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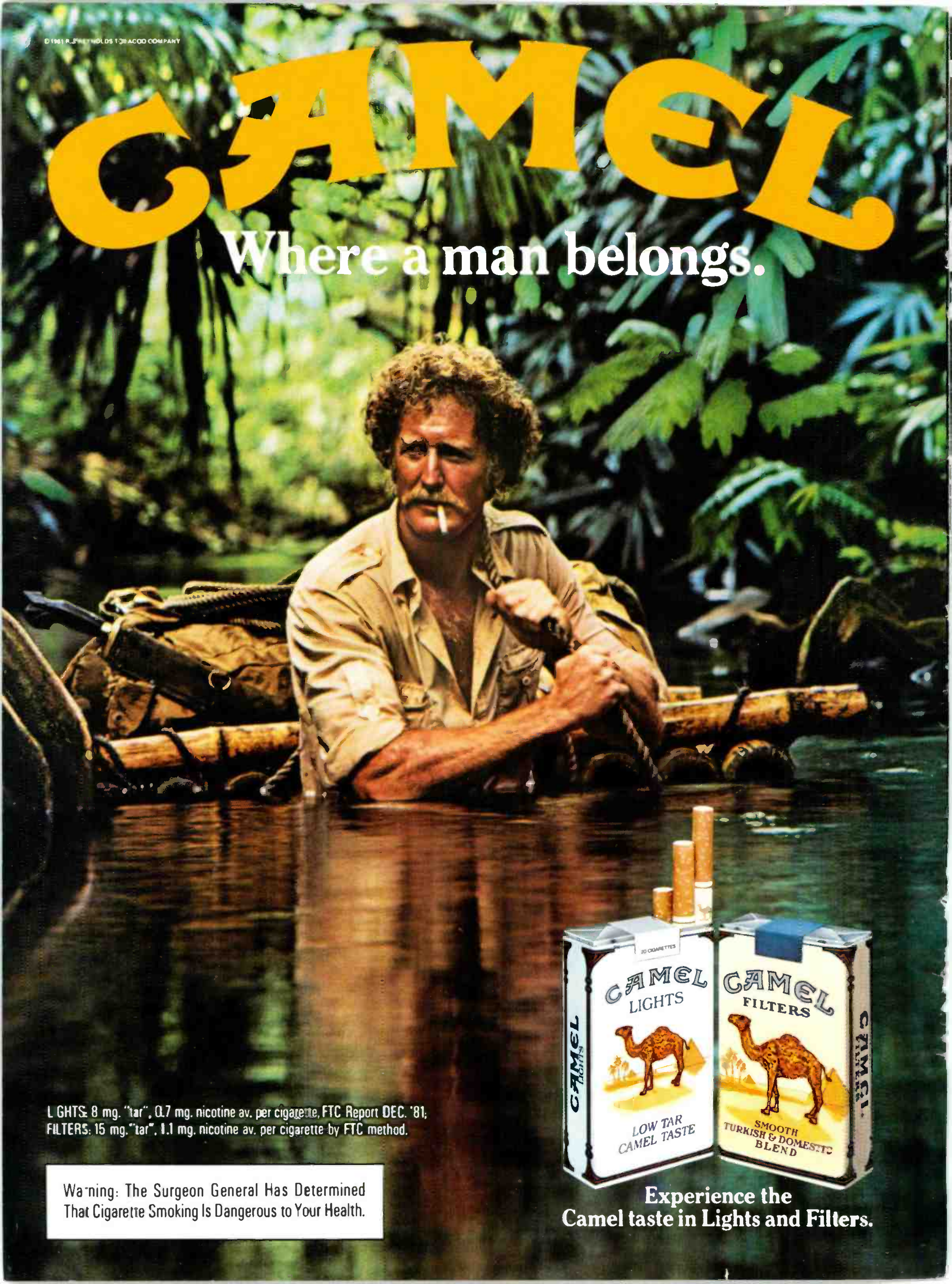
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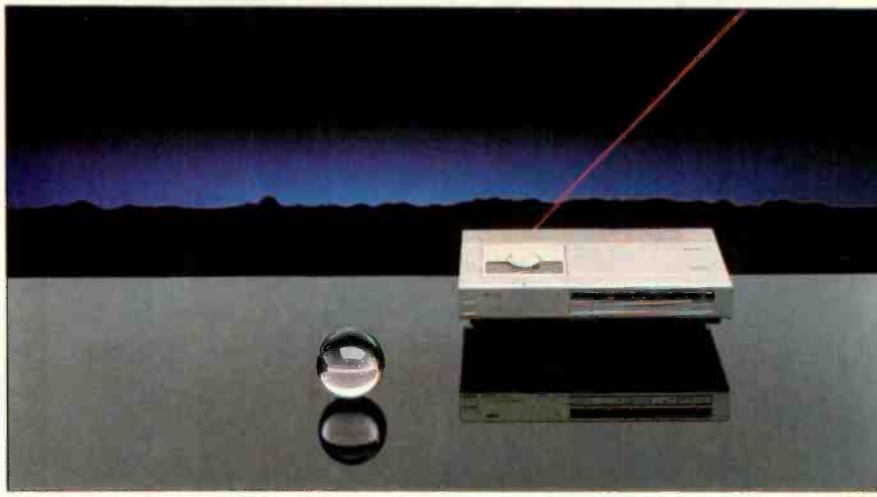

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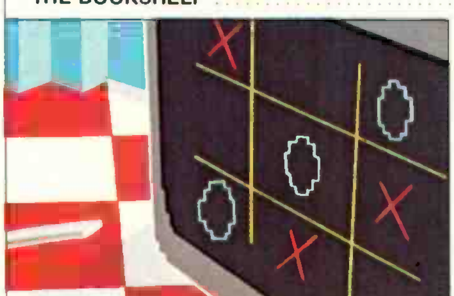

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GOODYEAR RUNS IN THE FAMILY.

EDWARD TATNALL CANBY

BINAURALLY SWAMPED

In one week's mail I recently received eight glossies, showing eight attractive new-model hi-fi reproducers. Seven of these were mini-headphones; One was a mini-speaker. It seems we are not quite finished with the headphone revolution. Nor, perforce, am I.

So far, and in spite of a few claims, virtually 100% of the sonic material we hear through these phone systems is, loosely speaking, stereo. It sounds fine on loudspeakers and was largely intended for them, embodying all that enormous know-how we have accumulated over so many years of recording. But it often sounds better, and different, through the little phones. Happy situation! (Though not for the speaker manufacturers.) We can have our stereo either way.

But, so far, we have not discovered the really radical sound effects that are available via what is still called binaural recording, intended for phones *only*. The stuff will play on loudspeakers but it sounds awful. Or just dull, noisy, confused, unfocused, unintelligible. In this case, there MUST be a clean distinction. If you record for phones, then you must listen through phones. So different!

Last spring one of our readers sent me a cassette copy of an outdoor recording he had made, mostly at night, in the depths of a Florida swamp. It was a nature preserve; they come that way in Florida. The recording lasts all of 30 minutes, with breaks, but this was only a sampling; he stayed in that swamp an entire night, until morning, taking down a more or less continuous document of its sonic ambience for future reference. Document of what? Well, in particular, birds. Also alligators, autos, insects and everything else that happended—and every bit contributing to the wonderfully eerie atmosphere of this recording. It is, of course, binaural. Couldn't be done any other way.

Now I am no birdologist, nor yet an ornithologist, but I listened to all 30 minutes and was enthralled even though I recognized only the owls and a cardinal. Such super-realism!

This was not the usual pro documentary, all neatly in order, bird A followed by bird B, one at a time and isolated (via parabolic sound reflector) in serviceable mono. Instead, out of that swamp came a grand mishmash of *noise*, undifferentiated, all the sound that was, so to speak, floating around—including, as was the intent, a host of the feathered creatures, some of them quite rare. This was their natural sonic environment, just as the swamp was their living place.

After awhile, let me tell you, I was *in* that swamp. It grows on you. When two big owls let loose, hoot-hooting at each other, one of them some distance off, the other terrifying close overhead, the very hair on my neck (I have none on top of my head) rose up. Brr! By the end of the recording, things were getting almost too realistic, for I'm one of those people who get scared when strange animals make noises in the dark. Atavistic. Of course, I am very civilized, but each time a new bird let go, especially with some wild and savage cry, I found I wanted very much to walk, not run, to the nearest exit.

The two most impressive sounds, however, were not birds at all, though both had wings. The first was an absolutely thunderous monster jet which had the gall to interrupt the natural sounds of this preserve by flying directly over it. Shook the daylights out of me. (The only comparable recording I know was of the Concorde taking off, made at the edge of the runway.) The other sound was short, almost instantaneous; I think it was a gnat. It flew suddenly into my left ear and just as quickly, without a thought, I slapped at it. OW! That hurt! I had slapped my headphones.

Does that give you an idea of what binaural can do? I am very familiar with recorded insects of this sort, whizzing flies, bumbling bumblebees, hovering mosquitoes, for it is this unexpected kind of sound that gives binaural such uncanny realism. You must hear to believe—as with every sort of other sonic mishmash, from swamps to cocktail parties. You'd get the same sort of mix, binaurally, if you were chasing Fords and Chevrolets and GM buses in the middle of New York. Very convincing. But not for loudspeakers.

Now I am not sure at all that this phenomenon is, in the usual sense, "commercial." That is, able to be applied to commercially released "prerecorded" material for sale alongside our present discs and cassettes. Informality, the unexpected, is the soul of binaural. Noise is its greatest virtue. I mean "real" noise, not the kind that Dolby and dbx go after. (In fact, noise reduction, as per last month, is absolutely essential for proper hearing of the genuine noises.) Leisure, length, is another strong point. Ten minutes of that swamp on loudspeakers, and your

Illustration: Philip Anderson

"We are not quite finished with the headphone revolution. Nor, perforce, am I."

attention span would be strained. An hour is nothing for binaural. You lose yourself in it—just as people already do via Walkman-type equipment.

All of this runs entirely counter to those techniques we have built up for loudspeaker recording, in all their enormous variety. Binaural recordings, I assure you, will not ever duplicate, let alone replace, the billions of regular stereo recordings we already have on hand. Binaural is NOT going to help the standard repertory, pop or classic. No use even thinking about it. Instead, it will have to be developed with wholly new and utterly different sources of material, completely removed from all that we know as standard recording. To begin with, at least, a sort of novelty area, unusual, intriguing specialties. For headphones only.

Not, for instance, a symphony! Much better a rehearsal of a symphony, such as a few that have appeared on disc. Much more interesting. And terrific for binaural, with all the incidental sounds you can get. Same for a play—a run-through with side comments would be fascinating. Famous actress, a few feet off to your right, forgetting her lines and laughing. Acid comments from the producer, over on your left. *Try that again, pullease! Give it more guts!*

How about a panel discussion, with famous people, sitting around you in a circle à la TV? That would be a lallapalooza in binaural.

You could even release that swamp, with maybe a bit of editing to pull things together for better cohesion (but not too much!). No, you would *not* remove the jet plane. Nor, for that matter, the gnat. Part of the effect. "Birds in a Florida Swamp." For headphones only. It might sell.

To be sure, all of these suggestions are to give you an idea of what binaural recording involves, or would involve if it were to become part of the record biz. Exciting but, on the whole, specialized. Even rock and disco would be the same. A rehearsal, session excerpt, anything informal, would be useful. But not a straight recording. Stereo does better. And, remember, it sounds good on phones.

Still, like Everest, binaural sound is *there*. And, now that it is technically practical, and so easy to listen to, remember Mr. Murphy. For his *second* law, he opined that what can be done *will* be done. So, sooner or later, we'll have something.

Meanwhile, right on our doorsteps, is another binaural area that maybe you hadn't thought of: Do-it-yourself. Remember the Kodak. And home movies. Not to mention Polaroid. Let the consumer make the recordings. He buys the equipment, the knowhow, and the tape from his dealer. Everything is in place! We have the equipment. With minor modifications, or gadget-like additions, it's all ready to go. Any portable "stereo" recorder will do. (You need to move around and get away from the a.c.) Mini-recorders are fine. Use the built-in mikes (not binaural, but better through phones than speakers) or any pair of external mikes. Cardioids are OK, but omnis are better. They pick up more noise. Spacing them on a dummy head isn't *de rigueur*. Even two inches apart gives some effect. More than three feet, and the sound goes out of binaural focus, becomes stereo. And then—the playback. Mini-phones, of course. Or maxi-phones if you wish. No loudspeakers.

It's a terrific hobby thing, if you ask me, and all you need to know is how to do it. Which, at this point, almost nobody can tell you. But we'll learn. It's so simple, once you detach yourself from standard recording. And do not think that sheer amusement is all there is to this consumer do-it-yourself. All sorts of practical and useful functions, like taking down lectures at school, for later listening—from anywhere in the hall. You'll get every word in the playback. Or seminars: let 'em all talk at once, you can still understand. Group therapy? Consciousness raising? Binaural might be a bit hairy here, as listened to later on. But still, useful.

Now, I could go on but you will find an extensive discussion of all this way back in our December, 1974 issue in this space. In all conscience, I can't rewrite that article and expect the Boss to pay me for it a second time. (Why not? You do it with every other article. -EP) So I refer you thereto. It was this piece, incidentally, that put my swampy friend onto the idea of recording that Florida preserve.

And, have you seen the quite recent Sony ads for their small two-channel cassette recorder, placed in the middle of a large corporation board meeting table instead of all those separate mikes they often use? The Sony idea is simple: Play the recording on phones. You can understand everything anybody says, even when they all talk at once. Now if you want to read all about *that*, please refer to the same issue of our mag, December, 1974, p. 18. Old prophet-for-profit Canby, that's me.

Here's a P.S. I'm beginning to feel strongly that we should go along with current usage, no matter how confused at the moment, and—in the playback—speak of *headphone stereo* as an alternative to *loudspeaker stereo*. Save the word binaural for the recording technique.

It's only reasonable. For one thing, what we now hear through phones is indeed conventional stereo in all its forms, good also for loudspeakers. More important, the word "stereo" simply means in the round, with shape in space. Thus, loudspeaker stereo and headphone stereo are equally accurate terms. Both are clearly heard in the round, with spatial effect, just as the term implies.

Binaural—"two-eared"—is obviously out of place in this playback context. Of course we use two ears! For both loudspeakers and phone listening. And if we use that other favorite, "3-D," we would be even further off the beam. Those dimensions, after all, are entirely arbitary, abstract, merely tools for geometric measurement, like a line (no width) and a point, (no dimension at all). "Stereo," though, says exactly what we want to say.

On the other hand, at the opposite end of things, binaural is very properly used for a recording technique that does, in fact, use two microphones as two substitute ears, at a head's distance apart, for strictly headphone playback. The recording process is definitely, two-eared. And I suppose that, by extension, a binaural recording is one that is specifically produced with this technique.

No doubt we'll continue to cross-mix these terms, as we always do. But from here on I'll refer to all general playback through phones as headphone stereo. It's already in general use among recording people.

AUDIOCLINIC

JOSEPH GIOVANELLI

A Touchy Situation

Q. My stereo system consists of turntable, cartridge, tonearm, amplifier, tuner, and loudspeakers. Sometimes while listening to the tuner, I lose the sound when I touch the knobs or face plates of the electronics. The music comes back when I no longer touch the equipment. This does not happen when I listen to records. What is the cause? —R. A. Buc, North Hollywood, Cal.

A. It sounds to me as though your FM signals sometimes disappear because of insufficient signal strength. My guess is that you are using an indoor dipole antenna. The combination of both your physical position with respect to this antenna and the capacitance to ground which comes into play when you touch the equipment produces the loss of signal.

Using an outdoor antenna should resolve the problem, but at the least find a better location for the antenna you are now using.

Direct Noise Pickup

Q. I have been recording for a few years and have spent a considerable amount of money on my equipment. Being a musician, I have tried to find information on noise reduction for direct-line recordings from my guitar to my recorders.

I have some knowledge of electronics and have attempted, on my own, to devise a system of filters to eliminate hum and noise. Although I have been moderately successful, I am fanatical about sound and have not yet attained the ultimate. Can you help?—Darrell Francisco, Karn's City, Pa.

A. If you're getting noise and hum, it often comes directly from pickups, contact mikes and similar devices. Certainly no noise-reduction system of the kind most generally associated with this concept will work. (By this I mean that the processing systems by dbx or Dolby Laboratories won't help your particular problem.) Your task is to keep noise, now present, from entering the recorder, and the dbx or Dolby systems won't know the difference between the music and extraneous noise.

Obviously, your first attack on this problem must be to use the best possible pickups and mikes. Where possible, adjust these devices so that they can extract all available signal from the strings of the particular instrument you are using at the time. The better the coupling between the pickup and the strings, the higher the electrical output from the system will be. Because the ambient background noise will be more or less constant, this will mean an improvement in signal-to-noise ratio without taking any further measures.

You may find it best to use a mike to pick up the sound from your instruments, placing it in front of the speaker of the amplifier rather than wiring it directly into the recorder. I have found that this often reduces annoying hum. It also allows you to record the sound of your instrument as it is heard by an audience, rather than the flat, often insipid sound produced by a direct feed into a recorder, and then later, played back on good speakers. Keep in mind that part of the character of electric guitars is the vibrato, echo and reverb which are often available only through the loudspeakers. The peaky quality of loudspeakers is definitely a part of the overall sound.

Beyond this, use good filters which can be set to roll off below the lowest frequency of interest and above the highest frequency of interest. A good graphic or parametric equalizer can often be used for this purpose. The two stereo channels can be connected in cascade, with the output of channel A feeding into the input of channel B. The actual program input, then, is the input of channel A; the actual, usable output is taken from channel B. Where any given band can be either cut or boosted some 12 dB, now, with the two devices cascaded, you have a total of 24 dB boost or cut. This is good enough in many instances for the kind of filtering we are discussing here. With most electric guitars, the harmonic content is rather slight above the fundamental musical tones (except for some "fuzz"). By limiting high frequencies, some "buzzy" sounds and hiss can be eliminated.

Keep your instrument separated from the rest of the electrical equipment, insofar as it is possible, to reduce the likelihood of hum being induced into the pickups.

If you have a notch filter, the fundamental component of the 60 Hz can sometimes be eliminated with not too great a degradation of musical frequencies in this region. Even so, powerline voltage is not sinusoidal, thus it is often relatively rich in harmonics, which are hard to remove.

Weak Shielding

Q. I am experiencing a most perplexing problem with r.f. interference in my audio system. On the recommendation of a friend, I installed 13-foot long Belden 8421 spiral-wound shielded cable between my preamp and my power amp. Even when the volume control of the preamp is turned down fully, I receive a modulated signal from a local FM station whose frequency is 107 mHz. By substituting another cable, Belden 8401 (braided shield), which is four feet long, interference vanishes.

What mystifies me is why a shielded cable of low capacitance, such as Belden 8421, could pick up this interference in the first place. By the way, the 13-foot cables are terminated with Switchcraft RCA-type miniplugs which are supposed to be resistant to r.f. interference.—Richard A. Links., San Francisco, Cal.

A. Basically, it isn't a question of one cable type vs. another, but rather of a 13-foot long cable vs. a 4-foot cable. You should always use the shortest length of cable possible if r.f.i. is a problem. The longer the cable with less than 100% effective shielding, the more area is exposed to the possibility of r.f. interference.

In stubborn cases of this kind, I suggest that you use Belden's Beldfoil cable. It will probably eliminate interference from this source. Its shield is a solid foil, not braided, and hence it doesn't have any openings through which r.f. can enter.

The Switchcraft connections are fine. With any RCA-type connector, however, the area exposed to r.f. is small relative to the area exposed by the braided shield of the cable. You may, thus, be able to get away with connectors of lesser quality.

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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For those interested in developing a basic library of classical music, this series is worth the investment. In addition to the regular catalog numbers, each entry has a simple number, starting at one and enabling the beginning collector to keep track of the entire series.

Most of the discs date from a period when three or possibly four tracks represented the available channel capacity in classical recording practice. Partly as a result, there is less dependence on multi-miking and in general a more natural and warmer sound than we are accustomed to hearing from the major labels today. Here are some capsule reviews:

Haydn: Symphonies No. 93 and 94. George Szell, conducting the Cleveland Orchestra. **MY 37761.**

A quiet retransfer with a nice sheen to the strings. Flawless playing. Produced by Paul Myers.

Stravinsky: The Rite of Spring. Pierre Boulez, conducting the Cleveland Orchestra. **MY 37764.**

This one was done multi-track, and highlighting of inner details is often overdone. This complex score can take that kind of treatment in stride, however. Probably a Dolby-A original with very low tape noise. An electrifying performance. Produced by Thomas Shepard.

Tchaikovsky: Symphony No. 6 (Pathetique). Eugene Ormandy, conducting the Philadelphia Orchestra. **MY 37768.**

This one is a little hissy by comparison with many of the others, and the overall sound seems to have been boosted for more "presence" than needed. This music is, of course, something that Ormandy and the Philadelphians do very well. Produced by Thomas Frost.

Tchaikovsky: Symphony No. 4. Leonard Bernstein, conducting the New York Philharmonic. **MY 37766.**

A recording of recent (quiet) vintage, and expansive in the usual Bernstein fashion. To my ears, there is a little too much reverberation. The third movement is taken at a breath-taking clip, and the fourth explodes in fury. Produced by John McClure.

Beethoven: Piano Concerto No. 4. Mozart: Piano Concerto No. 25. Leon Fleischer, Piano; George Szell conducting the Cleveland Orchestra. **MY 37762.**

Masterful performances by a virtuoso pianist no longer playing in public. The recordings are quite old and often show their age. However, in matters of balance and interpretation, they may be hard to beat. (When did you last hear a concerto recording with the piano in *proper* balance with the orchestra?) Produced by Howard Scott.

John Eargle

The Digital Fox, Volume One: Virgil Fox, organ
Ultragroove UG-9001, $14.98; dbx encoded No. PS-1020, $18.00.
The Digital Fielder: Arthur Fiedler and The Boston Pops
Ultragroove UG-7003, $14.98; dbx encoded No. PS-1021, $18.00.

The Digital Fox represents the coming together of several musical and technical ingredients, and the results are absolutely stunning. For once, the particular Fox brand of organ playing is given the important ingredient so often missing, dynamic range. I raved about this disc, and its companion Volume Two, when they were released by Crystal Clear as direct discs in 1977. At those sessions, a Soundstream digital recorder was running as backup, and this disc was encoded from it. Interestingly, the liner notes tell us the digital sampling rate at that time

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If you're familiar with Maxell UD-XL tapes you probably find it hard to believe that any tape could give you higher performance.

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Arthur Fiedler

"The awesome low-frequency response of the originals has been preserved intact."

was 37.5 kHz, yielding an upper cutoff frequency of 15 kHz. The notes also state that the performances and frequency balances in this disc are not the same as in the direct-to-disc original. Those who are familiar with the originals will note that a bit of artificial reverberation has been added to the naturally dry ambience of the old Garden Grove Community Church (now supplanted by the Crystal Cathedral). In general, this extra signal processing is welcome; however, the reverberant decay of final *tutti* chords reveals a bit too much midrange overhang, at least for my tastes. Handled a little more deftly, the effect would have been perfectly natural.

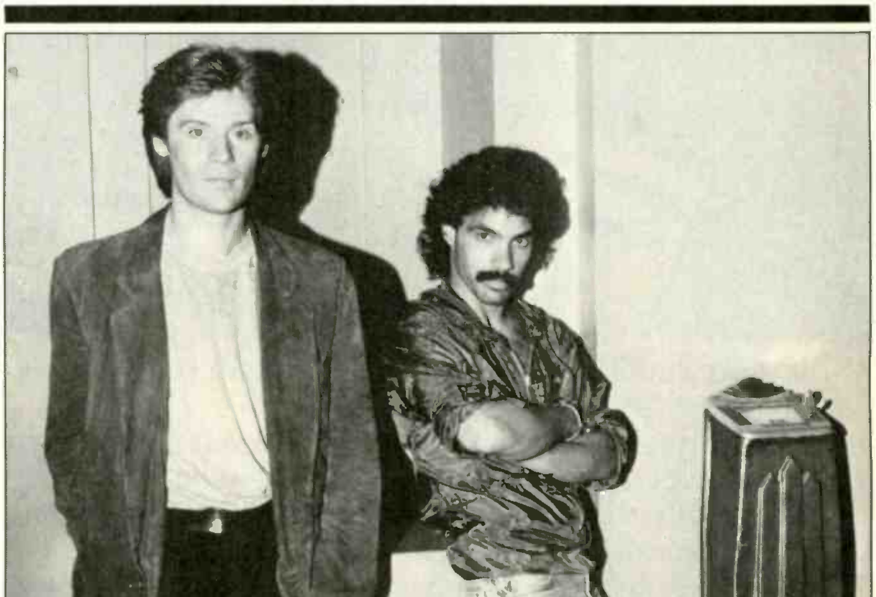
The awesome low-frequency response of the originals has been preserved intact, and, if you have a good set of subwoofers, you will be amazed by the 32-foot *contrabordone* stop in Fox's unorthodox treatment of the transition between the adagio and fugue in Bach's Toccata, Adagio and Fugue in C-major. This stop is electronic, that is to say, there are loudspeakers producing the sound in the church. But there are enough of them, and they are adequately powered, so that the resulting air volume velocities are equivalent to a large set of 32-foot Bourdon pipes.

One of the secondary virtues of the dbx process is the reduction of required modulation space on the disc. This comes about because of low-frequency attenuation in the encoding process, and the happy result is that the ending modulation diameter is somewhat larger than on a standard stereo disc. This will always result in cleaner sound.

Bach's Toccata and Fugue in d-minor and Jongen's finale to the Symphonie Concertante complete the disc, a fine tribute to the late Virgil Fox. One hopes that a dbx-encoded Volume Two is not far behind.

The Digital Fiedler is another Crystal Clear direct-to-disc original with Soundstream digital backup. It was made some three months after the Fox sessions, and during the short interval the sampling rate had jumped up to 42.5 kHz, with frequency response out to 18 kHz. The originals were sonically warm, but they lacked sheen in the upper strings. This has been "corrected" in the present release by adding a high-frequency boost roughly equivalent to the difference between the random incidence response and the on-axis response of the B & K instrumentation microphones used at these sessions. The result of this equalization adjustment is better overall balance and delineation of inner voices. Of course, a similar correction is possible in playing the direct-to-disc originals simply by adding an appropriate high-frequency boost, but this would surely cause an increase of surface noise. Doubtless, some listeners will perceive the spectral difference between the two issues as some kind of proof that direct is better than digital—or is it the other way around? As in the case with the Fox album, the low end has been preserved, and overall balances are quite musical.

Thanks to dbx and to Crystal Clear for making these classic recordings available in this format. Not only do they provide something of a chronicle of the development of Soundstream's technology (now up to the 48 to 50 kHz sampling rate with response in excess of 20 kHz), but they show us the skilled hand of the master himself, Bert Whyte, as recording engineer. Now, if we can just have the Crystal Clear London Symphony Orchestra recordings made by Whyte, issued in this format! *John Eargle*



Abandoned Luncheonette: Hall & Oates
Mobile Fidelity MFSL-1-069, stereo, $14.98.

Sound: B Performance: B−

Abandoned Luncheonette was regarded as a classic in its day. But that was during Hall & Oates's long, lean period when their main claim to fame was being a white act from Philly, before they were joined by heavy hitters like Mickey Curry and G.E. Smith and before such studio-perfected hits as "Sara Smile." Even then, these two guys almost knew their way around a song, and they were able to get by, slowly building a base of East Coast fans who were dying for them to have a hit.

The songs on *Abandoned Luncheonette* sound dated and contrived. The album barely stands the test of time as a collection of eclectic tunes, "A Night At The Opera is classic album which won over their worst critics."

hardly worth Mobile Fidelity's remastering. The new version's expanded range only further reveals the generally thin and shrill edge of the recording.

This wasn't a recording act, then, so much as a couple of songwriters looking for a hit, before they found the sound that's since made them the chart-toppers of the '80s. With the exception of "She's Gone" (which actually made the charts, thanks to Tavares' cover version), there isn't much timeless music here. "She's Gone," on the other hand, sounds very good and not unlike their current material. Hall & Oates stuck with the sound the public liked, leaving behind many areas of music they'd pursued in their formative years—and for good reason.

Jon & Sally Tiven

A Night At The Opera: Queen
Mobile Fidelity MFSL-1-067, stereo, $14.98.

Sound A — Performance: B+

Although not Queen's best performance by a longshot, this is the one which launched them into the superstar category and won over their most vehement critics. Masterfully produced by Queen and Roy Thomas Baker, the sound of its original pressing was hampered, somewhat, by the limiters and EQ employed in the cutting process, all of which have been dispensed with here. The sounds of all the instruments, particularly Mercury's keyboards, have the clarity and presence missing from the regular record.

But *Queen II*—a far better record even more brutally butchered in the cutting—would have been the definitive choice for a Queen album to bring up from the depths. The songs on *A Night at the Opera* were somewhat substandard for the group, even though two of them, "You're My Best Friend" and "Bohemian Rhapsody," became enormous hits. This record, made by Queen while it was separating from its management, is haunted by a certain despair and by indiscreet references to business hassles.

Queen was, and is, a great group. In the minds of the late-to-be-initiated, *A Night At The Opera* is a classic album, but a close examination of both early and later work proves this to be merely a transition piece. *Jon & Sally Tiven*

MICHAEL TEARSON
JON & SALLY TIVEN

FEAR LASHES OUT

The Record: Fear
Slash SR-111, stereo, $8.98.

Sound: C+ Performance: A+

Forget the notion that Fear is the most dangerous band in America. Disregard whatever you've heard about the Los Angeles Punk Scene. This quartet makes the most outrageous and energetic music since The Sex Pistols. They also can actually play their instruments extremely well, and instead of being the figment of some manager's machinations, they have minds of their own and a matchless sense of humor. Rather than Clash-styled political consciousness with stern faces, these guys' politics are up front but they aren't afraid of having a good time.

They've got a solution to the population explosion: "Let's have a war," sings Lee Ving. "So all of you can die. Sell the rights to the networks." This generally sets the tone for the record's lyrical approach, which is laced with language not heard on television. Not to downgrade The Sex Pistols, who were certainly needed in their day and an exciting kettle of fish, but all that stuff looks pretty tame next to Fear. There are bushels of intelligence, musical ability, and integrity behind Fear, and the 14 songs on their debut album show a great deal of consistency as well. Despite a somewhat clean recording job that downplays guitar distortion and doesn't fully convey the power of drummer Spit Stix, Fear comes across. If the Ramones and The Pistols provided entertainment for you and you're waiting for the next step in articulate, high-energy, antagonistic rock, Fear is absolutely indispensable. Absolutely. *Jon & Sally Tiven*

Business as Usual: Men at Work
Columbia ARC 37978, stereo.

Sound: C Performance: B

Men at Work have become one of Australia's favorite home-grown bands, and it is not hard to understand why. They make bouncy tunes which you might easily find yourself idly humming as the day goes by. There is a certain melodic resemblance to the music of the Police but without the high-gloss production values.

