone driver has several drawbacks. First is the matter of mass. A conical diaphragm is simply heavier than a flat radiator of similar composition and area. Any excess driver mass tends to impair efficiency, high-frequency response, and transient behavior. If other factors can be kept equal, the lower the mass of a radiator compared to the air it moves, the better. At the same time, response irregularities and distortion are introduced because, cone or not, it is impossible to achieve perfectly rigid motion when all driving forces are applied over a small portion of the diaphragm. Some flexing is inevitable, and this leads to deviation from ideal driver behavior; most notable are harmonic distortion and radiation-pattern irregularities. The concave shape of the radiator also has a negative effect on frequency response and radiation pattern, since different points on the surface create wavefronts with varying phase. However, this is a minor problem unless unusually deep cones are used to radiate a range of frequencies that is much wider than normal.

Pistonic motion produces very even wavefronts at frequencies where the wavelength is long compared to the cone diameter, but at higher frequencies cones begin to radiate with increasingly uneven polar patterns. Figure 2 shows approximate radiation patterns for a piston vibrating at three different frequencies in a small cabinet. The pattern gets more directional as the ratio of the wavelength to the diaphragm diameter decreases. At the highest frequency, the effects often called "beaming" and "lobing" can be seen.

Beaming, lobing, flexing, and mass are the undoing of the cone. Combined, they make it impossible to design a single-cone unit to cover the entire audible spectrum. Hence the need for multiple drivers and crossover networks, with their attendant response problems.

It's certainly true that cones can make good speakers, especially when given some help at the high end—by an electrodynamic dome radiator, for example. Cones really excel at low frequencies, where their mass and shape are not serious drawbacks. Electrodynamic loudspeakers also have significant advantages in power handling and can therefore provide very high sound levels at a reasonable cost. Numerous advances in materials and design technology have aided in the creation of really extraordinary electrodynamic cone loudspeakers, so I don't want to sell them short. Still, the fact remains that constant battles with crossover networks, response irregularities, and distortion have led many designers to consider various "flat" speaker technologies as advantageous alternatives. Or maybe it's just the sex appeal.


Flat-fronted electrodynamic driver from Phase Technology.

Electrodynamic Variations

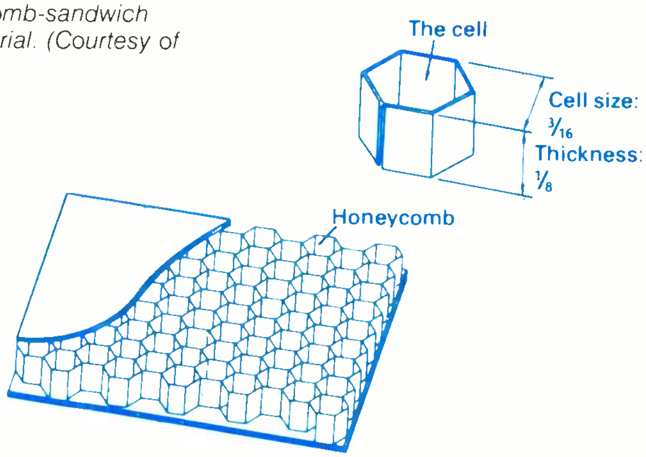
One thing loudspeaker engineers tried doing to improve the electrodynamic cone driver was to fill it with material to form a solid unit with a flat, front-radiating surface. KEF originally introduced its venerable B139 woofer in 1962, and it's still in use today. This oval-shaped unit is constructed out of polystyrene and thin metal foil. In addition to providing a flat radiating surface, the solid-cone approach allows very little diaphragm flexure and is effective at preventing internal cabinet reflections from exiting through the driver and coloring the sound. When compared to a conventional unit of similar dimensions, the B139 exhibits somewhat higher moving mass. This means that the driver is best suited to systems which have three (or more)

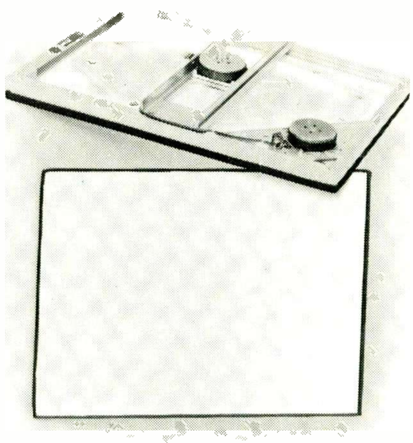
FLATTENING THE CONE CALLS FOR HIGH-TECH MATERIALS, SUCH AS HONEYCOMBS, TO MATCH THE STIFFNESS OF THE TRADITIONAL CONE SHAPE.

drivers and to subwoofers, since in both cases a lower cutoff frequency is acceptable. An American company, Phase Technology, has more recently introduced new approaches to manufacturing and materials technology. The result is a line of loudspeakers based on solid-cone drivers with diameters of 5¼, 6, 8, and 10 inches.

Another interesting variation on the electrodynamic driver uses a cone that is simply flattened back into a plane, with the required stiffness achieved through some other means, such as high-tech diaphragm materials, instead of the cone shape. The ultimate goal is to provide a nice, rigid radiating surface for low-distortion operation while also eliminating the cavity for smooth frequency response and a predictable radiation pattern. This "planar electrodynamic" approach is currently popular with several Japanese designers. Notable are the Mitsubishi, Technics, and Pioneer honeycomb drivers, among others. Usually the materials employed are laminates, with complex geometric structures composed of several layers. Mitsubishi's material is illustrated in Fig. 3. Sony has even gone so far as to combine the use of laminates with multiple voice-coils distributed around the diaphragm in an attempt to reduce flexing.

Fig. 3—Honeycomb-sandwich diaphragm material. (Courtesy of Mitsubishi.)





The B.E.S. speaker. The voice-coil-and-magnet assembly on the bridge drives the large, flat polymer woofer diaphragm; the voice-coil and magnet in the near corner drive a smaller diaphragm section for reproducing mid-frequencies.

Losing weight, however is not so easy, as everyone knows. By the time a practical planar electrodynamic driver is produced, what with the layers and the glues and this and that, it can be discouraging to put it on the scale. True, the cavity is gone; looks nice, can't hurt. Mass? Still a lot left. Flexing? Still hard to conquer, and the fundamental mode of operation remains pistonic. The best of the planar electrodynamics do show improved frequency response and lower distortion, but too often, the technology is used principally for marketing or cosmetic reasons.

An interesting relative of the flat diaphragm is sometimes called the electrodynamic panel speaker. These appeared as the first "picture frame" loudspeakers, predating Japanese honeycomb models by 10 years or so. Many seasoned audio hobbyists may remember the Poly-Planar series of products, made from Styrofoam by ERA Acoustics. According to Donald Grieg, who was heavily involved in the development of the Poly-Planars, the idea originated from a violin-playing engineer's desire to duplicate that instrument's mode of sound radiation. While successful in a wide range of applications, such as outdoor use, the Poly-Planar approach never really conquered audiophile territory.

The electrodynamic panel speaker puts less emphasis on eliminating diaphragm flexing, instead attempting to control and utilize it. In this approach, advanced in the line of panel speakers from B.E.S., vibrational modes are tailored to create a kind of diaphragm pulsation wherein the two sides of the radiator move in opposite directions, resulting in monopolar wavefronts. This helps to allow a relatively omnidirectional radiation pattern to be obtained without the use of an acoustical enclosure or baffle.

About Dipoles

Before we get any flatter, there is something important to discuss: Dipoles. The drivers discussed so far are most often used as monopoles. With pistons, this means that sound waves are radiated into the listening room from only one surface of the moving diaphragm. The waves that leave the opposite side of the diaphragm are either absorbed inside the speaker or are substantially altered in their amplitude and phase to supplement the front radiation, as in the bass reflex enclosure. With the B.E.S. speaker, front and rear surfaces pulse outward in unison. In either case, at any given instant the monopole loudspeaker is either "pushing" or "pulling"; it is either pressurizing or rarefying the air that surrounds it.

The speaker technologies we will examine next are best suited to dipolar (also correctly called "bipolar" or "doublet") operation, especially when

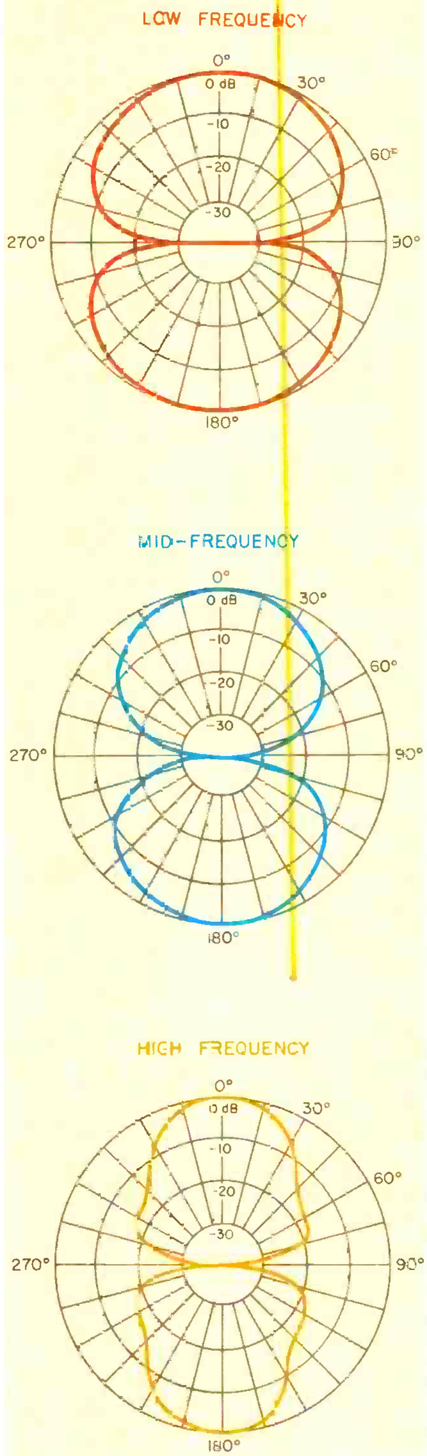


Fig. 4—Polar radiation patterns, at three frequencies, for a dipole speaker. (After Beranek.)

used full-range. In a dipole, sound waves are allowed to leave both sides of the moving diaphragm simultaneously. At every instant, the loudspeaker is pressurizing the air on one side of the diaphragm while rarefying it on the other side. The speaker radiates front and rear waves exactly out of phase. Directly to the sides of the diaphragm, these waves cancel and no energy remains. This results in the type of radiation patterns depicted in Fig. 4.

Dipole behavior is very much affected by operating environment. At the very lowest frequencies, the dipole can arguably be said to reduce the effect of room resonances. Unfortunately, small changes in room characteristics and speaker placement have a large effect on both frequency response and polar pattern. In an anechoic, free-field environment, the rear wave of the speaker disappears into the sunset; it does not in any way bother the on-axis response. In a real room, however, the rear wave will eventually catch up to the front wave, and cancellation will result. This is usually manifested as a weak bass response, especially on sustained notes such as cello or pipe organ. Sounds of a more transient nature—that of a kettledrum, for example—are reproduced more fully, due to the finite delay that occurs before the rear wave returns. This results in many panel speakers having a schizophrenic bass response, at times seeming deep and full, at other times rather thin.

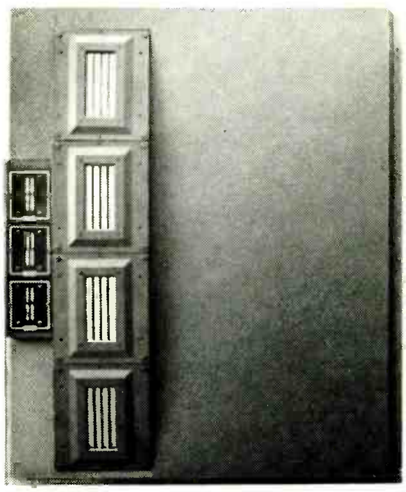
At midrange and treble frequencies, the reflected rear wave can be more of an advantage. Cancellation is still present, but at shorter wavelengths the rear and front waves tend to add in randomized phase, resulting in less average spectral error. The delayed rear wave can contribute a very appealing sense of depth and spaciousness to the sound, like a built-in ambience processor. This effect is, naturally, adjustable only through speaker placement, but it usually does work well.

By comparing the various polar patterns typical of the dipole (Fig. 4) with those of the monopole piston (Fig. 2), another important dipole characteristic can be seen: While the directivity of a dipole also increases with frequency, its polar pattern always remains symmetrical, front to rear. Unlike the monopole, the dipole never radiates energy directly to its sides, at any frequency. This helps to reduce unwanted early room reflections, to the advantage of both imaging and tonal accuracy. Although monopoles are naturally directional at high frequencies, they can never be so at low frequencies.

All in all, it is not possible to categorically state that either the monopole or the dipole makes a universally superior reproducer. Opinions vary, but theoretically the monopole can be said to allow a more accurate re-creation of an electrical input signal, owing to the absence of the antiphase rear wave. At its best it provides a more predictable low-frequency response and is less subject to room and placement variations. Nevertheless, dipoles sometimes sound subjectively superior. Divorced from the particular technology used, be it planar or box, electrostatic or electromagnetic, the dipole's real advantages are its ability to provide a very convincing illusion of depth and space and its reduction of side-wall reflections.

Planar Magnetics

The drivers we have looked at thus far are not the only ways to put electromagnetic energy to work making



A portion of Infinity's Reference Standard 4.5 system, showing the planar magnetic EMIT tweeters and EMIM midrange drivers. The EMITs are monopoles, the EMIMs dipoles.

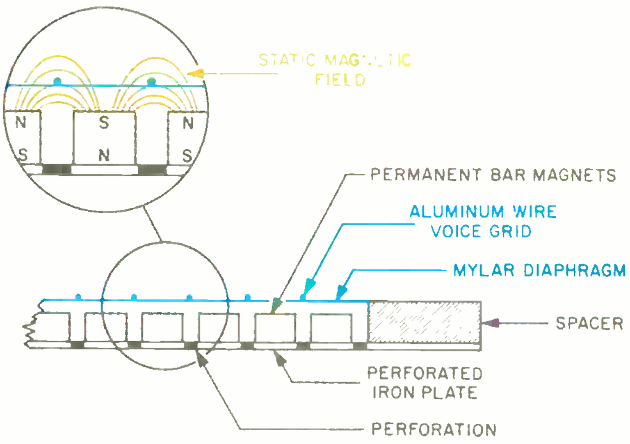
IN THE MIDRANGE AND TREBLE, THE DIPOLE'S DELAYED REAR WAVE TENDS TO ADD A VERY APPEALING SENSE OF DEPTH AND SPACIOUSNESS.

sound. Rather than concentrating a long electrical conductor in a small voice-coil, the planar magnetic speaker distributes its long conductor over a large, lightweight diaphragm. (Strictly speaking, the planar magnetic is still an electrodynamic speaker, but it is dissimilar enough from the typical one to warrant a name of its own.) The reason a very lightweight diaphragm can be used is that, by spreading out the conductor path, the generated force is distributed uniformly over the entire radiating surface. There is very little tendency for the diaphragm to flex, even if it is very large. This kind of force distribution is a key element in all wide-range planar loudspeakers.

An important consequence of distributed-force operation is that it gives the designer a great deal of flexibility in choosing the shape of the diaphragm. Some kind of retaining force is required to keep the diaphragm properly located when at rest, but there is no need for the kind of critical mechanism used to keep a voice-coil correctly positioned. This freedom to choose a shape helps the designer tailor the radiation pattern to some extent, including independent adjustment of horizontal and vertical directivity. For example, a tall, narrow radiator produces wavefronts that can reduce floor and ceiling reflections while maintaining good horizontal dispersion. It still remains extremely difficult to control directivity well enough to allow a planar magnetic loudspeaker to use one single, full-range driver, so multiple drivers are generally used.

Of course, new distortion mechanisms enter the picture in place of diaphragm flexing. One tricky problem encountered when designing a planar magnetic is how to make the magnetic field. This field must be strong and uniform over the surface of the speaker, it must be even enough so that no changes in force occur as the diaphragm moves in and out, and the actual magnet structure must not unduly disturb the radiation of the front and rear waves. This usually requires many small magnets on some kind of perforated structure, as shown in Fig. 5. The electrical conductor is often implemented by binding wires to a thin plastic sheet; this method works well for lower range units. To reduce moving mass for higher frequency operation, a conductor pattern can be etched directly on a piece of metalized plastic. In this case, care must be taken to provide adequate current-handling capacity in the conductor.

Fig. 5—Cross-section of a Magnepan planar magnetic loudspeaker.



How well the magnetic system works largely determines the dynamic range of the loudspeaker. Peak output is rarely limited by gradual heat buildup, as with a voice-coil driver, but rather by the diaphragm either leaving the linear magnetic field or actually hitting the magnet structure. Since this type of overload is essentially instantaneous and does not depend on the length of the input pulse, planar magnetics are not well suited to the very high transient sound levels which can be produced by regular dynamic speakers. On the other hand, overload is not usually destructive to the speaker, and acceptably high average levels can readily be generated.

An extra benefit of the planar magnetic approach is that the input impedance of the driver looks more like a pure resistance than does that of a conventional dynamic driver. This results mostly from the absence of a highly inductive voice-coil and from the smaller quantity of stored kinetic energy that the large-area, low-mass surface provides. A resistive input impedance is easier for amplifiers and speaker cables to drive, and simplifies crossover design.

In total, planar magnetics provide low-mass operation for good frequency and transient performance without incurring excessive diaphragm distortion. They allow a good degree of pattern control, eliminate the response effects associated with cone cavities, and can provide dipole radiation across the audio spectrum. Over the past decade or so, planar magnetics have been refined by a few dedicated companies and individuals. The technology has been applied with excellent results both in wide-range dipoles (such as Magnepan's Magneplanar loudspeakers) and in upper frequency drivers (such as Infinity's EMIT and EMIM drivers, which are monopolar and dipolar, respectively).

Going for the Ribbon

The logical extension of the planar magnetic concept is the complete metamorphosis of the electrical conductor into the actual radiating surface. A normal round wire couldn't possibly move enough air to be useful, so the conductor is shaped into thin, ribbon-like strips. Ribbon technology was used in some of the first high-quality broadcast and recording microphones, but at the time was not efficient enough for successful loudspeaker use. As magnetic-material technology improved over the years, it became possible to build ribbon tweeters with low, but passable, efficiency. Only recently have engineers, helped out by stronger magnets and bigger amps, been able to create really good wide-range ribbon loudspeakers.

A traditional problem with ribbons has been that their impedance, while

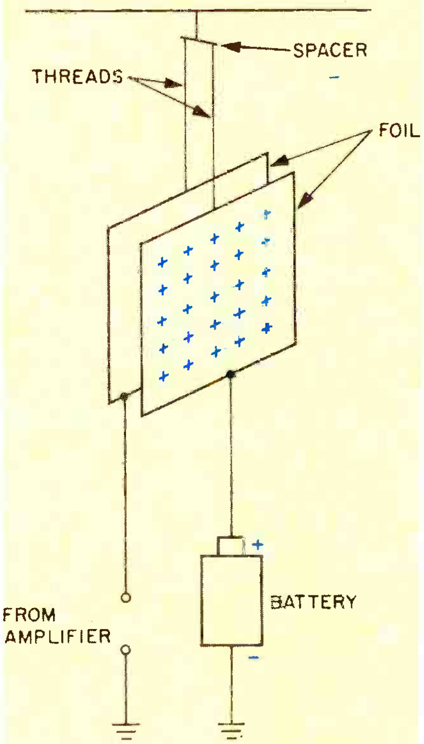


Fig. 6—Construction of an ultra-simple electrostatic driver. (See text.)

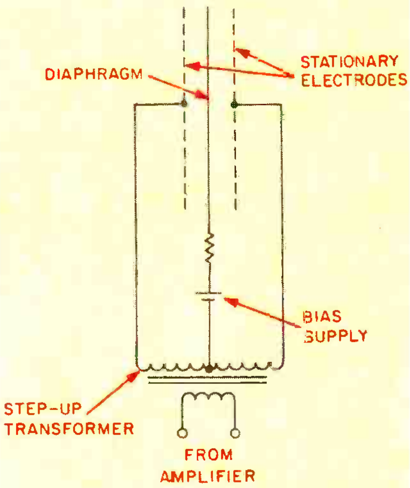


Fig. 7—Circuit of a modern electrostatic speaker. (After Arthur Janszen.)

highly resistive, is quite low. The luxury of using as much conductor as is required to achieve a satisfactory input impedance is not available to the ribbon designer. Some low-cost ribbons use impedance-matching transformers, but high-current transformers are difficult to make and can add response errors and distortion. Therefore, they are avoided in more critical designs. The very low impedance of ribbons used to mean instant amplifier trouble. It still can, but the best of the new amps with high current capability handle ribbon speakers quite well.

Impedance and efficiency aside, ribbons share most of the technical advantages and limitations of planar magnetics, including the benefits of distributed-force drive. Again, the magnet design is critical to success, and radiator shape is flexible. Ribbons have a still lower moving mass and are well suited to tweeters—this despite units of seriously questionable value adorning some moderately priced loudspeakers. For those willing to pay the price, top-quality ribbons are often the tweeter of choice. A few multi-driver, full-range ribbon dipoles remain secluded at the high end of audio. They tend to be hard to drive, hard to place, and hard to afford, but the best models are worth the trouble.

Repulsion and Attraction

At last, we come to the beginning. Electrostatic loudspeakers have been around for well over six decades, and it would be easy to fill several books detailing the theories, design variations, and patents related to them. The diverse electrodynamic transducers described above share a common principle of operation: They rely on the interaction of an electric current with a magnetic field to produce force. In contrast, electrostatic transducers, by definition, utilize the repulsion and attraction of like and unlike electrical charges as their fundamental basis of operation.

To best understand the workings of an electrostatic loudspeaker, we can build one from scratch—on paper, at least. The simplest electrostatic driver one could possibly construct is shown in Fig. 6. The electrodes might be made from very thin metal foil; they would, indeed, vibrate in response to an applied a.c. voltage. Varying positive and negative charges on the electrode connected to the power amp would repel or attract the positive charges on the electrode connected to the battery's positive terminal. In fact, the motional force would be well distributed over the radiating surface, so we could expect little flexing and good transient response. Unfortunately, both practical and theoretical limitations intrude. In examining these difficulties, many of the key approaches taken by successful modern designs become understandable.