Thus, *Business as Usual* has a straightforward, no-gimmicks sound. The band seems satisfied just playing their songs. Their appeal emanates from a wonderful, quirky, reggae-tinged sense of rhythm and Colin Hay's very Sting-like voice. Add intelligent, thoughtful songwriting, most of it involving Hay, and Men at Work begins to sound like a band that could take hold here in the States. As debuts go, this is classy. *Michael Tearson*

Avalon: Roxy Music
Warners/EG 23686-1, stereo, $8.98

Sound: B– Performance: C+

Calling Bryan Ferry's latest band Roxy Music is like calling Ian Hunter's new band Mott the Hoople—you've got the same lead singer, but all the other elements with any personality have been replaced by "good players." Paul Thompson, the drummer and keystone of the Roxy Music sound, has been replaced by Andy Newmark, a fine session drummer from New York. Eno is long gone, and there is no substitute. Founding members Phil Manzanera (guitar) and Andy Mackay (saxophone) remain in the band to keep up appearances and create atmosphere, but Neil Hubbard's guitar is the most noticeable.

Men at Work

What was once a fairly important art band has become a groove establishment, producing anonymous dance music, punctuated only by Bryan Ferry's droll delivery.

The latest Roxy Music album *Avalon* could well be described as cocktail music for the terminally hip. Ferry seems to be so laid back that he might as well have skipped the session. The music has some pleasant Byrds-like textures, but it bears more resemblance to Fleetwood Mac than Roxy Music. *Caveat emptor.*

Jon & Sally Tiven

One on One: Cheap Trick
Epic 4281, stereo, $8.98.

Sound: B | Performance: A

Aesthetically speaking, Cheap Trick has a hard row to hoe. In terms of financial returns, critical acclaim, and influence on contemporaries, C.T. is a music biz institution. The task for the group, however, is to preserve the musical essence that won such a vast audience while continuing to expand. Major ingredients of the C.T. formula are Beatle-like chord sequences done in a heavy metal mode and a broad-ranged vocalist whose access to high notes never relies on falsetto or whine. Throw in guitarist/songwriter Rick Nielson's prankish sense of humor (his stage garb and persona appropriately are modelled after the Bowery Boys' Satch) and you've got the flavor of this supergroup in a nutshell.

One on One proves C.T. to be greater than the sum of its parts, for, with the exception of one number which is more of a jam than a composition, all of the songwriting is outstanding, the playing sizzles as usual, and the variety of material provides a pleasant surprise. "Time is Running," for instance, has a relatively complex structure and suggests a composer trying to stretch out from his formula. However, the excellence of this tune owes less to its component variations than to its superb melody and harmonies. Two futuristic tunes, "I Want Be Man" and "Saturday At Midnight," give a nod to the synthesizer sector of the New Wave without losing C.T.'s rhythmic base, while "Oo La La" is a chugging rock 'n' roll number whose '50s

Cheap Trick

Still Life (American Concert 1981): The Rolling Stones
Rolling Stones COC 39113, stereo, $8.98.

Sound: C– Performance: B

That the new live Rolling Stones album contains a single record, rather than a pair, emphasizes the rotten state of the economy. Face it. This, the fourth live album by The Rolling Stones, is chiefly a souvenir for the multitudes who crammed into all those sold-out stadiums and hockey arenas last year. The Stones do not blaze new trails here. In fact, nostalgia is the album's big drawing card, what with four chestnuts from the '60s including—"Under My Thumb," "Time Is on My Side," "Satisfaction" (all three date back to the first live Stones album, *Got*

feel and horn section suggest there's a Roy Wood fan in the band. The strongest song may well be "If You Want My Love," the closest approximation of a ballad these boys will ever perform. Despite its grandiose production, the lyrics sound "real," and singer Robin Zander proves he can pull off a delicate vocal with style.

Cheap Trick has surprised all the cynics by putting out what is possibly their finest album after a somewhat fallow period without resorting to sell-out, lowbrow appeal or any major revamp in style. *Jon & Sally Tiven*

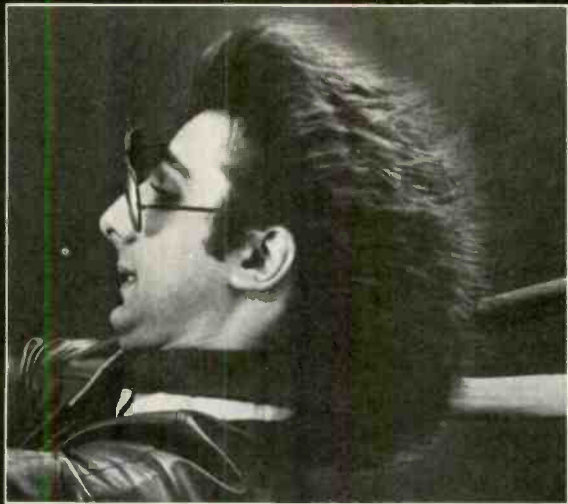
Abracadabra: The Steve Miller Band
Capitol ST-12216, stereo, $8.98.

Sound: C+ Performance: C

Rebounding from the disastrous 1981 album, *Circle of Love*, which marked a return to action after a three-year hiatus, we now have *Abracadabra*. It is your standard Miller time with most of the album in that middle tempo that Steve uses so frequently. And there is the usual supply of Miller's spacey tricks, goofy electronic sounds and lots of Ping-Pong effects for the headphone set. The sound is traditionally clean but remarkably punchless (are those powder puffs or drums?).

The songs are harmless and smooth enough. Certainly they are not going to threaten or offend anyone. Cotton candy never does. *Michael Tearson*

Steve Miller



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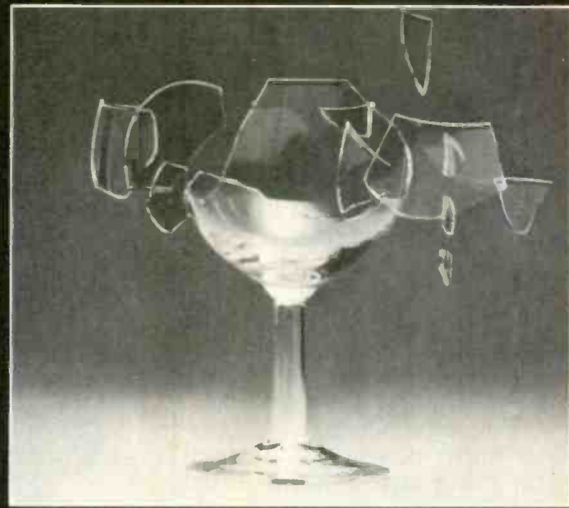

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Live If You Want It) and "Let's Spend the Night Together." In addition, there are three they didn't write—"Imagination," an Eddie Cochran oldie "Twenty Flight Rock," and Smokey Robinson's "Going to a Go Go." That leaves only "Shattered," "Let Me Go," and "Start Me Up" to represent the post-sixties Jagger/Richards songbag.

How are they playing? Well, spirits are high and everyone seems to be having a fine time, even guest sax player Ernie Watts. The band is loose and occasionally they swing on the old tunes. For these vets, that says a lot.

"Still Life" is nice light fun, most suitable as a party record; no more, no less. *Michael Tearson*

Madness

Complete Madness: Madness
Stiff (U.K.) HIT-TV1, stereo.

Sound: C + Performance: B +

It wasn't hard to miss the impact in America of the ska revival craze that absolutely swept England in 1979/80. All you had to do was blink.

The movement produced a couple of definitive albums, in the English Beat's debut *I Just Can't Help It* and the live performance-cum-film soundtrack album *Dance Craze* featuring the English Beat, the Specials, Madness, Bad Manners, the Selector, and the Bodysnatchers. To those two can now be added *Complete Madness*, a generous, 16-selection "best of" album.

Madness is perhaps the best example of the syncopated, high-stepping, wacky, nearly-out-of-control ska sound. For *Complete* the reprogramming of the selections is superb as they segue neatly one to the next so that Madness' wild antics never stop until the side is complete. In addition, the remastering has yielded a rounder, fuller sound than the original albums had, so these songs have never sounded better. On the back cover the members of the band have taken turns commenting on how the songs came to be and what they mean to the band, remarks that add depth and context to the project.

Rare is the retrospective that actually adds to one's perspective of a band. *Complete Madness* does that and more. It is the best Madness album by far. *Michael Tearson*

Kim Wilde
EMI-America ST-17065, stereo, $8.98.

Sound: B Performance: B+

Kim Wilde is already an established hit-maker in Germany, Holland, England and Australia, and with this album she takes aim at America.

Her material is fine, she has a sure sense of putting it across, and she gets solid support from her uncredited band. "Kids in America," "Water on Glass" and "Our Town," the first three songs, provide a snappy 1-2-3 introduction to what Kim Wilde is about—namely smart, bright, poppy songs. The Debbie Harry comparison, begged by her blonder-than-Blondie cover shots, is pushed only on the reggae-tinged "Everything We Do," a number that sounds perhaps too close to "The Tide is High" for comfort, but Wilde's supple and touching vocal measures up just fine. "You'll Never Be So Wrong," is a very mature, somewhat complex composition nearly hidden in the middle of the second side.

Kim Wilde is neither brilliantly new nor startling. But it is a quality piece of work that makes satisfying listening amid an eminently attractive setting.
Michael Tearson

Asia
Geffen GHS 2008, stereo, $8.98.

Sound: B+ Performance: C

The debut album by Asia is an attempt for some recycled "superstars" to put so-called "progressive music" back on the charts. The recycled ones include Yes alumnus Steve Howe, Carl Palmer of "Emerson, Lake &" fame, Yes/Buggles graduate Geoff Downes, and journeyman John Wetton who has survived Family, King Crimson, UK, Roxy Music and even Uriah Heep.

They play their music well enough,

Asia

but their compositions are from hunger, woefully dumb, drudgy, pedestrian efforts. Fortunately they elect not to bury their work beneath the endless instrumental excess of a Yes or EL&P. Their more direct approach is smart. If only their stuff wasn't so vapid. . . .

Even their production is surprisingly simpleminded for technicians of their calibre. The Quiex II pressing of the early copies is superb, giving them excellent clarity and definition.

Asia is not really bad, just terribly average, and in this case that is a major disappointment. Who'd have thought Asia was so close to Kansas?

Michael Tearson

Frogs For Snakes: John Hammond
Rounder 3060, stereo, $8.98.

Sound: B — Performance: A−

John Hammond is a blues purist whose limitation as a composer (if he does write, he doesn't record his own tunes) is more than compensated for by his execution of other people's material. The man's musical integrity is probably his greatest attribute, though as a vocalist he truly excels. Not far from Willy Deville in the blackness of his vocal sound, Hammond's emotive delivery shows us the blues is a spiritual state even a rich white kid could fall victim to.

If he displayed more confidence in his guitar playing, the instrumental portions of these tracks could have been as exciting as the vocals, but as is, most of these tunes cry out for some lead guitar work. Apparently, Hammond is used to playing guitar unaccompanied because the drumless acoustic numbers on this LP are the most ferocious. He allows himself to stretch out on the fretboard and does a good job of it on "Step It Up and Go" and "Mellow Down Easy." His instincts on electric guitar are good, especially to create a mood for "Louisiana Blues" and "Got to Find My Baby," but he permits his axe to be mainly a punctuative component of the vocal. Given the considerable feel for the genre he's displayed over the past 20 years, Hammond might want to showcase his own instrumental/arranging/songwriting talents a bit more on his next record. As it is, he serves as a keeper of the flame for blues forms that have yet to be popularized on anything greater than a cult level. With a guitar foil to drive his vehicle further on up the road—his previous sidemen include Jimi Hendrix and Robbie Robertson—Hammond could easily become as much of a household word as Johnny Winter, George Thorogood, or any of the second/third generation bluesers who have kept blues alive on the radio and in the clubs. *Jon & Sally Tiven*

The Blasters
Slash/Warner Bros. BSK 3680, stereo, $8.98.

Sound: B− Performance: B+

The explosion of rockabilly cat bands the last few years has impacted mostly in England, where bands like Long Island expatriates The Stray Cats as well as homegrown products like The Polecats, Rockats and others have carved a successful niche. The States have ignored the trend/fad with nearly total success. But now we've got an American band that's got these poseurs beat hands down, The Blasters from Los Angeles.

The Blasters play American music with style and that magical, usually missing ingredient, "swing." Singer Phil Alvin has the master's touch and a demon-possessed style heightened by razor-sharp timing. Particularly on the a cappella passages. And in person he is an astonishing performer. Drummer Gene Taylor is both anchor and propeller, the throb that everything else is built upon. Songwriter/lead guitarist Dave Alvin is another wonderfully charismatic figure.

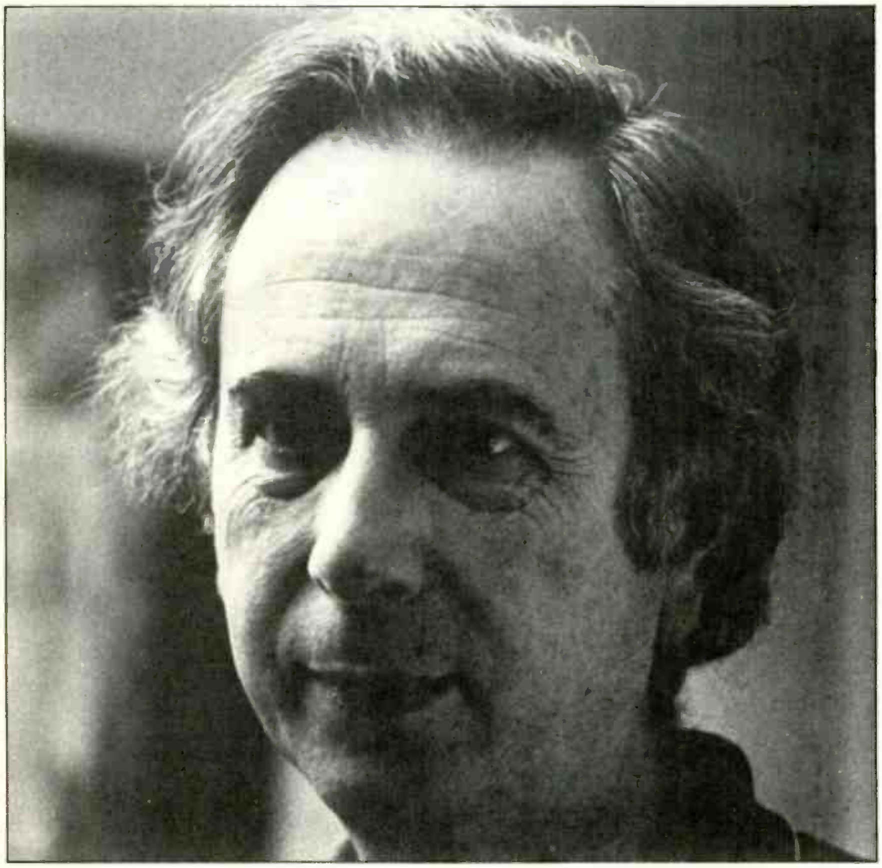
Dave's songs at their best are magical. They aren't 24 years old; they just sound it with perfect authenticity. One of them, "Marie, Marie," has been a smash in England and Europe for the relatively wimpy Shakin Stevens. Don't miss the original here. And with it The Blasters' anthem "American Music," only one of the best car radio songs in years. And their Chuck Berry-licks song "So Long, Baby, Goodbye." And some inspired covers to round out the set, stuff like "I'm Shakin' " and "Highway 61."

The Blasters are the real thing, the genuine article. No museum piece here. They are alive and most definitely lively. *Michael Tearson*

The Blasters

EDWARD TATNALL CANBY

MUSICAL COLLAGE



George Rochberg: Quintet for Piano and String Quartet. (1975) Alan Marks; the Concord String Quartet.
Nonesuch N-78011, stereo, $8.98.

Sound: B+ Recording: B+
Surfaces: B−

George Rochberg is an original, as they say. He is no spring chicken, being in his 60s, but plenty of younger "contemporary" composers (isn't everyone contemporary?) respect his ways and maybe stand in a bit of awe of them. Who else would dare — ?

Not what you think. What this man does is really startling. He brashly combines extreme dissonance, "contemporary" stylings, with plain all-out old-fashioned Brahms or Schumann. No halfway measures! Some of this Quintet sounds like Bartok (clearly a big influence, as the greatest modern Romantic), sometimes like Brahms, early Brahms, à la Schumann. There are segments, too, of late Beethoven, and of early-middle Stravinsky, just as openly. This is a kind of musical collage, and, indeed, Rochberg actually composed collages made out of pieces of older music, back in earlier days. He is too good, too fertile, for that; now he makes up his own. And it is remarkably good music, no matter what the style.

The unusual thing, which surely is the envy of many another living composer, is that this crazy mixture works. It sounds out, it flows, it coheres, as one. Now *that* takes skill!

The way I see it, this is ultra-logical, since in this day our music listening habits are precisely the same — we jump wildly from one period to another, old and new cheek to jowl, as no music listeners have ever done before. So why not *compose music* that way? That is, if you can.

A lovely, well-felt performance, too, tastefully impassioned. I particularly liked Alan Marks' piano, whether in the Bartok/Stravinsky segments or the Brahms. These performers understand Rochberg's idea.

Sorry to report that there are more ticks than there should be (today) in the recording and some unfortunate groove pre-echoes when the composer's dramatic silences come up. Tough job, though, to record and to cut Rochberg. He gives the engineers no consideration at all; he writes "live" music, like most composers of his generation! That's his privilege, is all I can say.

Weber: Der Freischütz. Behrens, Donath, Kollo, Moll, Brendel, Meven, Symphony Orchestra and Cho. Bavarian Radio, Kubelik.
London OSA 13136, three discs, stereo, $35.92.

This sensational German opera, the first Romantic opera of all, sprang full-blown in 1821 out of the earlier *Singspiel*, the popular German-language musical show which had combined rustic characters, ordinary speech and fancy operatic singing all in one. Mozart's *Magic Flute* took the half-sung, half-spoken format into high and serious matters, as well as comedy, but Weber launched the era of spook, the musical horror show, and it has never ended, as we all know.

Such goings-on you cannot imagine here, more than a stage would seem to make possible (but right in the Wagner track)—deep, dark, spooky black forest, magic all over the place, hideous wild beasts, visions, ghosts, howling wolves (quite literally), banshees, you name it, plus a pagan monster-god named Zamiel, the Devil himself in German, and out to do in our hero and his gal, purest of the pure. . . . It's a marvelous show and the music is quite lovely.

Curious—the spoken word (often shouted or bellowed at full voice, maybe I should say bayed, like a hound) is so thoroughly mixed in with the sung music that on occasions a conversation has one person speaking, the other singing. There is no separate, formal speaking cast here, an evil in too many opera recordings. The mix of speech and singing is astonishingly easy on the ears; few other operas do it so successfully.

This opera, of course, virtually requires an all German cast, and this recording is predominantly of that sort, a rarity in these international days. I found it a lively, lean, exciting perform-

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"There is a pleasing excitement in Bartók played by two native Hungarian orchestras under a young emigre to the U.S."

ance, though the orchestra, under Raphael Kubelik, is a bit on the sluggish side. You get a complete German text and translation, though they don't say which is sung and which is said. As I say, not much difference anyhow.

For us who listen via recording, perhaps the biggest asset of this performance is the thoroughly modern audio, and particularly the microphone setup, which places all those big German male voices (and one major female part, the blushing girl, Agathe) out on the stage where they belong and where we can place them easily in space, even as to right and left. No close-up bellowing here! It would be fatal in this loud-voiced opera. You may find this is the easiest listening opera yet, big voices or no.

Raphael Kubelik

Bartók "100"—The Major Orchestral Works. 100th Anniversary release. Budapest Philharmonic & Symphony Orchestras, Arpad Joó.
Sefel SEFD 5005/5, five digital stereo discs, $79.90. (Available from Sefel, 201 S. Cherokee Street, Denver, Colo. 80223.)

Just how a Colorado record label moved into modern Hungary, with Soundstream digital in attendance, to record this fantastic and monumental five-LP album, is beyond me! But here it is, opulent, beautifully turned out, authoritative, and surely one of the most important documents of Bartók's 100th year (he died in 1945). The recording is particularly unusual because it is a kind of orchestral retrospective of Bartók's work in the purely orchestral medium, taking us from the very early "Kossuth" of 1903, a Symphonic Poem much after Richard Strauss, all the way to that final orchestral work so well known by now, the Concerto for Orchestra, composed in the U.S.A. in 1943.

It is a revealing history, since most of Bartók's works with orchestra heard today are with solo instrument, notably the fabulous piano concerti. Virtually all of the music on these five discs, the Concerto for Orchestra aside, will be unknown to most listeners, and the more interesting for it. What a strong, prolific, forward-moving composer! One had the impression that Bartók personally was intense but inward. Not by any means in his earlier music, which lays itself out to absorb every new influence that comes along and spreads it wide and far in brilliant orchestral forms. Strauss, Debussy, Stravinsky! You'll hear them all, but in such an original and intelligent borrowing—is not all the greatest art based on tradition from the immediate past and so on back?

Now we can understand, via this album, how far, and how freely, Bartók moved from late Romantic straight through the Roaring Twenties and the most potent dissonance, into the mellowing that came in the last works. It is an immense evolution in a short time and only explained, as here, by sheer prolificacy. Bartók learned by doing, all-out and magnificently.

There is a pleasing excitement in the playing of the two native Hungarian orchestras, under the leadership of a young Hungarian conductor who in 1968 emigrated to this country for an American musical education. Now he is invited back, and brings new things to his countrymen concerning music by their own finest composer; one can sense the interest and fire in the performances, even though there are rough spots perhaps due to unfamiliarity. I have never heard the Concerto for Orchestra more enthusiastically played, in particular the wicked take-off of Shostakovich's Seventh Symphony, with the woodwind screams of laughter. Bartók could not stand that pompous, if dedicated, war-time monstrosity; these players obviously get the point and relish it. They surely have had to play the monumental Seventh, the "Leningrad." (As usual, the liner notes ignore this. I got it from Peter Bartók, the composer's son.)

Soundstream digital! Why are so many fine recordings attached to this firm? After all, they merely run the machines; others do the recording. Yet it happens. Maybe Soundstream picks the right musicians and engineers? This is superb, and no further word is needed. Surfaces, too, are so good that dynamic range seems larger than normal LP, not far from digital itself.

If you think big companies still have the lead, you had better sample this album. Music included: "Kossuth" (1903); Four Pieces, Op. 12 (1912); Suites Nos. 1 and 2 (1905, 1907); Miraculous Mandarin Suite (1919/27); Dance Suite (1923); Concerto for Orchestra (1943), and some shorter works. Bartók wrote no purely orchestral music between 1923 and 1943.

HOWARD ROBERSON

BASICS OF TAPE PERF

Tape tests and comparisons are aimed at pointing up performance differences between specific tapes. But the fundamental similarities between tapes are worth examining, too; they are the forest of context for these individual magnetic "trees."

Magnetic Properties

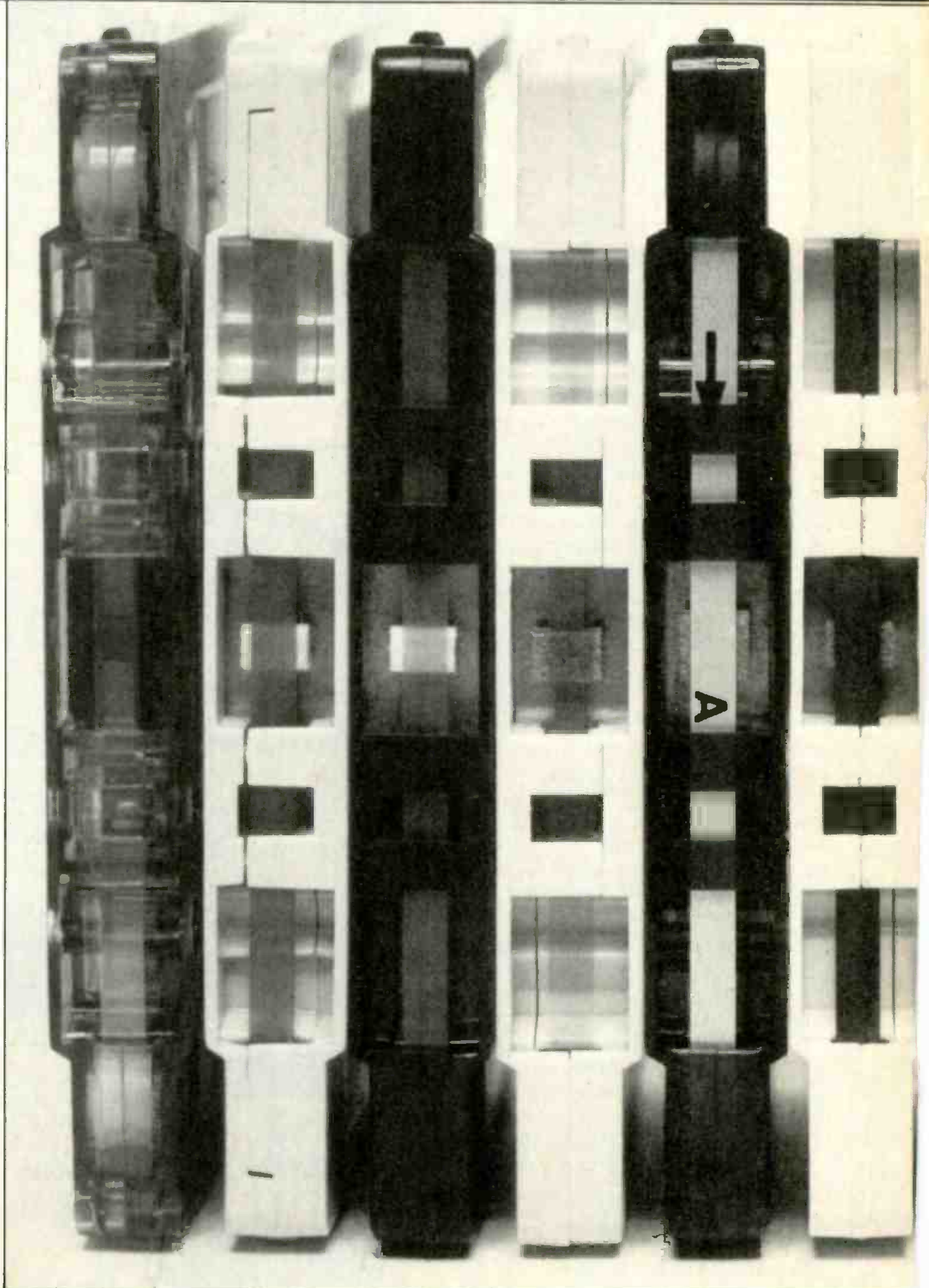
The most fundamental diagram of tape performance is the hysteresis loop, which shows the tape's response to magnetizing and demagnetizing forces. Figure 1 shows loops for three cassette formulations (loops for open-reel tapes have the same basic shape). The plots show flux density as a function of magnetizing force. For each tape there is a saturation point, where the flux density is at a maximum (B_m), and further increases in the applied field will not induce more flux.

If the applied force is reduced from the saturation point to zero, the flux on the tape does not return to zero. This residual flux density (B_r) is called retentivity; without it, there could be no tape recording, as the flux would disappear from the tape when the recording force was removed.

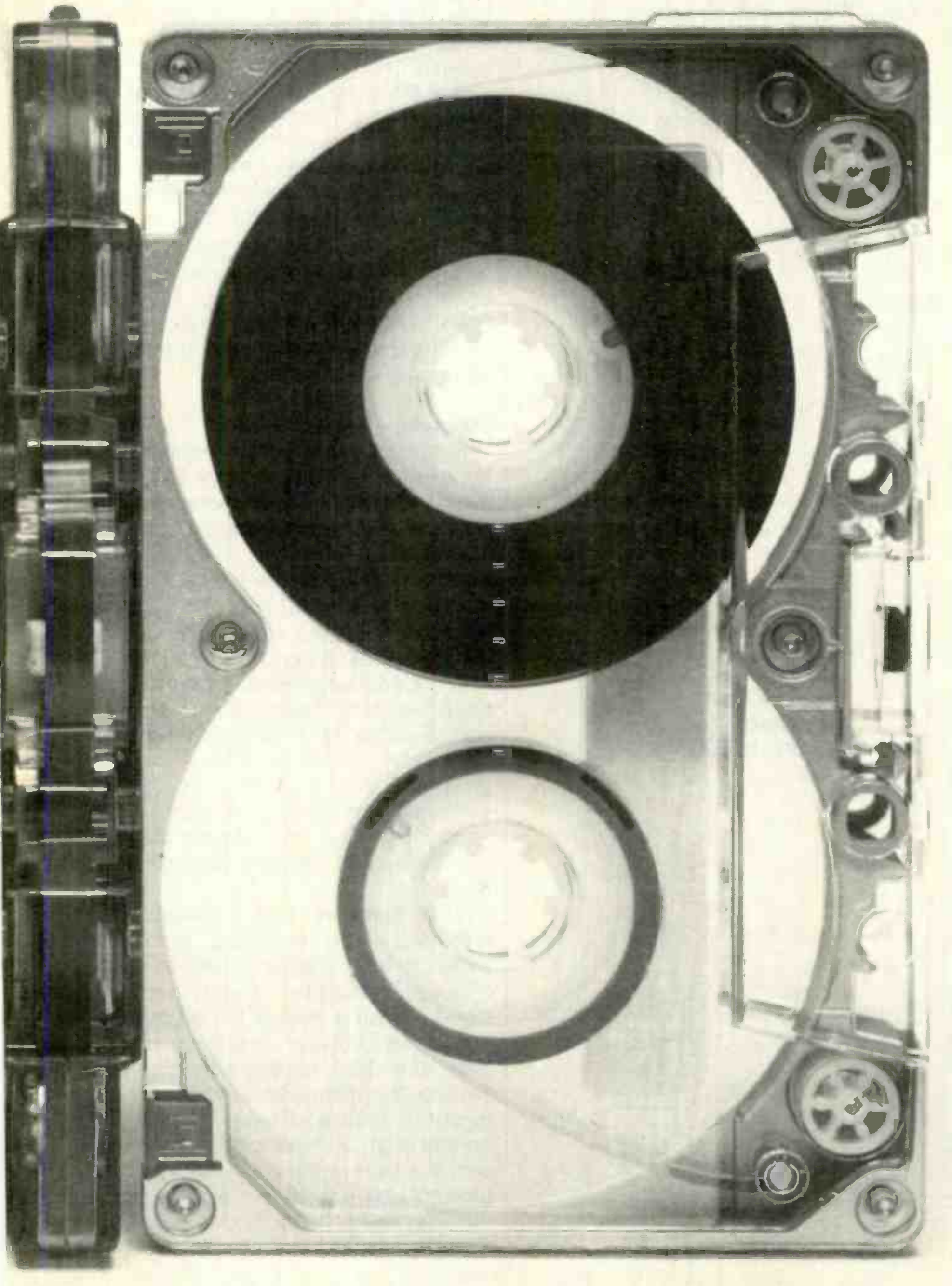
The B_m and B_r points are marked for the metal tape, and the corresponding points for the other two tapes are easily seen. The "squareness" ratio listed on many technical data sheets is the simple ratio B_r/B_m.

If a magnetic field of reverse polarity is applied, the flux will be reduced—all the way to zero, if this negative force is sufficient. The force required to reduce flux to zero is called the coercive force, or coercivity, and is designated as $-H_c$.

We can see the possible advantage in having high saturation flux densities, though that requires higher magnetizing force—a possible challenge to the recorder designer. Coupled with a high squareness ratio, a high B_m provides high retentivity. The high B_m of metal tape (more than twice that of the



ORMANCE



other tape) is quite noticeable in the figure. Quite a few Type I (normal ferric) tapes, however, have retentivities that match those for Type II (high bias) tapes.

Metal (Type IV) tape's advantage extends to its much greater resistance to erasure; Type II tapes are also superior to Type I formulations in this respect. Coercivities are on the order of 1100 oersteds for Type IV (metal), 350 to 650 for Type II, and 280 to 375 oersteds for Type I. These figures are actually developed with d.c. magnetization and demagnetization. Figure 1 also includes two dashed, demagnetization-loss lines, showing the extent to which the saturation loop's B_r might be reduced at higher frequencies by short-wavelength demagnetization effects such as self-erasure. Because of its low coercivity, Type 1 tape is much the most vulnerable to erasure of high frequencies by small magnetic fields such as might come from magnetized heads.

While Fig. 1 shows the tape's performance as it is cycled through saturation, it is, of course, common for magnetization and demagnetization to occur with smaller magnetic fields, resulting in lower flux densities, as in normal recording. A series of nested hysteresis loops, at flux densities from zero to saturation, form the natural magnetization curve. It is most linear in its central region, away from both zero and saturation. A.c. bias effectively linearizes the magnetization curve, and this linear range covers about ± 0.3 B_m. In the 10-dB range from ± 0.3 B_m to $\pm B_m$ (saturation), the curve is nonlinear, and overload distortion increases with increasing level. Examination of the signal-to-remanence curves of several tapes showed researchers that these curves were a nearly exact match, when normalized. From this, an equation was derived have a headroom of 10 dB between the point where the level of third har-

"The fundamental tape performance diagram is the hysteresis loop showing response to magnetizing and demagnetizing forces."

monic distortion (HDL_3) was 1% to saturation. This does not mean that all tapes have the same distortion level vs. recording levels; it does say that changes in recording level will cause the same *relative* changes in distortion.

Effects of Bias

It is common knowledge that high-frequency response and distortion change with bias level. So do several other tape characteristics. Figure 2 shows how the characteristics of one tape, Nakamichi SX, change as bias current is varied. As bias is increased above 1.2 mA, the 3% distortion limit (MML) at 400 Hz increases steadily, but the MOLs (maximum output levels or saturation limits) for 15 and 20 kHz drop a great deal. Distortion at 400 Hz with a flux level of 200 nWb/m decreases very sharply at first, then more gradually, reaching a minimum at about 2.9 mA of bias, then rising as bias is increased beyond that. Bias-noise level changes very little with bias current.

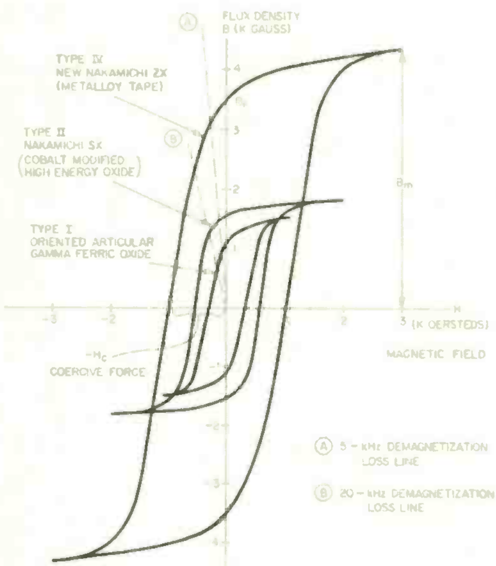


Fig. 1—Hysteresis loop characteristics of three cassette tape formulations.

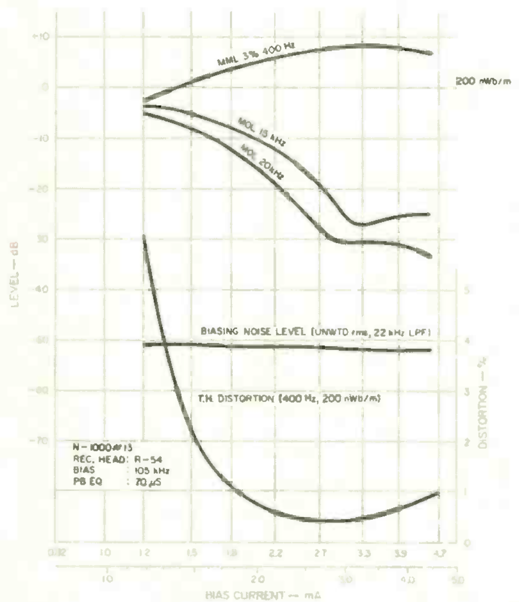


Fig. 2—Effects of bias change on Nakamichi SX tape.

It is not surprising that many audiophiles get somewhat confused when they see such a data sheet, because it's hard to reconcile the idea of flat response with the great discrepancies between the 400-Hz MML and the 15- and 20-kHz MOLs. In actual recording and playback, though, equalization is used to flatten the response. The main point to keep in mind here is that bias is a fundamental factor in frequency response and distortion.

Frequency Response

In general, the perfect amplitude response vs. frequency curve would be exactly flat with no deviations over the entire audio range. (There's little advantage, of course, in responding to frequencies below the lowest musical frequencies—music-search systems excepted—or to noise frequencies above the audio band.)

In the past, tests have shown that by adjusting bias (and equalization), it was possible to make the frequency respose of almost all tapes of any given type (I, II or IV) almost exactly the same for a given deck. It seems quite impossible, therefore, to state that any one tape does or does not have flat response.

While both bias and equalization affect frequency response, recorders which offer front-panel equalization trim adjustments are a rarity, with designers leaving manual EQ adjustment to the manufacturer or service technician. The deck comes with bias and equalization either set up for the manufacturer's choice of tape or under the control of an automatic adjustment circuit. If a user control is included, it will probably be a bias trim adjust; and if the user needs to do a little response trimming, he will probably use bias to do it.

"High-frequency response and distortion as well as other tape characteristics change with bias level."

But bias affects some inter-related problems. First, bias level has a direct relationship with distortion levels, and there is no direct indication of what is happening to distortion when bias is used to trim the response. Another potential problem is that, with many cassette decks, the best noise-reduction tracking may be obtained with the response somewhat un-flat. Recording sensitivity also affects noise-reduction tracking, of course, which is a further complication in selecting tapes and compensating for the differences from the manufacturer's set-up tape. The user is often best advised to try tapes which match the set-up tape's bias needs and sensitivity, to minimize response deviations when using noise reduction.

Recording Media Requirements

Matching the recording medium to the characteristics of the material being taped is a basic challenge. Figure 3 shows two curves of music spectra. One is an average of measurements made by Richard C. Cabot and others of levels and spectra in rock music. The other is based on measurements by Daniel Queen of maximum levels in live music. Placed somewhat arbitrarily on the figure's reference levels, notable similarities can be seen between the curves. Of particular interest is the fact that the fall-off in levels above roughly 1 kHz is close to a −6 dB/octave rate. Tape MRLs show the same slope, as we noted previously.

Work on orchestral instruments by David A. Luce has shown that their upper spectral envelopes have roll-offs of 10 dB/octave and more, with corner frequencies as high as 1300 Hz. An averaging of his curves would show a rough correspondence to Fig. 3, but a steeper roll-off above 1 kHz.

Figure 4 plots maximum octave-band levels of a rock-music FM station and two Mobile Fidelity recordings. The plots (made with an Ivie IE-30A analyzer in its accumulate mode) were deliberately shifted vertically to place their upper-end slopes close to the same reference −6 dB/octave line. The broadcast signal appears rolled-off at both ends. The opening of Respighi's "Feste Romane" contained considerable low-frequency energy, with a general drop in level above that region. The Hall and Oates record had energy distributed across the audio band, with the region around 500 Hz more elevated. It can be seen that if the same high-end criterion is used for all three cases, the mid-band levels will differ greatly for each—and if levels are set for equal mid-band energy, high-frequency levels will differ just as greatly. How, then, can the user set levels correctly to prevent distortion at the high-frequency end?

As a first step, let's consider how recording level meters respond to broadband signals such as music or, for testing purposes, pink noise. A meter that will register a zero-dB level when fed 0.5V at 400 Hz, might register −3 dB for pink noise at the same 0.5V level. The reason is this: The meter will read all the energy in a discrete tone, as long as that tone is within the meter's bandwidth. But if the signal's bandwidth is wider than the meter's, or

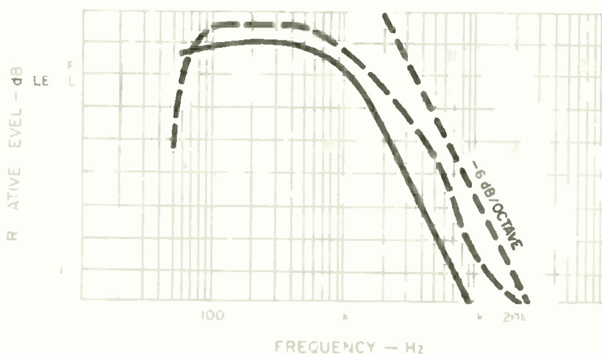


Fig. 3—Music spectra, after Cabot et al. (solid line) and Queen (dash line).

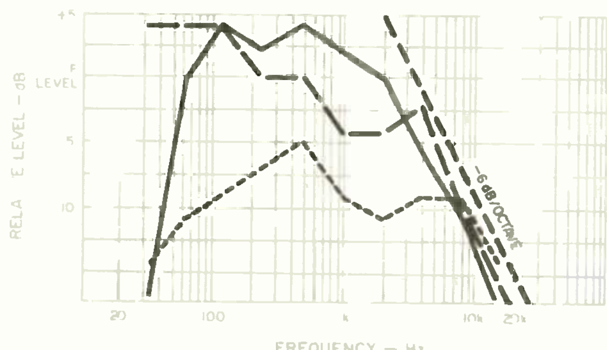


Fig. 4—Maximum octave-band levels from rock-music station (solid line), and Mobile Fidelity versions of Respighi's "Feste Romane" (dash line) and Hall and Oates's *Abandoned Luncheonette* (semi dash line).

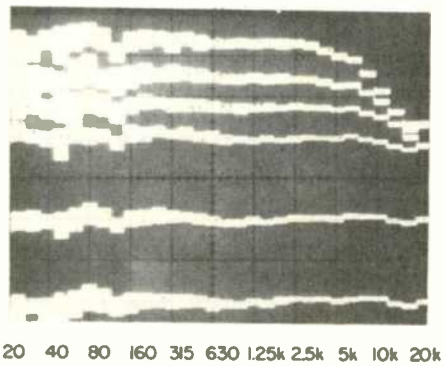


Fig. 5—Spectrum analysis of pink-noise response at +14, +8, +4, 0, −10 and −20 dB recording level.

"Although the meter will indicate the total energy in the music, knowledge of its spectral distribution helps prevent problems."

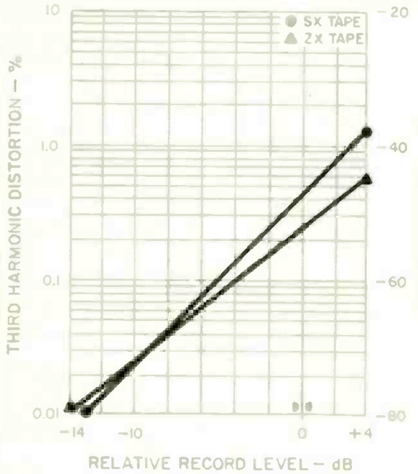


Fig. 6—HDL_3 as a function of recording level at 1 kHz with Nakamichi SX and ZX tapes on 700ZXL recorder.

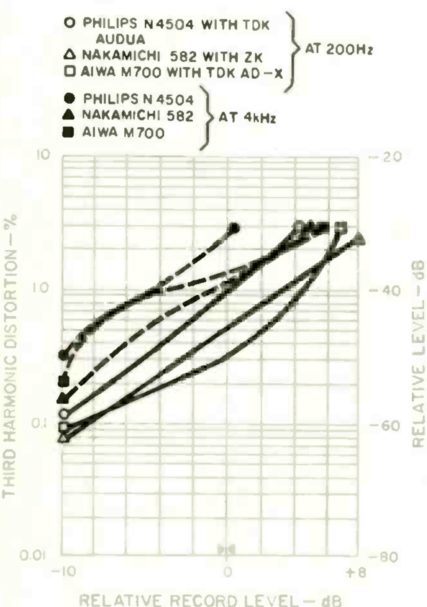


Fig. 7—HDL_3 vs. recording level at 200 Hz and 4 kHz for three recorder-tape combinations.

falls partially outside it, the indicated level will be lower.

The total level for a wide-bandwidth signal is the sum of the power levels of whatever individual bands (octaves, third-octaves, etc.) we are considering. This fundamental fact is one of the reasons that sine-wave testing is of limited use in testing for headroom. The high-frequency test tone exists *without* the presence of energy across the band, as would occur in music.

Figure 5 shows a recorder's record/playback response for pink noise recorded at levels from −20 to +14 on the recorder's meter. Some high-end roll-off is apparent by 0 dB, and the overall compression is obvious by +14 dB. At meter zero, the actual level in each band was close to −15 dB; with 30 bands, the total level is 14.8 dB above each individual band.

Referring back to Fig. 4, with the levels set as indicated by these plots, the rock station produced a +10.5-dB reading, the "Feste Romane" record got an indication of +11.5, and the Hall and Oates recording showed -3 dB. Considering the MRLs of several tapes, we would say that reducing the rock station's input level to normal meter indications should give us plenty of leeway on the high end. A similar reduction would be called for with "Feste Romane," with the possibility that some recorders would still distort its lowest frequencies. The Hall and Oates record is the deceptively challenging one: It has such a nice, smooth sound that the width of its spectrum is not obvious. We can see, however, that increasing its recording level even up to just zero would probably cause some loss at the highest frequencies.

To summarize this section: Although the meter will indicate the total energy in the music being recorded, knowledge of its spectral distribution should help prevent problems at the band limits. Listening carefully to the playback will help in setting record levels high enough for good signal-to-noise ratios.

Distortion

As many readers know, third-harmonic distortion is a fundamental characteristic of magnetic tape. Fifth and higher-ordered odd harmonics also make their appearance at high recording levels. (Even harmonics are usually not characteristic of tape recording. HDL_2, though, does show up regularly in testing, probably from poor bias waveforms, though possibly from leaky capacitors or magnetized heads as well.) The relative third-harmonic level (HDL_3) is a square function; when plotted in dB versus recording level, we can expect a 20-dB change in distortion for every 10-dB change in recording level.

Figure 6 shows measured HDL_3 vs. recording level for SX and ZX tapes on a Nakamichi 700ZXL recorder. Note how close the measured distortion curves (especially that for ZX tape) are to the theoretical 20-dB change (vertical axis) for each 10-dB change in level (horizontal axis). Note also that the curves are still straight, even at −14 dB record level and a distortion of only about 0.01%.

Figure 7 shows a similar plotting for three recorder and tape combinations: The Philips N4504 open-reel deck with TDK Audua, the Nakamichi 582 with ZX tape, and the Aiwa M700 with TDK AD-X. The results are plotted for two frequencies. All recorders showed a considerable increase in distortion with the frequency shift from 200 Hz to 4 kHz, though the increase varied from deck to deck. Even so, there is a general agreement with the 2:1 slope, especially with the 582 deck.

It is interesting that the two cassette decks have lower distortion than the open-reel machine for the same flux level. This is also demonstrated by Fig. 8, which shows the distortion products from recording a 1-kHz tone on the Philips (top) and Nakamichi (bottom) recorders. The open-reel deck had much higher second, third and fifth harmonic distortion, as well as some fourth harmonic not seen in the cassette deck's output. As the vertical scale is 20 dB per division, HDL_3 was about 7% for the open-reel deck and 1.1% for the cassette unit. Let it be said that no concerted effort was made to try other tapes with the open-reel machine or to optimize its bias for the tape used.

Figure 9, made with the same settings on the spectrum analyzer, shows three runs made with the 582 deck with ZX tape. First, a sweep was made with a zero-level 300-Hz tone. Then, a

> "The recordist must steer between the Scylla of distortion and the Charybdis of tape noise."

second sweep was overlaid (top traces) with a 1.5 kHz tone. Both tones produced third harmonics, and there's some HDL_2 with the 1.5 kHz.

Finally, both tones were fed in at the same time, with the levels reduced for the same meter reading. The results, in the bottom of the figure, show both expected and unexpected things: Note how the 1.5 kHz appears to have three upper-frequency sidebands, 600 Hz apart. Its own second and third harmonics do not appear, somehow suppressed by the added lower tone. This points out that the generation of distortion products becomes very complex when more than one tone is involved and there are *many* more than that with complex musical wave forms. The recordist must accept the fact that the fundamental approach to controlling the generation of distortion products is to avoid high levels as far as noise considerations permit.

Maximum Record/Output Levels

Most people use the criterion of 3% distortion as the maximum allowable output level, which is, of course, tied to the maximum allowable record level for any particular deck. It has been our practice to use MRLs, rather than MOLs, mostly because it tells the recordist what limits are imposed on the signal being recorded. The MRLs are always a bit higher than the MOLs, perhaps a dB or so, reflecting the compression that appears at higher distortion levels.

At the lower frequencies, the MRLs are based upon HDL_3 = 3%. Above a few hundred Hz, however, more accurate data is obtained using a twin-tone signal and measuring TTIM (twin-tone intermodulation) distortion, with 3% used as the limit.

In the last year or so, certain characteristics of the MRL curves have emerged, mostly because of more careful data taking and the inclusion of other decks in the test process. Figures 10, 11 and 12 are plottings of the range of MRLs for tape Types I, II and IV, respectively, on a Nakamichi 582 deck. Note that in all cases the spread in levels for the 3% distortion points was greatly reduced above 1 kHz or so. A basic conclusion was this: In any one tape type, there was little basis in the *high*-frequency MRLs to select one tape over the other. In the low-frequency MRLs, however, the choices were much clearer, and the data did show that the formulations with the best low-frequency MRLs were also best at the high end, albeit by small amounts.

There are other facets of these plots worthy of attention. The dashed line in Fig. 11 indicates the much poorer performance of two discontinued tapes. This figure and Fig. 12 show a gentle S-curve in the high-end MRLs, believed to be caused by the 70-µS record equalization. Previous tests with Type II tapes had shown that switching to 120-µS EQ eliminated the S-ing, increasing the headroom available; however, the change in equalization also leads to an equal increase in noise, so there is no increase in dynamic range.

On each of the figures is a −6 dB/octave reference line from +10 at 2 kHz to −10 at 20 kHz. We can see that all MRL curves fall off at close to this rate, which our earlier discussions showed to closely match the roll-off in a number of music spectra. Figure 13 shows the MRLs obtained with the

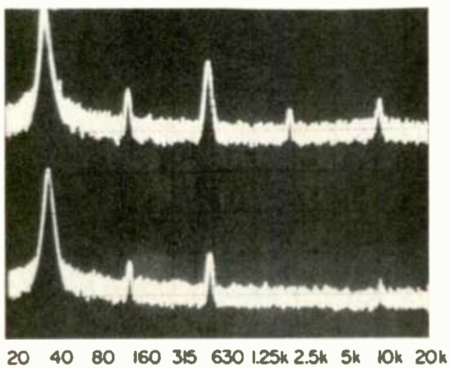


Fig. 8—Distortion products for 1-kHz signal at 200 nWb/m. Top: Philips N4540 open-reel recorder with TDK Audua (see text). Bottom: Nakamichi 582 deck with ZX tape.

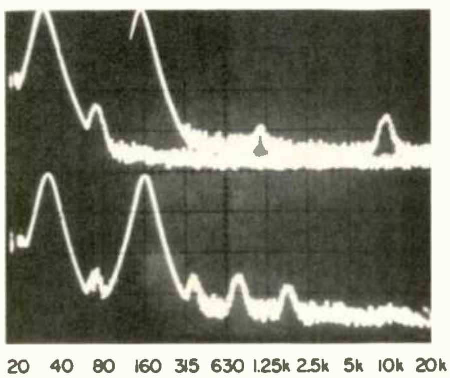


Fig. 9—Distortion with 300-Hz and 1.5-kHz tones. Top: Tones recorded separately, Bottom: Tones recorded simultaneously.

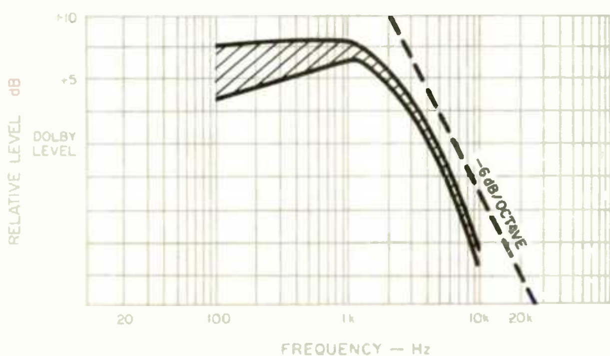


Fig. 10—Range of maximum recording levels for seven Type I tapes with Nakamichi 582 deck.

"Bias should be set high enough for low distortion without unacceptable high frequency losses."

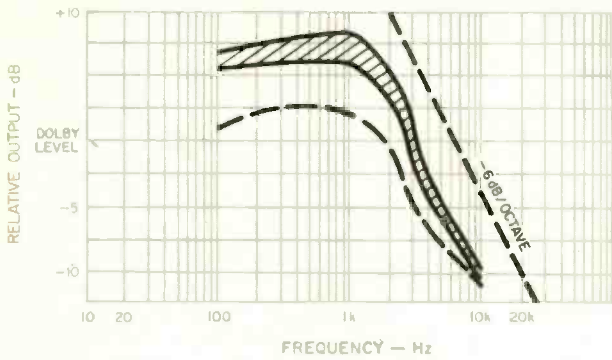


Fig. 11—Range of MRLs for five Type II tapes.

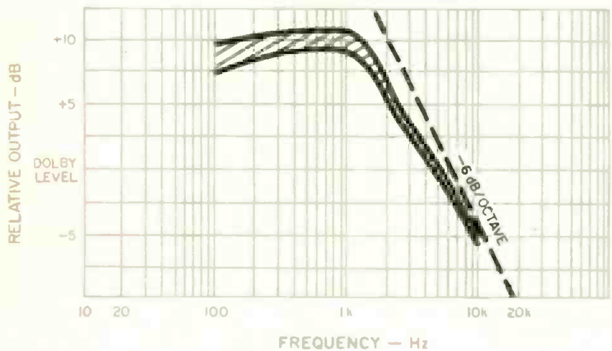


Fig. 12—Range of MRLs for five Type IV tapes.

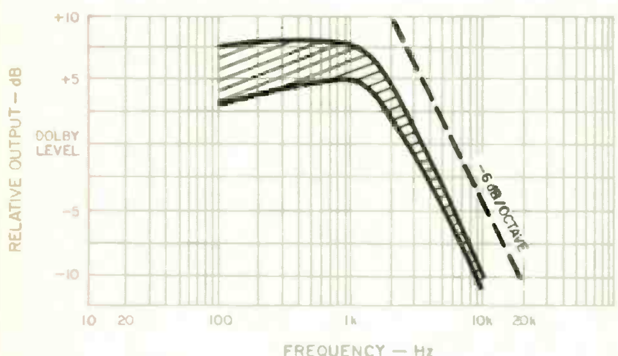


Fig. 13—Range of MRLs with Type I tapes on Aiwa AD3600 deck.

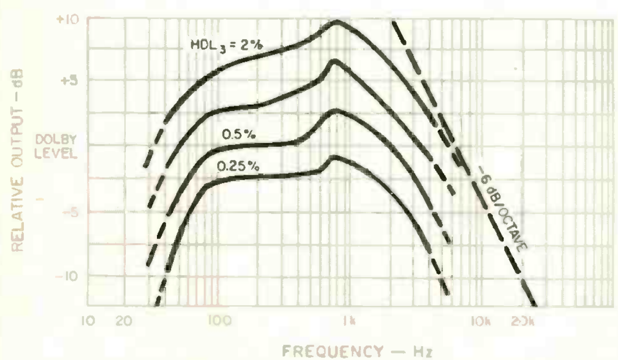


Fig. 14—Output levels for constant distortion percentages, using Nakamichi 582 deck and ZX tape.

same Type I tapes on an Aiwa AD3600 deck. The low-frequency MRLs are nearly the same as for the Nakamichi 582 in Fig. 10, though spread a bit more, and the high-frequency MRLs are a couple of dB lower.

One of the questions on distortion that remained unanswered was: What is the shape of the constant-percentage-distortion curves at less than 3%? Figure 14 presents the results of tests with the 582 and ZX tape from 0.25% to 2% distortion. The curves had quite a consistent shape, but there is some shifting, caused by the onset of compression. It is quite apparent that if a lower percentage of distortion is selected as the allowable limit, record levels must be lower or the spectrum of the music cannot be very wide-band.

Tape Noise

To some extent the recordist may very well feel that he is continually trying to steer his way between the Scylla of distortion and the Charybdis of tape noise. There is no doubt that there is lower noise with 70-µS EQ, and noise reduction has been an essential part of the cassette format in particular for some time. Figure 15 shows tape noise spectra with the 582 and ZX tape for three conditions: 120-µS EQ without NR, 70-µS EQ without NR and then with Dolby B NR. There is no doubt about the successive reduction in noise, and Dolby B shows benefits down to 400 Hz. Figure 16 shows the results of the same tests, but with BASF Professional II tape. The improvement over ZX tape is obvious in all three cases, with some reduction all the way down to 200 Hz. The benefits increase with frequency, up to about 4 dB at the high end. In fact, the BASF tape had about the same spectrum with 120-µS EQ as the ZX tape did with 70-µS EQ. There *are* differences in noise from one tape to another, and the dynamic range at higher frequencies could very well be determined by tape noise. The low-noise BASF tape would be a candidate for recording with 120-µS EQ for higher MRLs, albeit bringing up noise the same amount.

Bias Adjustment

As we stated earlier, there are relatively few recordists who adjust EQ as any sort of regular process. Adjusting

"Distortion becomes very complex when more than one tone is involved, and in music there are many."

bias, however, has become a common practice for quite a few cassette deck owners to get the most of whatever tape is tried. Figure 17 is provided as an aid to understanding the interrelationships of levels and distortion as the bias is changed. The figure is actually a time plot with bias being turned up from minimum to maximum during the sweep. The results shown are to be expected: The 315-Hz and 10-kHz levels increase with bias, but a point is reached where the high-frequency level is dropping rapidly, and the low frequency has reached its highest-level plateau. The 10-kHz level was at −20 dB, so the marked operating point has produced flat response. A short way up the bias-level curve, HDL_3 drops sharply, but then rises to a peak of over 3%. At the operating point, HDL_3 is slightly under 1%. Further increase in the bias does lower the distortion further, but with a severe drop in the 10-kHz level, and the 315-Hz level is starting to drop. The general guideline is that bias should be set high enough to get acceptably low distortion without unacceptable losses at the highest frequencies and without any bringing down of low-frequency levels.

While this article is quite lengthy, some areas have not been gone into in great detail. We hope that what has been presented will provide a framework to understand better the commonalities in tape recording.

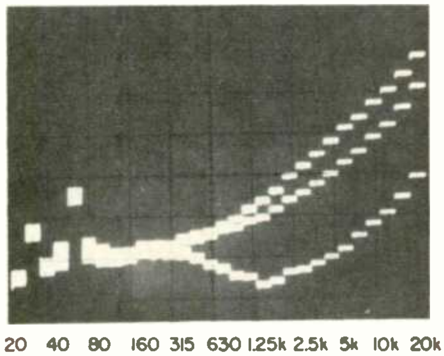


Fig. 15—Tape noise spectra with 582 deck and ZX tape. Top: 120μS EQ without NR. Middle: 70-μS EQ without NR. Bottom: 70-μS EQ with Dolby B.

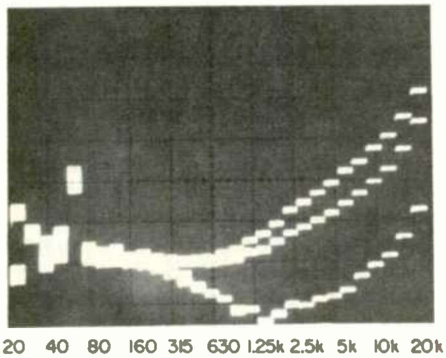


Fig. 16—Same as Fig. 15, but using BASF Professional II tape.

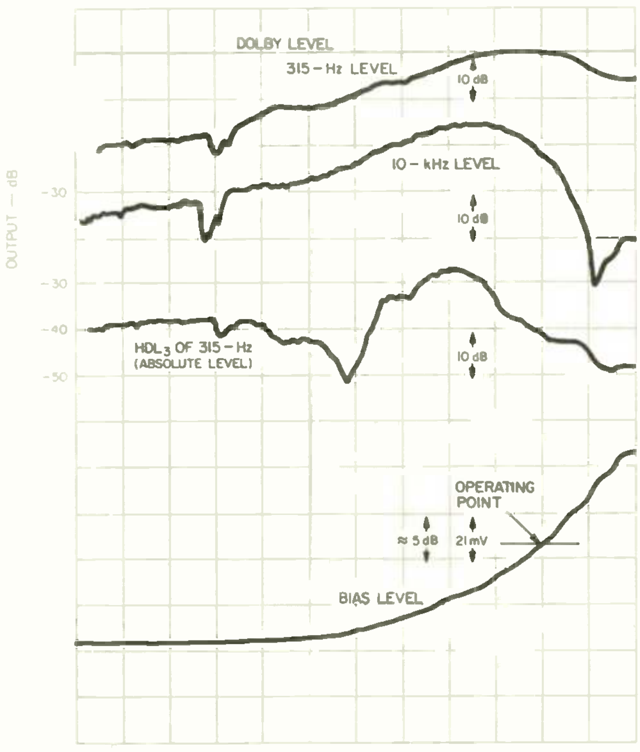


Fig. 17—Variations in 315-Hz and 10-kHz levels and 315-kHz distortion with changing bias level (Maxell XLII-S tape Nakamichi 582 deck).

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REFOCUS
REFOCUS
ON DEMAGNETIZATION

HERMAN BURSTEIN

Must you really demagnetize your tape deck's heads (and other metal parts contacting the tape) every so often?