The two main problems we would find immediately upon listening, or at least trying to listen, to the driver of Fig. 6 would concern sensitivity and distortion. Several thousand volts of signal would be required from our amplifier in order to hear any sound at all. Very little current flows in the system, so the actual power consumption (voltage times current) would be low. But even without current, the kind of voltage required is orders of magnitude beyond the output capabilities of even the most powerful audio amps. The distortion problem comes from the uneven way that force is generated in the system. A rapid increase in force occurs as the electrodes get closer together; likewise, the force quickly decreases as the separation becomes greater. This is an unavoidable result of the properties of charged particles, and it leads to a very nonlinear relationship between input voltage and the motion of the electrodes.

Assuming we didn't care about distortion and went ahead and built a special high-voltage power amp for our rudimentary system, we would soon discover a third problem, destructive electrical sparks. As high input levels caused the electrodes to get too close to one another, or perhaps even touch, high-voltage discharges would occur. These sparks might damage the electrodes or the power amp and would certainly be annoying to hear. So we must next find some insulating material that can stand very high voltages when used in thin layers. Since no current is supposed to flow across our electrodes, an insulator between them should not present any theoretical problem.

Rather than build a new type of pow-

TO OPTIMIZE POLAR PATTERNS, MAKERS OF ELECTROSTATICS HAVE TRIED USING MULTIPLE DIAPHRAGMS, SIGNAL DELAYS, AND CURVED ELECTRODES.

er amp, a more convenient solution to the problem of drive voltage is to use a step-up transformer to feed the electrodes. The design of such a transformer is very difficult, but because the electrode current is very low, it is not impossible. So we can move on to tackle the distortion problem. The force error we encounter is the result of the physical laws governing the behavior of our system. Therefore, we must explore an alternative system to solve our problem. Cleverly borrowing from other people's work, we realize that if we could use some sort of push-pull arrangement, constant force could be achieved and distortion would be eliminated.

Figure 7 shows a method of combining the use of a transformer with a push-pull approach. The stepped-up audio is applied to acoustically transparent electrodes which attract and repel a central membrane biased to a high voltage with a separate power supply. The use of a high-value resistor to isolate the center electrode results in a form of operation known as "constant charge," referring to the fact that the number of electrons on the electrode remains essentially fixed as it moves. Constant-charge operation became popular in the '50s, pioneered in England by Peter Walker, the inventor of the landmark Quad ESL, and in the U.S. by Arthur Janszen. Constant-charge operation provides very low distortion and is now universally accepted by designers.

Another of Janszen's important contributions to the development of the modern electrostatic loudspeaker was the introduction of what he called "sheathed conductor" technology. This was invented to address the issue of sparking, mentioned earlier. In Janszen's approach, now used by Acoustat, a grid of insulated wires comprises the fixed electrodes. This sounds like a trivial advance, but it is, in fact, very difficult to find insulation techniques that can withstand the voltages required and yet allow the complex system of fields and charges to operate correctly. There are many other ways to construct the fixed electrodes and prevent electrical arcing. Various conductor and insulator combinations have been or are now in use, including inert insulating gases filling the region between the various electrodes. In Walker's recent Quad ESL-63, an internal antenna rapidly detects electrical discharges, shutting off the drive voltage in response. This technique, combined with an input-limiting circuit, eliminates the need for insulated electrodes altogether.

Even with all the advances realized over the last few years, today's electrostatics are not the first choice for providing high-volume sound. It's true that they have finally shed their predecessors' propensity for catastrophic failure every time a stylus was dropped or a bass drum was hit too hard; in fact, modern units can be very reliable and are capable of high output. However, partly due to the transformers used, they are not efficient nor are they easy loads to drive. For a while, it seemed that manufacturers were making an effort to integrate high-voltage, transformerless amplifiers into electrostatic designs, but this trend seems to have waned, probably for a combination of technical and marketing reasons.

More than any of the designs discussed so far, electrostatic drivers are adaptable to full-range use (within the inherent low-frequency limitations of dipoles). By three-dimensional shaping of the diaphragm; by tall, narrow geometry, or by using a phased array of radiators, polar patterns can be optimized over a very wide range of frequencies. This is an important advantage over those planar approaches which are not so easily suited to these alterations. In the Quad ESL-63, an array of vertically oriented independent radiators are fed from a series of delay lines to maintain a very constant horizontal dipole figure-eight pattern over the audible spectrum. In this way, an essentially flat radiator can be made to combine many of the benefits of a point source with those of a dipole. In the ESL-63, multiple full-range drivers are used, so none of the usual crossover troubles appear.

Martin-Logan has refined a different approach to controlling directivity. By using a large, curved electrode-and-diaphragm assembly, their loudspeakers can produce a semi-cylindrical wavefront similar to that of a vertical line source. Although the shape is not inexpensive to manufacture, floor, ceiling, and wall reflections are reduced without sacrificing coverage. The curved shape is used in a single-driver, full-range speaker as well as one using an electrodynamic subwoofer. Acoustat too produces full-range speakers that have a vertical line-source characteristic, using instead a tall and narrow flat electrode.

Electrostatic loudspeakers have long held captive a core of fanatical devotees. Even at a time when listening to electrostatics invariably meant clamping your head in the right position to hear the highs, settling for background-music sound levels and thin bass, and making frequent trips to the repair shop, there were those who would have nothing else. Electrostatics do have a sound of their own, even if only due to their dipolar operation and lack of crossover effects. And something about transparent, high-voltage speakers seems to hint at communication beyond the sensory norm.

Contrary to common belief, though, electrostatics—especially full-range ones—do not have extraordinarily extended top ends nor fast rise-times. There are many high-quality dynamic tweeters that can easily outperform them in these areas. Transient response can be excellent from the point of view of damping and phase, but the truth is that the air-load mass on a large diaphragm requires a very large force to accelerate quickly. Since there is virtually no scientific evidence to support the audible need for response much above 20 kHz, this should not be considered a problem, just an interesting fact.

All things considered, there are many things that make sense about flat loudspeakers. As a group, they have really come into their own over the last decade or so, and I have every reason to believe they will continue to improve. We might expect to eventually see a resurgence of interest in direct-drive, high-voltage amplification for electrostatics, and new magnetic materials applicable to ribbons and planar magnetics are appearing regularly.

At some point in the future, the use of cones as we know them will probably be confined to the bottom three or four octaves of the audible spectrum, where I think they do what they do best. And, of course, we'll still use them for ice cream.

THE LEDE CONCEPT

DON DAVIS

The Live-End Dead-End (LEDE) concept evolved from an insight I had during the mid-1970s while measuring the acoustic response of monitor loudspeakers in recording studio control rooms. I was using analyzers that had been converted to do the Heyser Transform, which is the frequency-domain portion of Time-Energy-Frequency or TEF measurements. Most obvious to me was the inability of a monitor, in a typical control room of that period, to reproduce accurately the composite record of the signal delays recorded in the studio. I saw that the LEDE room could be a neutral playback environment that would allow the recording environment to be heard with correct temporal imaging of the recorded material.

The LEDE effect is a psychoacoustic effect. The original design goal for recording control rooms was to give the mixing engineer's ears the acoustic clues of a larger space, thus allowing the perception of hearing the studio rather than the control room. Those readers familiar with the illusive nature of the five physical senses should not be surprised to find that hearing is easily

Don Davis, who has more than 30 years of experience in the audio field, is a Fellow of the Audio Engineering Society, a member of the Acoustical Society of America, and a senior member of the Institute of Electrical and Electronic Engineers. He is co-owner, with his wife Carolyn, of Synergetic Audio Concepts or Syn-Aud-Con, as it is more often known. This audio consulting firm has had more than 6,000 persons attend its seminars on sound system design, installation, operation, and maintenance techniques.

Davis has written hundreds of articles, as well as the best-selling How to Build Speaker Enclosures *with the late Alexis Badmaieff and the newly revised* Sound System Engineering *with his wife. He is also a contributor to* Handbook for Sound Engineers: The New Audio Cyclopedia, *which is a recent addition to the Howard W. Sams & Co. Audio Library series.*

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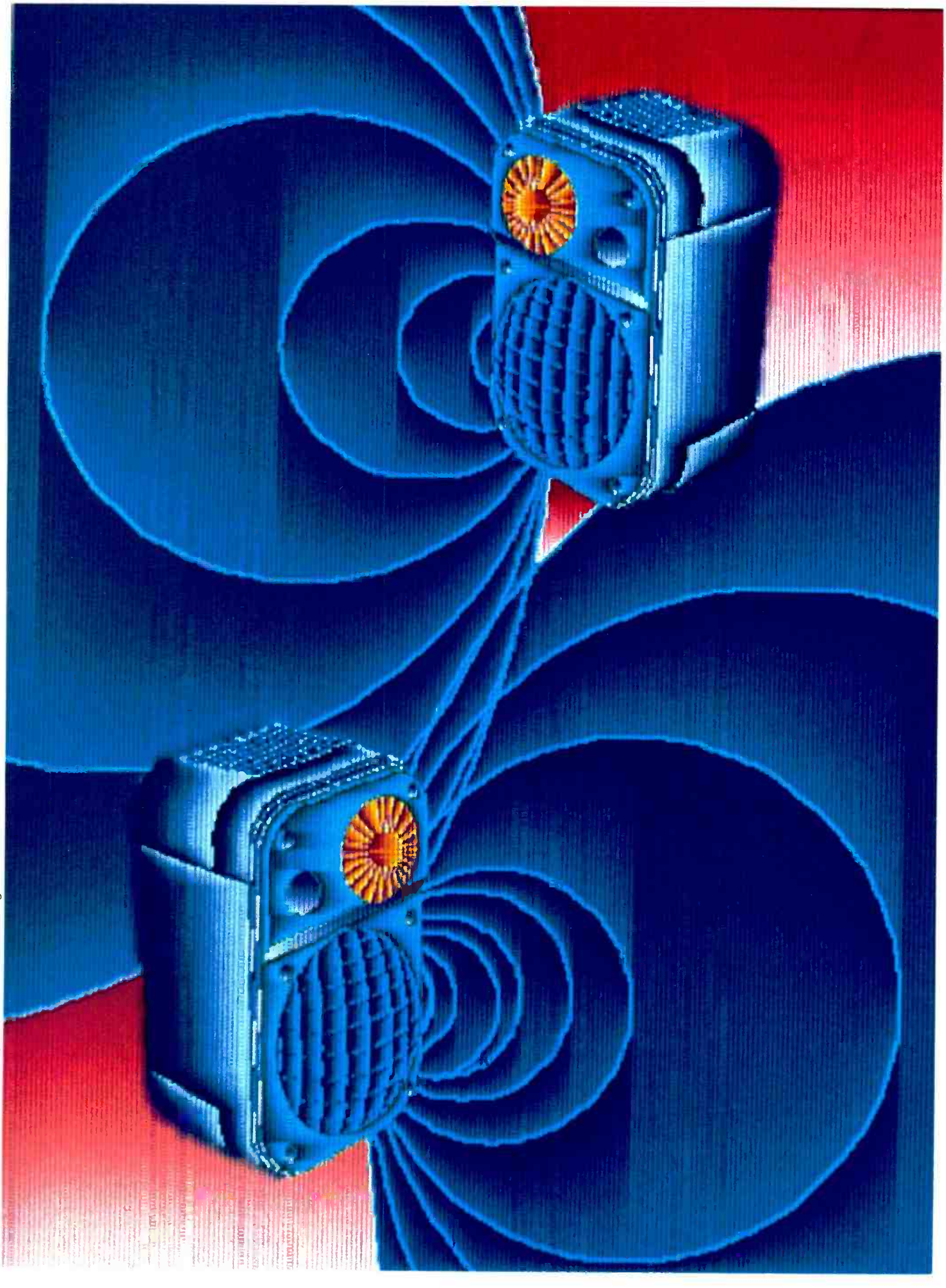

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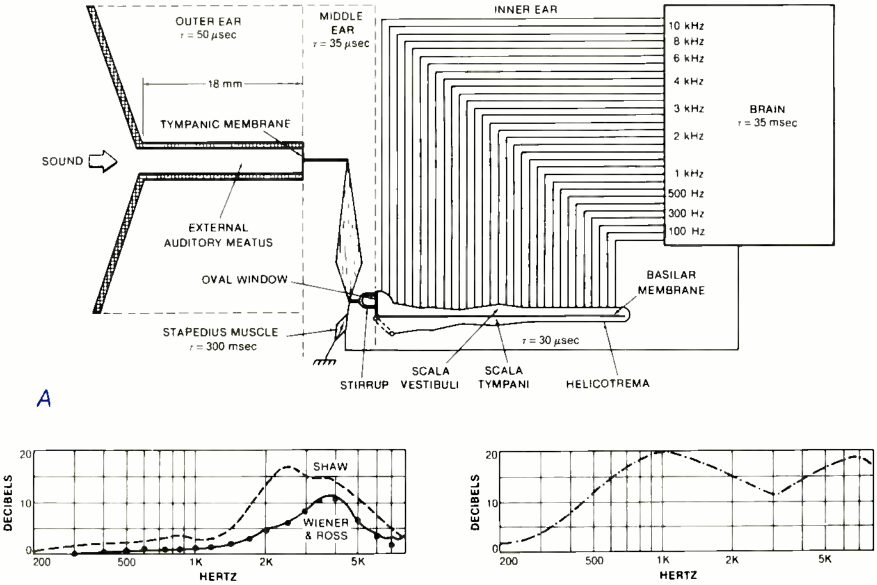


Fig. 1—Schematic of the human ear with the teletransmission system's most important time constants (A), and the transmission characteristics of the outer (B) and middle ear (C). (Courtesy of Brüel & Kjaer.)

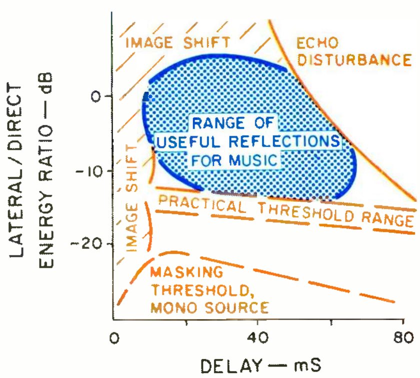


Fig. 2—Illustration (redrawn from Barron) showing the effect of reflections on the perception of music. The practical threshold for a stereo source was added by Marshall and Hyde. (Courtesy of Peter D'Antonio.)

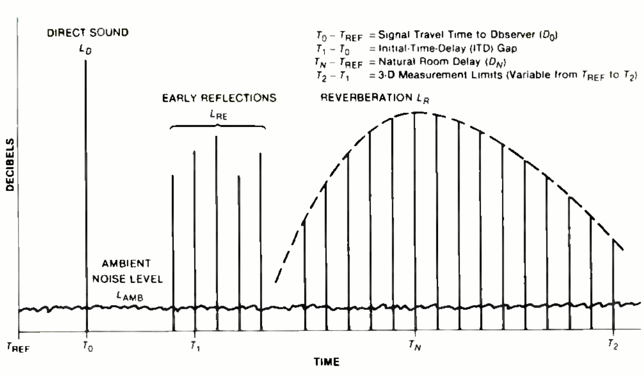


Fig. 3—A depiction of acoustic energy vs. elapsed time. In small, well-damped rooms, such as home living rooms, only the direct sound level, L_D, and early reflections, L_{RE}, are present. Reverberation, L_R, while theoretically present, is below the ambient noise level, L_{AMB}. In large rooms, such as concert halls, L_R actually develops. It is the reverberation in the recording that we would like to hear reproduced over the speaker before it is masked by the listening room's early reflections.

fooled. Human hearing is little understood even by those studying its complexities, despite the many devoted and talented workers in this field. As simple a subject as the integration time of the human hearing mechanism is under question as the newest measurement techniques reveal serious anomalies in the older data. Because LEDE theory and practice deal primarily, though not totally, with the time domain, understanding the various time relationships shown in Figs. 1 and 2 is important. The top portion of Fig. 1 is a schematic drawing of the temporal behavior of the ear/brain, with graphs of the amplitude response of the outer and middle ear below.

Sound Fields

To better understand the importance of the theoretical and practical work now being done, we should first discuss a few fundamentals of sound fields in small rooms—small in the acoustical sense.

Figure 2 illustrates some key time-domain characteristics of human hearing. The useful range of reflections is such that signal delay and signal level combine to create the Haas effect, but it does not evoke false imaging. This illustration encourages the belief that a "Haas-kicker" (i.e., a strong reflection which triggers the Haas effect following an initial signal delay gap) should be within 20 to 30 mS at a level optimally 5 to 10 dB below the direct sound. This would place it within the range of useful reflections and well past the danger of "image shift." The directivity of such returns is also a critical factor.

Initial Signal Delay Gap: A fundamental error often committed by those unfamiliar with small-room acoustics is to believe that classical statistical methods can be used. Let's first view the sound field as a record of signal delays using a chart with vertical coordinates of level, in dB, and horizontal coordinates of delay, in seconds, from some arbitrary zero point.

As shown in Fig. 3, the first signal to arrive is the direct sound, L_D. This is followed by the initial signal delay gap, ISD, well known in concert-hall acoustics as the initial time delay gap, ITD. (Since time can't be delayed, I prefer the term "signal," which can be delayed.) The conclusion of the ISD is

THE LEDE CONCEPT

signalled by the arrival of the first significant reflection (i.e., the first reflection that is higher in level than 30 dB) below the L_D, which is usually the highest level in its group of early reflections. Following the early reflections will be the reverberant sound field, if present. In small rooms, this reverberant sound field normally never appears above the ambient noise level, L_{AMB}, in the room, and consequently we are concerned only with the direct sound level, L_D, and the early reflected level, L_{RE}, and not at all with the reverberant sound level, L_R.

The kind of reflected energy capable of triggering the Haas effect can come from a single discrete reflection or from a cluster of returns, such as those from a quadratic residue diffusor like the ones discussed in Manfred R. Schroeder's 1984 *JAES* paper. A first significant reflection can be broadly defined as the first appreciable level of energy to arrive after the direct sound from the source. The first significant return also has constraints of coming from the proper direction (or containing the comb filtering that mimics the proper direction) and having the correct frequency content (i.e., containing the higher frequencies that provide the correct pinnae clues).

The primary goal of an LEDE listening space is to extend the ISD that occurs acoustically in the listening room to a value greater than that present in the performer's area, such as a recording studio (see Fig. 4).

Leo Beranek has written in *Music, Acoustics and Architecture*, "Persons trained in listening—for example, blind people, who receive all their clues about the environment around them through the senses other than the eye—can 'measure' the size of a room or judge the distance to a wall behind them by the length of the time interval between the direct sound and the first reflected sound." Beranek goes on to note that this capability is not restricted to the unsighted, but that "experienced music listeners . . . sense the approximate size of a hall . . . by the length of the 'initial time delay gap.' "

The LEDE technique, by virtue of the distance the direct sound must travel to encounter a first reflection, adjusts the initial time delay gap to the same figure that Beranek judged as desirable in the best concert halls, namely 20 mS. It is no coincidence that the same 20 mS is the optimum delay for the maximum Haas effect in good, diffuse, semi-reverberant spaces.

William B. Snow, of Bell Labs fame, in 1957 wrote in *Application of Acoustical Engineering Principles to Home Music Rooms*, "The direct sound alone carries the information giving the sense of direction, by allowing the listener to observe initial transients clearly during the short time interval before the many-directioned reflections begin to arrive at his ears."

Haas Effect: The Haas effect is the inability of the brain to discriminate between echoes and delays of sounds that arrive approximately 10 to 20 mS after the original waves. The reflected sound is still present but psychologically does not exist so far as the listener is concerned. The auditory system temporarily fuses sounds in this 20-mS zone. This ability to fuse sounds is what allows us to blend the direct sound, early reflections, and reverberation into one sound perception.

Critical Frequency: We can also generate a graph, as in Fig. 5, with the sound pressure level, in dB, as the vertical scale and the frequency, in Hz, as the horizontal scale. The key to this graph is the critical frequency, f_c, which is the frequency at which the wavelength is roughly comparable to the largest dimension of the room. Because the equation for f_c is merely a handy approximation for the point where the room modes begin to overlap, it can be condensed to this relatively simple form, 3 c/D, where c is the velocity of sound in air and D is the smallest room dimension. The rever-

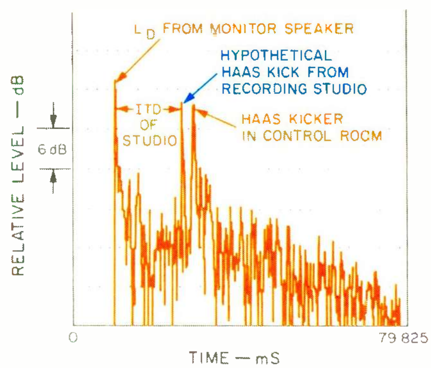


Fig. 4—An energy-time curve or ETC. The horizontal axis is 0 to 80 mS; the vertical axis is 6 dB/div. This ETC shows the actual distribution of acoustic energy vs. time in an LEDE control room. The increased density is created by the generation of deliberate specular reflections which repeatedly redrive through the quadratic residue diffusors, QRD.

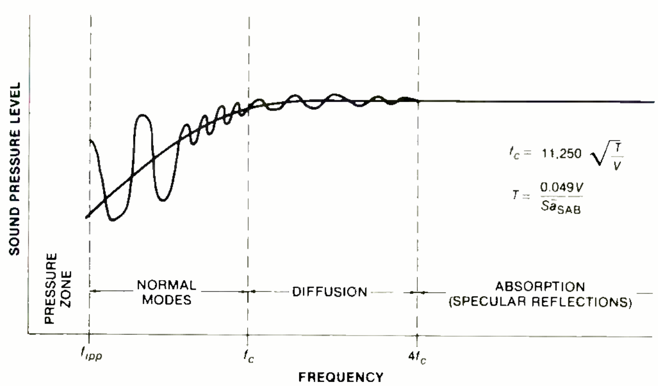


Fig. 5—Sound energy (sound pressure level) vs. frequency. The frequency dependency of the total sound field is the determining factor in the variations in room treatment vs. frequency. Soft absorptive material is useful only above $4f_c$, the specular reflection region. It would be difficult to overemphasize the importance of understanding these basic frequency zones in terms of handling a room's sound field. (Courtesy of BBN.)

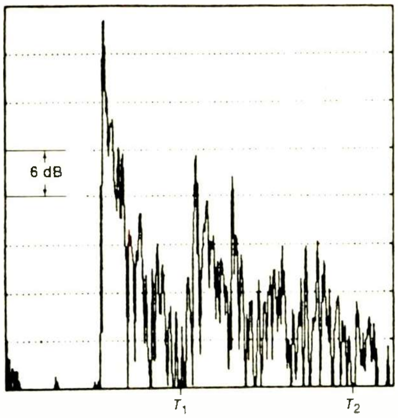


Fig. 6A—The ETC of a small, well-damped room. Note in particular the location of T_1 and T_2 on the horizontal scale. These indicate the start and stop points on the "3-D" view of Fig. 6B.

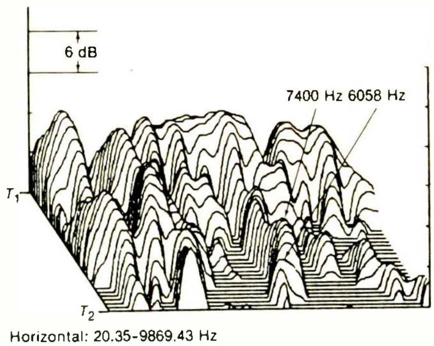


Fig. 6B—A "3-D" view of the energy depicted in the ETC of Fig. 6A. The horizontal axis is 20 to 10,000 Hz; the vertical axis is 6 dB/div. The oblique axis is time, with T_2 being later than T_1. Note here how rapidly the energy divides into room modes, definitely not a statistically random sound field.

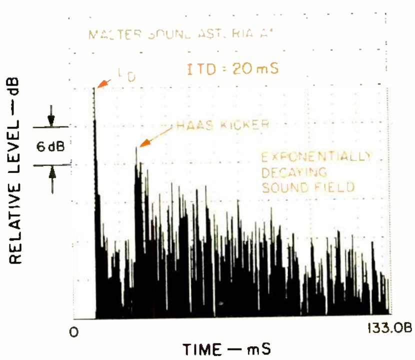


Fig. 7A—An ETC of the control room at Master Sound Astoria in Astoria, N.Y., designed by acoustician Charles Bilello.

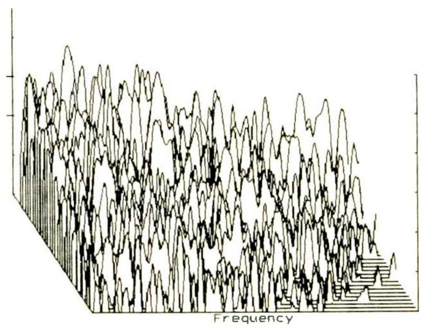


Fig. 7B—A perfect example of what a "3-D" sound field should look like, an exceptional LEDE control room. (Courtesy of Charles Bilello.)

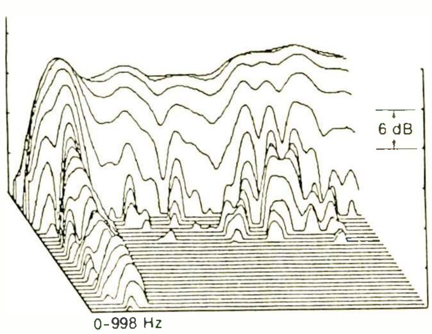


Fig. 8A—Here we have a small room with a pronounced low-frequency mode at 125 Hz, which causes a boomy sound.

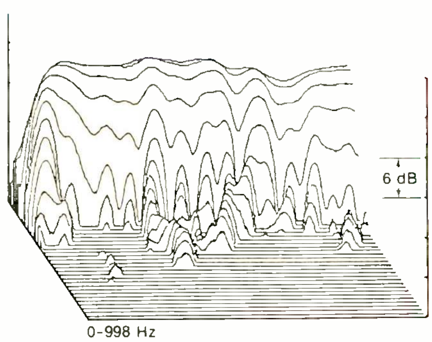


Fig. 8B—This is the same small room as in Fig. 8A, after the installation of a Helmholtz resonator. Note that the low frequencies cannot be absorbed by soft, fuzzy materials. (Courtesy of Doug Jones and WFMT, Chicago.)

beration time, RT_{60}, is simply the apparent rate of decay, in dB per second, converted to an equivalent RT_{60}. See Fig. 5 for a typical conversion.

Room Modes: In a room that has a decay of 300 dB per second, i.e., a room where a line drawn across the peak energy of the early reflections mimics a reverberant decay, the apparent reverberation time would be 0.2 S. Let's have a look at the actual density of the sound field in such a room; see Fig. 6. Note that T_1 and T_2 at the bottom of Fig. 6A indicate the time span of the oblique scale on Fig. 6B. It can be clearly seen that the modes do not overlap. Figure 7 shows what the sound field in a superb LEDE control room looks like.

Once again, looking at the frequency-versus-level graph, Fig. 5, we can see that below f_c there are standing waves, so that movement of the listener about the room can result in major changes in level as the listener's ears leave a peak and enter a null. The change in level can be in excess of 40 dB. Through the use of tuned resonators, these modes can be both broadened and damped. See Fig. 8 for an example of the effects of damping.

Pressure Zone: The pressure zone is that region of the room where the encounter of energy with a boundary is still adding to nearly 6 dB. If we accept a phase shift of 60° as still near enough to coherent addition (i.e., 5.5 dB), then the pressure zone you associate with the floor, for a frequency of 20 Hz, is:

$$\frac{60^\circ}{360^\circ} \times \frac{1{,}130 \text{ feet/S}}{20 \text{ Hz}} = 9.4 \text{ feet deep}$$

This formula takes the fraction of a complete wave that is still adding coherently (i.e., 60°/360°) and multiplies that fraction by the wavelength for the specific frequency, which is calculated by dividing the speed of sound, 1,130 feet/S, by the frequency, in this case 20 Hz.

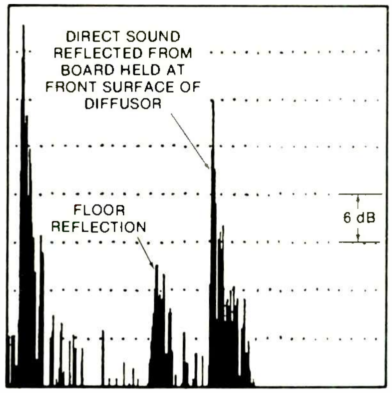
Diffusion Zone: In Fig. 5, the region from f_c to $4f_c$ is the diffusion zone. The diffusion problem has been elegantly solved through the mathematics of Manfred R. Schroeder; Peter D'Antonio of RPG Diffusor Systems has made the equations into practical products. The creativity of D'Antonio (known in the industry as Dr. Diffusor) is shown in Fig. 9. In AES Preprint No. 2365 from the 81st Convention, D'Antonio writes:

> The primary purpose of reflection phase grating (RPG) diffusion is to 1) provide uniformly high density of closely spaced reflections at the listener position, without any density gradients or discontinuities, 2) provide a dense pattern of uniformly distributed, irregularly spaced frequency notches, and insure that any inadvertent reflection combinations with slight time differences, which could result in broadband frequency anomalies, are minimized; 3) uniformly backscatter a broad frequency bandwidth over a wide angle, and 4) reduce the backscattered energy to minimize frequency coloration and image shifting, resulting from interference with the direct sound.

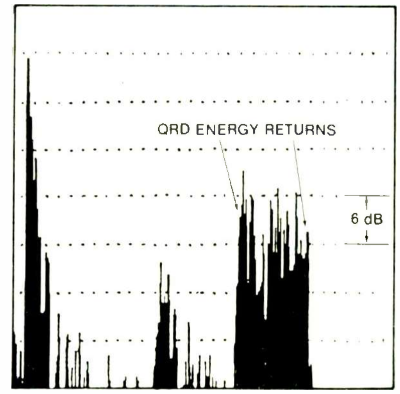
Frequency Dependency: Sometimes it seems that only polarity is not frequency dependent; indeed, polarity is defined in the IEEE Dictionary as "not frequency dependent." The question naturally arises, "What frequencies are pertinent to the LEDE concept?" The answer is, "The specular frequencies, those frequencies which can be modelled by light rays." The beauty of using reflections instead of absorption is that, once above the frequencies of diffusion, the result of reflecting the energy is non-frequency dependent. This frequency range is in the center of the ear's sensitivity, and the higher frequencies provide the pinnae with its directional clues.

Specular reflections occur in the region above $4f_c$, and it is in this region that LEDE must be applied. If the term LEDE is to be applied correctly, then the following rule must be satisfied: Control of frequencies between f_c and $4f_c$ by means of diffusors is such that no reflected energy departs dramatically from exponential decay or exhibits energy voids over time.

Reflection-Free Zone: The original *JAES* paper on LEDE in September 1980 stated that to qualify as an LEDE room there had to be "an effectively anechoic path between the monitor loudspeakers and the mixer's ears which extends for at least 2 to 5 mS beyond the studio's initial time delay gap." Note that no limitations were placed on how this was to be accomplished, inasmuch as it was realized at the time that the end result could be accomplished either by absorption or



A



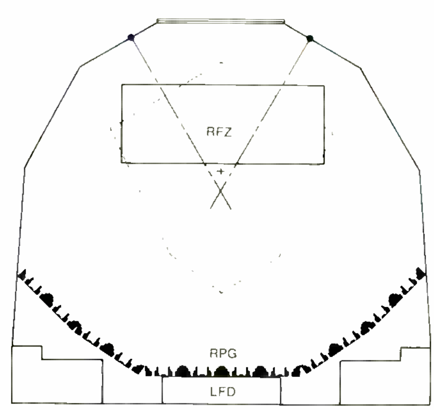
B

Figs. 9A and 9B—The temporal effect of a well-designed diffusor, before (A) and after (B) one is installed. Note that it lowers the level of the reflected energy by spreading reflections out over a wider angle, and that it spreads the energy in time because it is spread in distance travelled.

C

Fig. 9C—A control-room installation of diffusors like those of Fig. 9B, at Master Sound Astoria. (Courtesy of Charles Bilello.)

Fig. 10—Plan view of an RFZ/RPG control room with low-frequency diffusors. Limiting reflections from surface boundaries forms a symmetrical six-sided RFZ. (Courtesy of Peter D'Antonio.)



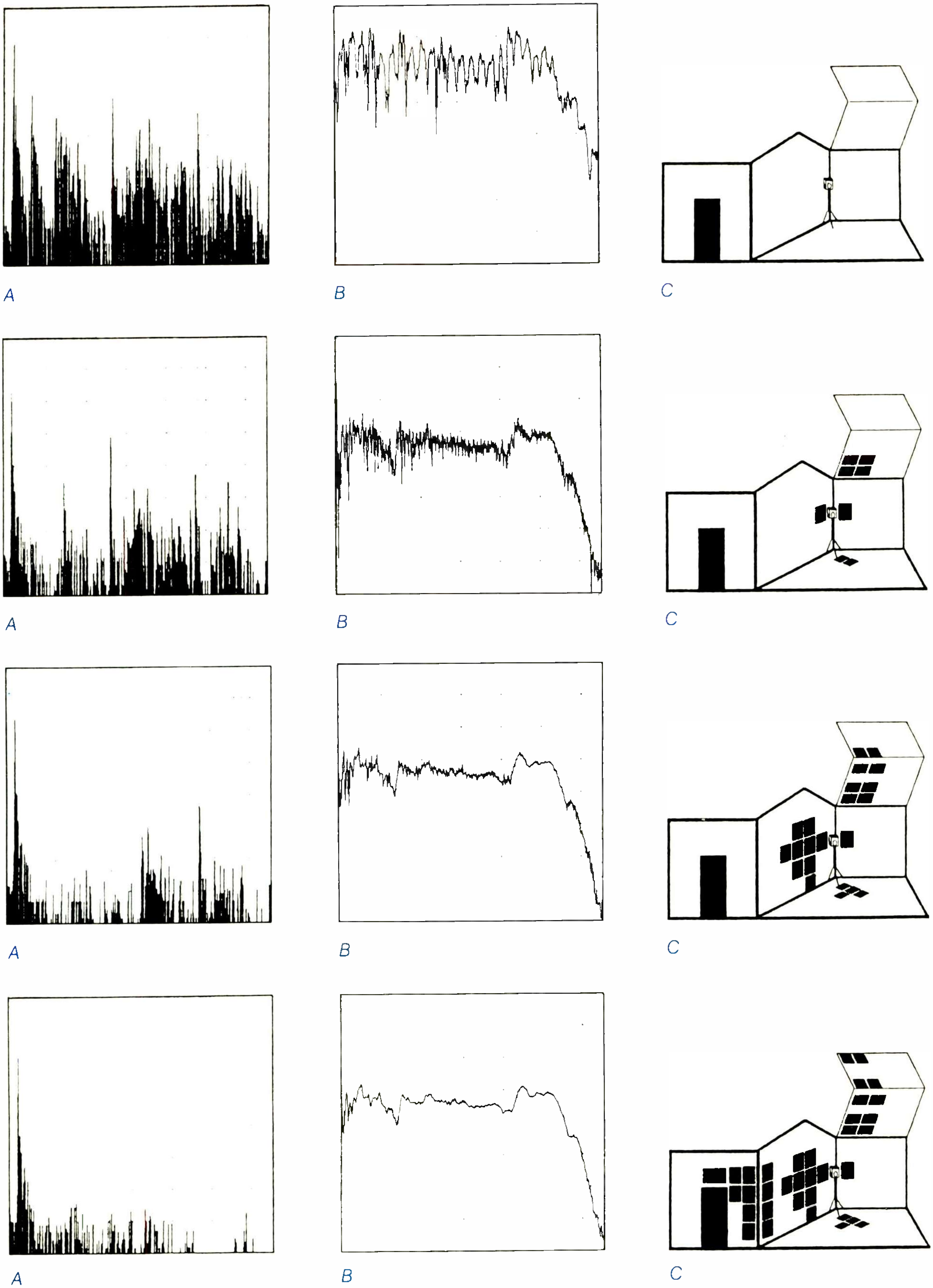


Fig. 11—The step-by-step identification of individual specular reflections and their interception by use of absorptive material. In each trio of drawings, (A) is the ETC, (B) is the frequency response with the filter window equal in time to the ETC display, and (C) is the specific room treatment made at each step. (Courtesy of Doug Jones.)

by the loudspeaker's directivity in combination with the room geometry, i.e., a highly directional loudspeaker in a wide room (see Fig. 10). An excellent example of the former approach is shown in Fig. 11, which illustrates how Doug Jones of Electro Acoustic Systems made an ordinary room meet this particular part of the LEDE criteria.

When this technique is employed, it allows the designer to use specular surfaces at the front of the room as sources of energy spaced later in time to again "drive" the rear wall diffusors, thus adding to the total energy density present over a longer time interval. In control-room design, taking advantage of source directivity has always been the way to avoid reflections from the control room window.

Monitor Loudspeakers

At frequencies below f_c, an LEDE room is a "live" room. If the room construction has been massive enough so that bass frequencies stay in the room, the wall in which the monitors are mounted lends substantial support. Loudspeakers should not be left standing outside of a wall surface in an LEDE room. They should be mounted on shock mounts inside the wall and should use the wall at low frequencies. Fortunately, at the specular frequencies above $4f_c$, there are loudspeakers available that approach reasonable control of their polar responses. In accurately engineering an LEDE listening space, the loudspeakers chosen must be measured carefully through the critical region from 500 to 2,000 Hz for their directional responses (see Figs. 12 through 14).

Bipolar and similar designs are not optimum choices for LEDE rooms. If one is used, the LEDR tape, discussed later, can reveal to the listener the audible compromise encountered.

Characteristics of a good loudspeaker include:

1) The fewer crossovers, the better (two-way systems are usually best);
2) Full signal alignment;
3) Identical amplitude and phase responses for *both* speakers;
4) Identically controlled polar responses for *both* speakers;
5) Ability to produce sound pressure levels of at least 130 dB SPL at 10 feet;

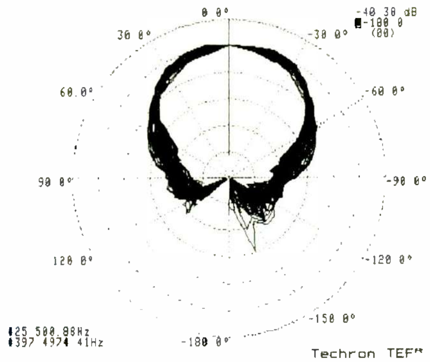


Fig. 12A—Overlaid polar responses, every 250 Hz from 500 to 5,000 Hz, for a high-quality loudspeaker for home or studio. With a device of this quality, it is easy to assign meaningful coverage angles and a meaningful directivity index or Q.

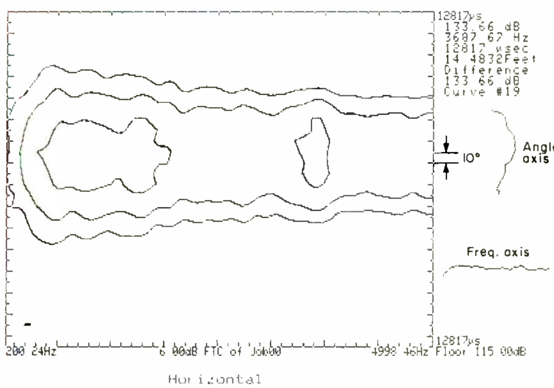


Fig. 12B—The same loudspeaker as in Fig. 12A but analyzed as a frequency-vs.-angle curve. The contours are in 6-dB increments; each vertical division is 10°. Note that the side plots show relative directivity and on-axis frequency response.

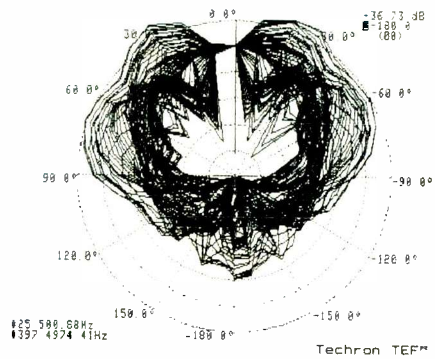


Fig. 13A—The identical measurement as in Fig. 12A but with a loudspeaker that has much poorer directivity.

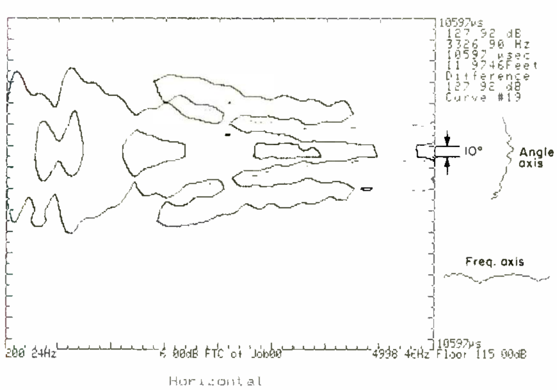


Fig. 13B—The same loudspeaker as in Fig. 13A, analyzed as a frequency-vs.-angle curve. Note that the three major lobes are present over a very wide frequency range.

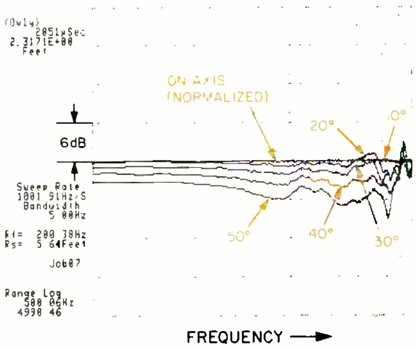


Fig. 14—A quick but efficient way to view on- and off-axis response, here from 0° or directly on-axis to 50° off-axis.

6) Sufficiently well-damped enclosures which, once shock mounted, radiate little spurious energy;

7) A reasonable impedance to match the narrow range of stable amplifiers capable of driving such loudspeakers to the sound pressure level specified above;

8) Harmonic distortion below 2% at all frequencies above 50 Hz;

9) Directivity factor of at least 5, with a Q of 10 the most useful, for the frequency band from 500 to 5,000 Hz, and

10) Time-domain behavior for each individual driver which is the conjugate of a network at the crossover frequency, and which adjusts the frequency-dependent behavior of the drivers back to uniformity.

Imaging

The work of Carolyn "Puddie" Rodgers has shown that the pinnae transform incoming signals, superimposing upon the original signal a comb filter-like spectrum. Recent evaluations of misaligned loudspeakers and early reflections (i.e., those from less than 3 feet away) reveal that they can generate pseudo-pinnae clues, resulting in dramatic image shifts. Directional clues to a large degree reside in comb filter information at high frequencies. Signal delays that generate comb filters cause specific and predictable directional effects.

Misalignment of loudspeakers causes comb filters. This effect can be devastating in an LEDE room designed for aligned loudspeakers, because the misalignment causes a change in polar response (see Fig. 15).

LEDR Tape

Researchers at Northwestern University have developed a special tape recording that, when played in an LEDE room over signal-aligned loudspeakers, causes the listener to perceive the sound as rising straight up out of the right loudspeaker almost to the ceiling, and then going in back of the listener, circling around the listener, moving forward, and finally dropping back down from the ceiling area into the left loudspeaker. Any aberration in either the loudspeakers or the room mars this remarkable imaging. (The LEDR tape can be purchased for $250 in two formats: Quarter-inch, 15-ips open-reel analog or Sony Beta F1 digital, from Doug Jones, Electro Acoustic Systems, 715 Monroe St., Evanston, Ill. 60202.)

LEDE in the Home

Where loudspeakers cannot be built into the wall, I suggest that great care be taken to avoid diffraction effects around the enclosure. "Wings" made of material such as Sonex mounted on plywood panels can be very effective. The greatest difficulty I encounter in consumer loudspeakers is their claim to be aligned when they're not. The high-resolution energy-time curves (ETCs) which the late Richard Heyser included in his loudspeaker reviews have been a totally reliable way to inspect loudspeaker alignment. Particular care needs to be exercised with regard to the vertical polar response of loudspeakers for use in the home, as the ceiling is quite often too low and highly reflective. Floors can be handled adequately with heavy carpeting and pads.

Paul Klipsch's advocacy of corner placement for the past 50 years is still correct. Corner placement has the following advantages: The entire audience-coverage angle is within 90°, polar control is excellent at specular frequencies, and the best low-frequency modal response in acoustically small rooms is obtained.