The answer which emerged from the various views expressed in my round-up on the subject in the April, 1981 *Audio* is that the need varies with different decks and situations.

We invited reader comment, and many illuminating letters have come in—but still none so illuminating as to reveal one clear, shining, completely unassailable truth. The different viewpoints do increase our understanding of the matter, and here they are:

To begin, Phil Sutterlin, of Ampex, Cupertino, Cal., suggests how the problem occurs: "Heads can be magnetized by an applied magnetic field or a current applied to a head's winding if this field or current is asymmetrical, thus containing a d.c. component, or if it is symmetrical but abruptly changes magnitude; Fourier analysis tells us that there is also a d.c. component in the latter case."

Sutterlin continues: "Magnetic fields can be applied to heads by recorded tapes, head demagnetizers, or other less common sources. Magnetizing currents applied to a head winding can originate in purposely applied signals, namely audio, bias, and erase; d.c. leakage from the amplifier connected to the head, and transients which occur when turning the deck on and off.

"In my experience, heads are most often magnetized suddenly by mistakes such as: Turning the tape machine off while in the record mode (which can magnetize the erase and record heads), or improper use of a head demagnetizer (the extreme case being that of unplugging the demagnetizer while it is in contact with the head). In these cases, a demagnetized head can change into a magnetized one in a fraction of a second, assuming that current is in mid-cycle and therefore flowing through the demagnetizer or the head.

"Slower magnetization does occur from asymmetrical waveforms, whether audio, bias, or erase. For example, I have found that recording a signal with a 10% second-harmonic component—hence an asymmetrical waveform—causes magnetization."

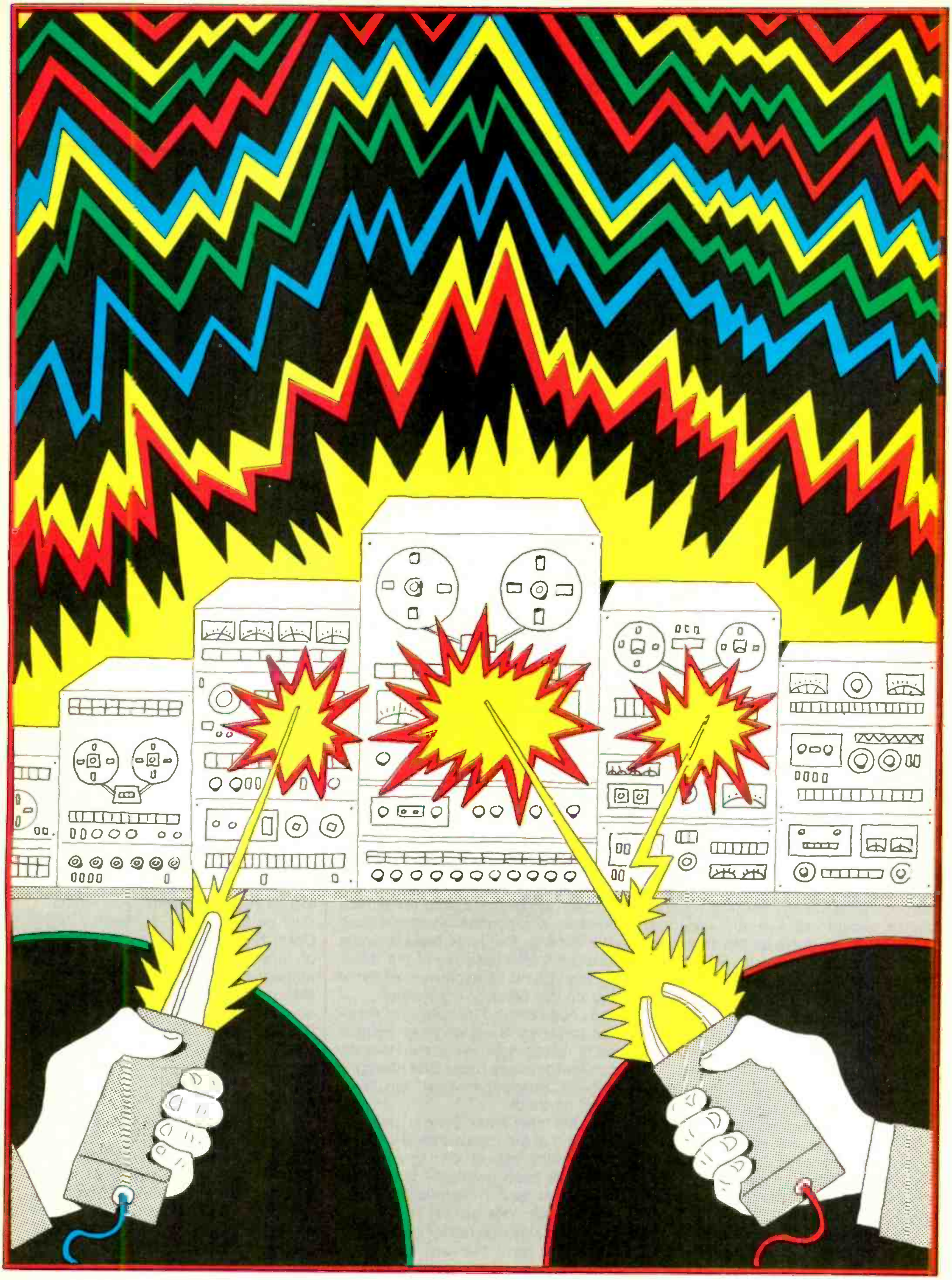
My April, 1981 article stated that a magnetized head produces noise and treble loss. Sutterlin, rightly and importantly, points out that it also causes distortion. "Magnetized heads cause an increase in second-harmonic distortion. Since third-harmonic distortion (caused mainly by the tape) is usually dominant, a spectrum analyzer is required to measure the second harmonics. If a tape deck has very low distortion in its electronics, it is very easy to measure any performance degradation caused by magnetized heads by measuring second-harmonic distortion. Noise and treble losses due to a magnetized head are also measurable with a spectrum analyzer."

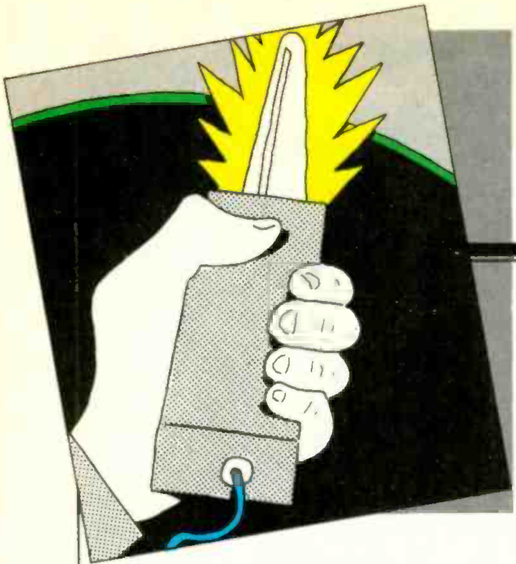
I. W. Borner of Revox (Regensdorf, Switzerland), is dubious that the asymmetrical waveform encountered in audio produces significant magnetization, and suggests that routine demagnetization, although widely performed, is based on ritual rather than necessity: "The theory of the asymmetrical waveform, which is supposed to be responsible for head magnetization, is difficult to accept. Would this not mean that the electronics in our recorders must be capable of passing the d.c. component resulting therefrom? Yes, the audio signal may be asymmetrical, but only in that a brief strong positive spike is followed by a longer but weaker negative half; the areas under each are equal, with no d.c. component.

"In querying the younger generation with experience in audio, I find that they have never come across a situation where demagnetization is necessary. Yet, they carry on the practice of regular demagnetization because this is what they have learned from the older generation." (Earlier in his letter, Borner agreed that the tape decks used by the "older generation" did frequently require demagnetization.)

"In essence, I don't believe that magnetism in the heads is something that creeps up with time, like head wear. It is something that may happen as the result of careless handling of magnetized tools, or it may be caused by design shortcomings, for example: A d.c. surge through the record head when it is connected to the record electronics, solenoids which create a strong magnetic field near the heads, or suddenness of the oscillator's attack (and possible decay). Since we usually don't know how a recorder behaves in such respects, we have an uneasy feeling that an important recording may not come out as well as it

Illustration: Kurt A. Vargo





"One professional machine actually showed an a.c. field, caused by a misplaced solenoid, of 34 Gauss."

should. The routine of demagnetizing heads is therefore performed with the same regularity as paying insurance premiums."

Like Borner, John W. Dana (Hamden, Conn.), is disinclined to believe that normal operation of a tape deck produces significant head magnetization; rather, he feels that normal operation tends to demagnetize the heads. "Unless d.c. is accidentally fed to the heads, I don't see how they can become more than minutely magnetized, no matter how much the machine is used. Magnetically recorded tape contains alternating north and south magnetized bits of equal and opposite intensity. If a head or guide were magnetized, it would be demagnetized by the alternating north and south magnetized bits as the tape is played.

"Along this line of reasoning, I believe that two-head decks, which use the same head for record and playback, would have no problem with head magnetization if the machine is used for recording at least once in a while. The alternating signal going through the head would create a strong alternating magnetic field, which would remove any residual magnetism, so long as the recording signal is strong enough to drive the VU meter into the red. One could occasionally record FM interstation noise, turn up the recording level so that the VU meter goes into the red, and *gradually* reduce the record level to zero."

Assuming that a strong a.c. signal through the record-playback head is an effective demagnetizer, Dana's expedient strikes me as unnecessary. Bias current is such a signal; its magnitude is roughly 10 times that of the peak audio signal ordinarily fed to the head.

Dan Dugan of Dan Dugan Sound Design (San Francisco, Cal.), points to a prominent cause of head magnetization and stresses the need for an *efficient* demagnetizer. "In my experience, first as an amateur and then as a professional recordist, the most serious cause of head magnetization is the transient which occurs when the deck is switched into the record mode. I had one machine, which didn't last long on the market, that would sometimes magnetize its head with just one actuation of the record button. But since 1970, many machines have included time-delay circuits in their bias oscillators to soften this effect.

"No discussion of head demagnetization is complete without mentioning the need for a really effective demagnetizer. I've found that most of the demagnetizers sold for consumer use are too weak to do any good, and the persons using them usually have no way of knowing whether demagnetization has been accomplished or not. The R. B. Annis Company of Indianapolis, Ind. sells heavy-duty demagnetizers that really do the job, and it also sells magnetometers to measure head magnetization."

Some types of heads appear to be more susceptible to magnetization than others. Nakamichi, in its "Technical Bulletin 4" published a few years ago, states: "Perhaps one of the most disturbing properties of ferrite heads is the spontaneous build-up of magnetism. . . . There are many stresses imposed on ferrite during the cutting processes because of its great hardness. The high temperature process of melting the crystal glass onto ferrite, furthermore, compounds the stress. Even after cooling, the ferrite head is under constant stress because of the differing coefficients of expansion of ferrite and crystal glass. . . . Whereas . . . it was once believed that physical shock was required to induce magnetism in ferrite heads, it is now known that the constant stresses caused by changing ambient temperature have the same effect as shock."

On the other hand, there is reason to believe that the disadvantage of ferrite heads, with respect to magnetization, may have been overcome to a significant extent, as demonstrated by Nakamichi which does use ferrite heads in its decks, although not for playback.

Still, the point remains: Depending on materials used and type of construction, some heads may be more subject to magnetization than others.

We are reminded that not only heads but also other metallic components may become magnetized and endanger our recordings: The *Standard Tape Manual*, published by Standard Tape Laboratory, Inc. (26120 Eden Landing Rd. #5, Hayward, Cal.), states that magnetization is possible in "the guides, the capstan, and any metallic surface which contacts the tape. Even 'stainless' materials called 'nonmagnetic' are capable of retaining some field and are therefore suspect."

The *Manual* goes on to warn of stray a.c. fields which may cause erasure for which the user may blame the heads. "Many top selling machines have been designed without any consideration by the engineering departments as to a.c. magnetic field contamination." As a horrible example, "one professional machine actually showed an a.c. field, caused by a misplaced solenoid, of *34 Gauss* (in nontechnical language, a helluva strong field—H.B.). . . . The field was concentrated at the supply reel side of the transport at the flutter idler guide."

Further, "a poorly filtered d.c. supply may carry enough a.c. ripple to do a lot of damage to a tape passing near a solenoid or relay coil."

We are indebted to Mike Hardwick of Westronix Hi-Fi (Salem, Ore.), for calling our attention to the above information in the *Standard Tape Manual*.

In closing, John J. Swetko (Glen Oaks, N.Y.), writes: "During 18 years of tape deck ownership, which has ranged from tape manglers to top-notch decks, I have experienced only one episode of tape degradation. When I first opened my TEAC I immediately played a tape, and in one pass I immediately destroyed it. After that event, I have never failed to demagnetize after moving a deck. Other than that, my demagnetizing has been haphazard yet without ill effect."

The correspondence indicates that what was once a definite threat is now less of a problem. Nevertheless, head magnetization can occur and caution should be exercised when conditions put recordings at risk.

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Today, only one high bias tape is able to combine outstanding sensitivity in the critical high frequency range with the lowest background noise of any oxide tape in the world.

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Professional II is like no other tape because it's made like no other tape. While ordinary high bias tapes are made from modified particles of ferric oxide, Professional II is made of pure chromium dioxide. These perfectly shaped and uniformly sized particles provide a magnetic medium that not only delivers an absolute minimum of background noise, but outstanding high frequencies as well.

Like all BASF tapes, Professional II comes encased in the new ultra-precision cassette shell for perfect alignment, smooth, even movement and consistent high fidelity reproduction.

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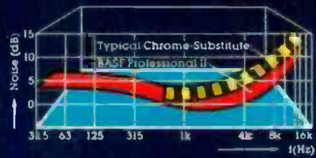

The difference in noise level between PRO II and ordinary high bias tape is greatest where the human ear is most sensitive (2-6 kHz).

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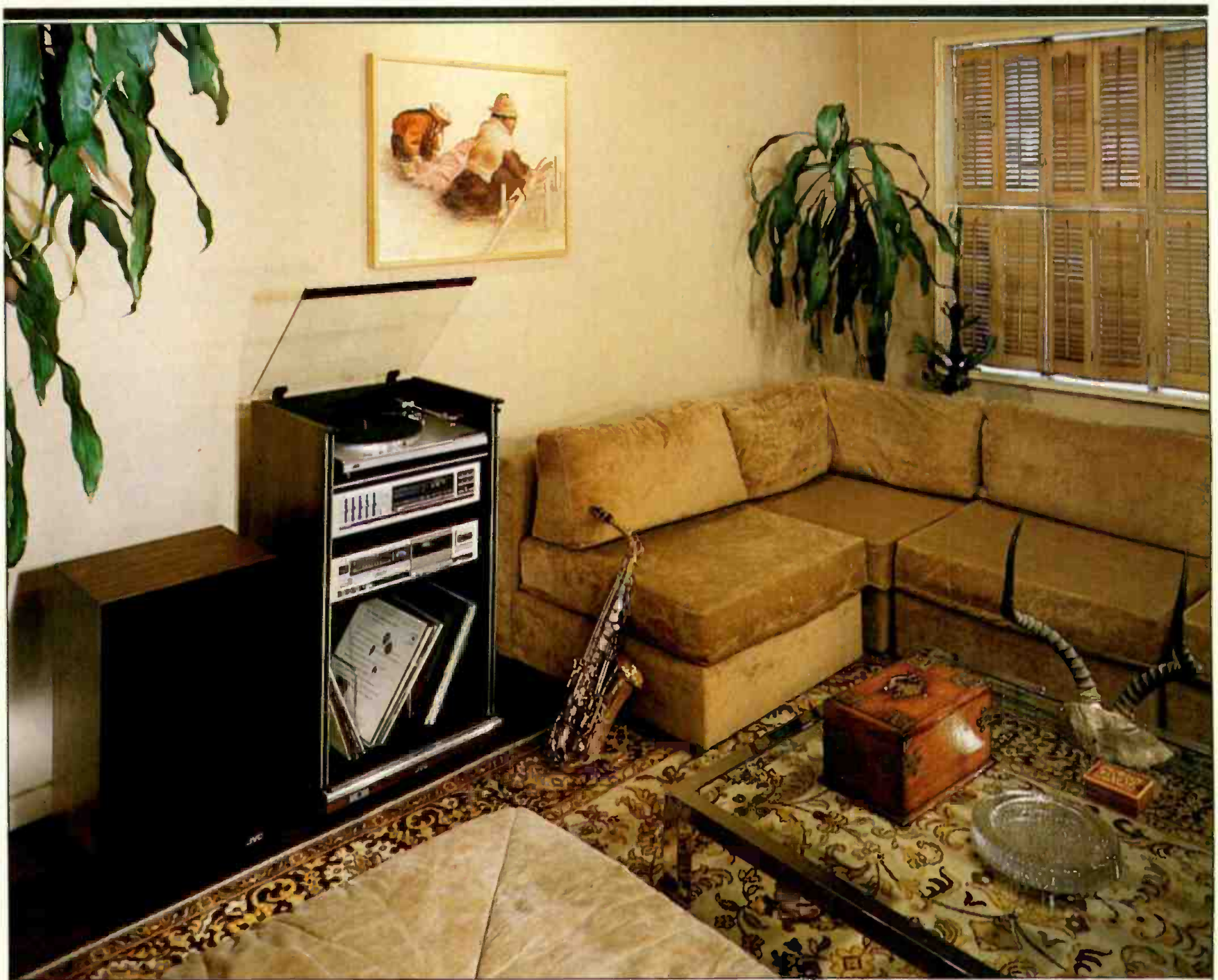
JVC S-40 SYSTEM



In creating their component systems, JVC seems to have overcome an objection voiced by many prospective purchasers, the lack of freedom of choice. Earlier one-brand systems offered by many manufacturers were take-it-or-leave–it propositions. You *had* to buy the speakers, you *had* to buy the tape deck (even if you had no desire to ever make a tape recording), and you *had* to buy the electronics in whatever form they came.

In the case of the JVC S-40 (and other systems in the JVC line), the obligatory items are kept to a minimum. Specifically, the receiver and turntable system (with cartridge already mounted) are included, as is the furniture or rack itself. However, the receiver and turntable can be purchased separately as Models R-X40 and L-A31. Suggested price for the receiver is $350 while the turntable carries a suggested price of $180. Speakers recommended for the S-40 system and available optionally are JVC's model SK-404s, which have a suggested price of $140 each. These are three-way systems with 12-in. woofers. While any of JVC's cassette decks can be used with the system (all have been sized and styled to match the receiver's front panel), we checked out the S-40 using JVC's recommended deck for that system, the Model KD-D30, which has a suggested price of $215. Purchased as a system, the S-40 has a suggested price of $1100, including cabinetry. This represents more than a $200 savings vs. the cost of the individual components.

Equipment designed to be sold separately must meet tougher standards than those items designed expressly for use in a specific system, since stand-alone components can't rely on other parts of the system correcting or compensating for their shortcomings. That JVC makes these components available separately suggests that they were designed to stand on their own.

In the cases of the R-X40 receiver and the KD-D30 cassette deck of this system, that certainly proved true. Each is a fine component that would earn good marks if examined on its own. The turntable system fared almost as well in our tests, but the car-

Photograph: Susanne Buckler

tridge supplied by JVC left more than a little to be desired and we would strongly recommend that buyers of this system replace it with something better right at the outset.

The R-X40 receiver of this system incorporates much of the advanced technology JVC has developed for their most sophisticated components. The tuner section employs frequency-synthesis for completely accurate tuning, and allows you to preset a total of 12 AM or FM favorite stations for instant recall. As with all such tuning schemes, tuned-to frequencies are digitally displayed and manual as well as automatic scanning provisions for tuning are provided. The total absence of rotary controls on the front panel makes for a very clean looking design. Instead of conventional bass and treble tone controls, JVC has incorporated a five-band graphic equalizer, which they still insist upon calling S.E.A. (for Sound Effects Amplifier). In addition to providing more accurate tonal compensation for room acoustics, poorly equalized program material and personal taste, the equalizer can be applied to the tape-recorder outputs, so you can equalize your tape recordings as you make them.

Though not as apparent as the panel-activated features just described, JVC's "Super-A" power amplifier circuitry is a welcome part of this receiver. The circuit reduces some of the more subtle forms of distortion commonly found in so-called Class-B amplifiers, without sacrificing Class B's high efficiency. Three-way circuit protection in this amplifier circuit ensures against speaker or amplifier damage. Power output capability and signal-to-noise ratios both exceeded published specifications (see Rating Chart), and harmonic distortion was inaudibly low, as claimed. Deviation from perfect frequency response in the phono mode was slightly more than specified, but not enough to be audibly distracting. While measured stereo-FM characteristics, such as 50-dB quieting sensitivity and distortion, were slightly poorer than claimed for our sample, they were nevertheless more than acceptable from a listening standpoint, and both separation and signal-to-noise ratios (in stereo) were excellent.

The optional KD-D30 cassette deck features *both* Dolby B and the newer, more effective Dolby C noise reduction circuitry. Styled to match the other components of the system, the deck has no rotary controls, and all tape transport controls are of the light-touch, logic-controlled type. A "music scan" system allows you to quickly find the beginning of the next recorded selection on a tape or the beginning of the previous one. Record/play frequency response for normal-bias and metal tapes proved to be exactly as claimed but, in my sample, overall frequency response for the high-bias tape formulation (I used TDK SA in my tests) was slightly poorer than

Continued on page 43.

ONE-BRAND SYSTEM RATINGS

Manufacturer: JVC **Model:** S-40 **Price:** $1,100.00.
Cabinet Dimensions: 36⅛ in. (917.5 mm) H × 16-15/16 in. (431 mm) D × 19-5/16 in. (491 mm) W.

Component & Specification	Claimed	Measured	Rating
Power Amp Section (R-X40)			
Power/Channel, watts	40	62	♪♪♪
Rated THD, %	0.008	0.008	♪♪♪♪
Preamp/Control Section (R-X40)			
Freq. Response, Phono	RIAA ±0.5 dB	RIAA ±1.0	♪♪
Phono S/N, dB	71	75.5	♪♪♪
FM Tuner Section (R-X40)			
50-dB Quieting, Stereo, dBf	38.3	41.0	♪♪
S/N, Stereo, dB	73	73	♪♪♪
THD, Stereo, 1 kHz, %	0.2	0.35	♪♪
Separation, 1 kHz, dB	45	46	♪♪♪
Alt. Chan. Selectivity, dB	65	65	♪♪♪
Turntable/Cartridge Section (L-A31)			
Freq. Response, Hz-kHz, ±dB (See text)	10-20k (No tolerance)	20-20k	♪
Separation 1kHz, dB	25	38	♪♪♪♪
Rumble, DIN B, dB	75	75	♪♪♪
Wow & Flutter, % wtd. rms	0.03	0.03	♪♪♪
Cassette Recorder Section (KD-D30)			
Freq. Resp., Hz-kHz, ±3 dB			
Normal Tape	30-14	22-14	♪♪♪
Chrome Tape	30-15	22-13.5	♪♪♪
Metal Tape	30-15	22-15	♪♪♪
S/N, Best Tape, with NR, dB	74 (Dolby C)	75.4 (Dolby C)	♪♪♪♪
Wow & Flutter, % wtd. rms	0.05	0.04	♪♪♪♪

Rating System
♪ = Poor; ♪♪ = Good; ♪♪♪ = Very Good; ♪♪♪♪ = Excellent; ♪♪♪♪♪ = Superb.

General Comments
Receiver: Excellent amplifier section with reliable protection circuitry and relatively low heat generation. Sound quality very good for all program sources, through phono response a bit off, partly because of preamp equalization, partly because of poor cartridge supplied. Tuner section easy to tune and to store favorite stations. Stereo station tuning a bit critical, but no problem when tuning in scan or preset selection modes. *Cassette Deck:* Very fine layout, well-calibrated Dolby B and C noise reduction systems. Performed best with standard high-grade tapes and with metal tapes. *Turntable:* Excellent as such, but cartridge should be replaced with better type.
Overall Comment: I admired the "graphic equalizer" incorporated into the receiver. An unusual feature at this price level—and a good one.
Overall Rating: ♪♪♪

IVAN BERGER

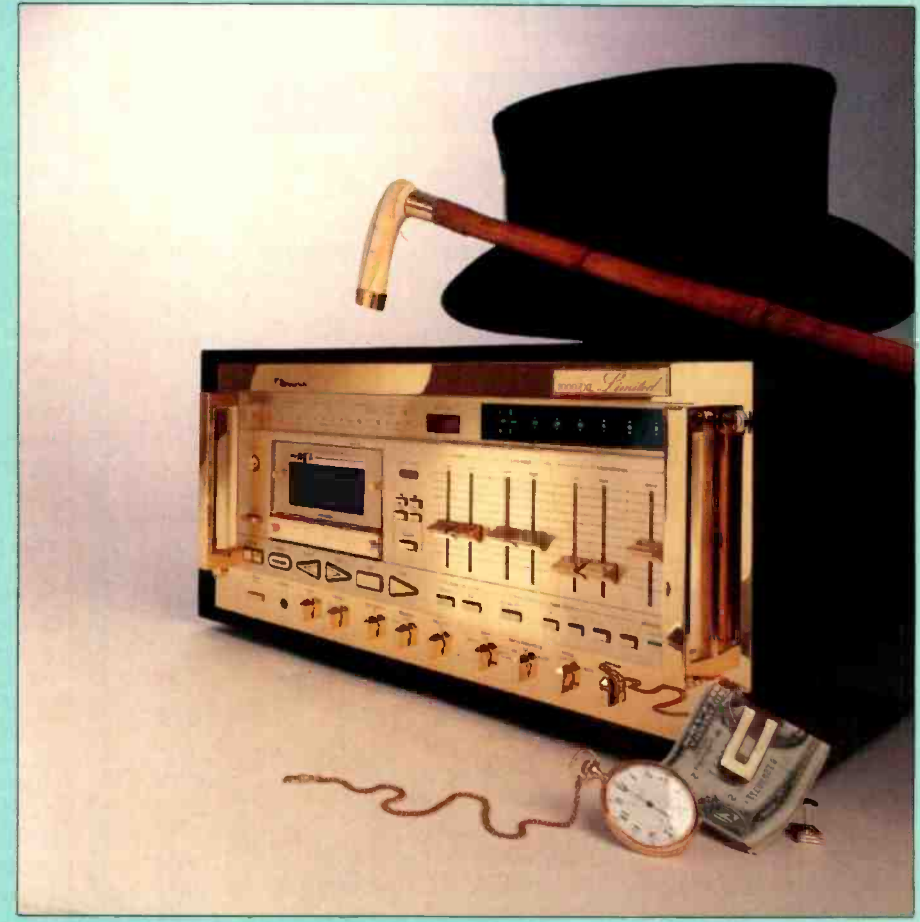
THE WORLD'S MOST EXPENSIVE CASSETTE DECK

Nakamichi's 1000ZXL Limited: The glitter is for the show, but the gold inside makes better music.

Jaws don't usually drop at the sight of a stereo component around here. But they did, wholesale, when we unwrapped Nakamichi's 1000ZXL Limited.

At $6,000, the Nak Limited is probably the world's most expensive cassette deck. But you don't have to know its price—or anything about audio, for that matter—to be impressed by its appearance. Where the regular 1000ZXL is a sober, technical black, the Limited has a front panel of gleaming gold, set off by a cabinet of polished rosewood. If you're bored with equipment which merely *sounds* exquisite, the Limited is expressly for you. To prove it, your Limited will come with a personally engraved name plate which fastens just below the tape well. (Our sample was engraved "Nakamichi," a subtle reminder to send it right back.)

Gold plating is also used liberally inside the deck, where it serves functional instead of merely psychological or esthetic purposes. All internal connectors (not just the input/output jacks, as on the standard version) are gold-plated, for low contact resistance which should last a lifetime without tarnish or corrosion. The tape head shields are gold-plated, too. According to Nakamichi, gold's superior conductivity not only improves their electrical shielding but also improves magnetic shielding by shunting surface eddy currents. Even the power-supply heat sinks are gold plated, to enhance their thermal as well as their electrical conductivity.



Performance Comparisons: Nakamichi 1000ZXL Limited Vs. 1000ZXL

	Manufacturer's Specifications	1000ZXL Limited Inspection Sheet	Standard 1000ZXL Audio's Measurments[1]
Frequency Response	20-20,000 Hz, ±0.75 dB	Same	17-22.000 Hz, ±0.75 dB
	18-25,000 Hz, ±3 dB	Not Measured	12-25,700 Hz, ±3 dB[2]
Wow and Flutter	Less than 0.04% wtd. rms	0.03% wtd. rms	0.03% wtd. rms
Signal-to-Noise	72 dB (Dolby C)	74.5 dB	75.5 dB[2]
	66dB (Dolby B)	70dB	68.5 dB
THD @ 400 Hz, 0 dB	0.8%	0.65%	0.40%[3]
Erasure	60dB @ 100 HZ	Not Measured	74 dB @ 100 Hz
Tape speed	Not Specified	±0%	±0%
Channel Separation	Not Specified	42.0 dB @ 400 Hz	50 dB @ 1 kHz

Notes: [1]*Audio*, June, 1981 unless otherwise specified.
[2]*Audio*, August, 1982
[3]Rose to approximately 0.52% at middle frequencies.

"Gold plating is also used liberally inside, for functional, not just esthetic purposes."

Where gold is not the best material to use, of course, Nakamichi uses other substances. The tape transport chassis has been surface-treated with black alumite, to damp its already well-damped resonance and to increase its corrosion resistance. The main chassis is also treated for improved corrosion resistance, this time with a substance called black chromate.

Critical circuit components are hand-selected, to make sure they're all not only within tolerance but *well* within it. This ensures against cumulative errors which can occur when components bunch up at one end of the tolerance range. The flywheel is turned from solid brass instead of the regular model's alloy, and is checked for optimum balance.

How much difference does all this tweaking make in the 1000ZXL's performance? The Limited's published specifications are the same as for the normal unit, save for its weight (1.1 pounds heavier). But that may not be the whole story. Each Limited comes with an individual frequency response graph and test sheet. According to the measurements accompanying our sample, the Limited exceeded its published specifications. On the other hand, so did the 1000ZXL we tested in our June, 1981 issue. (See box.)

The most clear-cut area of performance improvement was lower noise, due to the inclusion of Nakamichi's NR-100 Dolby C adapter, a $230 option on the ordinary model. (Reviewed in our August, 1982 issue.)

The Limited naturally has all the standard 1000ZXL features. It contains two separate microcomputers: The one which serves as the A.B.L.E. (Automatic Bias, Level, Equalization setting) computer tests the tape at four frequencies (400, 2.4k, 7.2k and 20k Hz) instead of the one or two frequencies typical of such systems; bias can also be manually varied ±12.5% from the automatically-chosen settings.