It is absolutely necessary to introduce diffusion behind the listener. Where the budget allows, quadratic

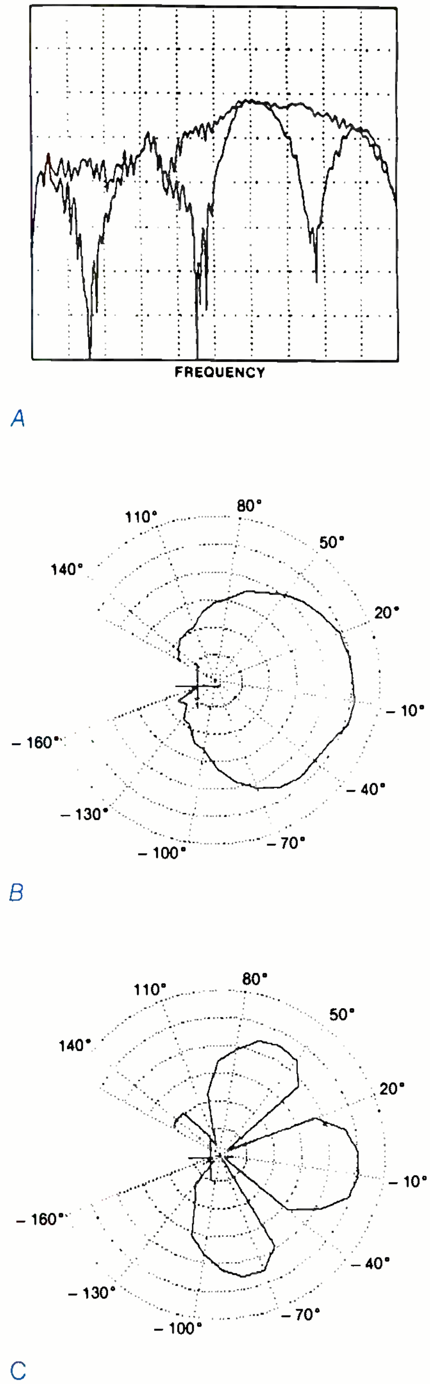


Fig. 15—What can happen when two loudspeakers covering the same frequency range are misaligned by 4 inches: (A) is the response both aligned and unaligned, (B) is the aligned polar response, and (C) is the unaligned polar response.

residue diffusors are best. Bookcases can also be useful. Just make certain that the rear surface is not a hard, flat wall. In addition, make certain that it is *not* absorptive.

Whatever absorptive material is chosen, it can and should be hidden behind acoustically transparent grille cloth-like material. I prefer using Sonex panels because the wedges of this material scatter sound at the higher frequencies, and they smooth the transition to acoustic transparency near the critical frequency, f_c, normally encountered in small rooms. Whatever material is chosen, the designer needs to know its behavior at specific angles of incidence, not its statistical behavior in a reverberation chamber.

Absolute Polarity

Figures 16 and 17 illustrate the phase measurement of a loudspeaker, in polarity and out of polarity. Energy-time curves and energy-frequency curves do not show any effect of being out of polarity, yet it is audible. Only phase measurements reveal absolute polarity.

Ed Long's MDM near-field monitors allow front-panel switching of polarity, as do a few preamplifiers. On a recent demonstration Compact Disc, I observed the need to switch absolute polarity on both channels for every selection. Incorrect absolute polarity manifests itself as sounding like two holes in the wall. When switched, the result is a solid curtain of sound with correct imaging between the two loudspeakers. These minor changes become quite audible when one is listening to good loudspeakers in an LEDE environment.

What does an LEDE room sound like? You shouldn't hear it at all. What you should hear is the characteristic acoustic signature of the room in which the recording you are listening to was made. Most good classical recordings include the sound of the original room on the disc, but the small listening room usually masks it. When the physically and acoustically small room is converted into a physically small, acoustically large room by LEDE means, then this signature is heard from the loudspeakers.

When the recordings are essentially multi-channel mono (often up to 32 channels), it makes little difference what kind of a room you listen in. Many folk, country-western, and some contemporary recordings are properly recorded, in terms of being useful to reproduce the ambience of the recording space over the playback system. Many recording engineers, upon first hearing one of their non-LEDE recordings played back in an LEDE environment, say "That's terrible!" Only after time elapses do they realize that what's terrible is the mix and not the environment. LEDE rooms are harsh critics of technically deficient recordings. On the other hand, technically proficient recordings are a sensuous reward in an LEDE room.

There are presently more than 200 Techron TEF analyzers in the field, mostly in the hands of professional sound contractors and acoustical consultants. These consultants typically charge $500 for a day of measurement, which includes an operator for the TEF analyzer. If five audio enthusiasts were to contract for such measurements to be made in a hi-fi dealer's showroom, choosing a loudspeaker would become an easily documented task—for just $100 per person. Use of the LEDR tape in their own listening rooms would reveal if they needed further TEF analysis of those rooms. Eliminating the loudspeaker as a variable by means of TEF analysis makes playing the LEDR tape in the home an acid test of a listening room's quality. You would be astounded to see how easy it is to find interfering reflections in a home listening room using the TEF analyzer (see Fig. 18). The direction from which reflections come has an important bearing on how that energy is perceived. Thanks to the creativity of Farrel Becker, we can now easily plot the direction as well as the travel time of each and every reflection. I am willing to predict that by the mid-1990s, no serious home system will be made without TEF analysis.

Kurt Graffy of Paoletti/Lewitz in San Francisco has recently started working with custom installers of high-quality music systems. Graffy's firm is hired to find the offending surfaces in the music room and suggest the placement of absorption and/or diffusors to establish a clean ISD gap and precise stereo imaging.

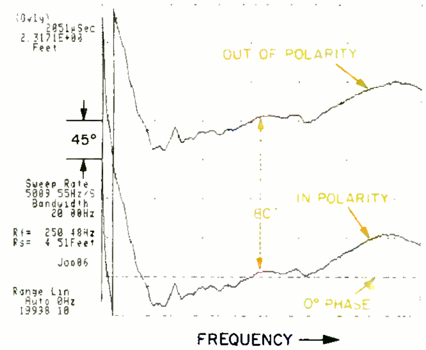


Fig. 16—The difference between phase response and polarity. Phase is frequency dependent; it varies with frequency. Polarity is not frequency dependent. Signal at each frequency has been changed exactly 180°.

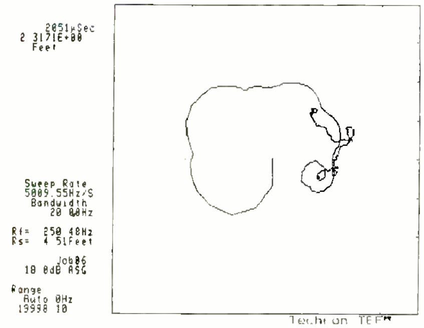


Fig. 17A—An "in-polarity" Nyquist curve. The vertical axis is the imaginary part, i.e., the kinetic energy; the horizontal axis is the real part, i.e., the potential energy. This plot is the tip of a rotating vector of the analytic signal traced out as a curve. Plato said, "God ever geometrizes." God must love modern analysis.

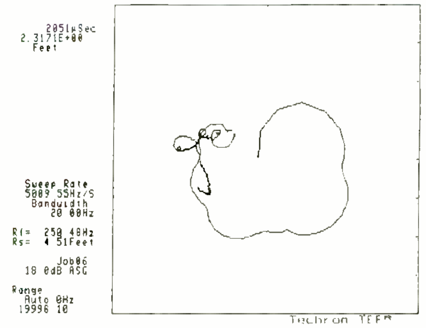


Fig. 17B—A Nyquist curve of the same loudspeaker as in Fig. 17A, this time out of polarity.

THE LEDE CONCEPT

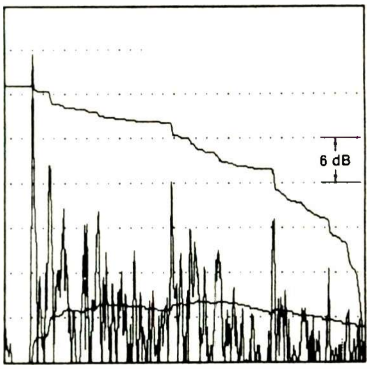


Fig. 18A—The ETC of a flutter echo with a conventional integration in the bottom curve and a Schroeder integration in the top curve.

Ideally, the consultant should be engaged at the time a listening room is being designed, just as with a control room. Doug Jones, for example, has been engaged to design and supervise the building of several home listening rooms in recent months. His wedding of psychoacoustics and TEF has enabled him to make valuable contributions to the design of home entertainment rooms.

I can't resist presenting the measurement shown in Fig. 19. It is a TEF-RASTI measurement (RASTI stands for rapid speech transmission index). We now are able to measure speech intelligibility objectively, with as great an accuracy as live listening groups can do with carefully constructed intelligibility tests. How long do you suppose it will be until we can do the same for music?

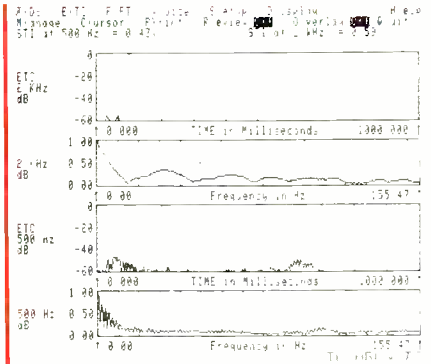


Fig. 19—Will there ever be a musical equivalent of the RASTI or rapid speech transmission index? How about an MPC or music preference curve? ("MTF" means modulation transfer function; overall STI = 0.51, which is fair intelligibility.)

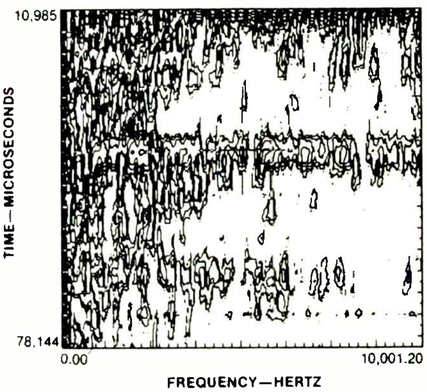


Fig. 18B—A frequency-vs.-time curve or FTC of the same flutter echoes as in Fig. 18A, showing the first, second, and third reflections and their frequency dependency.

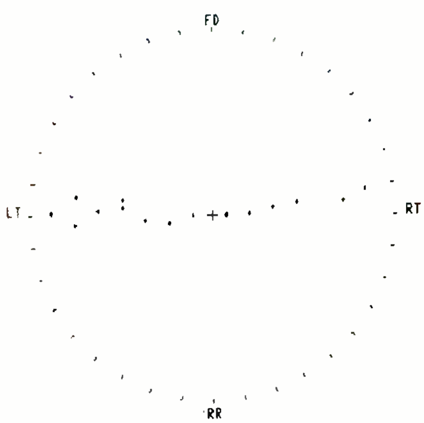


Fig. 18C—A polar ETC of a flutter echo, showing the direction from which each flutter came. Supporting the flutter are the side walls. (Courtesy of Farrel Becker.)

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The C-90 features three separate power transformers—two to power left and right audio channels for vanishingly low crosstalk, and a third transformer to drive the preamp's unique video capabilities, relays, display and microprocessor. All switching functions are accomplished by electronic relays. Thus the signal paths are as short as possible, improving signal-to-noise ratio and channel separation. Anti-vibration measures taken to further the C-90's sonic excellence include a solid aluminum volume control knob, polycarbonate chassis feet, and rubber-cradled PC boards. Soft copper-plated screws insure a snug fit of chassis, transformers, transistors, and help to dampen vibration.

The M-90 is a superb high-power stereo amplifier, utilizing dual-mono construction. It is conservatively rated at 200 W/CH into 8 ohms[1] and delivers 800 W/CH of dynamic power at 2 ohms.[2] The wide dynamic range of digital sources can now be reproduced effortlessly, with any loudspeakers. The M-90's high current capacity of 47 amps can handle the challenge of the most complex speaker loads. To further enhance S/N ratio and channel separation, relay-operated electronic switches and a long shaft volume control keep the length of signal paths down to a minimum. Why include a high quality volume control on a power amp? Simple. To pursue the straight-wire-with-gain philosophy when using a CD player connected directly. Pure sound, redefined.

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For your nearest Pioneer Elite Hi-Fi dealer, phone 1-800-421-1404.

 [1]Based on FTC rules regarding measurement of amplifier power ratings. [2]Measured by EIA method.

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1

MARK LEVINSON NO. 20 MONO AMP

Manufacturer's Specifications

Power Output (20 Hz to 20 kHz): 100 watts rms into 8-ohm loads; 200 watts, continuous, into 4-ohm loads; 400 watts, continuous, into 2-ohm loads.

Rated THD: Less than 0.2% maximum at 100 watts, 20 Hz to 20 kHz, into 8 ohms; 0.3% at 200 watts into 4 ohms; 0.4% at 400 watts into 2 ohms.

Frequency Response: 3 Hz to 140 kHz, +0, −3 dB, at 1 watt output.

Input Impedance: 50 kilohms shunted by 1 nF.

SMPTE-IM Distortion: Less than 0.2% at rated output into loads of 1 ohm or higher.

Gain: 26 dB.

Dimensions: Front panel, 17½ in. W × 8½ in. H (44.5 cm × 21.6 cm); optional front-panel width, 19 in. (48.3 cm). Chassis (including heat-sinks, handles, and rear connectors), 17½ in. W × 8¼ in. H × 22⁷⁄₁₆ in. D (44.5 cm × 21.2 cm × 56 cm).

Weight: 65 lbs. (29.5 kg); shipping weight, 90 lbs. (40.9 kg).

Price: $9,600 per pair.

Company Address: c/o Madrigal Audio Laboratories, P.O. Box 781, Middletown, Conn. 06457.

For literature, circle No. 90

Photograph: ©1987, Jay Brenner

The No. 20 monaural amplifier sits at the top of the prestigious Mark Levinson component line. It might have been designated the ML-20, but it is the first Levinson amplifier created under the ownership of Madrigal Audio Laboratories, hence its slightly different name. Still, it resembles earlier Levinson amplifiers, with its thick, engraved faceplate, extensive heat-sinking, and Camac coaxial input connectors (instead of RCA-type phono jacks). Like other Levinson amplifiers, it also carries a premium price.

Insofar as the No. 20 is a fully regulated, Class-A, 25-watt amplifier with modular construction, it can be viewed as a direct descendant of the previous Levinson flagship, the monaural ML-2. The No. 20 features regulation of power supplies for all audio stages, as the ML-2 did, but it also introduces some new circuit features to the line, such as separate power supplies and regulation for both positive and negative power-supply rails, extensive a.c. line filtering, a soft-clipping circuit, and an output stage that requires no load-isolation network.

This amplifier weighs in at 65 pounds, and two are needed for stereo operation. Each No. 20 is rated at 100 watts into 8 ohms; if more power is required, a pair can be bridged using the special inverting and noninverting inputs to yield rated power of 400, 800, and 1,250 watts into 8, 4, and 2 ohms, respectively. Distortion and bandwidth ratings are not given for bridged operation, and the No. 20's 10-ampere fuses may not allow a pair of these units to deliver the rated 1,250 watts into 2-ohm loads for very long. Unlike earlier Levinson amplifiers, the No. 20 has a balanced input with an XLR-type three-pin jack, in addition to its unbalanced Camac-connector inputs. For optimally low noise when either unbalanced input is used, the balanced input should be shorted with a plug supplied for this purpose.

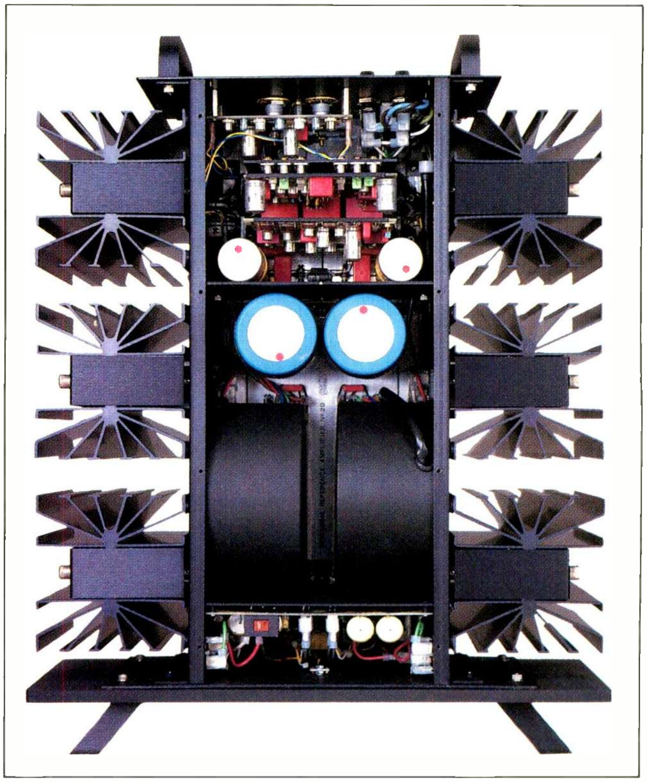
The ⅝-inch-thick engraved faceplate and the six radial-finned heat-sinks make the No. 20 the largest 100-watt audio amplifier we've seen. Actually, most of the audio circuitry is contained within the central chassis, which accounts for only 9¾ inches of the amplifier's 17½-inch width. The remaining width is accounted for by six elaborate heat-sink assemblies that line the amplifier's sides. Each sink extends 4¼ inches from the side of the chassis, has 14 fins, and contains a p.c. board holding numerous power transistors. The large chassis and multiple fins allow the No. 20 to run in Class A at full power into 8 ohms (which requires the dissipation of 500 watts of heat at idle) without a noisy fan.

Installation of the No. 20 is facilitated by solid handles at front and back. We found it easiest to move the amplifier by grabbing one front handle and the rear handle diagonally opposite it. The front handles are angled outward, an attractive design feature. The standard faceplate is 17½ inches wide, but a 19-inch-wide plate may be ordered (at no extra charge) for rack mounting.

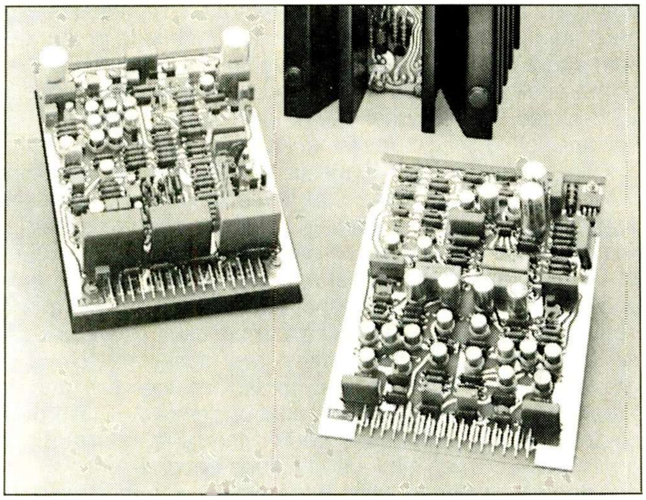
A single red LED is at the center of the front plate. As on other Levinson amplifiers, the only control is a rocker-type power switch. This switch, a single-pole type with a relay trip coil tied into the protection circuitry, controls only the hot side of the a.c. line. All other a.c.-line components are duplicated on both the neutral and hot sides of the line.

The rear panel provides a wide range of signal connection options, more than we've seen on other premium-priced amplifiers. These include the socket for the detachable a.c. cord (just under the 10-amp fuses for each side of the a.c. line) and a chassis-ground binding post. Toward the center of the back plate are the two outputs. These utilize special gold-plated, high-current (80-ampere peak) jacks for the Fischer self-locking speaker connectors supplied with the amplifier. The manual suggests that the owner or dealer solder the speaker cable into these connectors. (Special adaptors with five-way binding posts attached to a pair of Fischer plugs are available from dealers on special order.) At the far right of this panel is a balanced-input XLR jack and, below it, two Camac input jacks for the inverting and noninverting inputs. The locking Camac devices are used in all Levinson components; they are designed to make ground contact before signal contact on insertion and to break signal before ground contact on removal. These connectors avoid the potentially woofer-damaging hum that can occur when conventional phono plugs become loose or are accidentally removed while the amplifier is turned on. Cables to fit these connectors (both Camac-to-Camac and Camac-to-RCA) are available from Madrigal and from some independent cable companies; Madrigal also sells male Camac connectors.

The No. 20's exterior is all-black anodized aluminum. The amplifier is constructed around a narrow, deep, U-shaped chassis, formed from 0.090-inch stock, to which the front plate, rear panel, and heat-sink subassemblies are attached. Small p.c. boards are mounted in the center of each of the six radial heat-sinks to accommodate regulators, drivers, and output transistors. The front heat-sinks house



Circuit boards, which plug in with gas-tight Varicon connectors, have curved traces that reduce the likelihood of interactions.



Some of the amplifier's circuit modules, showing the gas-tight Varicon edge connectors.

regulator circuitry and contain 10 transistors each; the middle sinks contain a thermal cutout, a predriver, three paralleled drivers, and four paralleled output devices. The rear heat-sinks contain four output devices (paralleled with those on the middle heat-sink) and a single, small transistor to control bias. The amplifier is physically symmetrical, with all heat-sink-mounted circuitry for the positive rail on one side, and all such circuitry for the negative rail on the other.

The top panel is held on by eight stainless-steel, button-head, hex-driven machine screws. Removing it reveals a showcase of superb construction and high-quality components. The circuit card nearest the front panel is the power supply, with movable jumpers and a switch by which the dealer can select 100-, 120-, 200-, 220-, or 240-V a.c. mains operation. This card also contains power-on surge circuitry with turn-on delay. On the motherboard, extensive a.c. line filtering is carried out by r.f. capacitive bypasses and large metal-oxide varistors (MOVs). Circuitry here protects against line voltage spikes and shuts down power under such fault conditions as over-voltage or prolonged, high current draw. The partitioned-off power-supply compartment contains two large, potted, 600-VA toroidal transformers—one for each rail—mounted on the chassis side panels. During assembly, these transformers are rotated in their mounts relative to one another to achieve lowest possible hum in the output signal. Next come two 24,000-μF electrolytics which are bypassed with film capacitors. Two 35-ampere bridge rectifiers sit between the transformers and filter capacitors.