The other computer is for R.A.M.M. or Random Access Music Memory. It can identify up to 15 programs or selections, and store up to 30 commands for playing and repeating those selections in any order. Uniquely, it encodes selection numbers on the tape, together with the EQ and NR settings with which the recording was made. In playback, the system automatically duplicates those settings, regardless of front-panel control settings. Even the recording-level meter display is out of the ordinary, with a full 56 segments for finer level discriminations than is possible with most "bar-graph" meters. And, being a Nakamichi, the deck has three microphone inputs—left, right and center blend.

There's one area of response we know the Limited will enhance: your friends' reactions to your system. It's not just as if you'd bought a new Mercedes, but more as if you'd parked one in your living room.

Ivan Berger, a well-known writer on audio for 20 years, has just joined Audio's *staff as Technical Editor.*

JVC ONE-BRAND SYSTEM

Continued from page 41

claimed, indicating perhaps that the machine was not perfectly adjusted for this brand and formulation of tape. Wow and flutter was extremely low for a cassette deck in this price category, measuring an inaudibly low 0.04% wtd. rms. And, as might be expected, best signal-to-noise ratio, obtained while testing with metal tape and with Dolby C noise reduction, was a very high 75.4 dB—even higher than the 74 claimed by JVC.

My chief criticism of this JVC system has to do with the phono cartridge supplied with the otherwise excellent L-A31 automatic-return, direct-drive turntable. My measurements disclosed that this cartridge has a severe peak at around 13 to 15 kHz, which results in overly bright reproduction, and there is diminished stereo separation above 8 to 10 kHz, where the peak first becomes apparent. The peak reaches a maximum of 6 dB (which accounts for our perhaps overly generous specification of "plus or minus 3 dB" in the rating chart). As we suggested earlier, replace the cartridge or have your dealer install a better one for you. It will be a very worthwhile improvement at small cost. The table itself, with its low wow and flutter and low rumble (−75 dB, DIN B) deserves a better pickup, in my opinion—preferably one that can track at less than the 2.0 grams specified for the supplied cartridge.

Instead of conventional tone controls the JVC R-X40 has a five-band graphic equalizer.

From what I was able to judge, JVC did not compromise in their design of these components. If there has previously been any snobbish, negative stigma associated with one-brand systems, the approach taken by JVC (and one or two others) should help to dispel such negativism. The system is easy to assemble, looks good in its cabinet and is easy to operate. Best of all, it delivers crisp, full-bodied sound equal to or better than many systems consisting of mixed and matched components in the same or higher price categories. *Leonard Feldman*

Seeing Sound

GRAHAM BANK

Graham Bank is the Technical Director for Celestion International, Ltd. in Ipswich, England and is responsible for the company's research, including the design and development of loudspeaker systems for professional and home use.

For the past 50 years, the moving-coil speaker has probably changed least of all major audio components and we have learned very little about basic speaker behavior during this period.

Essentially, a speaker is a sound-producing vibrator which attempts to recreate, mechanically, the sound waves made by a person's voice or a musical instrument. The goal of a manufacturer is a speaker which correctly imitates the vibrations of live sound. But if the vibrations cannot be seen or measured, how is it possible to make sure they are mechanically correct?

Until recently, the measurement techniques for evaluating speaker performance have been indirect, analyses of the sound created rather than of the process that results in the sound waves. The most famous of these indirect measurements is, of course, the amplitude response curve. Using microphones in an anechoic chamber, this test gauges the sound pressure of a speaker's output across the audible frequency range. Ideally, a speaker should emphasize all frequencies equally, resulting in a "flat" response curve and, theoretically at least, reproducing all of the music signals with perfect accuracy.

However, if a speaker flunks its amplitude response test, showing a curve that resembles the jagged peaks and valleys of an EKG, the designer still does not know the reason for the failure. Furthermore, even if the speaker produces a perfectly flat response curve, that's no guarantee that it will actually *sound* good. How many times have you read a review of a speaker—or heard one—whose musical performance flew in the face of the tests? Also, quite frequently two speakers with similar amplitude response curves sound completely different.

For years, scientists sought a more direct way to evaluate speaker performance. Early experiments included dumping lycopodium powder onto operating loudspeakers and then observing the patterns that developed on diaphragm surfaces with a stroboscope, techniques borrowed from general theories on vibrating bodies. Such research made possible mathematical models that could predict vibrational modes with a fair amount of accuracy. With the advent of computers, these mathematical models formed the basis for more sophisticated tests. But the methods were not wholly satisfactory, and very often there were anomalies in performance that defied the computers' mathematical intelligence.

In the 1970s, the development of holography made possible a new kind of analysis. A hologram can be consid-

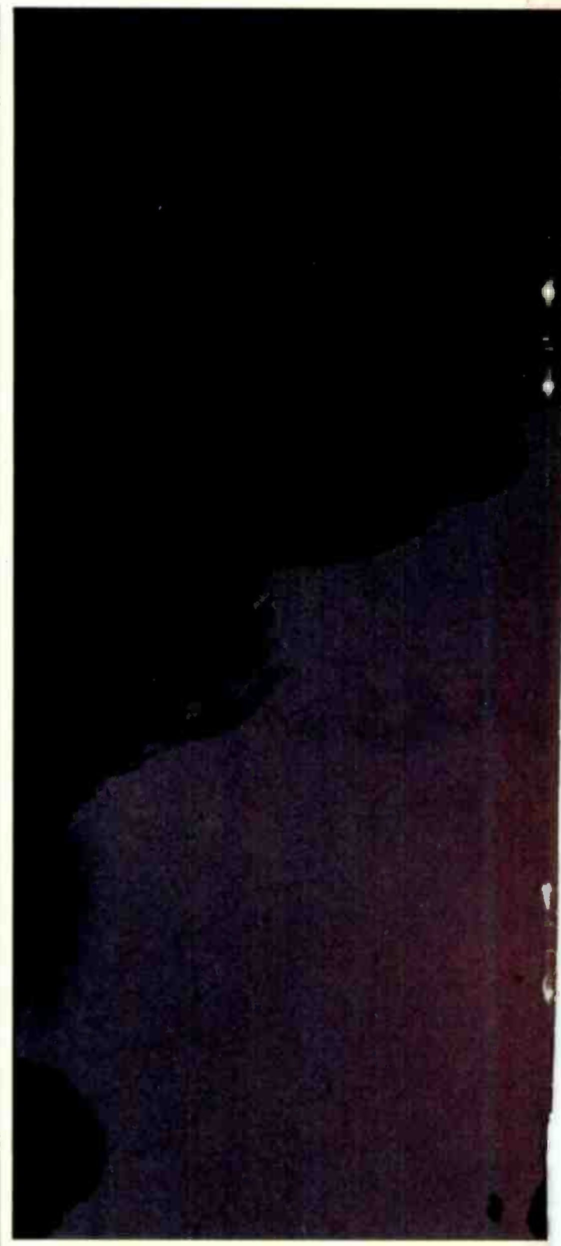
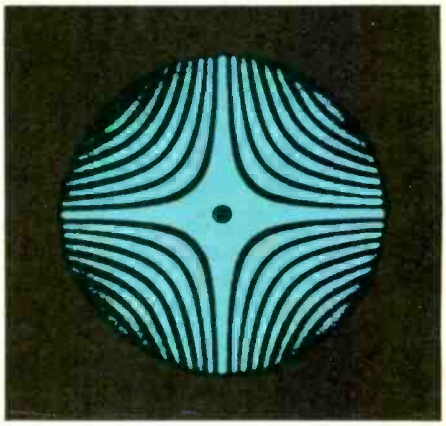
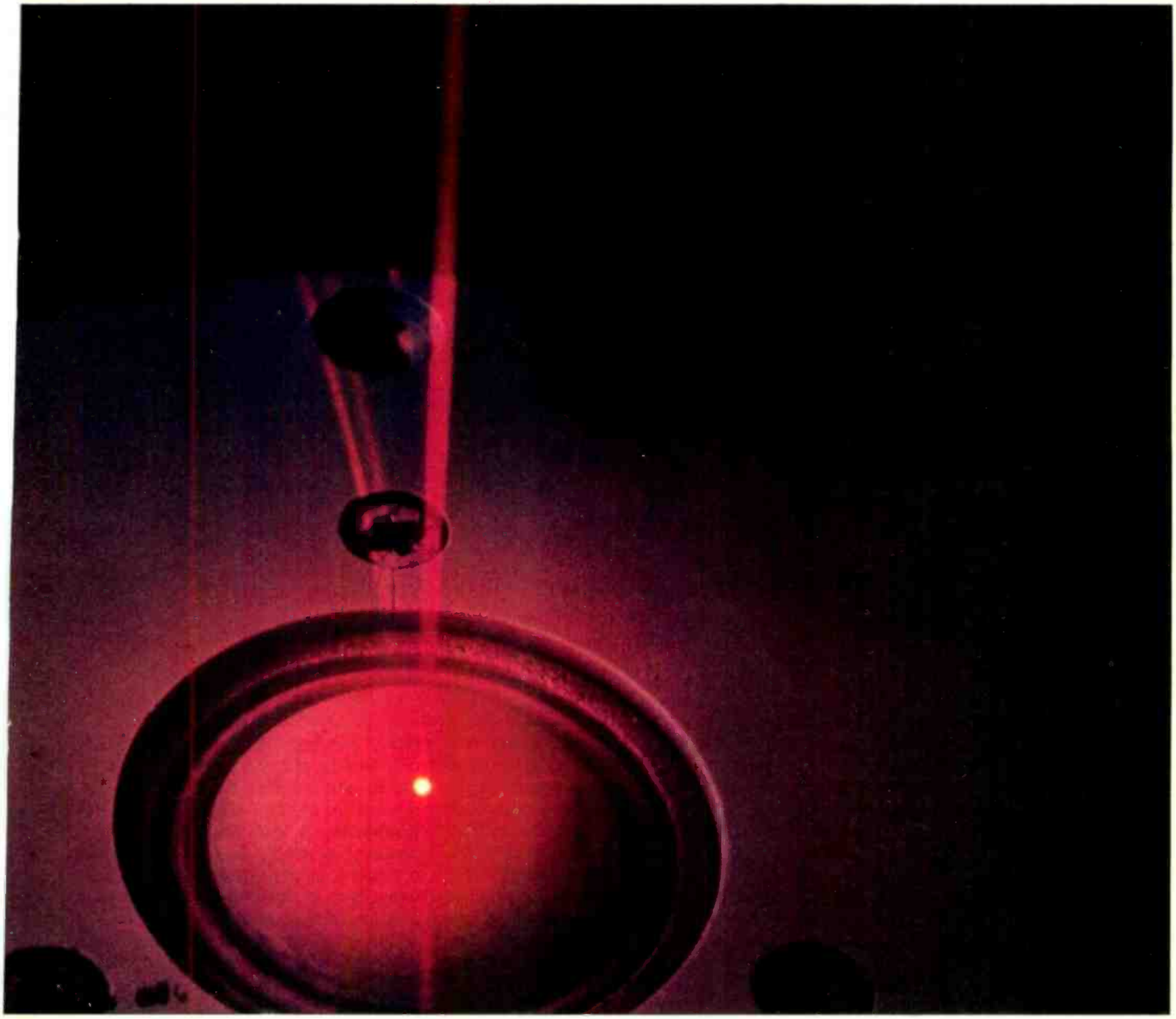


Fig. 1—Holograms can reveal microscopic problems, but without depth or direction.



With a laser



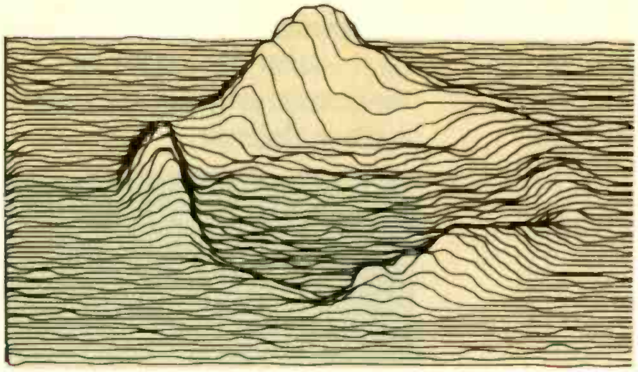


Fig. 2A—At 8kHz, this 19mm plastic-dome tweeter shows severe asymmetric surround resonance.

Celestion engineer Gordon Hathaway also uses conventional amplitude response plots to supplement the animated computer plots.

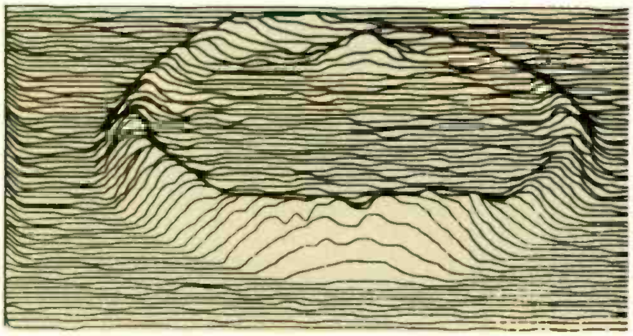


Fig. 2B—Ultra hard metal dome shows asymmetric decoupling of its surround at 8kHz.

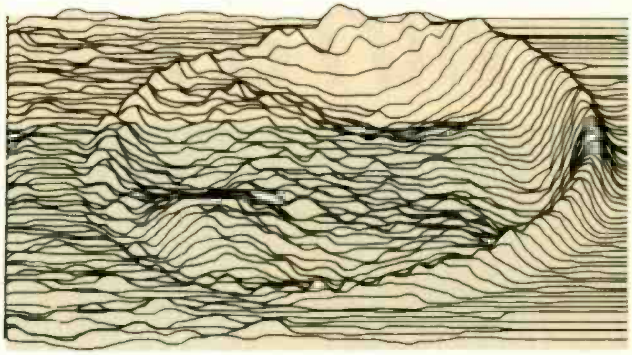


Fig. 3—At 780 Hz., this conventional bass/midrange unit shows four irregular bell modes and an asymmetric surround problem.

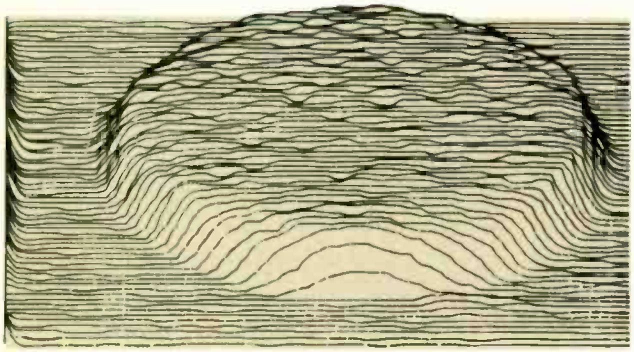


Fig. 2C—Copper alloy treble unit at 8 kHz is correctly controlled, nearly a perfect piston.

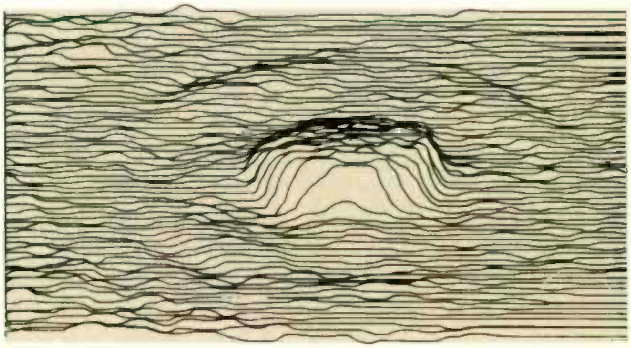


Fig. 4—A severe dust-dome problem shows up in the bass/mid unit at 1.3 kHz.

ered as a three-dimensional measurement made by bouncing phase-coherent light off a moving or three-dimensional object and then comparing or interfering it (hence interferometry) with a reference beam that is also phase-coherent. The technique creates a "beat" frequency which is transposed onto film or another two-dimensional recording medium to produce a hologram.

Holograms provided the first glimpses of speaker behavior on a microscopic level, but they pose some frustrating limitations. They can be used only with small speaker diaphragms and displacements. Another drawback is that holography is analogous to contour map illustrations. As Fig. 1 shows, you can see where the problems occur only via line intensity or thickness. The burden of determining where the problems occur on the diaphragm itself and the level of displacement, was left to the engineer and his imagination.

Furthermore, holograms are at best blurry and indistinct. Worse, they are only two dimensional, and it is impossible to see whether the vibrations are moving up or down. Using a laser and a specially programmed computer, a group of researchers at Celestion have created a system that shows speaker vibrations in animated form, clearly and unambiguously.

The laser-computer system operates in three steps. First, at the command of our computer, a neon-helium laser scans the surface of a vibrating speak-

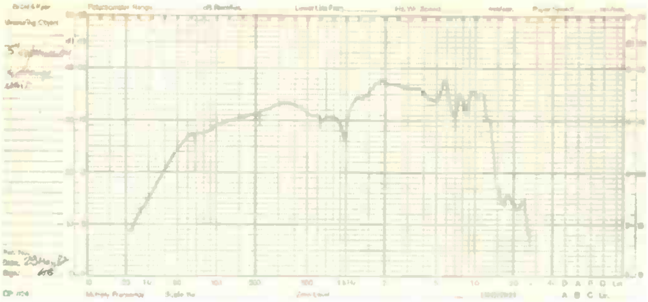


Fig. 5A—In the amplitude response curve of a 5-in., paper-cone midrange unit a sharp dip occurs at 1 kHz.

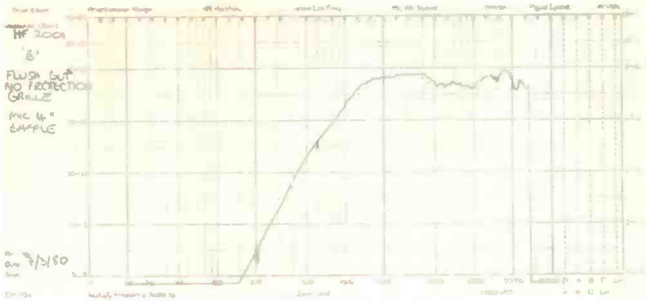


Fig. 6A—Sharp 14- and 21-kHz dips mark amplitude response of a ¾-in. Mylar tweeter, which is relatively flat from 1.1 to 28 kHz.

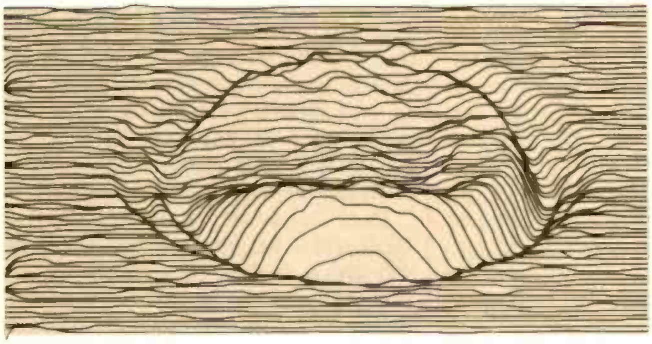


Fig. 5B—At 1022 Hz, laser-computer animation reveals a rocking mode, caused by the mass of the lead-in wires.

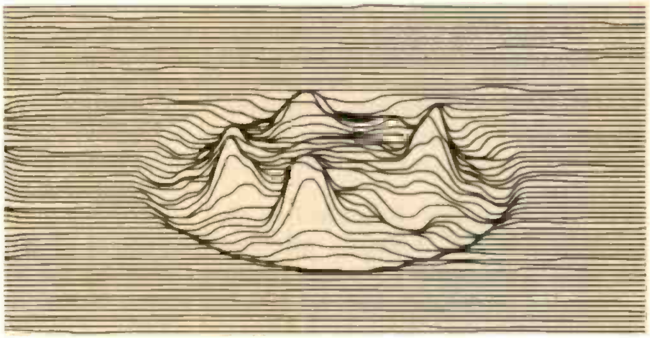


Fig. 6B—A high-resolution plot at 14,274 Hz shows a severe, four-pole bell mode.

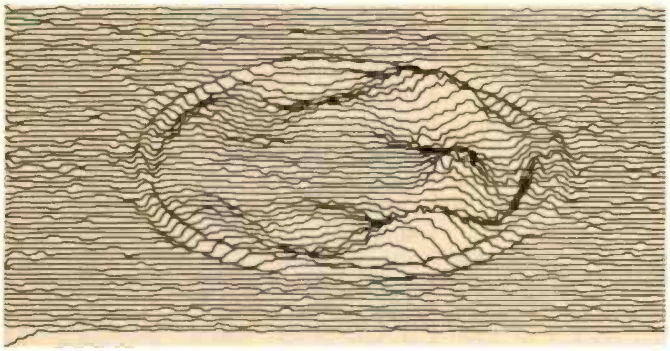


Fig. 5C—A high-resolution plot at 2.4 kHz shows the lead-in wires' "leash" effect even more dramatically.

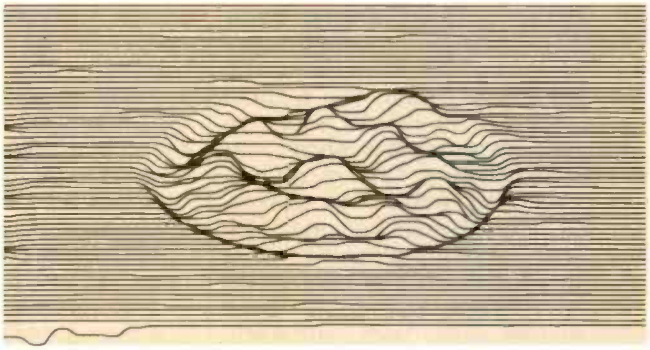


Fig. 6C—At 21,031 Hz, the bell mode is eighth-order, but with less effect than the 14,274-Hz mode.

er diaphragm, gathering information on diaphragm motion at more than 32,000 points. The computer instructs the laser how to scan, either straight across or in an arc, and at any frequency in the audio range, from 20 Hz to above 100 kHz. Second, a phase-sensitive detector gathers the data and relays it into the computer, where it is processed and fed to an X/Y plotter. Third, the plotter draws a three-dimensional picture of the diaphragm movement as it appeared at the instant of the laser scan. Successive plots are stored in the computer and can be displayed later on an oscilloscope as a three-dimensional diagram, providing a clear indication of the direction of surface waves moment to moment.

At first glance, a single frame from the animated plot might resemble a topographical map of a bizarre, far-off planet. Actually, what one sees is speaker diaphragm displacement or velocity, magnified thousands of times and frozen in time. It is as if you were able to shrink yourself to about a fifth of a millimeter in height, and hover a bit above and to the side of an operating loudspeaker.

Rendered graphically in this fashion, speaker vibrations begin to make a great deal of sense. And speaker misbehavior becomes apparent even to untrained eyes. Good sound—that is, sound born of perfectly formed vibrations—is produced when the diaphragm rises up in the form of a broad, flattened piston. Depending on

SEEING SOUND WITH A LASER

"The laser computer has found problems in many of the most accepted techniques."

the frequency, the surrounding area will either be flat and unmarked or ringed with a circular, moat-like indentation. Departures from this ideal "topography" represent varying degrees of sound distortion.

Examining both test speakers and actual, marketed models, our engineers believe they can confirm much of what had long been theorized about speaker vibrations. More interestingly, they've found that many of the problems existing in speakers, their own as well as competitive brands, arise from design features that have been conventions of moving-coil speakers for decades.

One of the areas Celestion has researched is the materials speaker cones and domes are made of. New diaphragm materials like Bextrene, polypropylene and Mylar are a feature of each new generation of loudspeakers. But now there are concrete, quantifiable means of judging their performance.

Consider for example the laser computer plots in Figure 2. The first, Fig. 2A, shows a 19mm plastic dome tweeter at 8 kHz, with a severe asymmetric surround problem, distorting the sound well within the audible range. The second, Fig. 2B, shows an ultra-hard dome tweeter whose diaphragm is behaving; but this unit also has a surround problem. Its smooth, piston-like response is conclusive proof that the new, harder material is able to withstand higher frequencies without distortion. But as with most conventional drive units, surrounds and suspensions can lead to many mechanical problems—few of which are evident on amplitude response curves. The third plot, Fig. 2C, is a new copper alloy tweeter with no major diaphragm or surround problems.

Configurations of drive units can also be scrutinized for distortion-producing flaws, and this is an area where the laser computer has far outdistanced other measurement techniques. The standard amplitude response curve has for many years enabled us to see the acoustic effect of one particular moment of speaker motion over a range of frequencies; or, by averaging amplitude responses at different angles from the speaker, to build a polar curve at one frequency. What it takes for granted is that what we see at one moment of measurement is true over time. In fact, this is not so. By using the laser computer to animate vibration modes, we have been able to see how energy moves through a drive unit over time, and to understand the dynamic relationship of the speaker's parts.

For example, a critical problem to solve is how a woofer cone can be terminated by its surround so that energy which is not propagated into the air as sound (but travels sideways into the cone instead) can be stopped dead by the time it reaches the woofer basket. As the woofer is driven at higher and higher frequencies, a smaller portion of its surface is occupied with delivering the source sound, and the edges of the cone are left behind to "ripple" as energy flows rapidly outward from the center. Ideally, this energy is quickly slowed down by the surround and will decay completely by the time it reaches the edge of the basket. If the surround does not properly—and symmetrically—damp this energy, it radiates back into the cone, where it can be released into the air in delayed fashion, coloring any new sound being generated in response to the drive signal. This phenomenon is known as a "standing wave," and it will continue going back and forth in the cone until all of the energy is eventually released.

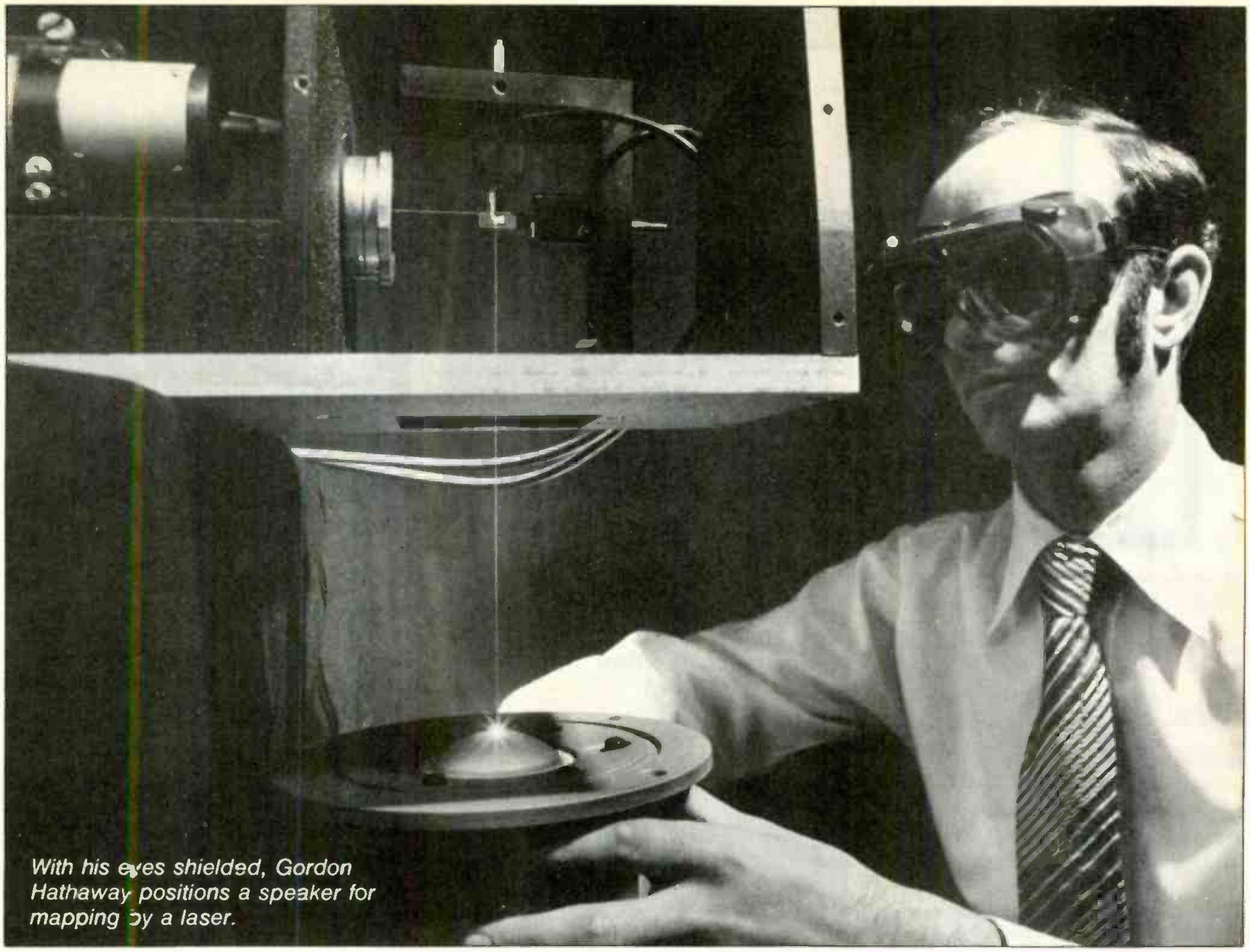
As standing waves occur in the midrange, where the ear is most sensitive to sonic aberrations (and where vocals and the fundamental energy of most musical instruments are generated), it can be said to be responsible for a major coloration effect of loudspeakers.

To illustrate how the laser "sees" the woofer surround, we have shown in Fig. 3 a woofer driven at 780 Hz, having bell modes and a severe edge-termination problem. At the moment illustrated, the energy is concentrated on the right-hand edge of the surround. With the computer in animation mode, we can see the cone rising first on one side, then the other, as this undamped energy "swishes" back and forth until it finally decays. Clearly, this surround is not properly damping the cone. A response curve of this phenomenon might show a slight peak or dip, depending upon the moment at which the measurement was recorded, but would not begin to illustrate the dynamics of the problem. Designing this problem away using conventional test techniques would be time-consuming, to say the least.

After considerable observation of such plots in animation, we have realized that a basic theme underlying speaker behavior problem is *complexity:* Too many parts, too many joints and boundaries, each vibrating more or less differently from the other and each more or less contributing to a whole that only approximates vibrations as they occur in live music.

Dust caps are notorious—and almost every woofer has one. They pin the cones at their outer diameter, absorb some of the sound radiating from the coil, and are likely to take off completely independently of their cones (see Fig. 4). This can be a real problem if the speaker has been basically designed and a "cosmetic" dust cap is put on later.

The laser computer has illuminated problems in many of the most accepted speaker assembly techniques, such as bringing the signal lead wires from the top of the voice coil through the diaphragm. A typical five-inch, paper-cone woofer of this type has been measured (Fig. 5A). Its amplitude response shows a sharp dip—5 to 8 dB across a narrow range centering at about 1 kHz. Seeking the culprit, we took some laser plots. At 1022 Hz, we discovered the severe rocking mode shown in Fig. 5B. In animation, this appeared as if the cone were tilting or rocking from side to side. With the computer in high-resolution mode, magnifying our view of velocity over 20,000 times, we pin-pointed at 2.4 kHz the "tether" or "leash" effect of the lead-out wires, slowing the cone's velocity. The leads' additional mass, unevenly applied to the vibrating cone, caused the rocking mode. Such a problem will not only limit the speaker's overall output, but will create lobes in the polar response until the energy is "sucked out" at the sides. Proponents of this lead-out wire configuration have often found it necessary to apply eyelets or other damping material where the wires come through the diaphragm. Such devices can only



With his eyes shielded, Gordon Hathaway positions a speaker for mapping by a laser.

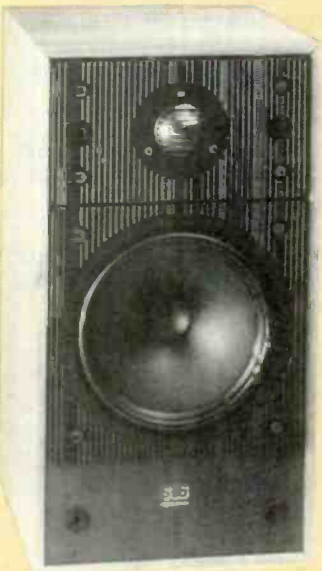
compound the problem of unequal mass.

Sometimes problems of complexity show up on amplitude response curves, and sometimes they don't. A subtle example of this not-so-subtle challenge in speaker design shows up when we measure a relatively good, ¾-inch Mylar dome tweeter. The response curve would lead us to judge this tweeter a very good one (Fig. 6). It's within ±4 dB from 1100 Hz to 28 kHz with only a slight dip, on the order of 1½ dB, at 21 kHz. A closer look at the "wobble" area under the laser, however (Fig. 6B), reveals a severe, four-pole bell mode at 14,274 Hz. With a high-resolution plot (Fig. 6C), we can trace the eighth-order bell mode to 21,031 Hz. While it is more evident on the response curve, this eighth-order mode is less critical to speaker performance in its redistribution of energy than the 14-kHz wobble, which was minimized in the response curve.

The cause in this case is a resonance set up in the glue joint between voice-coil former and diaphragm. The Nomex former is folded at that point, and the wrinkles at the fold put localized stress on the diaphragm assembly, transmitted through the glue joint. Once again, the joining of unequal materials at a critical stress point caused a problem, visible primarily with the laser, a problem which will limit both performance and reliability of this otherwise fine tweeter.

The task facing us, now that our ability to understand speakers has taken a step forward, is to find ways of making speakers vibrate simply, purely and, most of all, more faithfully to the original sound. The ideal loudspeaker system is still far in the future; but we believe it will incorporate drive units whose vibration modes are well-controlled. Such a system will not require elaborate crossover circuits to correct the drivers, since two wrongs do not make a right—not even in physics. We have seen, in the lab, woofers whose uncontrolled resonances may be equalized out, only to reappear if they are mechanically excited by the tweeter.

These are just some of the aspects of speaker design that Celestion has been able to investigate with lasers. As an analytical tool, it paves the way for further improvements and a whole new generation of loudspeakers.



Celestion's SL-6 is the first system to use drivers designed with the aid of laser-computer animations.

ADC Sound Shaper SA-1

Real Time Analyzer

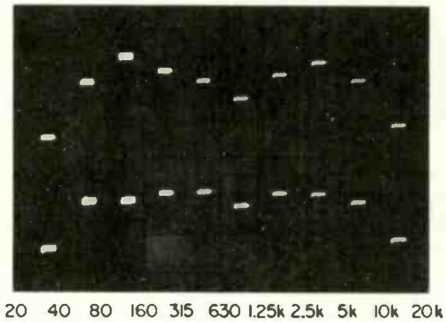


Fig. 1—"Loudspeaker" response before (top) and after (bottom) equalization. (Vertical scale: 10 dB/div.)

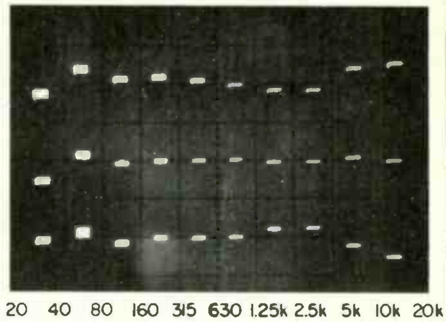


Fig. 2—"Tape recorder" response before (top) and after (middle) equalization, with actual equalization (bottom). (Vertical scale: 10 dB/div.)

Manufacturer's Specifications

Frequency Response: 31 Hz to 16 kHz ±0.5 dB at line input, ±3 dB at microphone input.

Filter Center-Frequency Accuracy: 31 Hz to 1 kHz, ±10%; 2 to 16 kHz, ±5%.

Amplitude Accuracy: ±1 dB at 12-dB range, ±2 dB at 24-dB range, and ±3 dB at 36-dB range.

Input Sensitivity: Line, 150 mV; mike, 0.5 mV.

Input Impedance: Line, 100 kilohms. Mike, 33 kilohms.

Pink-Noise Output Level: 150 mV.

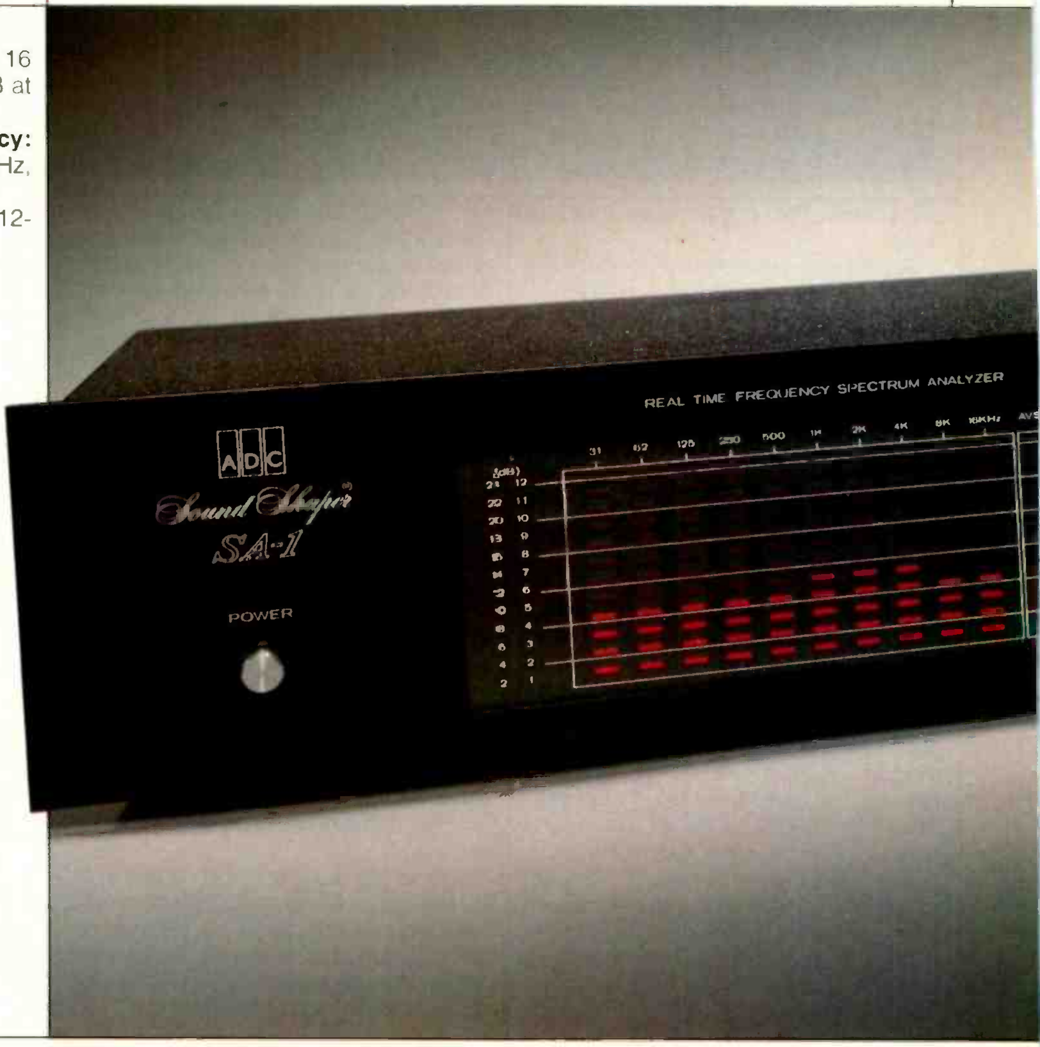
Microphone Type: Electret condenser.

Pickup Pattern: Omnidirectional.

Dimensions: 17 in. (435 mm) W × 3⅜ in. (86 mm) H × 9½ in. (240 mm) D.

Weight: 6.5 lbs. (2.9 kg).

Price: $230.00.



In the Sound Shaper SA-1, ADC provides an octave-band real time analyzer (RTA) with a built-in pink-noise source and a matched test microphone at a most-attractive price. The front panel is black with white designations, which are easy to read in any type of lighting. The display consists of columns of horizontal-bar LEDs for each of the 10 octave bands (31 Hz to 16 kHz), plus one that shows the average of the 10 bands. Each column is 12 LEDs high for a total range of 12, 24 or 36 dB as selected with a rotary switch, corresponding to 1, 2 or 3 dB/step, respectively. There are scales at the ends of the display to aid in checking relative levels. A nice feature is the white, side-lighted graticule with horizontal lines every 2 dB which make reading the display especially easy, much better than most such units.

There is a "Calibration" pot, which is really just a level-set control for shifting the display up or down. Each bar graph of turned-on LEDs shows the level in its respective band. There are push-button switches for "Pink Noise" on/off, "Mic/Line," "Peak Hold," "Left" and "Right Mode," "Slow/(Normal) and "Power" on/off. The peak-hold switch acts to hold whatever is in the display, and subsequent higher levels do not change what is held. "Peak Hold" is sort of a misnomer in ways, but it's quite useful just the same. The "Mode" selector allows feeding in just left or right channels, or both together with a push in of both buttons. The microphone phone jack is just below the mike/line switch.

On the back panel are phono jacks for left and right line in and a pair for the pink-noise generator output. A slide switch allows inserting 26 dB of attenuation to prevent overloading the line inputs if connection is made to power amplifier outputs. This is another useful feature, quite unexpected in an inexpensive unit. There is also an unswitched accessory a.c. outlet. Removal of the steel top and side cover revealed a large, almost chassis-size p.c. board with a neat, orderly layout and quality components. All parts and adjust pots were clearly labeled. The pots are trimmers for 12-, 24- and 36-dB ranges and for 1-, 2- and 3-dB initial steps. These are potentially useful for the owner or serviceman for maintaining long-term accuracy. Soldering was very good, with a little flux residue in spots. Interconnections were made with multi-conductor cabling (soldered) or wirewrap. The hardboard back and bottom panels of the SA-1 contribute to its light weight, albeit giving it a possible vulnerability to interference from strong fields.

The provided test microphone is powered by a type-N battery, and close to shelf life should be possible if the switch is at "Off" whenever the mike is not in use. The cable is about 16 feet long, and extension is possible.

Performance

The first series of tests were on the filters of the analyzer. With a CW test tone, the peak responses of the 10 filters were within ±0.4 dB, very good performance. The center frequencies were within 7% for the lower bands and within 4% for the upper bands, better than most such units. The crossovers from one band to the other were down 4.7 dB which is quite acceptable. The adjacent-channel response to a tone at center frequency was about −9.8 dB on the average, adequate for the intended purpose of the unit. By the centers of the second bands, the responses were down 17.5 dB (acceptable) and the final slopes of 6 dB/octave were established.

With an Ivie IE-20B as the pink-noise source, the band responses were all within ±1 dB, with the minor exception that there were some "+2" indications occasionally in the bands below 500 Hz, particularly when in fast mode. In switching to "Slow," the lower bands shifted down slightly (less than a dB), and the upper bands shifted up a dB. All bands were still within ±1 dB. The "Average" indication appeared to be a rough average, and it was most accurate when band levels were fairly close to each other. It did indicate relative total power correctly as −3 dB when a bandpass filter was used to drive just half (five) of the filters to reference level. (Reference level energy in half of the filters equals one-half the power for the 10 filters at reference level, or 3 dB less.) "Peak Hold" maintained whatever was in the display at the time of switching for a long period of time, whether the signal was removed or not.

Tests of the vertical display thresholds were run, using "8" on the 12-dB range as the reference. All of the thresholds were very close for all three ranges, with most within

"With its low price, the ADC SA-1 analyzer is undoubtedly an excellent value."

0.3 dB, which is excellent performance and quite superior to a number of other units. Total-range errors were less than 0.9, 0.2 and 1.3 dB for the 12-, 24- and 36dB ranges, respectively—also excellent results. The line input sensitivity (with "Calibration" at maximum) was about 23 mV for pink noise to turn on the bottom row of LEDs. For a mid-display 12-dB-range "6," 45 mV was needed. An input of 90 mV got a "12" on the 24-dB range, and 180 mV produced an "18" with the 36-dB range. With a 1-kHz test signal, "6" (12 dB range) turned on at 20 mV input. Input levels up to 25 V were controllable with the level-set pot. The "−26 dB" switch on the back panel shifted the 1-kHz sensitivity (pot at maximum) to 0.5V, and that would facilitate matching the voltage levels from even high-power amplifiers.

Attention was then turned to acoustic tests with the supplied microphone. By comparison with an Ivie IE-30A, it was determined that first indications on the display occurred at about 58 dB SPL. This was not a reliable level for measurements, however, both from the standpoint of system noise and external effects. The level from the reference loudspeaker was increased to 85 dB SPL, which is a good level for such tests. It is higher than what many would prefer for classical music, and it is lower than what might be desired for rock music. The Ivie IE-30A was operated in octave-band mode to allow direct comparison with the ADC analyzer results. The tests were conducted in the direct field of a single loudspeaker to eliminate two-source and room effects. The hold functions of both analyzers were used to aid in making the response comparisons. In the main, the SA-1 showed close agreement with the known, excellent performance of the Ivie. The 31-Hz band (of the SA-1) was up perhaps 3 dB relative to the other bands, and the 8- and 16-kHz bands were slightly high. The supplied microphone did show some directivity, and the flattest response in the direct field, was obtained with the microphone at close to grazing incidence (*not* pointed at the loudspeaker). In a reverberant field, such as might exist at a listening position, the pointing of the microphone would be less significant, but the user should avoid pointings that cause a sharp 16-kHz rise.

The line input impedance was 86 kilohms over most of the band, down to about 48 kilohms at 10 kHz. These figures are somewhat lower than the specification, but they are more than high enough for any possible application. A 1-kHz tone burst was used to check the analyzer's dynamic responses. In fast mode, a burst of 200 mS duration was needed for a 20-dB change in indication, with a decay time of about 7 seconds. In "Slow," the on-time required was 355 mS, and the decay time was about 18 seconds. The decay times are particularly long, but they are quite acceptable for the purposes of equalizing a sound system. They are limiting, however, for any sort of music monitoring, except to observe general spectral patterns on an averaging basis.

The pink-noise generator output level was 200 mV, dropping to 140 mV with a 10-kilohm load, indicative of a 4.2-kilohm source impedance. The spectrum, as indicated on the analyzer display, was within ±1 dB, with the exception that the two lowest bands were at +2 dB. Or it could be said that the 16-kHz band was the sole exception at −2 dB. Either way, the results were really quite good.

In-Use Tests

The instruction manual makes the point directly that the analyzer is designed as a complement to a graphic analyzer. The text is not detailed in most places, and some of the English would have to be classified as rather clumsy. The statements on white and pink noise are confused and confusing, but there are good points made about avoiding excessive bass boost and the desirability of some high-end roll-off. A full schematic is included, which is good; the addition of a block diagram would be helpful for the neophyte. A short time was spent doing some music monitoring, and the unit did give good average-spectrum indications. The unit's sensitivity was not quite high enough to show the lower levels with classical music from a particular FM station, but there was no such problem with pop-rock.

The advantages of the SA-1 were demonstrated much more completely with two simulated tests. In the first, a speaker-like response was generated with an MXR ⅓-octave equalizer. An MXR octave-band EQ was added to the output of the ⅓-octave EQ, feeding the SA-1 in turn. To show what was involved, the Ivie IE-30A was operated in octave-band mode and its output fed to a storage scope. Using the ADC unit's display, the MXR octave-band EQ was adjusted to flatten the response. No reference was made to the IE-30A response until the task was considered complete. Figure 1 shows the original response with a boost at 125 Hz, a crossover dip at around 1 kHz and a peak around 4 kHz. Also shown is the result after using the SA-1 to make adjustments. The improved response is obvious.

In the second test, the same approach was used, but the response of a tape recorder was simulated:—a rise at the low end, some droop around 2 to 4 kHz and a definite rise around 8 to 16 kHz. Figure 2 shows the set-in conditions, the response after adjustments per SA-1 display and the EQ that was introduced to effect the change. It usually seemed best to start adjustments in fast mode to speed up removal of the major deviations. Then, "Slow" was used with a more expanded scale for less display shifting and better resolution.

"Peak Hold" was very useful a number of times, and it had very little drift over long periods of time, except at the lowest microphone levels. It was definitely much better than indicated by a statement in the manual to the effect that it would drift after 10 seconds. The bar graph form of the display made it particularly easy to read, but somewhat dim lighting seemed best for quick assimilation of the data presented by the red LEDs.

It would probably be helpful to most users if ADC had given some general guidelines in the manual as to what settings of the so-called calibration control would give center-display indications at various SPLs. Our tests showed that SPLs would be high enough with the pot near its center of rotation or above. A quiet environment might permit somewhat lower settings.

All in all, the SA-1 octave-band RTA is a well-performing instrument, and it will give good results with octave-band or parametric equalizers in smoothing sound system responses. With its low price, the ADC SA-1 analyzer is undoubtedly an excellent value. *Howard A. Roberson*

2

HEATHKIT AA-1800 STEREO POWER AMP

Manufacturer's Specifications

Power Output: 250 watts continuous per channel into 8 ohms, 20 Hz to 20 kHz.

Rated THD: 0.025%.

TIM: Less than 0.03% (3.18 kHz square wave and 15 kHz sine wave, 4:1, measured at full power output).

Frequency Response: 20 Hz to 20 kHz, +0, −0.2 dB; 3 Hz to 100 kHz, +0, −1dB.

SMPTE-IMD: Less than 0.02%.

Dynamic Headroom: 2.5 dB.

Damping Factor (Low Frequency): More than 100.

Hum and Noise: 85 dB, A weighted, below 1 watt.

Input Sensitivity: 110 mV for 1-watt output (1.75 V for rated output).

Input Impedance: 20 kilohms, shunted by 50 pF.

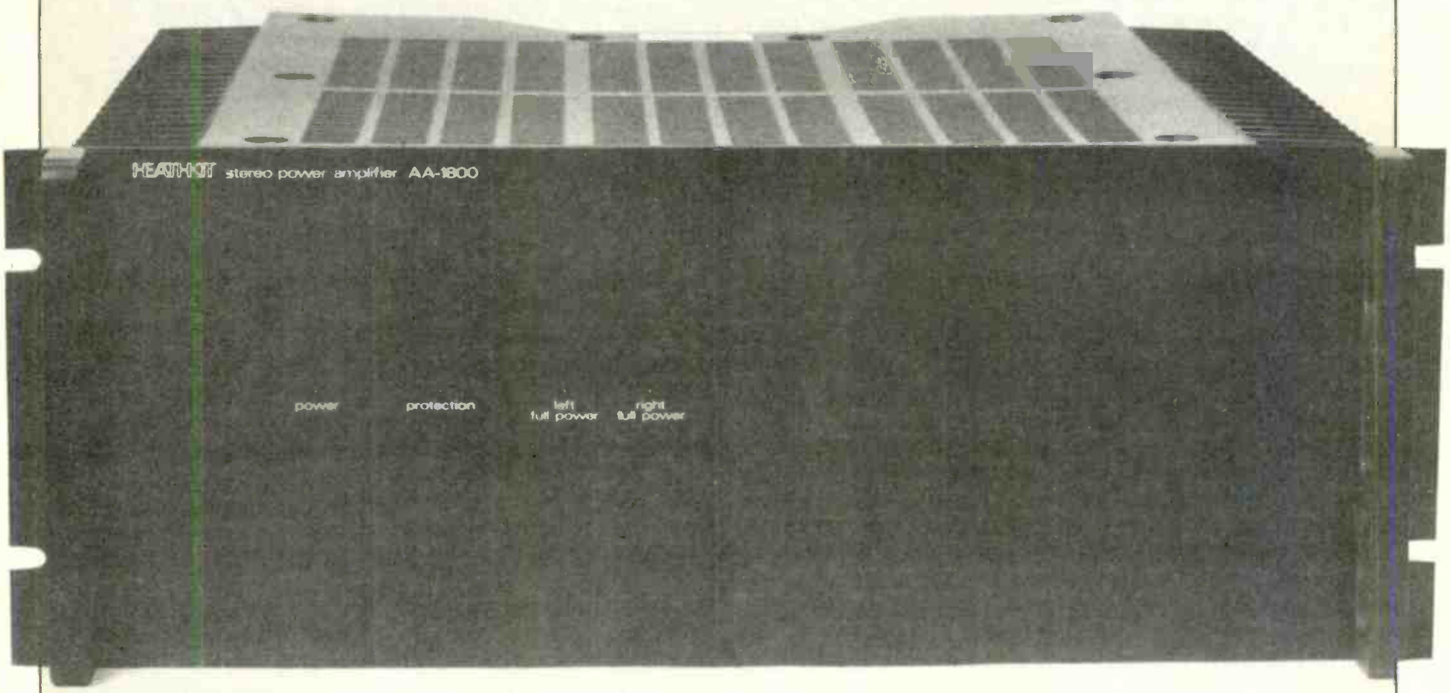
Power Requirements: 108 to 132 V, 60 Hz, 10 A.

Power Consumption: 240 watts at 0 output, 1,200 watts at rated output.

Dimensions: 19 in. (48.07 cm) W x 7⅛ in. (18.03 cm) H x 17¼ in. (43.64 cm) D.

Weight: 50 lbs. (22.72 kg).

Price: $599.95 (kit only).



Amazingly high headroom permits peaks of 500 watts per channel or more before encountering noticeable clipping.

If you think that the audio industry has rejected the idea of ultra-high powered amplifiers for use in home audio systems, consider this power amp from those innovative creators of Heathkits in Benton Harbor, Michigan. By far the most powerful amplifier ever offered to audiophile kit-builders by Heath, the AA-1800 not only boasts a rated power output of 250 watts per channel into 8-ohm loads, but upon testing dynamically, it shows a dynamic headroom of just about 3 dB. This means under short-term musical signal inputs it can deliver around 500 watts per channel, or a total of a kilowatt or more. This amplifier is available in kit form only, though I was supplied with a unit assembled by Heath personnel. Interestingly, once it is fully assembled, Heath does not recommend shipping the unit anywhere with its power transformer installed. Instead, the massive power transformer is equipped with locking-type multiple pin connectors which can be easily disconnected should it ever become necessary to transport the unit. The amplifier, therefore, arrived in two cartons!

To protect the preamp's on-off switch, the AA-1800 can be turned on by a built-in relay, activated by a second, low-current power cord connected to the pre-amp's switched, a.c. convenience receptacle, as well as by its own, rear-panel power switch.

The black front panel is a single, wide expanse of metal interrupted only by four tiny LED indicators. One of these lights up when power is applied. Another is a protection circuit indicator, while the remaining two are peak power LED indicators which are activated when a full 250-watt output level is reached.

The rear apron of the AA-1800 is equipped with individual input level controls (one per channel), left and right phono-tip input jacks, five-way color-coded speaker connection binding posts, a fuse-holder which houses the main 10-A line fuse, and a three-position switch. The two required power cords also emanate from the rear apron.

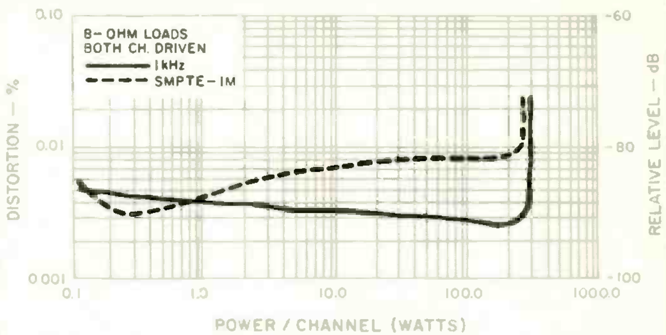


Fig. 1—Distortion vs power output, Heath AA-1800 power amplifier.

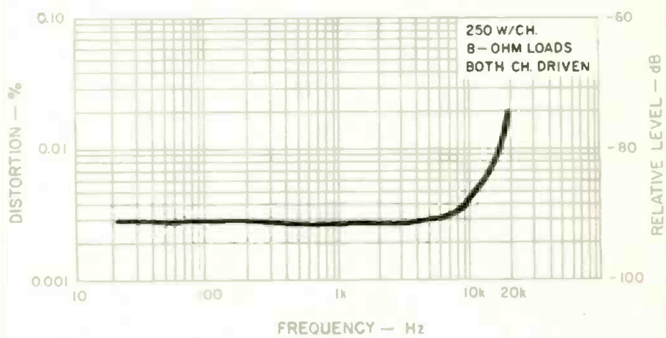


Fig. 2—THD vs. frequency at rated output.

Circuit Highlights

Aside from the major power supply parts, such as the aforementioned power transformer and two large 13,000-µF electrolytic capacitors, most of the other electronic parts of this amplifier are mounted on three major circuit boards, two identical output amplifier boards and a circuit protection board.

The output stage for the positive-going signal consists of multiple emitter-follower transistors and a parallel-connected pair of transistors. Another pair of transistors completes the series-parallel output configuration, which is biased by a pair of common emitter-follower transistors. This configuration has each of the main output transistors sharing half the output current and half the power supply voltage. The output stages for the negative half of the signal are identical in operation to those of the positive half and are symmetrical and 180° out of phase. Additional circuit blocks handle speaker turn-on delay, peak power indication, and speaker protection.

An interesting method is used to protect speakers from potentially damaging signals, whether due to amplifier malfunction or improper input signals, and is based on one transistor serving as a safe voltage detector in conjunction with an associated integrated circuit. If voltage remains outside a "safe region" for more than 50 mS, the complex circuitry disconnects the outputs from the speakers, and in addition, two circuit breakers function as temperature sensitive switches. At normal operating temperatures, these switches are closed. If the temperature of the heat sink ever exceeds 90° C, outputs again automatically disconnect from the speakers.

Measurements

With 8-ohm loads in place, the amplifier delivered over 300 watts per channel before rated harmonic distortion of 0.025% was observed, using a 1-kHz test signal. At the 20-Hz test frequency, power output for rated THD reached 287 watts; at 20 kHz the reading was 265 watts. A plot of power output versus THD is shown in Fig. 1. When input levels were reduced to produce exactly the rated 250 watts per channel (again into 8-ohm loads), I observed what amounted to test-equipment residual distortion levels at 1 kHz and

The rough or edgy kind of high response associated with solid-state circuitry seems absent with the Heathkit AA-1800.

20 Hz of just under 0.003% and approximately 0.02% at 20 kHz. SMPTE-IM distortion measured 0.014% at the equivalent of rated output. Damping factor at 50 Hz measured 185, well above the 100 claimed by Heath. Using the Otalla method of TIM measurement, I was unable to detect any amplifier-produced IM products over a dynamic range of 75 dB on a spectrum analyzer, which means that if there were any TIM it had to be less than 0.018%!

Dynamic headroom was amazingly high, measuring a full 3 dB. This, as said earlier, means that when driving the amplifier with music program signals, you can expect to reach peaks of 500 watts per channel or more before encountering noticeable clipping of the waveforms. Distortion versus frequency, for rated output, is plotted in Fig. 2. Frequency response for a −1.0 dB roll-off extended from around 3 Hz to 110 kHz.

Signal-to-noise ratio, as measured in accordance with the new IHF/EIA Amplifier Measurement Standards (0.5 V in and level controls adjusted for 1-watt output, with an A-weighting network in series with the measuring instrument), was 88 dB. Worst-case channel separation over the entire audio band was never poorer than 65 dB.

Use and Listening Tests

Heath makes a point in their well-written instruction manual about never connecting input grounds to output grounds when using this amplifier. This caused some grief when testing the unit on the lab bench (I had to "float" much of the equipment that ordinarily shares a common ground), but once that was worked out things went quite smoothly. When I transferred the unit to a listening installation, I encountered no such problem, of course, since my reference loudspeakers are hard-wired individually to the test setup in the listening location. I was a bit fearful at first about really opening up the amplifier while driving my fairly efficient KEF 105 II reference loudspeakers, but the latter have their own protection features with a control that can be set as high as 200 watts per speaker. That's the way I ran the amplifier during extended listening tests, and I can report the sound was clean at those peak levels and that with many musical test records, including some wide dynamic range dbx-encoded discs, it is not at all unusual to come up to such peaks, however briefly.

The amplifier's sound might best be described as on the tight and bright side, delivering the kind of tight bass that characteristically occurs with amps having high damping factors and traditionally high overall loop feedback. The somewhat rough or edgy kind of high response that one also associates with this kind of solid-state circuitry seemed absent, providing further correlation between low TIM and absence of irritation when listening to high-frequency transients or other high-frequency program material. Still, some adherents of vacuum-tube sound may find the highs from this amplifier to be just a bit too brilliant, however clean they may also seem.

Physically, the AA-1800 needs a lot of space and adequate ventilation, but given those things it operated without even getting warm to the touch when reproducing music programs at the levels previously mentioned. Although I did not construct the amp, I did read the construction manual, and as usual it is written in the typical Heath manner—meaning just about anyone who can hold and use a soldering iron and can read English should have no real trouble assembling this power amplifier. They may, however, have a bit of trouble lifting it into its final resting place, in which case that plug-in power transformer can always be dropped into place last.