Another compartment holds three vertical cards, the first two of which plug in. Regulator voltage-gain and protection circuits sit on the first card. The second card, which has a black aluminum heat-sink plate on its back, contains audio voltage-gain circuitry. The third card, holding additional protection circuitry, is bolted to the rear panel. A motherboard and discrete fault-sensor wiring interconnect all of these functions. Six ears on the motherboard protrude through slots in the side panels to connect to circuitry on the six heat-sink assemblies.

By dividing the circuitry into so many modules, as was done on the earlier Levinson ML-2, Madrigal claims they can test and match internal parts more accurately. They further claim that, as a result, any two No. 20 amplifiers should match each other perfectly. This modularity also greatly increases ease of service in the field, thus avoiding the need to ship the entire amplifier (which weighs 90 pounds when boxed) back to the factory for service. It also allows the manufacturer to offer updates to the amplifier. (Madrigal says, however, that they intend to offer such updates infrequently, and only after many significant production changes have accumulated.)

To a great extent, the amplifier can be disassembled and put back together as easily and precisely as a rifle. To remove any of the six heat-sink assemblies, each of which is secured by two bolts, one must first release the knurled nuts holding a protective cover in place, then simply unscrew two hex spacers to unplug the assembly.

Good signal contact is maintained between these plug-in subassemblies by Elco Varicon contacts which connect each heat-sink to the main circuit board. These mil-spec connectors employ 45° bevelled tines which form gas-tight surface junctures rated for over 1,000 insertions. They carry a high (10-ampere) current rating and have extremely low (0.006-ohm) contact resistance.

Circuit-board and component quality is as high as we have seen in a hi-fi unit. All p.c. boards are double-sided, high-quality glass-epoxy types. The circuit traces on the boards are curved to reduce the interactions possible with parallel traces. There is a minimum of point-to-point wiring, aside from the 6-gauge, oxygen-free-copper bus lead from the motherboard to the output connectors. Inputs are soldered directly to the circuit board. All audio signal paths employ soldered connections, except for the Varicon connectors at the heat-sinks and the plug-in audio circuit cards.

No trendy designer-label capacitors can be found in the No. 20. Madrigal's use of mil-spec RN-60 resistors, metal-can transistors, and Elco Varicon connectors is ample evidence of the No. 20's extraordinary parts quality. In particular, better quality capacitors are used extensively to bypass critical circuit areas. For example, although the electrolytic capacitors used are the best available switching-grade types, each is bypassed by both a foil-type polypropylene capacitor of a small value and a metallized polypropylene capacitor of larger value. The manufacturer claims that this utilizes the best parts of each capacitor type's equivalent series impedance-versus-frequency curve.

The ruggedness and reliability of the No. 20's circuit construction stem from the manufacturer's experience in maintaining many ML-2 amplifiers in the field over the past 10 years. Thanks to its sturdiness, the No. 20 should provide 10 to 25 years of maintenance-free operation.

Circuit Description

The No. 20's circuitry features Class-A biasing, regulated power supplies, extensive protection, and conservative circuit configuration. Of course, each No. 20 is a monophonic amplifier, so crosstalk and other interactions between chan-

The Class-A No. 20 moves into Class AB for music peaks, doing so at lower levels as the load impedance falls below 4 ohms.

nels in a stereo setup are kept to a minimum. Normally, when we speak of "dual mono," we are referring to two separate amplifiers on a single chassis, each with its own power supply. The No. 20 takes this concept one step farther: It uses dual-mono supply rails! Each half of the waveform has its own power supply and regulator.

Fixed-bias Class-A amplifiers, favored by audiophiles, are very inefficient because they dissipate as much power during quiet passages as they do at full power. With an amplifier delivering high current and reasonable power, a pair of amps can demand more electricity than the average home's wiring can draw from the power company. Levinson's solution is to fix the bias at a reasonable level and design the circuitry to move into Class-AB operation for music peaks, doing so at lower output levels as the load impedance falls below 4 ohms.

Most amplifiers do not use the No. 20's level of regulation (regulation of all stages, including outputs) because of increased cost and decreased power available for momentary music peaks. Unregulated amplifiers, on the other hand, are somewhat dependent on the open-circuit voltage of the a.c. power line. The No. 20 is highly independent of the power line. Even if a brownout smokes your air conditioner, the No. 20 will play with full power. The regulated power supply in the No. 20 actually does more to stabilize and purify the power source than even the expensive line conditioners sold for use with computers.

Madrigal has designed a highly sophisticated protection circuit for this amplifier. Some protection schemes have interfered with sonics by mistaking a difficult but normal load for a fault. This unneeded protection results in snapping sounds or premature clipping. The No. 20's protection scheme analyzes and handles an extremely broad range of load conditions without sonic interference. Part of this ability derives from the No. 20's overbuilt "eight-up, eight-down" output stage, which uses eight transistors in each half of the push-pull circuit. While even a simple protection scheme could protect such circuitry without affecting performance into normal loads, the No. 20 goes much farther, sensing and reacting to only those extreme conditions that the amp is not designed to handle.

The No. 20's protection consists of a fusing system, elec-

ARC WELDING WITH AN AMPLIFIER

An enthusiastic reviewer might call a beefy amplifier an "arc welder" as an exaggerated compliment to its ruggedness and current-handling capacity. However, no one would really expect an amplifier to actually melt steel. Almost no one, that is, except this reviewing team. We say this amplifier is an arc welder and back up this statement with a photograph (Fig. B1) of two 0.05-inch steel plates welded together by a pair of Mark Levinson No. 20s.

Arc welding is accomplished by creating an electric arc that melts metal. The molten sections of the items to be joined flow together and are then allowed to cool. In practice, the power source is connected to the two pieces to be joined and to a flux-coated welding rod. The arc is struck by momentarily shorting the rod to the work pieces. The flux is vaporized, forming an ionic conducting path for the arc and cleaning the metal. The arc stabilizes at about 100 amperes and 30 V (creating temperatures of 3,000° F), depending on the thickness of the metal and welding rod. If this sounds like the world's worst amplifier load, you're right!

Coauthor Clark summoned Paul Grzebik to carry out the task. Paul has the reputation, in Detroit's technical community, for a willingness to try anything once, from building a parade float to scaling a TV transmitting tower. He readily agreed to our assignment. Clark drove both No. 20 amps with a 1-kHz square wave to full output into a series resistor mixing network that combined both amplifier

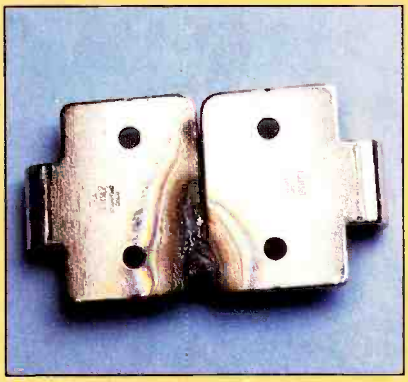


Fig. B1—Results of the arc-welding experiment.

outputs in parallel to obtain the high current needed. After experimentation (and several blown line fuses), approximately 1 ohm was found to deliver the maximum current for starting and sustaining the arc.

Wearing a mask and gloves (the intense blue light from the arc can burn the unprotected retina, while molten metal can splatter on the hands), Grzebik began welding. The arc turned out to be a fairly effective plasma tweeter, creating strong 1-kHz square-wave sound radiation that required wearing ear protectors as well. Grzebik completed a small weld and, impressed, pronounced it satisfactory.

After the welding, the No. 20s, still only lukewarm, were again put on the test bench. Distortion tests verified that no change in their performance had resulted from this extraordinary exercise.

What's the point? With this test, Clark verified his confidence in the exceptional output capability and comprehensive protection built into these amplifiers. A few other amps might be able to weld steel without destroying themselves, but the No. 20s were certain to survive the experiment.

One note: Don't attempt this feat yourself unless you are an accomplished welder, have the proper equipment, and are using amplifiers with extraordinary protection circuitry and output stages that can handle current extremes. Injury to yourself and destruction of lesser amplifiers may result. Don't expect manufacturers to repair your damaged amp under warranty, either!

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Each has a different size, maximum acoustical output and bass extension. All have the same enhanced stereo imagery, improved transient response, low distortion and total freedom from colouration.

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Even a simple protection system could safeguard the overbuilt output stage, but the No. 20's system is quite sophisticated.

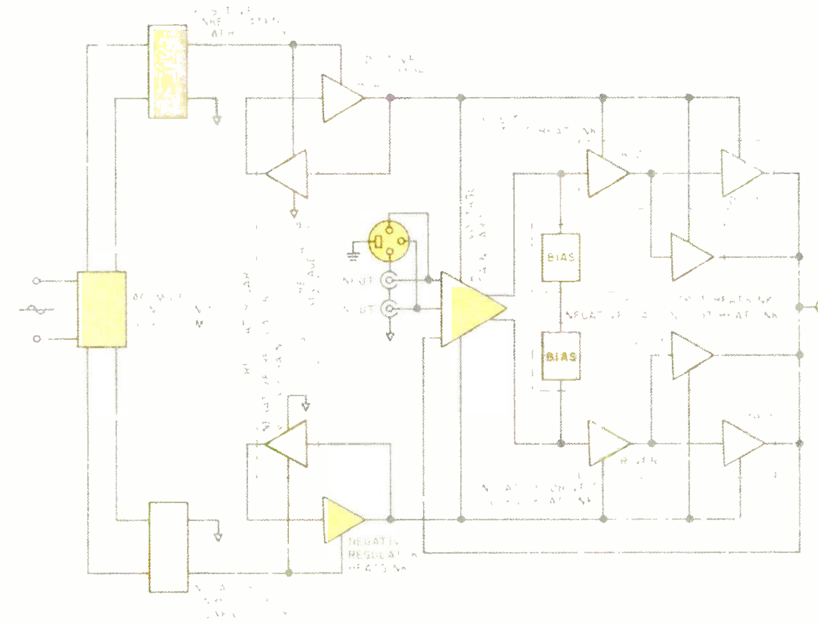


Fig. 1—Block diagram showing the No. 20's main functional subsystems. Note the independent power supplies and regulators for both the positive and negative voltage supplies, and the use of balanced inputs plus positive and negative unbalanced inputs.

tronic limiting, and the on/off relay trip switch. This system continuously monitors the a.c. mains voltage, the current and voltage level of the positive and negative power supplies, the amplifier temperature, d.c. offset level, power dissipation in the output stage (particularly the influence of phase angle), and short-circuit conditions at the output. A detector circuit located on the first plug-in card monitors the d.c. offset at each channel's output and will trip the a.c. line on/off switch if the offset becomes excessive. Three thermal cutouts are used, one for each of the two middle heat-sinks and one at the center of the chassis. These will trigger the No. 20's shut-down circuitry if their temperature exceeds 80° C (176° F).

A new type of soft-clipping system is also used in the No. 20. A voltage-limiter circuit, primarily in the second voltage-gain stage, monitors the level in this stage and reduces the amplifier's open-loop gain as the signal nears a level which could cause saturation here or in subsequent stages. Additional parts of the system, residing in the first voltage-gain stage, prevent saturation at the input. Because the circuit's action is gently contoured, rather than abruptly beginning at some preset point, it does not generate nearly as much higher-order harmonics as such limiting circuits usually do.

Like many high-end amplifiers, the No. 20 uses almost all bipolar transistors, in a straightforward configuration but with an unusually large number of support parts to improve linearity and reliability. The regulated power supplies are an example of this complexity. The simplest bipolar supply can be built with five components. In the No. 20, more than 200 components—fully half of the circuitry—are devoted to this function.

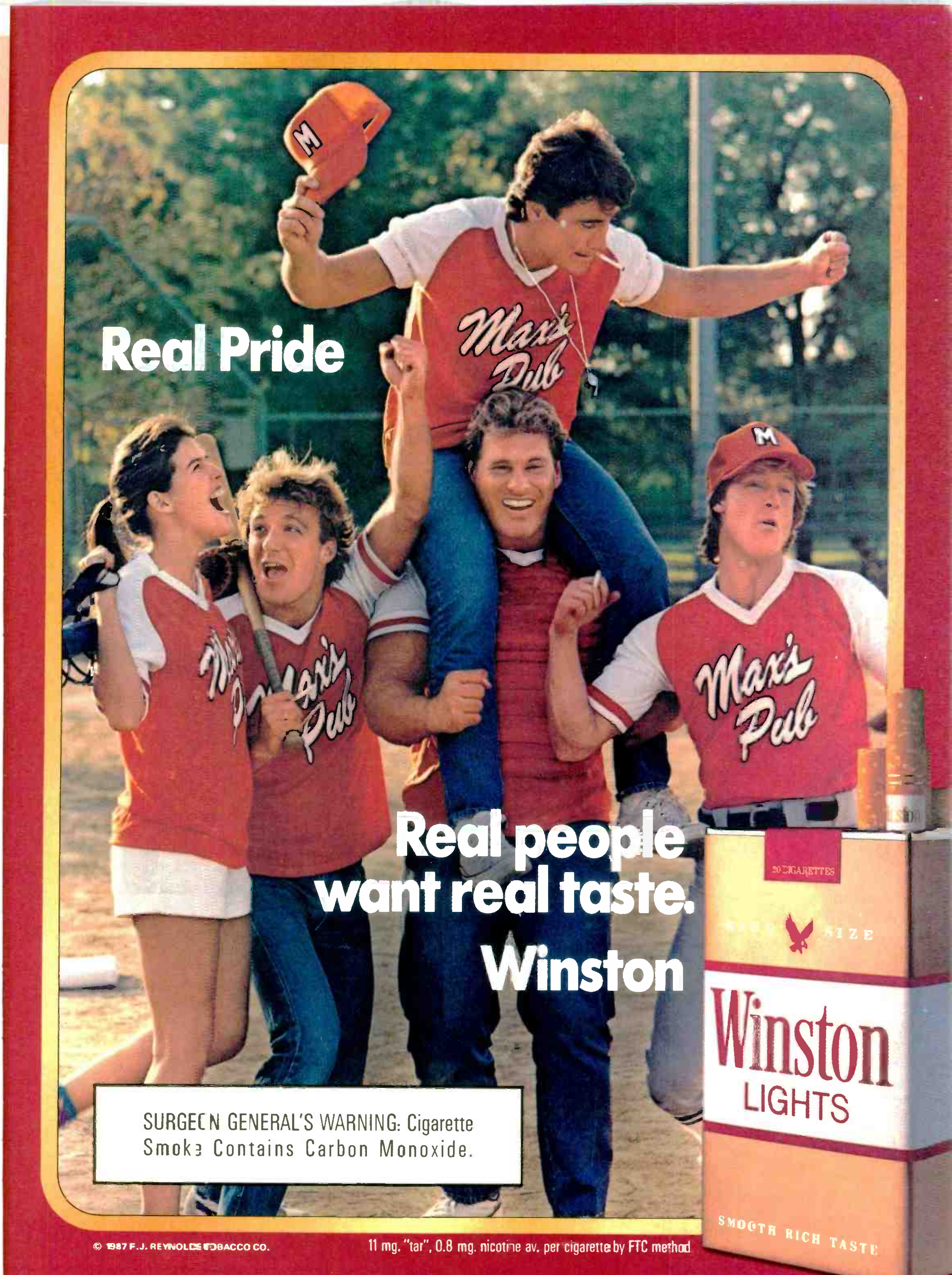
The amplifier's circuitry is shown in Fig. 1. On the a.c. mains card, a resistor, shorted by a relay, is wired in series with the transformer primary to reduce inrush current. A transistor time-delay circuit operates the relay, which bypasses the series resistance after about 1.5 S. This turn-on surge-delay circuitry prevents damage to the electrolytic filter capacitors and other power-supply circuitry, which could result from repeated, rapid turn-on and turn-off of the power switch.

Separate power supplies for each d.c. rail are provided. Each rail has its own power transformer, full-wave bridge rectification, and high-quality filter capacitors. To prevent mechanical noise from the d.c. sometimes found in European or older American a.c. power grids, the two transformers have a special "anti-buzz" circuit.

Following the power supplies, the No. 20 has completely independent, nontracking regulation for each rail. This is accomplished by a very substantial regulator amplifier, composed of differential amplifiers (on the regulator card) driving series-pass regulating output stages (on the heat-sinks). Madrigal claims that the regulators' on-board voltage sensing provides negative-feedback error correction, using operational-amplifier techniques. The regulating system prevents d.c. voltages from fluctuating due to severe current demands from the load. This unusual feature yields a very low power-supply impedance. The regulated d.c. voltage rails are further filtered by two 9,000-μF capacitors bypassed with various film capacitors.

Although the ML-2 has power-supply regulation for all its audio stages, the amount of regulation decreases above 5 kHz. In contrast, the No. 20's regulation is rated from d.c. to 22 kHz. The manufacturer claims that this means the power-supply output is ripple-free down to four decimal places, even beyond 50 kHz.

All amplifying stages in the No. 20 are direct-coupled. The first signal stage (on the audio voltage-gain card) consists of a cascode differential amplifier biased by a current sink. The signal input transistors are two matched NPN types. The outputs of these transistors are direct-coupled to a pair



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The No. 20 acts as a true voltage source: When its load impedance is cut in half, its maximum power output doubles.

of N-channel junction FETs which act as the output section of the cascode. The second stage is a cascode differential amplifier with a current-mirror load. This stage uses PNP bipolars, and its current mirror uses NPN bipolars.

The second-stage differential amplifier, in turn, feeds the pre-drivers, which are mounted near the drivers on the heat-sink. These low-power, wide-bandwidth devices act as the first current-amplifying stage; they feed three paralleled complementary emitter-follower drivers which then drive the bases of the output transistors. All voltage-gain and driver stages maintain Class-A operation at all levels, even if Class-AB operation is required from the output stage.

That output stage, which occupies four of the six heat-sinks, uses 16 parallel output transistors (eight PNP and eight NPN) in a complementary push-pull design. The transistors are rugged, wide-band, high-power (200-watt) types. This stage is heavily biased to remain in Class-A operation at 8 ohms up to rated power. Each transistor in both the driver and output stages has its own individual negative feedback. The open-loop gain of the amplifier itself is approximately 80 dB. The manufacturer claims that the No. 20 employs 50 to 60 dB of negative feedback.

The No. 20 is unusual in that it has no output load-isolation network, so the output stage's very low impedance is presented directly to the speakers. As a result, the damping factor remains high, even at the upper frequencies.

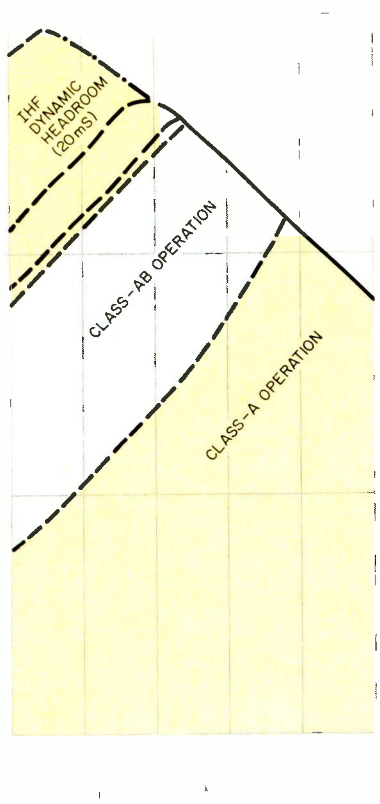

Fig. 2—Maximum power envelope. Note the straight-line relationship between log power and log impedance, showing that the No. 20 behaves as a true voltage source. Dashed lines are boundaries between Class-A and Class-AB operation and fuse limits for different time periods. Line dividing Class-AB and IHF dynamic power regions is limit of continuous operation; line just above that is the 4-hour fuse limit, with the 1-hour fuse limit slightly higher; upper boundary of IHF dynamic power region is protection limit.

Measurements

Before any measurements were taken, the No. 20 was run for an hour at 33% of rated power, or 33 watts per channel into 8-ohm loads. This standard preconditioning period, normally taxing for Class-AB amplifiers, poses no problems for Class-A amps. The No. 20, instead of being cycled on and off by its thermal protection circuits during this period, as some Class-AB amps are, actually cooled down a bit!

The No. 20 is a very unusual amplifier, and standard IHF measurements do not fully reveal its power capabilities or its sonic attributes. In fact, the owner's manual reads, "The correlation between published specifications and sonic quality is unreliable. A list of numbers reveals virtually nothing. All technical measurements must be subject to qualitative as well as quantitative interpretation." We agree that a modern amplifier's specs don't tell us what it sounds like. Still, we shall report measurements, some of which can be related to the performance of 100-watt amplifiers in general, and others that show how special the No. 20 actually is.

The Madrigal design team had their own list of priorities for this amplifier, which apparently was topped by the ability to deliver power into a very wide range of difficult loads. Accordingly, our first task was to define the limits of the amplifier's power output. The unit's fully regulated power supply is designed to handle the most unfavorable loads under brownout conditions. Measured into 4-ohm loads, the No. 20 maintained its output voltage between 31.5 and 31.7 V (234 to 251 watts) at a.c. line voltages from 90 to 132 V. Levinson's official power ratings for the No. 20 are 100 watts into 8 ohms and 200 watts into 4 ohms. The output voltage at both ratings is 28.28 V. This shows that the amplifier is a true voltage source, for only a source such as this will deliver twice the power when the load impedance is halved.

Within the limits of its fusing and protection circuitry, the No. 20 maintained the same 28.28 V into loads of 8, 4, and 2 ohms. The current drawn from the a.c. line at 400 watts into 2 ohms was 12 amperes, which exceeded the 10-ampere rating of the a.c. fuses. Only when coauthor Clark used a 1-ohm load did a line fuse blow (at 18 amperes!) as he neared the 28.28-V output rating of the No. 20 (which would have been 800 watts into 1 ohm). After replacing the fuse, he

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For starters, our CD Cleaner uses a computer-aided design to deliver a true "radial" cleaning (that's what the manufacturers recommend). And Discwasher's CD-1™ Cleaning Fluid is scientifically formulated to lift and suspend contaminants as our non-abrasive cleaning pad easily and safely removes the debris from the disc surface. The result is no audio drop-outs or playback skips to mar your enjoyment.