Leonard Feldman

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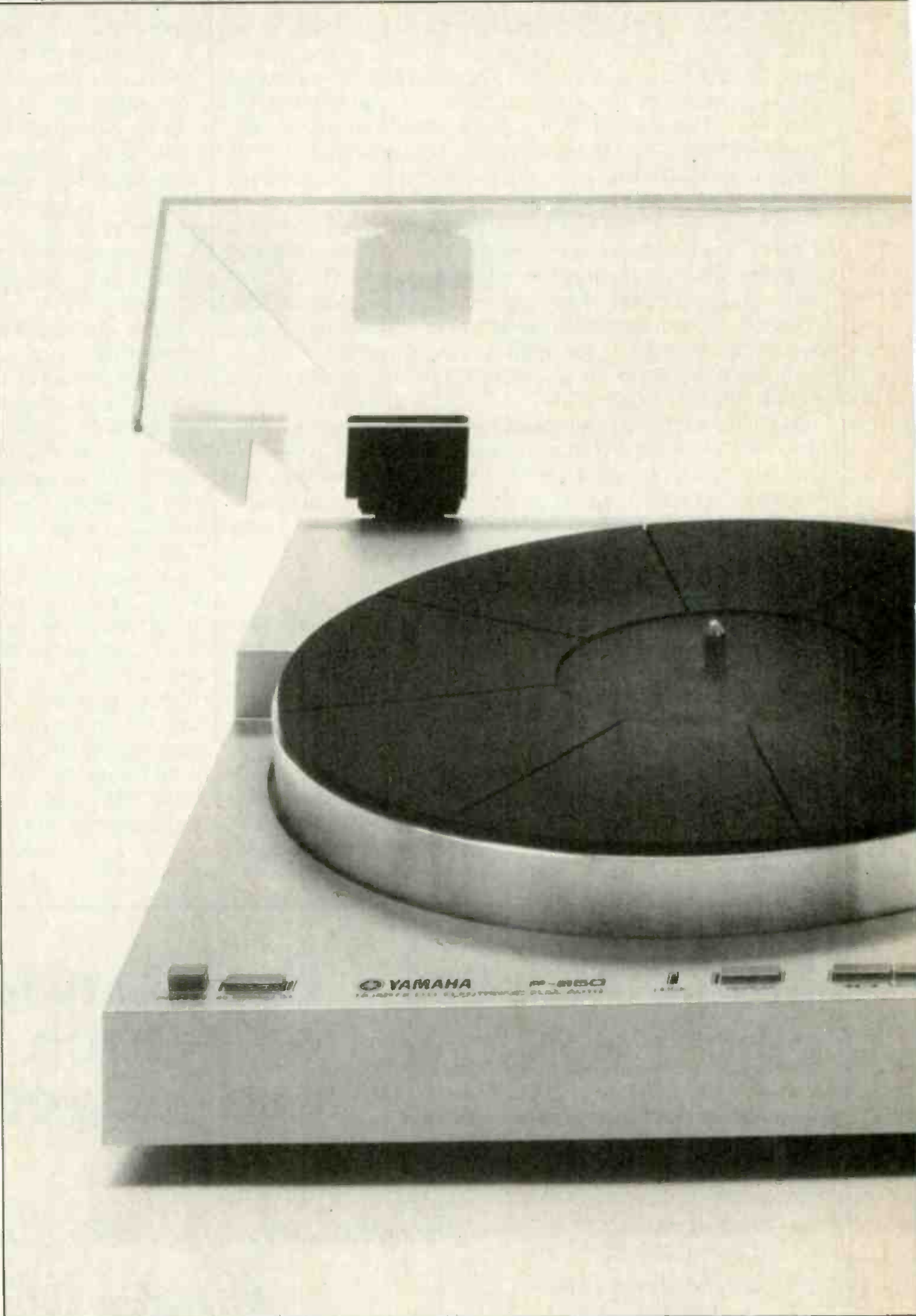
3

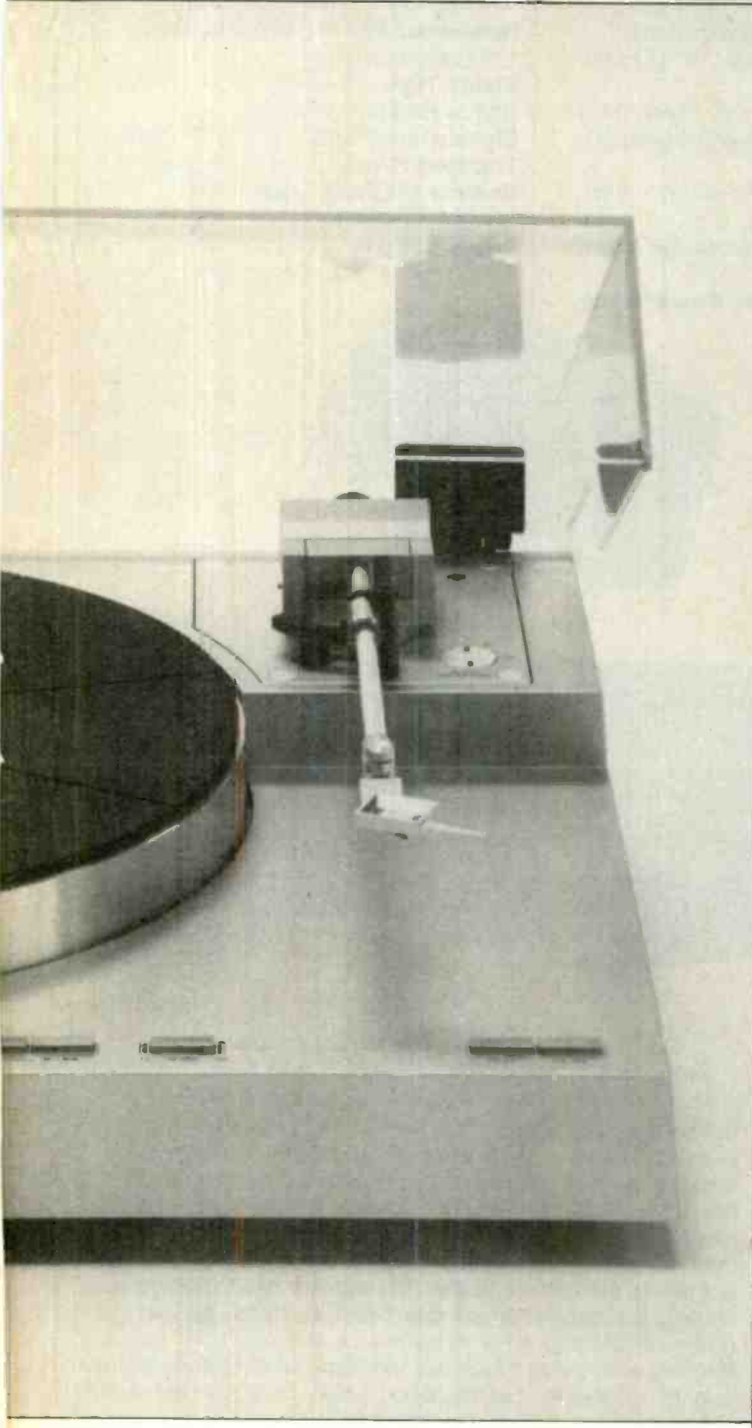
YAMAHA P-850 TURNTABLE



Manufacturer's Specifications
Motor: Direct-drive, quartz-lock PLL.
Speeds: 33⅓ and 45 rpm.
Wow & Flutter: 0.015% wtd. rms.
Rumble: Better than −77 dB (DIN-B).
Arm: Static balanced, sliding weight.
Anti-Skating: Spring type.
Suitable Cartridge Weight: 2.5 to 10 g.
Cable Capacitance: 100 pF.
Dimensions: 17⅜ in (44.1 cm) W × 14¾ in. (37.5 cm) D × 5⅛ in. (13.0 cm) H.
Weight: 16½ lbs. (7.5 kg).
Price: $360.00.

Yamaha's new P–850 is a typical example of modern turntable design, with its sleek, low-profile styling and impeccable performance. It uses a direct-drive servo-controlled motor, while its arm is controlled by two separate motors. The arm itself is a straight tubular type, mounted on a platform at the rear, which extends the full width of the unit. A neat rectangular counterweight slides on two runners and is adjusted by a small knob. The actual tracking force is set by a sliding weight in front of the pivot. The arm is calibrated from 0 to 3 grams in 0.1–gram steps, on a scale which extends almost up to the carbon-fiber resin headshell.

The shell is secured to the arm by a set-screw, eliminating one potential source of trouble. Length of the arm is 8¾



inches (222 mm) and effective mass is stated as a low 11 grams (without the cartridge). The spring–type anti-skating control is located in front of the arm base, to the right of the arm rest.

The operating controls are in the form of nine pushbuttons lined up at the front. From left to right they are: "Power" (On-Off), "Speed," "Repeat," arm movement left, vertical and right, record "Size," "Cut," and "Play." Indication for record size (12 and 7 in.) and the first three functions is given by tiny illuminated "windows" at the side of the pushbuttons.

The drive motor is a d.c. brushless, coreless eight-pole type, and the aluminum diecast platter weighs 3½ lbs. It is unusually deep, with the top of its highly polished edge about an inch above the base and its mat extending nearly ¼ inch above that. I noted with approval that this mat is of rubber with no ribs or projections that could form cavities. The base is made from a Bulk Molding Compound finished in a satin silver.

Measurements

For test purposes, Shure V–15 Type V was mounted in the shell (which has a very low mass), and both tracking force and anti-skating adjustments were set to 1.25 grams, making due allowance for the Shure stabilizer "brush." Arm resonance was measured at 9 Hz with a broad rise of less than 2 dB. The cartridge was aligned with the Shure two-point gauge (supplied with the cartridge), and checked with the Dennesen protractor; it was found to be right on the nose. The actual error figures were −1, +2 degrees, a little better than claimed. So full marks to Shure for an easy-to–use device which enables even the most ham-handed to achieve remarkable accuracy.

Wow and flutter measured 0.025% (DIN 45-507) while rumble was −63 dB, using the ARRL weighting. By employing the Thorens *Rumpelmesskoppler* (which allows measurements to be made via the center spindle), the figure increased to −70 dB. Both vertical and lateral arm bearing friction were extremely low, with no sign of irregularities. The tracking force calibration was found to be within 5% down to 1 gram. Speed was less than 0.1% fast.

The unit is fully automatic; after the "Play" button is depressed, the arm moves to its correct position and the motor is switched on. Before the stylus is actually in the lead-in groove, a speed lock indicator, positioned next to the "Repeat" switch, lights up. At the end of play, the arm returns to its rest, taking about five seconds. The three cue buttons give complete control over the arm via the two independent motors. If the left or right button is only slightly depressed, the arm will move slowly; but pressing harder will increase the speed. If one of these two buttons is depressed while a record is being played, the arm will rise, just as if the center Up-Down button were used.

Because there are so many conflicting requirements, there is no "right" way to deal with the problem of acoustic feedback and Yamaha has elected to mount the arm and motor to the base to provide "mass" instead of isolation. The unit is mounted on four resilient feet, and tests showed that it was not particularly susceptible to airborne or vibrational feedback.

Although the P–850 does not boast a variable speed control, digital readout or other eye-catching features, it does offer fine basic performance. It certainly deserves a top-flight phono cartridge, preferably a high–compliance type to match its remarkably low-mass arm.

George W. Tillett

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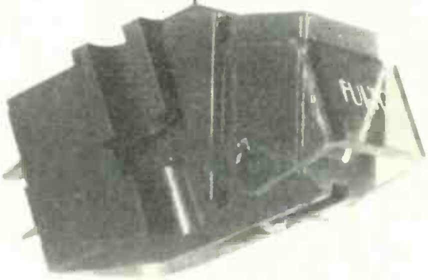
4

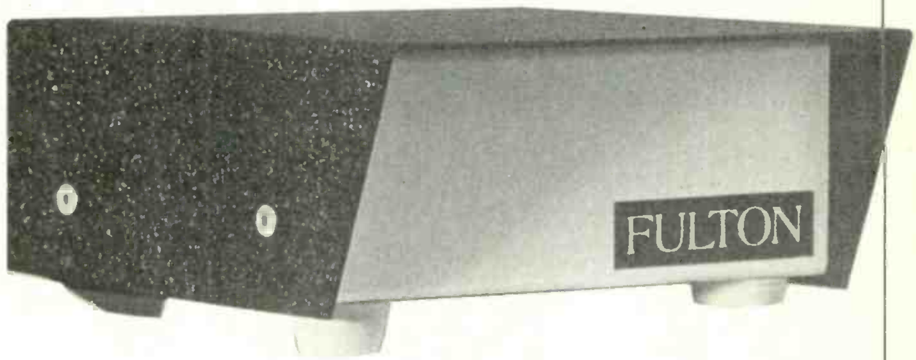
FULTON RS-1 MOVING-COIL PHONO CARTRIDGE

Manufacturer's Specifications
Frequency Response: 10 Hz to 60 kHz, +0, −.5 dB.
Channel Separation at 1 kHz: 34 dB.
Channel Separation at 10 kHz: 30 dB.
Output Voltage: 0.33 mV at 1 kHz.
Impedance: 4 ohms.
Recommended Transformer Impedance: 3 to 4 ohms.
Recommended Load Capacitance: 30 pF.
Recommended Pre-Preamp Load: 125 ohms minimum.
Stylus Type: Conical.
Stylus Radius: 0.65 mils.
Stylus Compliance: 12×10^{-6}cm.
Tracking Force: 1.5 to 1.75 grams.
Vertical Tracking Angle: 20°.
Weight: 5 grams.
Price: $350.00.



FULTON MC-1 MOVING-COIL TRANSFORMER

Input Impedance: 3 to 4 ohms.
Frequency Response: 5 hz to 65 kHz.
Gain: 28 dB.
Price: $289.00.



Fulton Musical Industries (FMI), manufacturers of the Fulton Premier loudspeakers, have introduced a high performance miniature transducer to their line—the Fulton RS-1 moving-coil phono cartridge with matching transformer. In general, it is not unlike other moving-coil cartridges except that its stylus has a spherical (conical) tip.

The stylus is a nude diamond with a square shank and a spherical tip having a radius of 0.65 mils. Fulton elected to use a spherical tip because they believe that both elliptical and Shibata shape styli are subject to forces that twist them as they pass over modulated groove walls. Further, this twisting motion of the stylus is transmitted down the cantilever and is reproduced as distortion by the phono cartridge. There is much less extraneous torquing of the cantilever by its stylus with a conical tip: At 5 kHz, Fulton engineers have measured three times the distortion with elliptical and Shibata styli than with a conical. Accordingly, the tendency of an elliptical or Shibata stylus to twist or torque indicates that the nuances of music are lost and, at the same time, distortion in the critical 2- to 9-kHz frequency range is added. A conical tip apparently sidesteps this problem.

While there are certain theoretical advantages to the elliptical or Shibata shapes, Fulton engineers believe that those advantages are seldom realized in the conventional phono playback system. Both elliptical and Shibata designs assume a perfect tangential-tracking tonearm to constantly keep the cantilever at right angles to the radius of the record groove. However, since most tonearms are pivoted, they have only two points where the cantilever is perfectly tangent to the record groove. On all other points across the record, the cantilever will labor with as much as two degrees of tracking error imparted by the tonearm. Lateral tracking error plays havoc with an ellipitcal or Shibata stylus due to its shape, but is never much of a problem with spherical-shaped styli, according to Fulton.

It is claimed that a modern spherical design, with lighter tracking and higher compliance, does not have a problem with record wear. In fact, Fulton claims that a 0.65–mil spherical tip provides some of the same advantages as a 0.3 × 0.7–mil elliptical stylus. The stylus assembly is not user–replaceable, but must be returned to the manufacturer or dealer for replacement, as with many moving coils.

Measurements

I mounted the Fulton moving-coil cartridge in a Technics headshell on the Technics EPA-100 tonearm on a Technics SP-10 Mk II turn-table. Voltage step-up for the cartridge was provided by a Fulton moving-coil cartridge transformer. Wherever necessary, I made measurements using this transformer; its measured frequency response was +0, −1.5 dB from 48 Hz to 20 Hz. The measured gain of the transformer was 28.3, and the square wave rise time at 1 kHz was 9μS.

The cartridge was oriented in the headshell and tonearm with the Dennesen Geometric Soundtracktor. Laboratory tests were conducted at an ambient temperature of 76°F. ± 1° (24.4°C) and a relative humidity of 58% ±3%. The tracking force for all reported tests was at the optimum force of 1.6 grams, with an anti-skating force of 1.85 grams. As is my practice, measurements are made on both channels, but only the left is reported unless there is a significant difference between the two channels.

Frequency response, using the CBS STR-170 test record, is flat within −0.5, +1 dB from 40 Hz to 20 kHz. Separation is 22 dB at 1 kHz, 23.5 dB at 8 kHz, 22.5 dB at 10 kHz, 18.6 dB at 15 kHz, and dB at 20 kHz. From these data, it is evident that the Fulton cartridge has an excellent frequency response and a most satisfactory high-frequency separation for a well-defined stereo effect on playback. We might comment that the separation for the right channel was slightly less than that for the left channel.

The 1-kHz square wave is typical for most moving-coil cartridges, showing ultrasonic ringing indicative of its wide bandwidth which can reproduce the 43-kHz cutter resonance on the test record. The cartridge-arm low-frequency lateral resonance was at 9.4 Hz and of 4.8 dB amplitude with the Technics EPA-100 tonearm. The vertical resonance was about 12 Hz in the same arm.

The following test records were used in making the reported measurements: Shure TTR-103, TTR-109, TTR-110, and TTR-115; Columbia STR-170, STR-100, and STR-112; Deutsches Hi-Fi No. 2; Nippon Columbia Audio Technical Record (PCM) XG-7002, and Ortofon Direct-Cut Pickup Test Record 0001.

Wt., 5.1 g; opt. tracking force, 1.6 g; anti-skating force, 1.85 g; output (without transformer), 0.048 μV/cm/S; output (with transformer), 1.21 mV/cm/S; IM distortion (4:1) +9 dB lateral, 200/4000 Hz, 0.65%; +6 dB vertical, 200/4000 Hz, 4.6%; crosstalk (using Shure TTR-109), 24.5 dB; channel balance, 0.5 dB; trackability: high freq. (10.8 kHz pulsed), 30 cm/S, mid-freq. (1 kHz + 1.5 kHz, lat. cut), 31.5 cm/S, low freq. (400 + 4000 Hz, lat. cut), 24 cm/S; Deutsches Hi-Fi No.2 300-Hz test band was tracked cleanly to 77 microns (0.0077 cm) lateral at 14.5 cm/S at +8.7 dB and 55.4 microns (0.00554 cm) vertical at 10.32 cm/S at +5.86 dB. The latter measurements are relatively good, especially the vertical one. Few cartridges can track the higher velocity 300-Hz bands on this test record.

The Shure Obstacle Course—Era III test record offered no challenge to the Fulton cartridge. On the Shure Obstacle Course—Era IV test record, the cartridge passed all test bands except for the level-5 harp and harp-and-flute test bands, where just a hint of mistracking was heard.

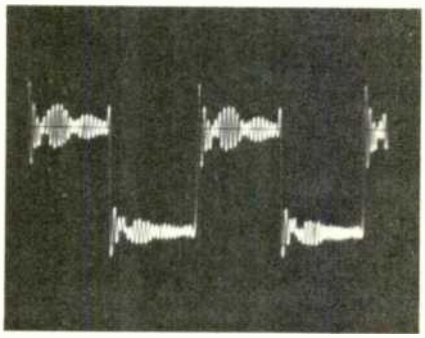


Fig. 1—Response to a 1-kHz tone burst.

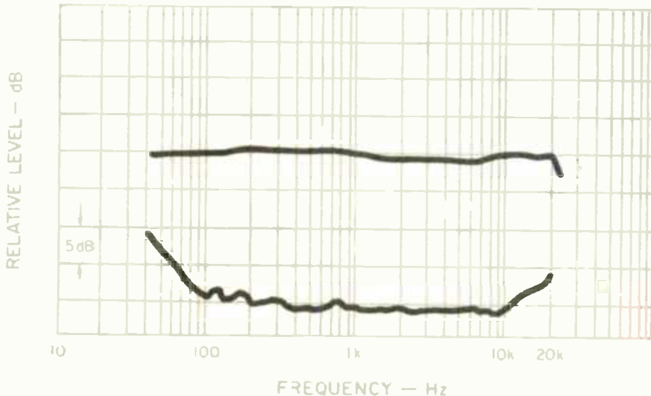


Fig. 2—Frequency response and separation.

Use and Listening Tests

The following equipment was utilized in the listening evaluation of the Fulton moving-coil phono cartridge: Technics SP-10 Mk II turntable, Technics EPA-100 tonearm, Nikko Beta 1 preamplifier, Crown IC-150 preamplifier, Audionics Space and Image Composer, Audire DM-700 power amplifier, Audio Innovation LED 2C Dynamic Power Display, and a pair of stacked Duntech DL-15B speakers in each channel. Each pair of speakers was connected to the Audire DM-700 power amplifier with Monster Cable. The turntable was equipped with the Hiraoka Disk-SE22 turntable mat.

As usual, I performed listening tests both before and after measurement. During this period, I was particularly impressed with the cartridge's ability to track extremely warped records without affecting reproduced sonic quality. Without a doubt, the Fulton moving-coil cartridge acquitted itself very well, especially in superb transient response (including percussion transient response), excellent applause definition, sonic clarity, and transparency of sound. The bass was sonically well-cefined and tight, with a good reproduction of the 19.2-Hz organ pedal note. The Fulton cartridge introduced no apparent coloration nor audible distortion to the music being played. The human voice was reproduced particularly well, especially the male voices.

All in all, the Fulton moving-coil cartridge should be considered as an excellent choice for anyone desiring a top-notch moving-coil phono cartridge. *B. V. Pisha*

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5

AUDIO-TECHNICA AT813 MIKE

Manufacturer's Specifications

Element: Back plate electret, permanently polarized.
Polar Pattern: Unidirectional (cardioid).
Frequency Response: 20 to 20,000 Hertz.
Sensitivity: −55 dB (0 dB = 1 mW/10 dynes/cm^2).
Open-Circuit Sensitivity: 0.28 mV (−71 dB) re: 1v/dyne/cm^2.
EIA Sensitivity: −149 dB.
Impedance: 600 ohms nominal, matches 150 to 1,000 ohm inputs.
Maximum Input Sound Level: 125 dB.
Signal-to-Noise Ratio: Greater than 50 dB at 1 kHz, 1 microbar.
Battery Type: UM3 (AA) (or Mallory MN1500 Alkaline).
Battery Current: 200 microamps.
Battery Life: Up to 5,000 hours.
Weight: 6.5 oz. (185 grams).
Dimensions: 8 in. (204 mm) long; 2 in. (51 mm) head diameter, 13/16 in. (21 mm) body diameter.
Cable: Model AT8302, 16½ ft. (5.03 m) two-cond. shielded, vinyl jacket, with Switchcraft A3F connector at microphone end, ¼ in. phone at output end.
Accessories Furnished: Model AT8201 Slip-in Stand Clamp for ⅝-27 threaded stands, carrying case, battery.
Price: $110.00

The Audio-Technica Model AT813 is a cardioid unidirectional electret microphone powered by an internal battery. It was designed for audiophile or professional recording applications, or sound reinforcement. The large metal screen on the head end encloses an integral wind/pop screen. The handle includes a professional-type three-pin output connector and a power on-off switch. The output is balanced and low impedance. The cable supplied with the mike has a ¼-inch phone plug on the output end, for use with many models of cassette and open-reel tape recorders.

A slip-in stand clamp as well as a padded carrying case are supplied with the AT813, and many other accessories are available. The Line Matching Transformer (AT-8201) will match the low impedance of the microphone to recorders having high-impedance inputs, and the accessory cables permit connection to three-wire balanced inputs. A snap-in stand clamp and a shock mount are available as alternatives to the fitting supplied with the microphone.

The Audio-Technica data sheet is unusually complete, as it includes a detailed schematic with component values and very clear illustrations on wiring of the output connectors. The text explains the virtues of the so-called "back-electret" design which, in theory, should yield performance similar to the more expensive air condenser (externally polarized) microphones.

The data sheet indicates that the electret element is internally shock-mounted, and the accessory shock mount may be used also for additional isolation with stand or boom mounting. Most electret elements are extremely resistant to shock and vibration, an advantage for microphones which may be handled (or dropped) by performers. The handle and head of the AT813 are all metal and sturdily constructed, and the low-reflectance gray finish is highly scuff-resistant. The power on-off switch is recessed so that t is not easy to operate accidentally. The battery is easily replaced by unscrewing the head from the handle and is the readily available alkaline penlight type. I noted that the rated battery life (5,000 hours) is longer than that of a recently reviewed low-cost electret microphone which has no on-off switch. Many audiophiles will obtain shelf lifetime from the cell (two to five years) and ought to remove the cell from the microphone if it's not to be used for a week or more. Therefore, the switch could be omitted, with a possible improvement in reliability and a cost saving. Any power switch which can be finger-actuated by the performer may occasionally be misused as a "push to talk" switch, so that AT813 should not be just handed to the user without also giving them a briefing. One alternative idea would be to change the switch to a type which must be actuated with a pointed tool.

The data sheet states that the AT813 is designed for very high input sound levels, but the rated SPL is only 125 dB. This is 5 to 10 dB lower than the ratings of other electrets I have reviewed, but some of those are internally powered by 6-V batteries or externally by 9- to 48-V power sources. Naturally, the peak-to-peak output voltage swing cannot exceed the supply voltage. The instructions do not indicate that higher voltage batteries may be used to obtain higher input SPL/output voltage capability. (I would think that most FETs in microphones could withstand 6 volts, which could result in up to 12 dB higher SPL rating.)

The frequency-response proximity effect (bass boost with close talking, which is inherent with most types of cardioid microphones) is cited as an advantage: If the microphone is used with a flat-response audio amplifier, the effect adds "warmth" which may be desired by the performer. If an external bass roll-off equalizer is used, the voice sounds natural, and distant low-frequency noise, such as room "rumble," is attentuated. My choice would be to nclude such a roll-off filter in the microphone which could be actuated by a third position on a power switch. An internal equalizer and "voice-mus c" switch is desirable on all directional microphones exhibiting proximity effects, unless they are used only in recording studios where equalizers are available on every microphone channel. The curves shown in the data sheet show substantial proximity effects, because the response is shown to be flat for sources at 12 inches or farther. Our measurements show that the response at 12 inches and farther is rolled off so that proximity-effect bass boost is less drastic than the data sheet indicates.

Measurements

The impedance-versus-frequency curve (Fig. 1) shows a nominal 600-ohm impedance throughout the midrange. The impedance rises to about 1,400 ohms at 70 Hz, which appears to be a resonance between the microphone transformer inductance and the coupling capacitor. As with other microphones I've tested, I "mismatch" the 600-ohm impedance to the 150-ohm output of the broadcast-type preamp in my test rack. This is an "unloaded" input with a center-tapped transformer. The actual input impedance varies from 1,000 ohms at the extreme low and high frequencies, to several thousand ohms at mid-band. Since our frequency response graphs are corrected to open-circuit conditions, it is necessary to show loading effects on a separate chart (Fig. 2). With most 150- or 200-ohm mikes, loading effects are negligible, but with 600-ohm mikes, some nonlinear responses are encountered. The loading of our preamp on the AT813 caused a 3-dB "valley" centered at 70 Hz. Loading could be more severe with other equipment rated at 150/200 ohms; however, the loading generally acts to reduce bass response and compensate somewhat for proximity effect. "Low-impedance" inputs of tape recorders vary from about 200 to 2,000 ohms, the rating based on the microphone impedance. The AT813 will work satisfactorily with most of these recorders; however, if the user is bothered by loss of bass with a 200-ohm input, or high noise (usually hiss) with a 2,000-ohm input, a line matching transformer may correct the problem. The Audio-Technica AT8201 line transformer may only be used with high-impedance inputs (approximately 50,000-ohms rating) though lower-ratio transformers are available from other manufacturers for line matching in the 200-2,000 ohm range.

We would also recommend that, to prevent pickup of radio stations or power line noise, a balanced circuit be used for applications requiring more than the 16½-ft. cable supplied with the microphone. This will require cables with A3 connectors (such as AT8303), plus a suitable line transformer located near the recorder.

The measured frequency responses (Fig. 3) of two AT-813 microphones show smooth and flat characteristics from 100 to 5,000 Hz, which includes the entire range of voice frequencies. This is a desirable response characteristic for many voice and music pickup applications, and the bass rolloff (for plane waves or distant sources) is useful to attentuate room noises. The dips at 6,500 and 10,000 Hertz were initially thought to indicate a defective microphone (unit #1). A second microphone (unit #2) was furnished by

"The AT813 can be used in very quiet studios without introducing noise into the audio."

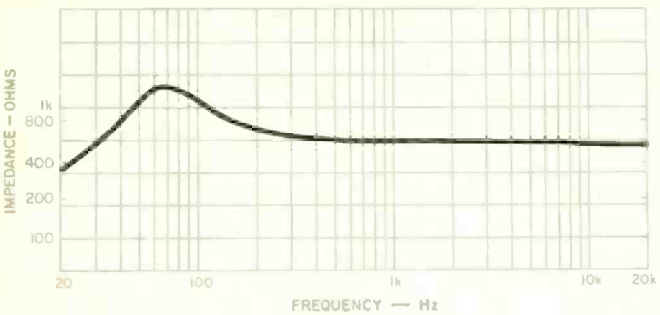


Fig. 1—Impedance vs. frequency.

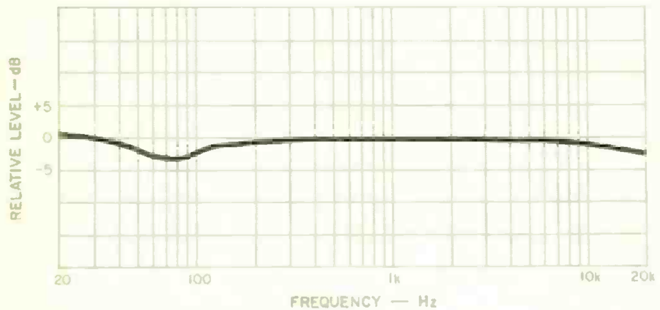


Fig. 2—Frequency response loss due to loading of our microphone preamp.

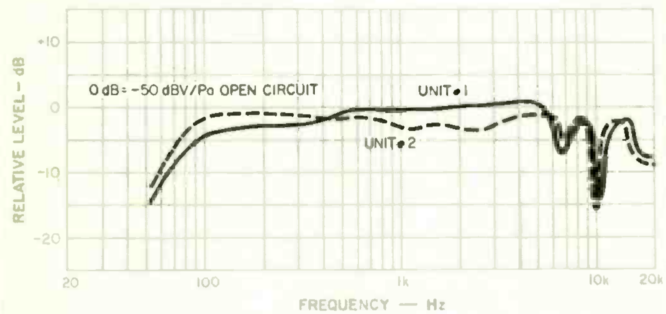


Fig. 3—Plane wave frequency responses for two AT813 samples.

Audio-Technica with a custom-drawn frequency response strip chart (Fig. 4). The vertical scale of the chart was not marked, but as a 50-dB potentiometer is supplied with B & K recorders, we assume that the chart is 50 dB wide. This is more compressed than our scale, but the response may be correlated with our curve (Unit #2 in Fig. 3). Such response variations at extreme high frequencies were not found in electret microphones previously reviewed. (See *Audio*, August 1980 for an example.) We suspect that they may be a function of geometry, that is, of the large head of the AT813, which includes pop noise blast filters. They will not affect voice reproduction, but could add undesirable coloration to very high frequency musical sounds. Thus, the designers of the AT813 may have traded some music pickup quality to obtain pop-free vocals.