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The Levinson's current capacity—36 amperes continuous, 50 amperes peak—is as high as we've found for any amplifier.

limited the line current to 10 amperes (130 watts into 1 ohm) and retested with a 1-ohm load. The amplifier performed beautifully, showing maximum distortion of 0.42% THD + N at 20 kHz. This distortion level would not be audible on music and is comparable to published ratings for high-quality tube amps driving standard loads; here, we were using one-fourth of the amplifier's minimum rated load!

Figure 2 shows that the No. 20's power output almost exactly doubles with every halving of load impedance. This held true over the entire impedance range we measured, from 16 ohms to 0.5 ohm, and demonstrated how the No. 20's regulated power supply maintained virtually constant maximum voltage over that load range. The dashed lines perpendicular to the power-output curve are current limits which define the following performance boundaries: Shift from Class-A operation to Class AB (7 ohms at 140 watts); limits of fuse operation for continuous, 4-hour, and 1-hour periods (10 amperes, 11 amperes, and 13.5 amperes, respectively), and the protection-circuit limits (0.7 ohm at 800 watts for 20-mS pulse tests). The No. 20's tightly regulated power supply does have a down side; it limits both dynamic headroom and clipping headroom to 1.1 dB (129 watts). In fact, this headroom is not "dynamic" at all; it simply is a reflection of Madrigal's conservative underspecification of the power rating.

A surprise came when we checked the No. 20's current-delivery capacity. The amplifier sensed our standard 0.1-ohm load as a short circuit and limited the 20-mS current output to 18 amperes. Using the same 20-mS pulse test into a 0.67-ohm load, we found that the No. 20 could deliver 36 amperes continuous (50 amperes peak) current. This current-delivery capacity into 0.67 ohm is as high a current output as our lab has found for an audio amplifier. The combination of high current capability and short-circuit protection inspired us to experimentally use the No. 20 as an arc welder (see sidebar). Although we do not recommend this test (it will void most warranties, destroy lesser amplifiers, and expose to injury those who are not experienced welders), the No. 20 proved itself to be rugged, stable, and able to handle this bizarre task.

Voltage gain was found to be 26 dB into 8-ohm loads. IHF sensitivity for 1 watt output into 8-ohm loads was 141 mV.

Figure 3 shows THD + N as a function of frequency for four load impedances and power-output levels. Overall, distortion was lowest at low frequencies, low levels, and high impedances. It rose gradually as the load impedance dropped but was always well within its rated limits. At 20 kHz, where distortion was highest, THD + N at 100 watts into 8 ohms remained below 0.07%; into 4 ohms at 200 watts, it was below 0.13%, and at 400 watts into 2 ohms, it remained below 0.22%. Even at 1 ohm, THD + N never surpassed 0.42%. At frequencies below 1 kHz, THD + N was less than one-tenth of these maximum values.

IHF signal-to-noise ratio (referred to 1 watt into 8 ohms) was 79.0 dB, wide-band, and 89.0 dBA. Part of the noise was contributed by an a.c. synchronous buzz. These figures are not the best we have measured, but no noise was audible in use with medium-efficiency speakers.

Frequency response at 1 watt into 8-ohm loads was 3.4 Hz to 168 kHz, +0, −3 dB. Input impedance was 50 kilohms below 1 kHz but dropped off as frequency rose, measuring 9.2 kilohms at 20 kHz.

Damping factor was measured next. To minimize resistance in our test-lead connections, we soldered our leads to the Fischer speaker plugs; according to Madrigal, this is the best way to make speaker connections. We also checked our damping-factor test setup by measuring the lead resistance when the connectors were unplugged from the ampli-

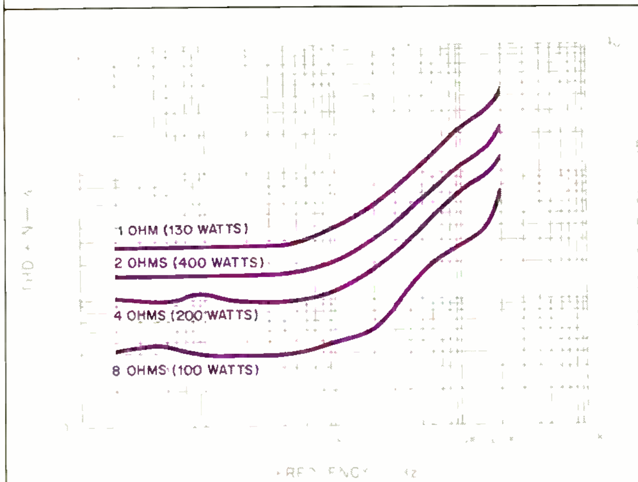

Fig. 3—THD + N versus frequency for four load impedances and power levels. Though distortion rises at higher frequencies and lower impedances, it remains generally low.

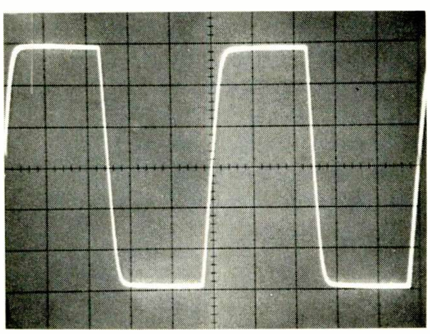

Fig. 4—Large-signal, 20-kHz square wave at 100 watts into 8 ohms, showing 5-μS rise-time. (Scales: Vertical, 10 V/div.; horizontal, 10 μS/div.)


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Adding capacitance to the load left the No. 20 relatively unfazed. Even highly reactive inductive loads did not shut it down.

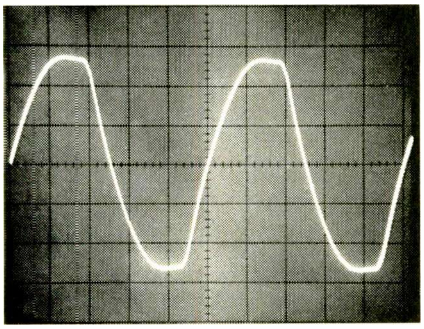


Fig. 5—Same as Fig. 4, with 2-μF capacitor paralleling the 8-ohm load, simulating the load of an electrostatic speaker. The large phase angle activates the amp's protection circuit, and limiting occurs. Note how rise-time increases from 5 to 15 μS.

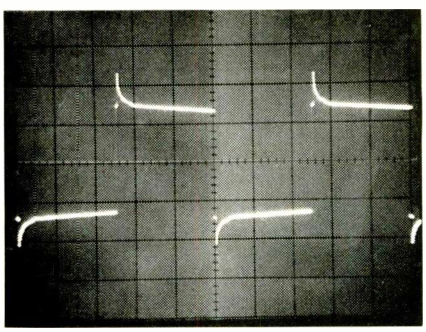


Fig. 6—Large-signal, 100-Hz square wave at maximum output into a 1.8-ohm resistance in series with a 2.25-mH inductor. Although the limiting circuitry is not tripped by this "worst-case" load, the amplifier has difficulty sinking the flyback current stored in the inductor. Note the peaks at each leading edge as the current rushes back into the amplifier from the inductor; this is still very good performance. (Scales: Vertical, 10 V/div.; horizontal, 2 mS/div.)

fier and shorted together. Our measurements showed a maximum damping factor of 899 at 40 Hz, falling to 129 at 20 kHz. These are excellent figures, verifying the low impedance of the output stage.

Rise- and fall-times, measured with a 20-kHz square wave at rated power into 8 ohms, were found to be 5 μS up and down, as shown in Fig. 4. With this purely resistive load, there was no ringing or other anomalous behavior, even near clipping. The amplifier's slew rate was 14.5 V/μS down and 13.0 V/μS up. The IHF slew factor was 2.5, the ratio between 50 kHz (the maximum input frequency at reference input level for clean, 100-watt sine waves when driving 8-ohm loads) and 20 kHz.

Determined to explore the boundaries of the No. 20's performance, we tried two other, more difficult, loads. To approximate the capacitive load of an electrostatic speaker, we paralleled a 2-μF capacitor across the 8-ohm resistor; the results are shown in Fig. 5. Most amplifiers would show some ringing on such a load, but this is usually due to the output network, a feature not found in the No. 20. Instead, we see evidence of the protection circuitry (detecting the large phase angle in this reactive load), which rounds off the edges of the square wave, increasing the rise-time of the amplifier from 5 to 15 μS. This effect is also seen at lower power levels, to a lesser degree.

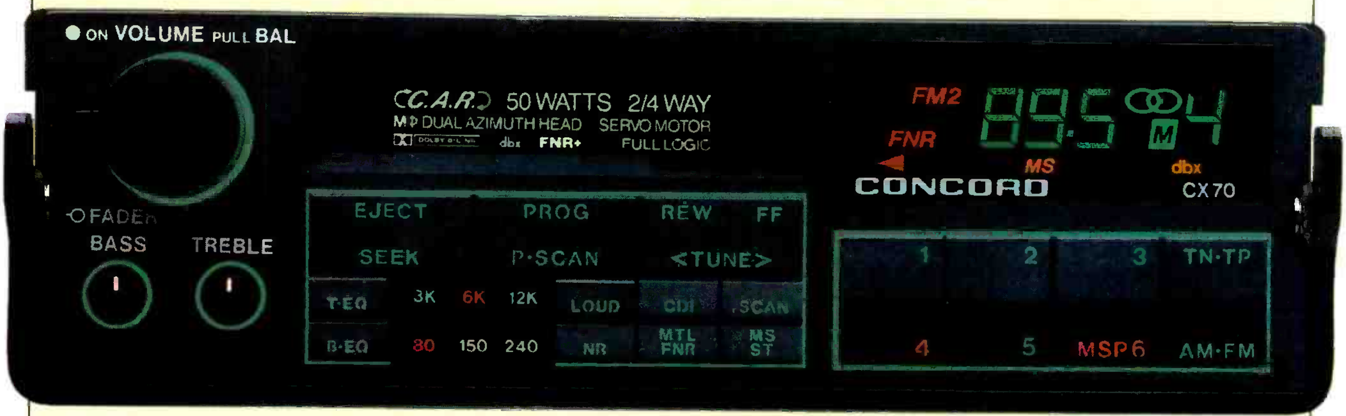
The second "torture test" load was a 2.25-mH inductor in series with 1.8 ohms. This highly reactive load is not specified in any standard amplifier test; it might be approximated if eight high-efficiency dynamic loudspeakers were wired in parallel. The No. 20 handled this test beautifully for most frequencies. However, after changing test conditions a number of times, Clark did find one test signal, a 100-Hz square wave at maximum output, which "pushed the envelope" of the No. 20's performance domain when fed into that brutal load. This combination of load and test signal would trip most amplifiers' protection circuitry. The No. 20's protection did not cut in, but as Fig. 6 shows, the amplifier was not altogether successful in managing the load. The stored energy in the inductor produced spikes at each leading edge, as the No. 20 could not completely sink the energy released from the inductor at those points in the cycle. To its credit, the No. 20 showed no such anomalies at high frequencies. Meanwhile, the inductor itself became too hot to touch.

Use and Listening Tests

First impressions are important, and unpacking a pair of No. 20s gave us a sense of the care Madrigal takes with its product. Huge cartons, fitted with massive plastic "shipping buttons" at their base, ensure safe transit and handling in this day of express air service and overstressed forklift truck drivers. Styrofoam inserts protect the amplifiers' finish, and the large front and rear handles on the units themselves make them easy to remove and repack.

After unpacking, input and output connections were made. Power connection to the a.c. is via two detachable cables, one per amplifier. Some owners may want to beef up their lines to 20-ampere circuitry to handle the constant 11-ampere draw we measured for this pair of amplifiers. Coauthor Greenhill, already having a Levinson preamp, felt

THE NEW CONCORD CX70.



IT OUTPERFORMS OTHER CAR STEREOS EVEN BEFORE YOU TURN IT ON.

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Concord's new CX series. Designed to perform like no other car stereo in the world. Every element, from the tri-color display on the front to the precision components deep inside it, was designed with a single goal – high performance.

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These hefty, finned black beauties are costly, but superior in their ability to handle tough loads and the worst a.c. lines.

right at home, having purchased cables with Camac connectors. Because he has two-pronged a.c. wall sockets, and the two amplifiers were plugged into a different wall socket than the preamp, a slight hum on one channel of the high-gain phono inputs occurred. The two-prong wall sockets did not automatically ground the amplifier chassis to the ground established by the rest of the system. This hum was present both during double-blind listening tests (using two amplifier systems) and during normal listening. Greenhill eliminated the residual hum easily by using a 16-gauge wire to interconnect the chassis-ground binding posts of the Levinson amps and preamp and the signal grounds of the affected channel. The separation of chassis and signal grounds gives this equipment extra grounding flexibility.

Clark, having a conventional RCA-fitted preamp, used a pair of Madrigal's RCA-to-Camac interconnects. Several types of copper and silver cables are available; the ones Clark used were 5-mm-per-strand copper coaxial, size RG-58, 3 meters long. Speaker cables of all types are accommodated by the No. 20's special Fischer connectors, though a small amount of soldering skill is required to attach them. The owner's manual recommends a 140-watt gun. Clark found terminating his 12-AWG speaker cable an easy and satisfying chore.

Equipment used by Greenhill to evaluate the Levinson No. 20s included a Linn Sondek turntable, a Magnepan Unitrac 1 arm, Marovskis MIT-1 and Shure V15 Type V-MR cartridges, a Magnavox Compact Disc player, a newly modified Mark Levinson ML-7A preamp, and Snell Type A-III, Dahlquist DQ-10A, and Quad ESL-63 loudspeaker systems. A Levinson ML-9 amplifier, rated conservatively at 100 watts per channel into 8 ohms, was used for sonic comparisons. Both amplifiers under test were evaluated in a biwired arrangement when connected to the Snells, using four lengths of Monster Cable. Clark's system consisted of a Technics SL-P1200 CD player, a Hafler DH-101 preamplifier, and Magnepan MG-IIIa speakers.

Subjective comments by both authors were similar, despite the differences between their systems. Greenhill, using orchestral and organ records, was struck by the extended dynamic range, the lack of "typical solid-state" midrange grain, and the strengthened bass response and detailing. The Snells' sound stage was widened and deepened. The organ recordings, which sounded somewhat aggressive and brittle with the ML-9, became far more balanced, less bright, and more listenable with the No. 20s. Transient information was far more apparent, as heard on the sharp attack of bass-drum notes. The Quad ESL-63 is not a loudspeaker renowned for its bass response. Yet Greenhill's pair, when driven by the No. 20s, were able to deliver impressively deep bass, as evidenced by a surprisingly solid 30-Hz pedal note in the "Also Sprach Zarathustra" reprise on the Telarc *Time Warp* CD. Even so, the No. 20s' subjective sonic superiority seemed more pronounced with the dynamic loudspeakers than with the Quad electrostatic speakers.

Clark's listening experience with the No. 20s driving Magnepan MG-IIIa speakers was also rewarding. He was surprised at how loudly the systems would play; the amplifiers reached levels subjectively comparable to those reached with the much more powerful amplifiers on hand. This may be due in part to the clean waveform clipping of the No. 20s when they are overdriven, which lets one turn the volume up louder before distortion becomes audible.

These sonic impressions were created by the No. 20s in unstructured listening tests, but would they sound different from other good amplifiers under double-blind conditions? Clark connected a comparator from ABX to select either the outputs of the No. 20s or the outputs of another amplifier, a Fender 2235 stereo unit. Inputs to all the amplifiers were driven at all times; this was observed to cause no input distortion or other problem for any of the amps. After checking polarities and matching gain settings, Clark was joined by a friend for an afternoon of listening. Music included selections of Bach organ music, cuts from Philip Glass' *Liquid Days*, and the Mannheim Steamroller *Christmas Album*. Clark identified the correct amplifier on nine out of 16 tries, and the audiophile friend did so seven out of 16 times. Greenhill, comparing the No. 20s to a Levinson ML-9, got seven out of 16 correct IDs with the Snell loudspeakers and eight out of 16 using the Quads. Since a 50% score is the most expected outcome if there is no audible difference between amplifiers, we have to conclude that our scores, hovering around the 50% mark, are likely to be due to chance.

Recognizing that the controlled tests had failed to correctly identify the No. 20s, Greenhill continued to audition these amplifiers in his home system. His impressions in open listening tests remained the same. He preferred the No. 20s' sound via the Snells, Dahlquists, and Quads to that of the other amplifier in the room. Extended dynamics, bass power, high-frequency extension, transient speed, and soundstage depth were heard on recording after recording—and all over the listening room, not just in the "sweet spot" in front of the loudspeakers. A single pair of No. 20s delivered outstanding transient speed, control of deep bass response, and a lack of midrange grain; this was a vast subjective improvement over Greenhill's biamped system heard on the Snells. The two high-quality, 100-watt/channel, solid-state stereo amplifiers (driven through a Snell EC-2 electronic crossover) in Greenhill's reference setup seemed brighter, harsher, and more fatiguing. This biamped stereo setup just didn't match the subjective smoothness delivered by the No. 20s.

The No. 20s make a strong statement about audio amplifier design. At present, we know of no other design with dual-mono power-supply rails and with regulation of the output-stage power supply. These hefty, finned black beauties are among the most expensive amplifiers on the market today. For their lofty price tag, we believe them to be superior to any other home amplifier now available in terms of ruggedness, sophistication of protection circuity, and the ability to handle the toughest loads when powered from the worst a.c. lines. Clark, for one, believes the multiple double-blind test sessions show that, given a good 120-V a.c. source, one could find similar sonic pleasures with a lesser, but reasonably made, amplifier. Greenhill, on the other hand, has yet to hear any amplifier that sounds as good as a pair of Mark Levinson No. 20s.

Laurence L. Greenhill and David L. Clark

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For years you've relied on Yamaha to faithfully reproduce the vibrancy and clarity of your music.

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The powerful new video-enhancing circuitry restores clarity and sharpness to even the weakest, noisiest video signal. So any prerecorded tape looks network crisp.

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You'll have a hard time telling the dub from the original.

While you're at it, experiment with the new video Rec Out Selector feature. Use it to mix your video with different audio sources to create original music backgrounds and sound effects.

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Next, take the most musically demanding CD, crank open the 125 watt/channel* amplifier, and listen to what's missing.

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It's not there because the RX-1100U boasts our new Absolute Linear Amplification (ALA) circuitry.

This advanced amplifier technology injects a mirror image of the output distortion back into the input stage. The distortion component drops virtually to zero.

What's more, this receiver has plenty of headroom—up to 360 watts/channel into a 2 ohm load—so it's never cramped by the wider dynamic range and varying speaker impedances associated with digital sources.

Now, walk to the other side of the room, where you can appreciate the new RS interactive remote control to its fullest.

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Because when you want to know what's new in top performing equipment, we've always been the ones to listen to.

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*125 watts RMS per channel, both channels driven into 8 ohms, from 20 to 20,000 Hz, at no more than 0.015% Total Harmonic Distortion.

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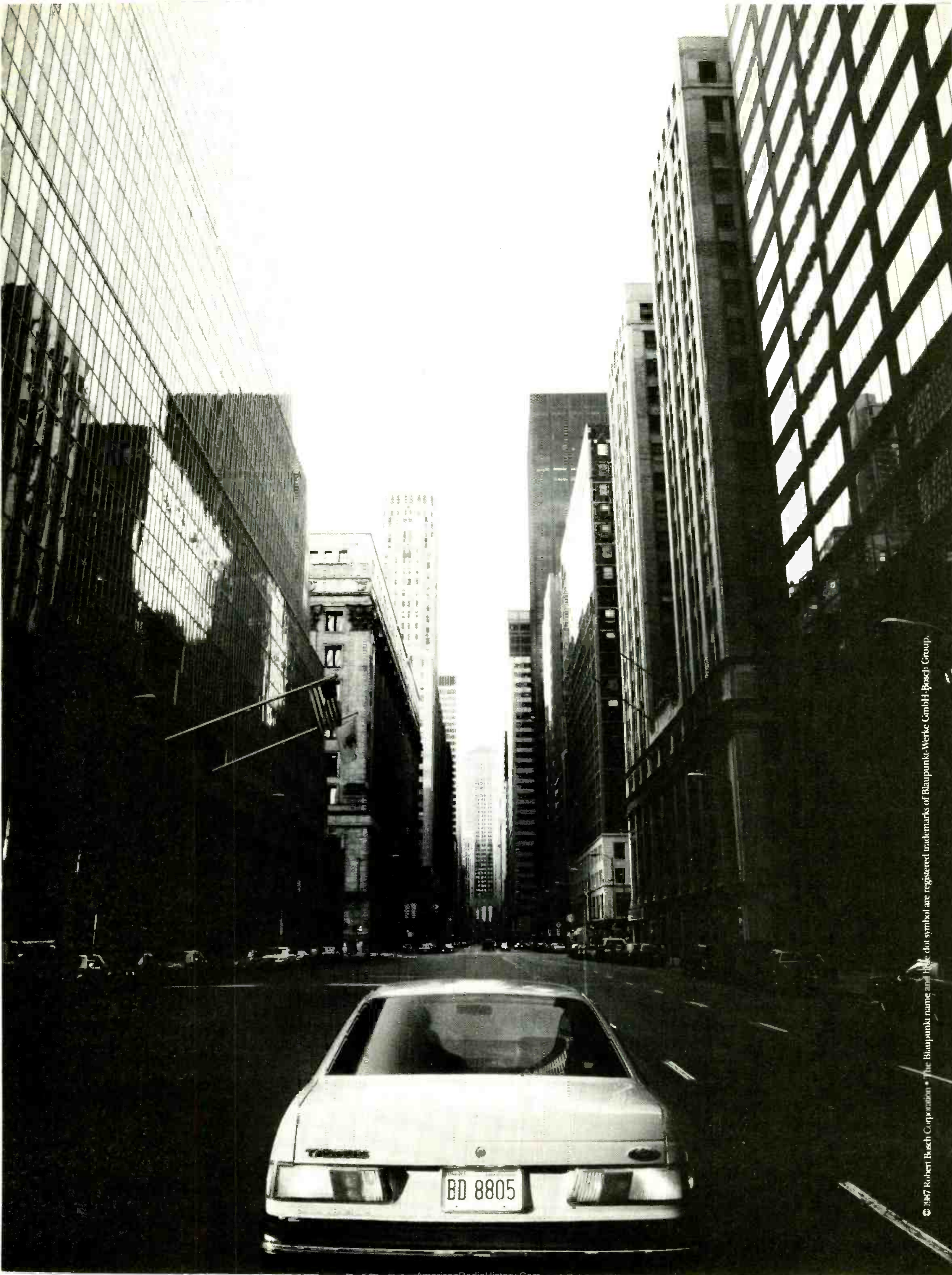
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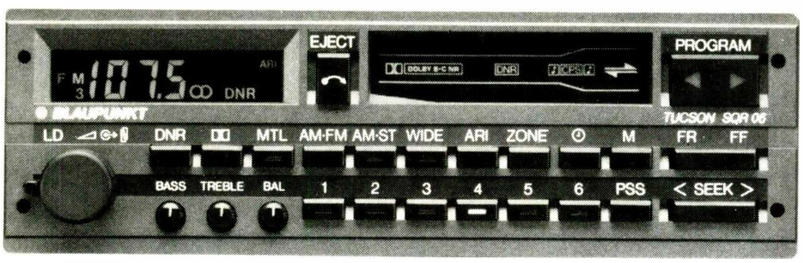
After the mountains of Europe, the canyons of North America pose no problem for a Blaupunkt.

For a Blaupunkt car stereo, the radio reception difficulties created by big city buildings are no big deal.

Because ever since the first



Blaupunkt was introduced in 1932, our tuners have had to overcome much bigger obstacles.

The Alps.

The Pyrenees.

The Apennines.

These European mountain ranges make even the towering headquarters of modern mega-corporations appear puny by contrast.

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You see, a car stereo's ability to capture an FM radio signal is determined by five factors: FM sensitivity. Selectivity. Multi-path distortion. Signal attenuation. And RF intermodulation.

Most car stereo systems do a reasonably good job with two—perhaps three—of these factors.

But due to the persistence of our engineers—and the dozens of patents we've earned in this area alone—Blaupunkt's CODEM III and ORC II dynamic tuning systems do exceptionally well in all five areas.

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What you hear will be music to your ears.

Without all the static you've been accustomed to.

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2

MISSION PCM-7000 COMPACT DISC PLAYER

Manufacturer's Specifications

Frequency Response: 20 Hz to 20 kHz.

THD: 0.003% at 0 dB, 0.008% at −10 dB.

CCIF IM: 0.002% at 0 dB, 0.003% at −10 dB (19- and 20-kHz signals).

S/N: 96 dB.

Channel Separation: 90 dB.

Channel Balance: ±0.2 dB.

Disc Fault Correction: 900 microns for faults in data layer.

Mean Track-Access Time: Less than 2 S.

Range of Electronic Volume Control: 0 to −63 dB.

Output Level: 2.0 V rms at 1 kHz, 0-dB level.

Dimensions: 16 15/16 in. W × 3 5/16 in. H × 11 13/16 in. D (43 cm × 8.5 cm × 30 cm).

Weight: 11 lbs. (5 kg).

Price: $999.

Company Address: 5985 Atlantic Dr., Unit 6, Mississauga, Ont., Canada L4W 1S4.

For literature, circle No. 91

As is true of so many CD players manufactured in Europe, this latest Mission unit—by far the best player the U.K.-based company has offered thus far—is based upon a Philips transport and digital-to-analog conversion. Its performance and features are not entirely unlike those of the highly regarded Magnavox CDB650 player (which I evaluated in the March 1987 issue), but this is not just a repackaged Philips unit. Since Mission builds its own chassis, there are visible differences in cosmetics, control layout, and the display. By far the greatest differences, however, lie in Mission's proprietary implementation of the analog filter and output sections, as well as their error-correction logic algorithm. The Mission PCM-7000 is also one of the new breed of players that employs true 16-bit, four-times oversampling. Digital-to-analog conversion is accomplished by means of a twin converter on a selected single chip, which exhibits extremely linear performance.

Mission's experience with high-quality amplifier and preamplifier design has stood them in good stead here in the areas of circuit philosophy and layout, grounding techniques, and component selection. The digital filters used in the PCM-7000 are said to have an audio-band amplitude response that is accurate to within 0.02 dB, phase response accurate to within 0.5°, and out-of-band rejection of more than 60 dB. Equal attention has been given to the design of the analog filters which follow D/A conversion. Thanks to the high oversampling rate, this filter is able to maintain the signal's phase integrity within the audio band while at the same time improving out-of-band spurious rejection. I suspect that this model may originally have had two sets of analog outputs, fixed and variable. A note included with my sample indicated that the fixed outputs had been removed "in the interest of sound quality." I'm not sure exactly how removing fixed outputs improves sound quality, but this

The player's ergonomics are well executed, and a full-function display lets the user know exactly what is happening at all times.

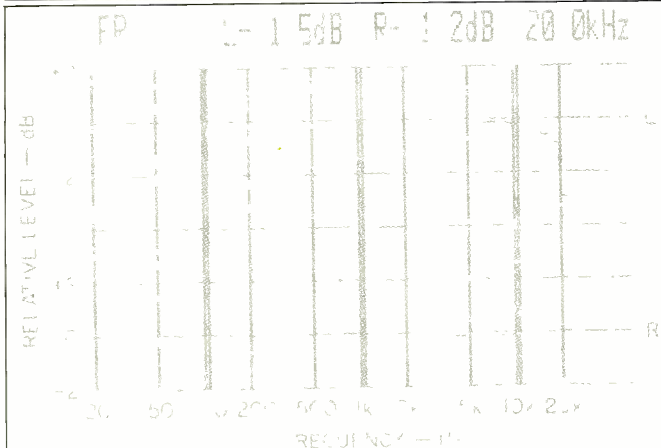

Fig. 1—Frequency response, left (top) and right channels.

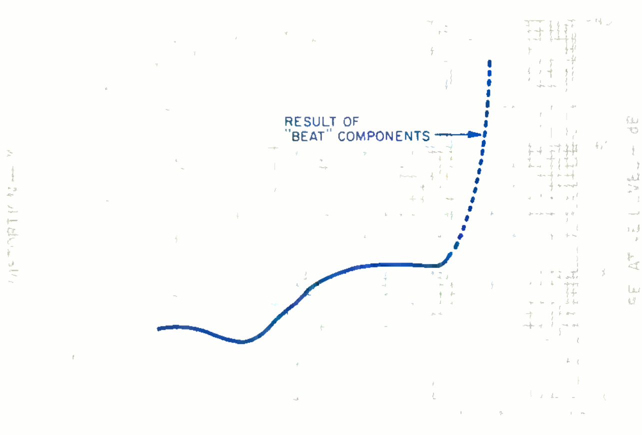

Fig. 2—THD vs. frequency at 0-dB recorded level. Dashed portion of line shows out-of-band "beat" components rather than true distortion.

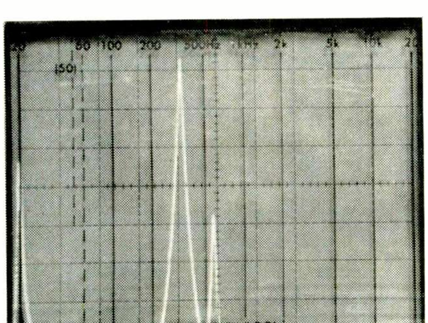

Fig. 3—Spectrum analysis of reproduced 20-kHz test signal from 0 Hz to 50 kHz.

much I did discover: The variable outputs can be controlled only by the supplied remote. This control alters output level in 1-dB steps from 0 (maximum output level) to −63 dB. Furthermore, the variable outputs have a rather unusual frequency response characteristic which I'll say more about presently. (Hint: Notice the absence of any tolerance given with the manufacturer's stated frequency response!)

The drive mechanism of the PCM-7000 is well isolated from the main chassis. The subchassis is injection-molded from nonresonant material. Nonetheless, Mission recommends that users add the Mission Isoplat supporting platform for further isolation of the mechanism from external vibration. I did not use this extra platform during my evaluation, thinking that I should do "worst-case" tests.

As for convenience features, the PCM-7000 allows programming of up to 20 selections on a disc in any order. Programming to a specific index point is also possible; this cuts down on the actual number of selections that can be programmed, since index programming also requires one memory slot for the track number. The laser pickup can be made to skip forward to the next track or back to the previous track; to search in fast-forward and reverse, and to repeat a track, an entire disc, a phrase, or a program.

Aside from the fact that the major operating keys have black-on-black symbols which are a bit hard to read in subdued light, the player's ergonomics are well executed. A full-function, fully interactive display lets the user know exactly what's happening during play and programming. The remote control (which distinguishes the PCM-7000 from the less costly PCM-4000) adds to the versatility of the unit and operates the electronic level control described above. (The PCM-7000 also differs from the PCM-4000 in having four independent power supplies rather than two, and in being equipped with special nonmagnetic jacks.)

Control Layout

The power on/off key is at the extreme left end of the panel, below and just to the left of the disc drawer. A row of six major operating controls on the lower right side, below the large display area, is angled nicely upward; this compensates somewhat for the hard-to-read designations, which are similar to the transport symbols used on cassette decks. This row includes an open/close button; a stop button (which also clears any program that may have been memorized), and pause, play, reverse-search, and forward-search buttons. Four smaller keys above this row are used to call up desired tracks and index points (either for immediate play or for programming) and to toggle the time display from elapsed time to total or remaining disc time. Three more keys, arranged in a vertical row near the right edge of the front panel, are used to store or recall programs and to repeat a whole disc or a section of it.

The fluorescent display is essentially divided into two sections. One contains illuminated legends that correspond to the key functions in use, and the other indicates status and real-time information such as track and index numbers; elapsed and remaining time; program storage, and play, search, and pause modes. Error lights tell you if you have improperly inserted a disc, inserted a faulty disc, or made a mistake in track or index selection.

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I measured a relatively high attenuation at 20 kHz and suspect Mission has allowed the analog filters to roll off the high end.

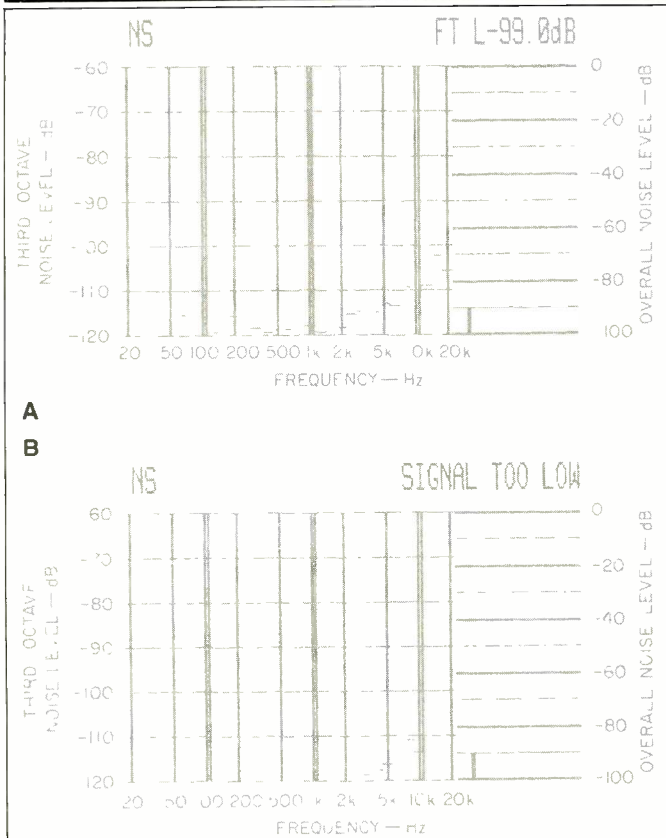

Fig. 4—S/N analysis, both unweighted (A) and A-weighted (B).

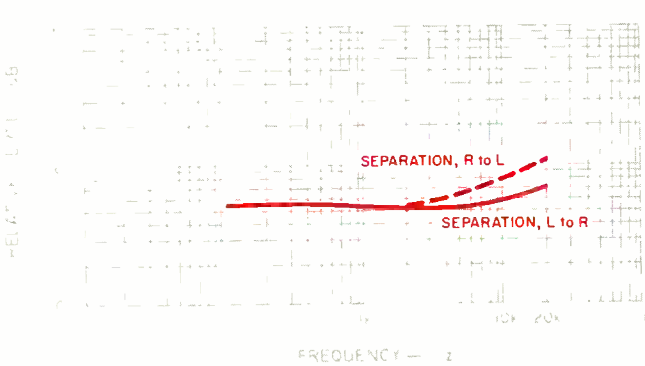

Fig. 5—Separation vs. frequency.

The rear panel is supplied with the pair of variable outputs mentioned earlier. (It was quite obvious, in my sample, that a secondary pair of fixed outputs had been covered over.) In addition, there is a digital output. This, according to Mission, "will allow direct recording, without degradation on a digital tape. . .once the digital tape medium is introduced on a wide basis for consumer use—subject to legal requirements." (This ignores the very strenuous objections which the software manufacturers are putting up, not to mention the fact that the sampling rate for DAT is different from that for CD. However, even if the sampling rates were the same, some sort of interface device would be necessary—beyond the digital output jack on the CD player and digital input jack on the DAT recorder—since the formats of the information "blocks" of the two systems are quite different.) A detachable power cord is supplied with the PCM-7000, making the unit easily adaptable to different types of receptacles used in different countries. The detachable line cord is intended to serve another purpose, I was told by one of the people at Mission. It enables a user to try both polarities of the a.c. plug to determine which sounds best. This, plus choosing the better of two possible connections for each of the audio cables supplied with the unit, is supposed to yield *instantly discernible improvements* in overall sound quality, improvements which "anyone" can hear. I'll have more to say about *that* too.

Measurements

Figure 1 shows the frequency response obtained at the output of each channel when playing back a swept-frequency test signal from below 20 Hz to above 20 kHz. At 20 kHz, I measured a relatively high attenuation from reference level of 1.5 dB on the left channel and 1.2 dB on the right. I suspect that Mission has allowed their analog filters to roll off the high end slightly in order to overcome some listeners' objections to the "harshness" attributed to some discs. The roll-off begins at around 10 kHz, which may explain why Mission's literature quotes frequency response as extending from 20 Hz to 20 kHz but doesn't append a tolerance to that specification. Harmonic distortion at 0-dB (maximum) recorded level was as low as claimed (0.003%) at around 250 Hz, but tended to rise somewhat at higher frequencies, as shown in Fig. 2. The dashed portion of the curve, above 10 kHz, is not a true measure of harmonic distortion, but rather denotes the increased influence of out-of-band "beats," one of which is clearly evident in the spectrum analysis photo of Fig. 3. For this test I played a 20-kHz tone and ran the output of the CD player into a spectrum analyzer, sweeping the analyzer in a linear fashion from 0 Hz to 50 kHz.

Unweighted signal-to-noise ratio, analyzed in Fig. 4A, measured an exceptionally high 99.0 dB. When an A-weighting network was added in the measurement path, S/N increased to values that were actually too high for my instrumentation to record, as indicated in Fig. 4B.

Dynamic range, not specified by Mission, was a very high 114.0 dB. As in earlier tests, dynamic range is calculated by adding the THD for a −60 dB signal (expressed in dB rather than as a percentage) to 60 dB. With the PCM-7000, THD for a 1-kHz test signal at −60 dB measured 0.2%, corresponding to −54.0 dB below the test-signal level. So,

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MICHAEL TEARSON
JON & SALLY TIVEN

LOS IS MORE

By the Light of the Moon: Los Lobos
Slash 25523.

Sound: B — Performance: A

The latest from Los Lobos, *By the Light of the Moon*, is musical eclecticism at its best. On it can be found the rhythms and melodies of R & B, rock, gospel, Mexican-American and New Orleans music, and it all combines to produce a great, original package.

Many of the songs on *By the Light of the Moon* are about people living the tough life in America, people poor in means but rich in dreams, who pray that not every dream will remain unfulfilled. The stories get their vividness from the excellent lyrics and melodies set down by the two principal writers, David Hidalgo and Louie Perez. They are able to say more about life in America in four minutes than most songwriters are able to say in 40. In fact, in "One Time, One Night," they tell *several* stories at once, convincingly.

A third band member, guitarist/vocalist Cesar Rosas, writes in a more self-indulgent fashion, not sharing his stories so much as recounting them. His "Shakin' Shakin' Shakes" (written with T-Bone Burnett, who shares producing credits with the band), "Set Me Free (Rosa Lee)," and "My Baby's Gone" are of the bop-'n'-boogie school. At first, their contrast to the other songs was annoying, but on repeated listenings I found that the material does hang together as a whole. The songwriting differences and the careful attention to the order of the cuts give the feeling of being at a live concert each time the album is played.

There is no fat in the arrangements and few frills in the recording of the instruments. Los Lobos, Burnett, and recording engineer Larry Hirsch worked to present an album that features the great, classic sound of Fender solid-body guitar, with apparently minimal overdubbing. The final sound quality is very good, with little vinyl noise and plenty of punch.

Los Lobos have stepped into an elite class of songwriters with the release of *By the Light of the Moon*. I would like to hear more traditional Spanish songs on their albums (here there is only one, "Prenda Del Alma"), but if that means hearing fewer new originals, then I accept the trade-off without a whimper. As with Los Lobos' previous release, *How Will the Wolf Survive?*, *By the Light of the Moon* is a must-have album. Hear its messages and enjoy its music.

Hector G. La Torre

Safety in Numbers: David Van Tieghem
Private Music 2015-1-P.

Sound: B– — Performance: B–

It makes sense that percussionist David Van Tieghem's music evokes large, graceful arcs of movement rather than short, jerky steps: He's worked extensively with choreographers including Twyla Tharp, and, in fact, four compositions on this album were derived from his scores for ballets. What is amazing is just *how* Van Tieghem creates these sweeping waves from a dense, complex collection of sounds. He employs not only a bank of synthesizers and traditional percussion instruments, but many offbeat objects as well. Metal ashtrays, plastic milk bottle, jingle ball toy, plastic mailing tube, soda cans, hose, lamp parts, and scrap metal all get a mention on the cover of *Safety in Numbers*.

Most of the nine songs float along with a hip kind of grandeur—panoramas already painted by Tangerine Dream, Tomita, and Vangelis. Only one, "Night of the Cold Noses," which features Tony Levin on Chapman stick, gives us the kind of bouncy funk Van Tieghem came up with when he performed with Talking Heads.

I wish the percussion had been mixed closer to the front of the sound stage on all cuts. It deserves to be more distinguishable, and little purpose is served when it's obscured by a translucent layer of synthesizers. It's also unfortunate that at times Van Tieghem relies too heavily on sequencers; a kind of cold monotony creeps in. This effect, useful in some contexts, seems incredibly out of place with a man who, in earlier efforts, has pumped life into music with his bare hands. It makes me wonder if perhaps the title of the album should be pronounced with a silent "b."

Susan Borey

Dave Edmunds' live album of Brit-hits and '50s faves has little of the punch he packs in his studio work.

About Me," followed by the almost giddy "All Mixed Up," a moody "Self Made Man," a vintage Petty off-hand rocker in "Ain't Love Strange," the even more casual "How Many More Days," and the title song, rife with subtle echoes of The Rolling Stones' "Gimme Shelter."

Several songs begin with a fade up, which adds to the album's informal feel. It sounds like Petty and the boys whipped this one up in quick fashion, one song right after another. They recorded live in the studio, with overdubs used only to flesh out a couple of tracks. The finished sound is appropriately lively; I prefer the thinner but harder edged LP to the cassette version, which is boomy by comparison.

Let Me Up (I've Had Enough) has Tom Petty & The Heartbreakers doing what they do best: Playing smart, lean, compact rock with great verve and energy. Clearly, they are one of the hottest bands on the boards right now.

Michael Tearson

I Hear You Rockin': The Dave Edmunds Band
Columbia C 40603.

Sound: B – Performance: B –

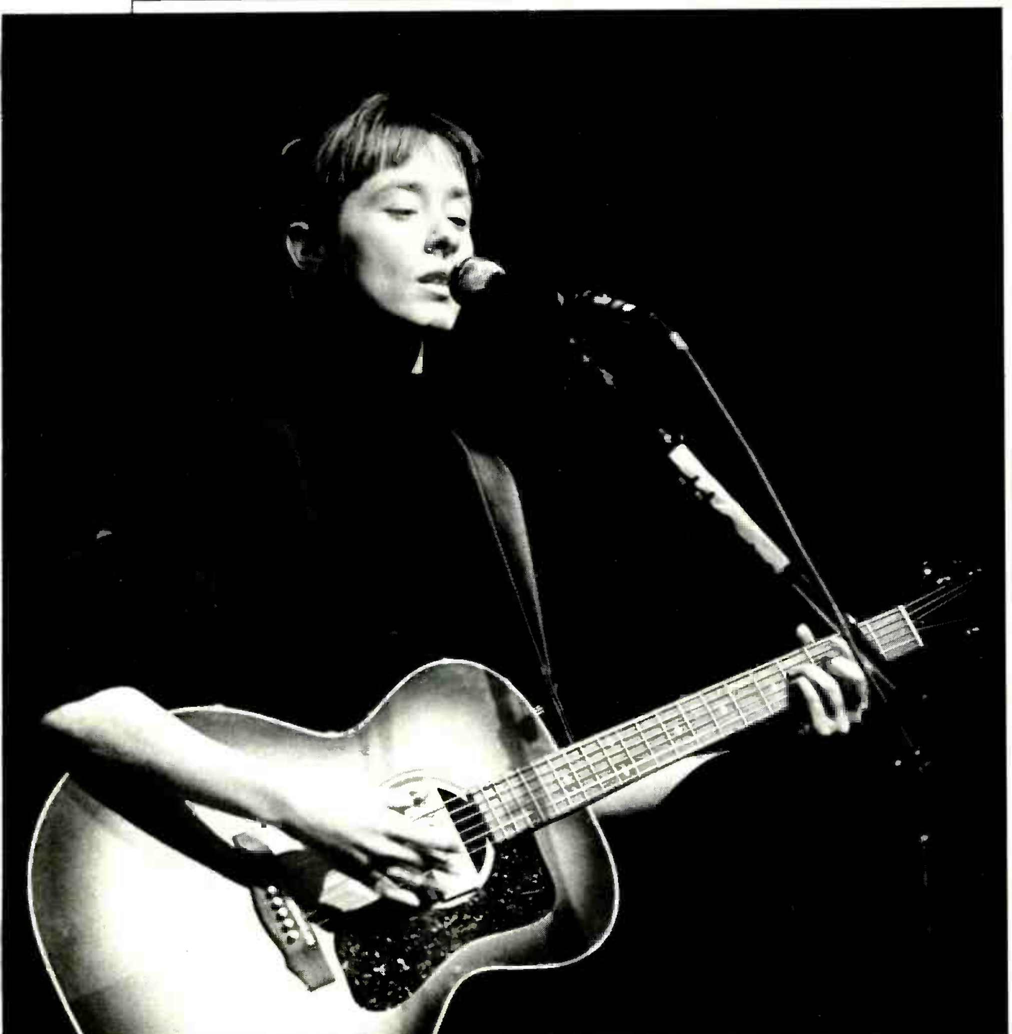
Dave Edmunds, whose rootsy passions have given us some of the jauntiest pop-rock on record, chops himself off at the Gibson on this album of old-time rock for old-time rockers.

I don't understand how or why, since he produced it himself, but this live album of Brit-hits and '50s faves has little of the punch Edmunds packs in his studio work. He's pushed his own voice way off into the background, and so the swirling guitar work and Fats Domino-style piano runs have no center. The last time I was so disappointed by an album was when Edmunds' and Nick Lowe's Rockpile released their inexplicable dud *Seconds of Pleasure*. At least he's consistent.

Dave Edmunds the musician is unpretentious and good-timey, but Edmunds the producer takes away the music's raucous rawness in favor of slickness. In any case, rockabilly fans get "Here Comes the Weekend" and "Queen of Hearts." Dion nostalgists get "The Wanderer." And of course there's the patented power-pop of "Girls Talk," "Crawling from the Wreckage," and "Ju Ju Man," among other Edmunds singles. It's all bright and twangy and energetic, but also completely straight-faced, un-updated and un-ironic.

It's a party mix, no doubt, but mostly for people who lived through hula hoops and tail fins. Didn't we already do '50s nostalgia? *Frank Lovece*

MEGA VEGA



Photograph: ©1987, Ebet Roberts

Solitude Standing: Suzanne Vega
A&M CD-5136.

Sound: A Performance: A+

Solitude Standing is a brilliant and brilliantly made album, one on which a young artist not only fulfills early promise but demonstrates growth which is downright startling.

On her debut album, Suzanne Vega sounded tentative and almost shy among the light, airy, mostly acoustic settings, but her songwriting was already uncommonly skilled. Encouraged in no small amount by the surprise success of the debut plus two years of touring with a band, Vega's reach has extended quite a bit. So, too, has her grasp.

Suzanne's performance shows confidence and strength that elevate her work by a quantum leap. This is evident from the first as she nervily opens with the a cappella "Tom's Diner," a sharply drawn New York City slice of life. "Luka" is next, a scary portrait of a nine-year-old boy whose parents abuse him. "They only hit until you cry/ And after that you don't ask why," he says. "Ironbound/Fancy Poultry" is another vivid cinematic picture, of the Newark, N.J. marketplace "where the Portuguese women come to see what you sell." "In the Eye" and "Night Vision" are superb examples of Vega's poetic skill and uncanny sense of detail. So, too, is the title song, an internal dialogue about what it feels like to live alone, a curious and heady mix of courage and fear.

"Calypso" and "Gypsy" date from 1978; their inclusion offers us a chance to chart the artistic growth of the songwriter. Each sounds like the product of a much more youthful writer; in them there is a real naiveté that darkened and deepened later on.

As with the debut, Steve Addabbo and Lenny Kaye are the producers. What they have wrought here is a much more full-bodied and gutsy sounding record than the first. Still, it remains uncluttered, unhurried, and very spacious. The instruments sound wonderfully natural, and Vega's voice—as much an instrument as a carrier of lyrics—is treated beautifully. The LP sound is uncommonly good for vinyl, but the CD is by far the better showcase for *Solitude Standing*. One of the producers told me that the equalization settings were specifically chosen to optimize CD playback; the result is a digital sound as warm as I've ever heard on a popular recording. A salute should go to CD mastering engineer Stephan Marcussan for his outstanding work.

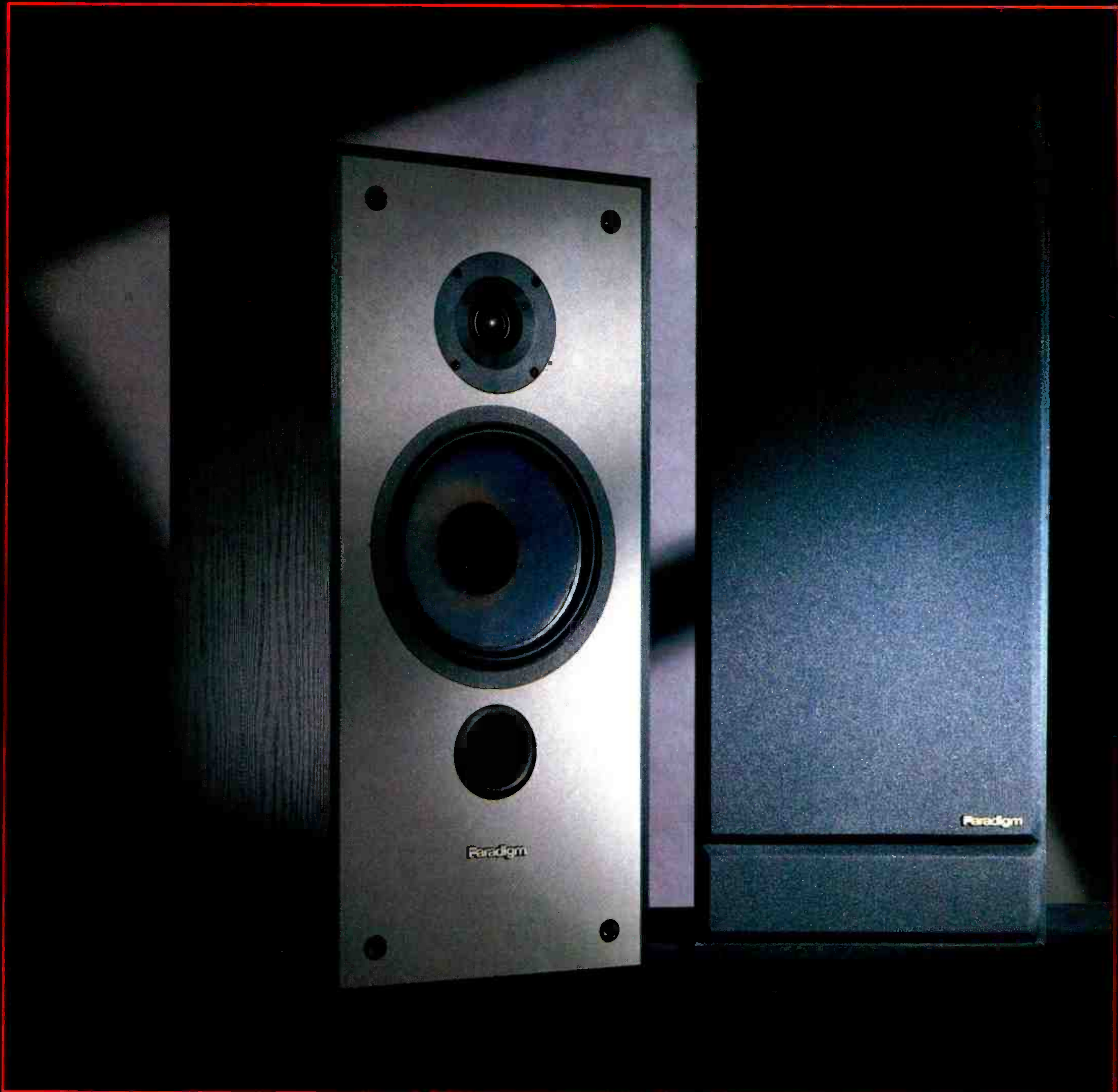
Solitude Standing certainly contains some very demanding, sometimes difficult material, but it is fully realized and sure, nonetheless. Suzanne Vega and her fine band have created a fascinating body of songs that don't sound like anything else around. With her hard-won confidence, Suzanne has opened up her musical and poetic horizons. Now the possibilities are boundless. *Michael Tearson*

Dvořák: Symphony No. 7 in D Minor.
Czech Philharmonic Orchestra, Vaclav Neumann.
Supraphon C37-7704.

Well, it may be Supraphon, the longtime major Czech record label, but the copyright is Nippon Columbia, alias Denon. I assume that Denon did the digital recording, back in 1981 in Prague. As far as I am concerned, it is a Denon CD, all-digital (DDD), produced in Japan.

I recently visited Avery Fisher Hall in New York to hear this very ensemble play precisely these same notes. The living performance of the music was absolutely superb, no two ways about it, a true reflection of the long Western tradition of music in Czechoslovakia.

. . . . remarkable!



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I found this Dvořák disc slightly less convincing than the live performance I attended, but it is still a remarkable recording.

Interesting comparison—state-of-the-art live music versus digital recording. Yes, between the two I could recognize the same musical characteristics, even though the recording was made some six years ago and the live performance was recent. But I found the disc slightly less convincing, if by only a few hairs. I wonder why. Perhaps it is because a recording does not duplicate the sights, the social situation, the whole ambience of a live performance, nor will it ever, even with video to help. The music, never forget, was intended for a live concert! That is its normal and true medium; we are translators, adapting to a different medium altogether. It is wonder enough, as always, that we come up with a useful and enjoyable recording. Digital perfection simply gives us more to work with in this translation.

So—if it were not for the live performance, I would have thought this a remarkable recording, musically on a par with the greatest, technically the latest and best. You may safely think so. *Edward Tatnall Canby*

Schubert: Winterreise, D.911; Piano Sonata No. 15 in C, D.840. Sviatoslav Richter, piano; Peter Schreier, tenor.
Philips 416 289-2, two-disc set.

The Compact Disc has brought with it an astonishing flood of lengthy "albums"—if we may use the ancient term that was first applied to housed collections of 78-rpm records a half-century ago. No, it is not merely the economy of space that has caused these mini-monsters to appear so widely. Indexing is really the key.

These Schubert songs, assembled in "Winterreise" in a long and deliberately continuous cycle by the composer, were first recorded one by one on the sides of innumerable 10- or 12-inch 78s, with two or three per side and no visible dividers, for the most part. You could not play the series unbroken, as intended in performance; you had to change sides every few moments. Nor could you isolate individual songs, unless at the beginnings of sides or by the painful hunt-and-peck method. The banding on LPs was a big step forward for such music. But as technology advanced, "spotting" individual bands became progressively more difficult by hand, and even worse when the stylus was taken out of our clumsy fingers in favor of indirect manipulation.

But on CD, in an instant you can play any one of these many songs, to taste. Or you can listen to the whole cycle with just one break (the complete cycle being too long for one disc, as Philips has spaced things). Or you may start right off with the big piano sonata in the middle of the second disc—or, for that matter, with any one of the sonata's constituent parts.

Richter and Schreier are distinguished collaborators on the concert stage and these, significantly, are live performances—a far more important factor than the analog original for one and the (later) digital recording for the other. The songs were composed basically for Schubert's own modest baritone in relatively intimate surroundings. Peter Schreier sings (and Richter plays), instead, in vast halls and for enormous audiences. That means a powerful sound such as was unimaginable for Schubert. Yes, the mikes and audio equipment can cope with it, but can *you*? We are too close to the powerhouse vocal sound (the piano is more adaptable) in these recordings, and the listening is not easy when the great singer lets loose with full force, to fill the hall. Yes, Schreier offers fine interpretations, profound and dramatic, with the piano going along in artistic sync. But it's not good for recordings, especially of live performances. Be warned.

By the way, you may wonder why the sonata suddenly trickles off to a stop in the last movement, as if the power for the amplifiers had faded away. No such thing. Schubert didn't finish the piece, and Richter plays the notes exactly as Schubert left them.

Edward Tatnall Canby

Help!: The Beatles
Capitol CDP 46439.
Sound: A Performance: A

Rubber Soul: The Beatles
Capitol CDP 46440.
Sound: A Performance: A–

Revolver: The Beatles
Capitol CDP 46441.
Sound: A Performance: A+

It's time to get nostalgic again with *Help!*, *Rubber Soul*, and *Revolver* now on CD . . . and in stereo! What's notable about this event, of course, is the way the dramatically enhanced sound sheds entirely new light (laser sharp, of course) on these classic recordings.

First of all, the CD's extended frequency response and dynamic range greatly exaggerate the drama of the fairly wide stereo separation, especially on the more simply produced *Help!* and *Rubber Soul*. The original LPs


The Beatles with George Martin, circa 1963.

The space on the latest Beatles CDs is subtly rearranged: It's as if you are there in the studio, right at mike position.

have the same production values, but sonic compression lessens their overall impact. The broader sound spectrum also has the initially startling effect of adding a clarity which is almost strident, particularly on the highs of Harrison's guitar parts. You'll find, too, that the space has been subtly rearranged to place you right at microphone position, where you can hear everything that's going on as if you were there (Ringo singing in the background, new-found details of The Beatles' slightly "off" vocal harmonies, and plenty more).

Of the three recordings, *Rubber Soul* (1965) is revealed as the most rudimentary, and the CD's clarity is least flattering to its cruder production values. *Help!* (1965)—the British version, without the orchestral overlays that American consumers were subjected to—shows The Beatles in transition from rough rockabilly to the more progressive strains of "Yesterday." And then there's *Revolver* (1966), with its more sophisticated production ("Yellow Submarine") and experimental instrumentation ("Love to You," whose sitar calls for sandalwood incense). *Sgt. Pepper* (1967) is remembered as the revolutionary "concept" album, but *Revolver* is where the true genius of The Beatles began to shine. It's the record that turned them on the road to transcendence.

If you fondly remember The Beatles and still don't have a CD player, go buy one today, just so you can hear these discs. *Michael Wright*

Editor's Note: As we go to press, *Sgt. Pepper* has just been released, and I note that it has indeed been 20 years ago . . .—*E.P.*

Benda/Quantz/Frederick the Great: The Flute at the Court of Frederick the Great. Ensemble Orchestral de Paris, Jean-Pierre Wallez; Jean-Pierre Rampal, flute.
CBS MK 39702.

This is, of course, a solo celebrity record, but as such it comes off remarkably well for the general music listener. Only a certain loudness and nearness of the solo flute and a certain too-longness in the flute cadenzas gives the celebrity show away. I'd still call it a valuable recording, on any basis.

King Frederick's astonishing musical establishment, set up as a kind of everyday music salon, with gourmet luncheons and suppers and a plethora of flute music—thousands of works—was in violent contrast to his "boorish" father's establishment. You must have seen the pictures, the gorgeous music room, the handsomely dressed males in their white wigs, the sumptuous chairs and couches occupied by the ladies in enormously wide dresses, everyone looking pensive—as one should while hearing music! "Old Bach," J.S. Bach, came there to per-


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Mendelssohn's organ works are played on an instrument that has thunderous pedals, brilliant reeds, and a very lovely flute stop.

form, his son being chief keyboard accompanist to the King.

These are highly styled pre-Mozart works, sounding much the same in their gallant fashion, all frills and fancy work but with more than a bit of passion too, as here performed by an enthusiastic French orchestra and the well-known Rampal—whose flute just barely keeps up with the high-speed figurations in the flute parts. They could play in those days, and without benifit of all the fancy keys on Rampal's modern instrument.

Quantz was a celebrated flute specialist and Frederick's teacher, as well as composer of enormous quantities of music, mostly for the King. Brenda, a Czech, was the King's first violin and accompanied him for an estimated 10,000 performances, so say the notes with this disc. It was a factory, new music every day, and all sounding the same, more or less—but they never tired. Even Frederick himself tried composing and didn't do too badly, as evidenced by the slow movement included here. Could *you* write music as skillfully? Have to hand it to him.

Sonically, there's nothing especially spectacular about this one, but I still prefer the CD version by far to the alternative formats, not only for sound (and for silence when needed) but for the ease of play and the handy indexing.

Edward Tatnall Canby

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London/Argo 414 420-2.

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The cathedral has a comparatively short 3.5-S reverb period, so all the pipes are reproduced with fine articulation. The organ has some really brilliant reeds and a very lovely flute stop. Everything is so clean and well defined that you can hear initial "chiff" sounds from the pipes, much as they are heard on tracker-action organs. Without question this is one of the best organ recordings on Compact Disc.

Bert Whyte

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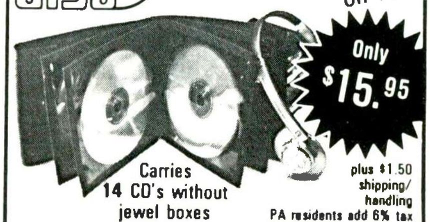

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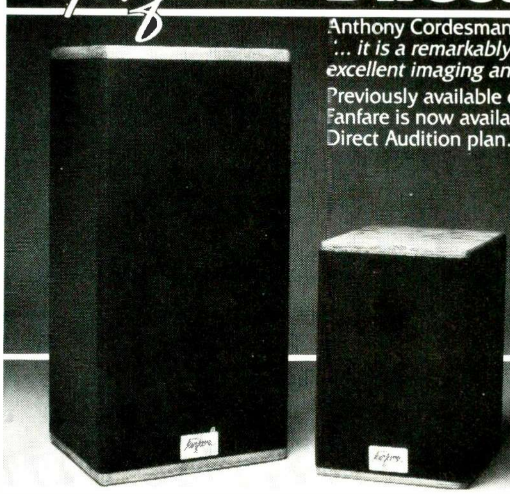

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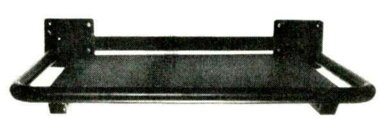

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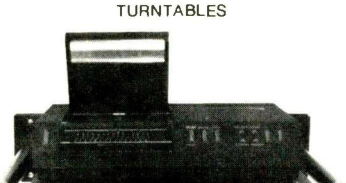

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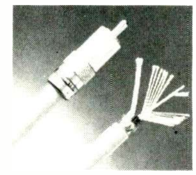

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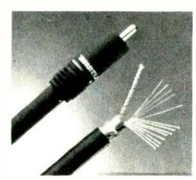

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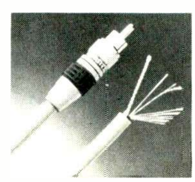

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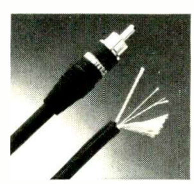

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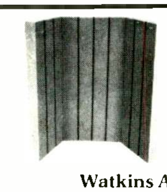

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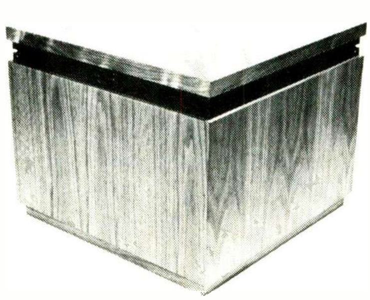

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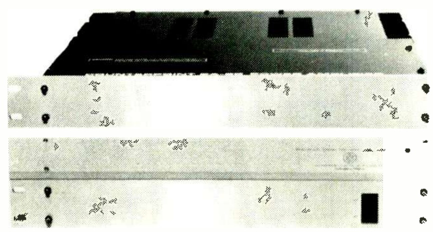

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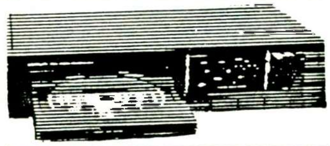

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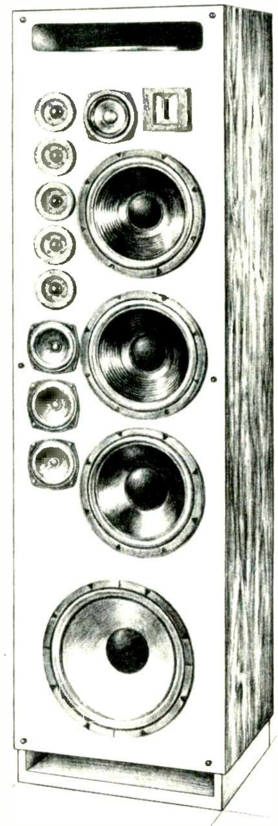

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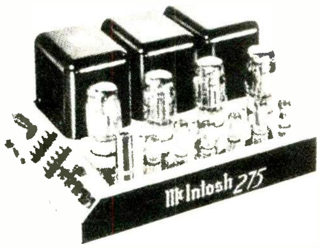

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AD INDEX

Firm (Reader Service No.)	Page
Adcom (1)	81
Audio Research (2)	92
Audiophile Systems (3)	98
AudioStream (4)	95
B & W (5)	67
Blaupunkt (6)	78 & 79
Boston Acoustics	37, 39
Bridgestone	87
Bryston (7)	91
Carver (8)	14 & 15
Chrysler Conquest	7
Columbia House	11
Concord (9)	75
Coustic (10)	13
Discwasher (11)	71
Dodge Dakota	59
Dunlop	33
Ford Thunderbird	34 & 35
Fostex (12)	93
Intersound (13)	96
Jensen (14)	29
Kenwood (15)	83
Lincoln Mercury Tracer	25
Luxman (16)	22 & 23
McIntosh (17)	89
Nakamichi	3
Onkyo (18, 19, 20)	19, 21, 85
Pioneer (22)	60 & 61
Plymouth Sundance	73
Polk (23)	8 & 9
Rowland Research	Cover III
Sansui (24)	26 & 27
Sherwood (25)	65
Signet	38
Soundcraftsmen (30)	16 & 17
Studer Revox (26)	100
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Now there are two home CD players more advanced than the CD players many radio stations use. The new Technics SL-P720 and the SL-P520.

Innovative Class AA circuitry provides you with silky highs, spectacular mid-range and chest-thumping bass. Precision 2-speed search dial cueing—a Technics exclusive—enables you to move precisely to any point on any track on the disc. Both forward and backward. And anti-vibration construction minimizes the effects of external shock and vibration.*

These new CD players offer a high-resolution digital filter for the cleanest possible sound. For programming ease, you can access any track in under a second. There's even 20-selection random access programming and wireless remote.

So if you're a disc jockey, a radio station owner or a music freak, you'll be crazy about the new Technics CD players.

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The science of sound

*SL-P720 recommended for higher vibration applications

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