The curves of the two microphones (Fig. 3) fall within a ±2 dB (4 dB wide) envelope. If these units represent extremes of manufacturing tolerance, then the variations conform to acceptable limits for professional microphones. However, the audiophile is advised not to buy a pair of AT813s off the shelf, assuming they are matched well enough for, say, orchestral recording, because the mismatch between our two units would be easily heard. We do not usually test two microphones, but our review of the Shure SM-81 (*Audio*, August 1980) shows an example of frequency response curves of two units. Those curves match exactly except for 1- or 2-dB differences below 100 Hz. The AT813 is a much less expensive microphone, but since electret elements are manufactured by automatic machinery (at a cost of a few dollars each), we would expect to find close-tolerance elements in microphones that sell for more than $100.00.

The low-frequency response of the AT813, similar to other cardioids, varies with distance, more or less in accordance with theory (Fig. 5). However, none of our curves shows an essentially flat response down to 50 Hz, as the data sheet and the A-T strip chart do. We think that the observed bass rolloff (plane wave) is proper for a microphone which has no integral voice-music feature, because this results in flat response at 6 to 12 inches on voice. It also aids in reduction of room noise.

The directional frequency-response curves (Fig. 6) show a pattern which tends toward hypercardioid. A hypercardioid has more rejection than a cardioid at 90° (greater than 6 dB) but less at 180° (less than 15 dB). The greatest rejection for a hypercardioid is at approximately 135°. We are very impressed by the 8-dB rejection at 100 Hz and 90°. Rejection at 90° is important in sound reinforcement applications because speakers are frequently placed in the 90° plane. Hypercardioids, in these circumstances, will allow higher system gain before feedback than cardioids will. The directional characteristics are uniform and well-behaved over the entire audio range, and the peaks and dips at high frequencies simply reflect the response curves at 0°.

The measured spectrum of microphone noise (Fig. 7) shows a pronounced hum peak at 60 Hz which could be extraneous noise pickup in the circuitry, and is perhaps related to the high microphone impedance at 60 Hz. This had relatively little effect on the overall "A" weighted noise level, which is 20 dB equivalent SPL. The AT813 can, therefore, be used in very quiet studios without introducing noise into the audio.

The peak output voltage (clipping level) on speech is ±0.2 volts. The equivalent rms input sound pressure level is 127 dB. This is adequate for most applications, but on extremely close and loud vocals, some clipping may occur. Also, the AT813 may clip if placed extremely close to high-level musical instruments or instrument speakers.

The total dynamic range or maximum S/N of the microphone is 127 − 20 or 107 dB. The specifications refer to S/N relative to one microbar, accounting for the large differ-

"More dynamic range than specified . . . adequate for both analog and digital audio recording."

ence between rated and measured values. Based on one microbar, rated noise is 74 − 50 or 24 dB, and total rated dynamic range is 125 − 24 or 101 dB. The microphone tested, therefore has 6 dB more dynamic range than specified. This is adequate for both analog and digital audio recording.

Last, but not least, the phasing test showed pin #2 positive, as per the specifications.

Use and Listening Tests

For comparison purposes, we used a Nakamichi CM-700 electret microphone with a cardioid capsule as a reference. The reasons for the choice of the reference microphone have been stated in previous reviews.

The AT813, with distant music and speech sources, sounded very similar to the reference mike, but the AT813 audio was, pleasingly, freer of disturbing low frequency room noise (air-conditioner sound). The sound quality of the AT813 does not vary significantly on or off axis, same as the reference mike's. When used for closeup speech, the AT813 sounds much "heavier" than the reference, with the latter in Lo-cut mode. The overall sound quality with close talking is duller than the reference microphone's.

Magnetic hum pickup is very low, about 10 dB less than the reference. Pop or breath blast sound with the AT813 was about 5 dB *higher* than the reference. In this test, the reference mike was on Lo-cut with the accessory windscreen. We conclude that the integral pop filter may be doing a good job, but a bass-rolloff equalizer or voice filter is required to achieve higher pop noise reduction.

Vibration and handling noise is much less (approximately 20 dB) than the reference, so the AT813 is well designed in this regard.

Except for the previously mentioned potential problem with the accessible power switch, I find that the AT813 has excellent feel and balance for hand-held use. I think that most performers would find the microphone to be attractively styled.

As a final test, I listened to the AT813 with one of two test preamps connected for unbalanced input (one line grounded) and compared the sound to the other preamp which is connected for a balanced, center-tap grounded input. There was no difference in sound quality, audio levels, or noise.

Conclusions

I think that the AT813 is a good choice for a wide variety of speech and music recording and sound reinforcement applications. It is an excellent microphone choice where feedback immunity is required. For close-up speech or vocals, a bass-rolloff equalizer may be desired by many users. Also, for sound system use, additional treble boost may be desired because of the flatness of the AT813's frequency response. The AT813 is a good choice for close-miking in popular music recording if the SPL limits are adhered to, though it is not our top choice for highly critical classical music recording using two microphones in stereo. The dynamic range of the microphone is excellent.

Jon R. Sank

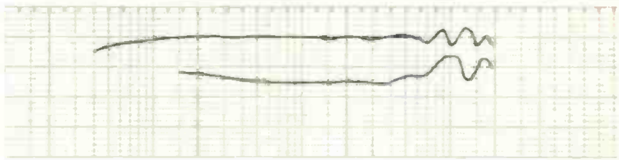


Fig. 4—Frequency response curve supplied by manufacturer for sample #2.

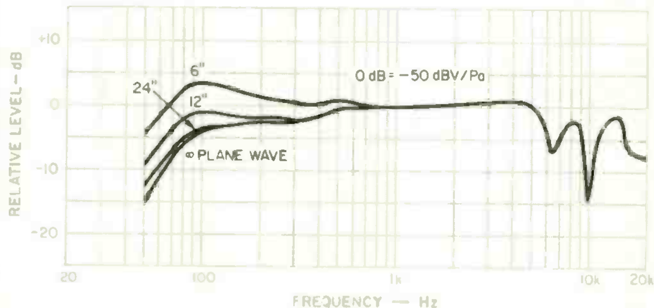


Fig. 5—Frequency response vs. distance from source (sample #1).

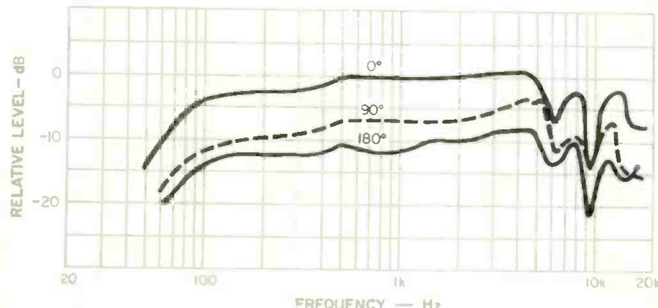


Fig. 6—Frequency response vs. angle (sample #1).

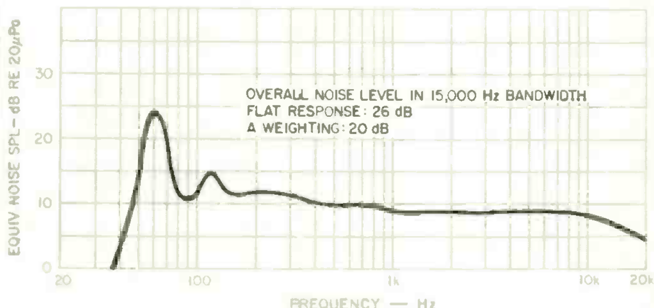


Fig. 7—Microphone noise spectrum (one-third octave bands) of AT813.

WHAT'S NEW

Discwasher Video Head Cleaner

Video Head Cleaner is a nonabrasive, dry system available for both VHS and Beta formats. A special fiber grid removes tape oxides in 30 seconds, and it cleans along the entire VCR tape path—including both the video and the audio heads. The manufacturer suggests that the cleaner be used after every six to eight hours of videocassette recording and playback. Price:$20.00.

Enter No. 100 on Reader Service Card

Technics Receiver

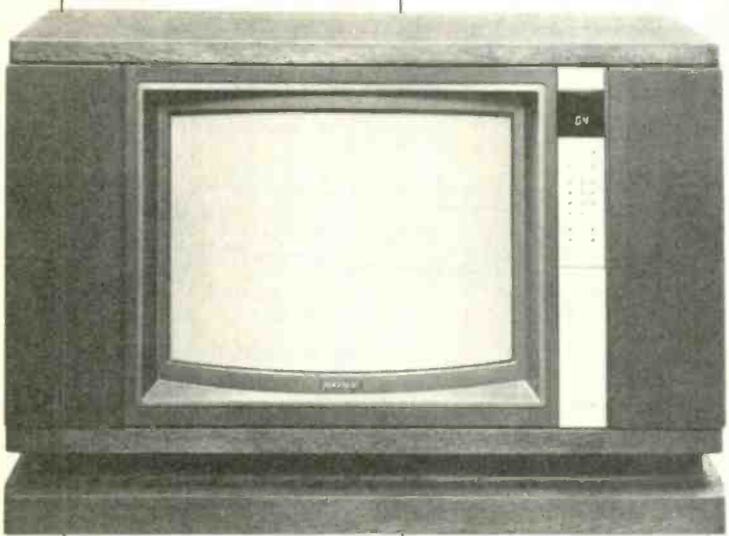
The Model SA-206 quartz synthesizer digital receiver uses an autoscan tuning system that audibly samples each station in turn before stopping at the selected one. The unit offers memory preset for six stations on both FM and AM, and it delivers 25 watts per channel, 20 Hz to 20 kHz with no more than 0.04% total harmonic distortion. There are input jacks for phono, tape and auxiliary, and two-speaker system connection capability with A or B and A & B.
Price: $240.00.

Enter No. 102 on Reader Service Card

Quad Tuner

The only controls on the FM4 are preset buttons, a power switch and a tuning knob, because a microprocessor handles all other functions. The design reflects emphasis on using wide bandwidth for the lowest possible distortion, as opposed to higher selectivity. Station frequencies entered into the tuner's memory will remain there almost indefinitely, up to five years even if the unit is disconnected. Price: $625.00.

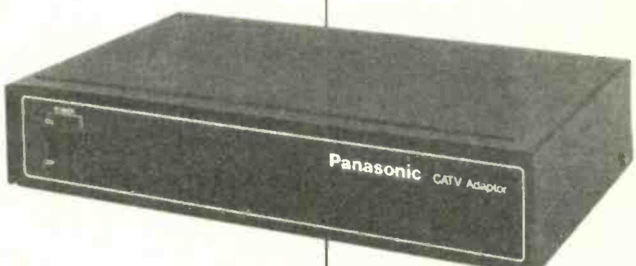
Enter No. 103 on Reader Service Card



Sony Color Console TV

The 26-inch KV-2649R features the Trinitron one-gun, one-lens system and frequency synthesis tuning for quartz-locked accuracy. The console is equipped with 10-key Express Tuning to allow a viewer to punch in a particular channel or search mode, while frequency synthesis provides easy cable adaptability plus instant access to 107 channels. An audio output jack permits TV sound to be plugged into a hi-fi system. An antenna switch enables a user to shift between direct cable TV reception through the TV tuner or scrambled pay-TV through a converter box, and it controls access to regular TV/cable reception, video games or VCR. The KV-2649R comes in an oak veneer wood cabinet. Price: $1,399.95.

Enter No. 101 on Reader Service Card



Panasonic CATV Adaptor

The PV-CT2 permits a viewer to record one channel while watching another, and permits programming a VTR's channel change when using a cable decoder-tuner box. Standard antenna cables, supplied with the unit, are used to connect the cable tuner box, VTR, and television to this adaptor. Price: $129.95.

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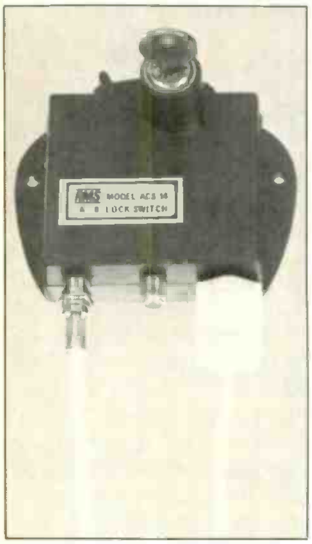

RMS Electronics Lock Switch

The ACS-14 has two r.f. inputs, one of which may be locked with a key. This will prevent the viewing of video program material which parents, for example, may consider inappropriate for their children. The lock switch also has security shields to prevent tampering that could defeat the locking mechanism. Price: $22.45.
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Acoustic Research Loudspeaker

The AR58s is a three-way acoustic suspension bookshelf speaker with a 12-inch woofer, 1½-inch dome midrange, and ¾-inch dome tweeter in a vertical array. The speaker produces 87 dB SPL at one watt/meter and requires minimum power of 15 watts per channel. The oiled walnut veneer cabinet measures 27⅛ × 14 × 10⅞ inches. Price: $325.00.
Enter No. 107 on Reader Service Card

Zenith Component TV

The system includes the CV1950 19-inch color video monitor, CV510 TV tuner, CV540 source selector, CV520 stereo audio amplifier, and CV150 Allegro speaker system. The TV monitor features the exclusive EFL electron gun and Tri-Focus picture tube and is equipped with direct video/audio inputs for improved picture and sound performance. For teletext and microcomputer display, the monitor has direct red, green and blue inputs. The TV tuner has a quartz-controlled, microprocessor-based electronic tuning system. The stereo amp offers 20 watts per channel, from 20 Hz to 20 kHz into 8 ohms with 0.2% or less THD. The Allegro speaker system is a bookshelf unit. Prices: Color monitor, $469.95; TV tuner, $279.95; source selector, $169.95; stereo amplifier, $149.95; Allegro speaker system, $99.95.
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BASF EE Open-Reel Tape

Low noise and distortion, outstanding high-frequency sensitivity, and greater dynamic range are said to be afforded by the new EE LPR 35 Cr tape, to be used on open-reel recorders having the Extra Efficiency (EE) bias/EQ position. The tape's high-coercivity chrome formulation offers performance at 3¾ ips previously available only at 7½ ips. Prices: 1800 feet, $18.99; 3600 feet, $49.99.
Enter No. 108 on Reader Service Card

DEAR EDITOR

Sybaritic Style

Dear Editor:

I enjoyed Mr. Fantel's sensitively written boyhood remembrance in the December issue. This style of writing seems to be strangely out of place in a magazine which panders shamelessly to aural Sybarites. Mr. Canby is very much your type of writer. He hasn't anything of great importance to say, but he says it so well.

Larry Mark
Mississauga, Ont.

Win Some . . .

Dear Editor:

I would like to commend you and your staff for the excellent job done on the November 1981 Todd Rundgren interview. I do feel, however, that the whole idea of a two-way multi-media system in my home sounds a bit 1984-ish to me. Albums will be around for a long time and will be more immediately replaced by purely audio laser discs. Standards for these discs are being decided upon, and if all goes well, expect to see them sometime in 1982.

David Smith
Angola, Ind.

. . . Lose Some

Dear Editor:

I am writing to say that I am very disturbed by recent developments in the way *Audio* is being edited.

I note that in the November 1981 edition that *Audio* has apparently decided to publish frequency response of cassette recorders only at the unrealistic level of −20 dB. The reader is thus left with the impression that the Sony TC-K81 deck under review gives ruler flat response. Maybe it does, but only at −20 dB. The previously published tables and charts were not only more easy to read, but also included the 0 dB levels. Feldman's statement (p. 54) that "The Sony TC-K81 is one cassette deck that has taken proper advantage of the metal-tape formulation" is neither supported nor refuted by the published graphs because of the −20 dB level of the graphs presented to the reader. You can't tell whether or not it's a good machine.

Secondly, I resent the sharp decline in the level of technology presented to the reader. While technology is not my occupation, I subscribed to *Audio* because it was an advanced publication, not a beginner's "where does the plug go" publication. Right now you seem to assume we are teenagers.

Lastly, the "interview" with Todd Rundgren is as much out of place as an article on how to fix an Oldsmobile diesel. Does not CBS know anything but television and TV cameras anymore? Todd may be your friend, but he is of no interest to me. If I were to read an article about him, I'd assume it should be in an art magazine. Why not an article on computers? After all, digital technology, not cheap out-of-date video technology (as in "Video-Scenes") is the wave of the future.

I subscribe to a large number of magazines in many different subjects. I am sorry to say that the arrival of *Audio* is becoming a depressing event. Shape up!

George H Conklin
Durham, N.C.

Up with Noise

Dear Editor:

On page 76 of your April 1982 issue, you carry an advertisement for the Lirpa I Distortion Demodulator. I cannot believe that a publication of your high standards has the audacity to print the claims of Lirpa Laboratories with respect to this product.

Having owned a Lirpa I receiver for several years, I am more than willing to attest to its superiority over any other audio product available. (As you well know, this receiver was initially marketed by Ultima Electronics—see *Audio*, April 1975, pg. 54.) However, I must take exception to the claims made for the Distortion Demodulator.

Having purchased a unit myself at the suggested retail price of $13.11, I rushed home to further improve my unimprovable receiver. After carefully following the enclosed instructions and hooking up the input cables as directed, I sat back and heard *NO AUDIBLE DIFFERENCE*. After a careful scientific investigation, I came to the conclusion that the only thing that saved my system was the inherent 0.0003% distortion level in my Ultima One.

The reason the Lirpa unit does not function properly is quite simple. Refering to basic transmission line characteristics (i.e. the input cables), everyone knows that the reflection coefficient (gamma) is found from the following:

$$\Gamma = \frac{E_r}{E_I} = \frac{R_L - Z_0}{R_L + Z_0}$$

Where E_r is the reflected voltage, E_I is the incident voltage, R_L is the load resistance, and Z_0 is the characteristic impedance.

Since the characteristic of the incident that we are observing is reflected with resistance, it stands to reason that since the source impedance is not equal to the characteristic impedance of the cables (Z_0), reflection will occur from the load end of the line back toward the source.

Now, it is known that any receiver below the specification of the Ultima One will amplify these reflections in the form of noise. Hence the product was inaccurately termed a demodulator when in fact it acts as a modulator.

A copy of this letter is concurrently being sent to the Federal Trade Commission, for obvious reasons.

Peter S. Jasion
Succasunna, N.J.

Our Number's Up

Dear Editor:

What a disappointment! I have been reading the "For Sale" columns over and over again, issue after issue, and what do I find? Well, I'll tell you, I found a Lirpa 1 Distortion Demodulator, that's what.

I carefully studied the Lirpa ad with a 50X magnifying glass. After three days with no sleep, I finally gave the ad to my wife, she gave it to my 11-year-old daughter, and she gave it to my 7-year-old son. None of us left the confines of home for a week.

I am now under a doctor's care and the rest of the family won't associate with me. The problem is that the ad for the Lirpa did not contain any telephone AREA CODE.

My hi-fi is totally dismembered and my component rack is lying sideways on the floor ready to receive the Lirpa. I have sworn off music and have refused any food for two weeks. If *Audio* has any heart, I implore you, send the telephone area code.

Milton Michelstein
Ozone Park, N.Y.

Editor's Note: We suggest you try looking in old cereal boxes for a decoder ring.

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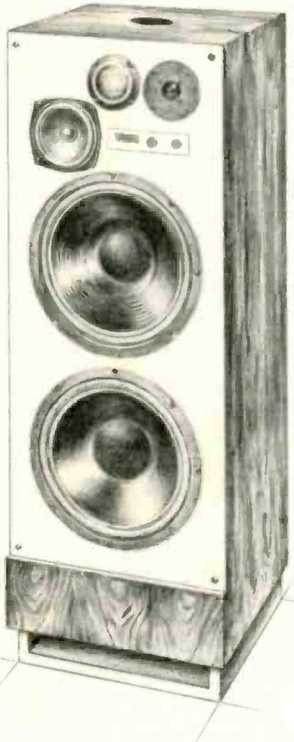

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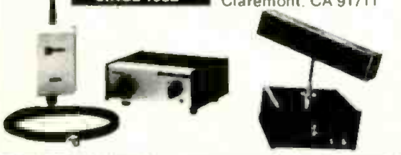

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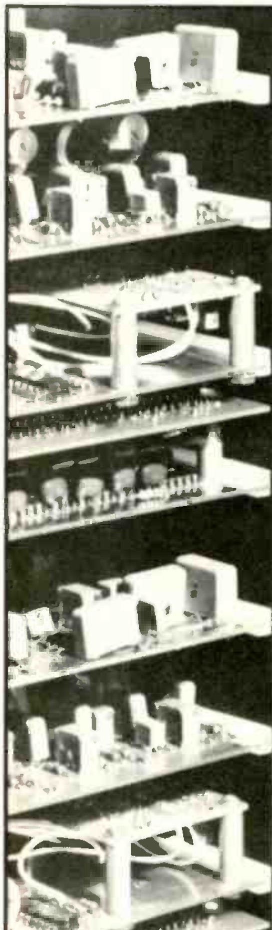

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As part of our continuing expansion program, we recently exhibited at the Summer CES in Chicago. We shared our suite with Stan Klyne of Klyne Audio Arts, and the combination of our loudspeakers and his superb electronics made for what many experienced listeners described as (once again) one of the finest sounding exhibits at the show.

As might be expected, we received a large number of inquiries from prospective new dealers, especially from the Midwest who seemed to dominate the attendance at this year's show. In addition, we received a significant amount of interest in our loudspeakers from both European and Asian distributors, who are known for being exceptionally selective and demanding about the new products they represent. We are carefully screening the applications we received from dealers and distributors alike, for our growth plans call for a gradual expansion of our production capability while paying strict attention to maintaining our rigid quality control standards. We hope that by the time you read this column, a local dealer may have our loudspeakers available for you to personally audition.

We were also pleased to meet with many more of the noted "underground" audio journalists, all of whom were so impressed by our speakers that they immediately requested review samples. But as these reviewers realized, our first obligation is to our customers to satisfy their demand for our speakers. You can be assured, however, that we will provide review samples as soon as possible.

Clearly, these are most peculiar times in the audio industry. We continually hear reports from our fellow manufacturers and retailers that the uncertain state of the economy has severely depresssed audio sales. And yet our **GNP** loudspeaker business is increasing daily. Perhaps this demonstrates that a superior, quality product can transcend the difficult conditions of uncertain times.

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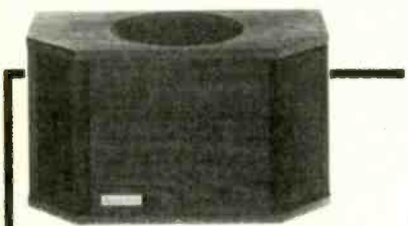

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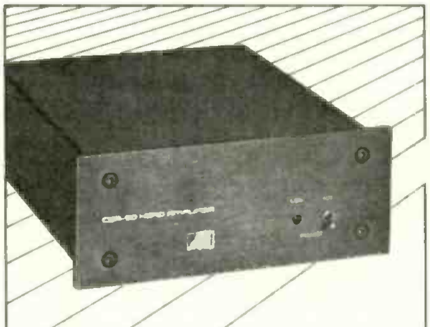

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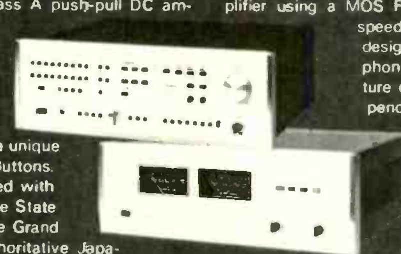

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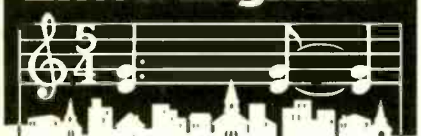

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AD INDEX

HERMAN BURSTEIN

Head Demagnetization

Q. In demagnetizing tape heads, I wonder how important the speed of withdrawal is. If one withdraws the demagnetizer in only a few seconds rather than extremely slowly, will the heads still be demagnetized? How important is it to demagnetize the capstan? Does the deck need to be demagnetized after eight hours of operation or eight hours of recording? Do tape players (car or home) need to be demagnetized?—Randy Webb, Pullman, Wash.

A. The advice typically given about withdrawing a demagnetizer slowly from the heads implies that this is done in a few seconds, say three to five. I doubt there would be any difference in the results if one took, say, 30 seconds.

Typically, one is advised to demagnetize all metal objects encountered by the tape, which includes heads, guides, mechanical filters, tension arms, the capstan, etc. If demagnetization is required, it should be done after about every eight hours of use, whether recording or playback. Tape players are not exempt.

Longer May Not Be Better

Q. I am presently using 90-minute tapes with my cassette deck, which can operate at 1⅞ or 3¾ ips. Many retailers are discounting the 120-minute tapes because of warnings that these cassettes may cause a loss of fidelity and may strain the deck's motor. If I buy the C-120 cassettes, I would gain about 15 minutes of recording time when operating at 3¾ ips. Would I have the same problems with C-120 cassettes at 3¾ ips as at 1⅞ ips?—Donald McHugh, Brooklyn, N.Y.

A. Use of a C-120 cassette would be just as disadvantageous at 3¾ ips as at 1⅞ ips. The disadvantages consist not only of possible motor strain but also of more dropouts and poorer signal-to-noise ratio due to the very thin oxide, greater distortion, and greater wow and flutter owing to susceptibility of the tape to stretching.

Obiter dicta: In view of the remarkable performance possible today at 1⅞ ips with cassette, and the continuous improvements at that speed, I find myself in opposition to those who are promoting the use of cassettes at 3¾ ips. As a result, persons like you find that recording time is cut in half and seek to compensate by using extra-thin tape, namely C-120. The net result tends to be that worse performance is obtained at 3¾ ips than at 1⅞ ips. Not all change is progress.

The chief advantage of 3¾ ips over 1⅞ ips is greater headroom in the treble range—that is, less tendency to saturate the tape when recording high-level treble frequencies. But this headroom can be substantially restored by such expedients as metal-particle tape, the Dolby HX system, and other noise-reduction systems (which signify that one can record at a lower level and avoid saturation, yet without deterioration in signal-to-noise ratio).

Finally, let me point out that at least one manufacturer, Nakamichi, has gone in the opposite direction by bringing out a cassette deck which records at 15/16 ips in addition to the standard 1⅞ ips.

Second-Hand Deck

Q. I plan to buy a cassette deck and am trying to make up my mind between two units. One is a new deck that sells for $258. The other is a used deck whose original price is substantially higher, but that is offered to me for $150. Which do you think is a better buy?—Dan Scanlon, Detroit, Mich.

A. On general principle I advise against buying a mechanical component on a second-hand basis because there is so much that may soon need replacement or repair—heads, belts, etc. New heads alone could cost in the vicinity of $150.

A Clunker?

Q. I have cassette tapes recorded off radio with a Panasonic deck. I want to transfer them to open-reel tapes using an Akai 1722. But no matter how I do it, there is always a "clunk" as I release the pause button on the Akai to start recording. Suggestions to eliminate this sound would be appreciated.—Farrel Sveslosky, Long Beach, Cal.

A. Regretfully I cannot give you specific instructions for eliminating the "clunk" sound. This is a problem whose best solution tends to vary from one deck to another. Often the solution requires only an inexpensive capacitor, and perhaps a resistor too, wired into an appropriate part of the deck, usually across the pause switch. However, your wisest course is to contact the deck's manufacturer for the solution he thinks best. Or you can contact an authorized service shop for your deck. If the shop charges fair prices, the modification should not be expensive, but it is a good idea to ask for an estimate.

Metal Tapes for Open Reel?

Q. I would like to know if and when metal tape will become generally available for open-reel decks, and whether there will be a new generation of open-reel decks that can meet the bias and other requirements of metal tape.—Jim Boros, Euclid, Ohio.

A. As yet I have heard no reports that metal tape and metal-capable decks are to be available for the open-reel format.

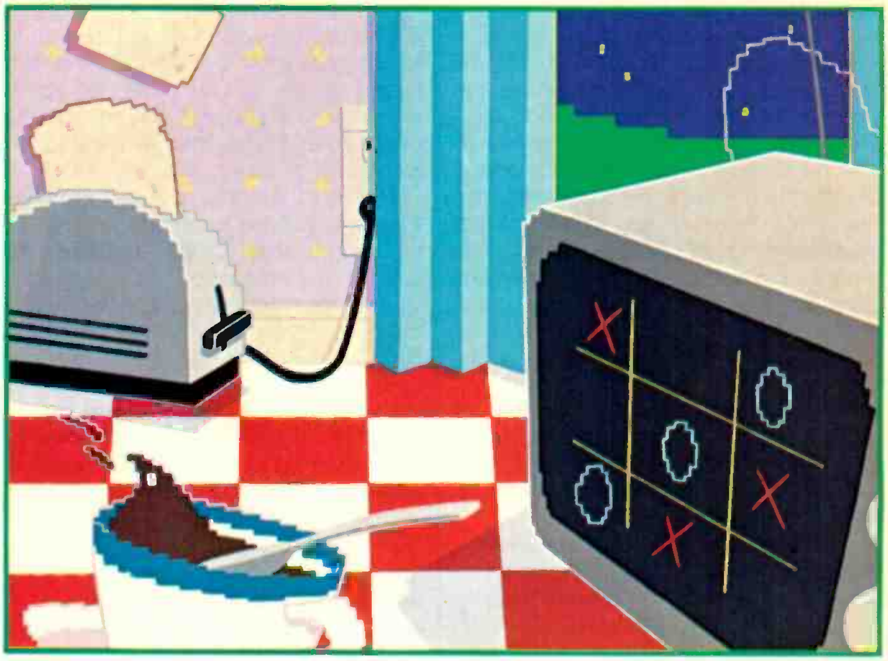
The benefits of metal tape tend to be more audible at the low tape speeds than at the high ones. Thus, metal tape finds a greater welcome in the cassette format with its 1⅞ ips speed than in the open-reel format, where the speed is customarily 3¾ ips and upward. Inasmuch as metal tape costs substantially more than the other types (so far), few recordists would be willing to pay a premium price for a minimal improvement in recording quality. Furthermore, there have been improvements in ferric oxide and cobalt-modified (EE) tapes which have narrowed the performance gap between them and metal tape. So there is still less call for metal tape in the open-reel format.

On the other hand, some open-reel decks do provide a 1⅞ ips speed and they could benefit somewhat from metal tape. If there are a substantial number of such decks, if the price of metal tape relative to other tapes continues to descend, and if makers of open-reel decks with the 1⅞ ips speed are willing to make their machines metal-ready, we might find metal tape available on open reel. A

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.

BERT WHYTE

CES: GAME SHOW



At the SCES in Chicago, video in all its multi-faceted diversity clearly dominated. The scope of the video product offerings was simply mind-boggling: Color TV sets; component TV monitors and tuners; projection sets; VCRs big and complex, portable and complex, or small and simple; color cameras; processors; enhancers; lighting equipment, and videodiscs. And, of course, video games, where the scramble to climb aboard the game bandwagon is just incredible. The established game companies—Atari, Mattel, Bally, Activision—are being challenged by newcomers like CBS and 20th Century-Fox. I would be only mildly surprised if IBM joined the fray! It is easy to understand the lure; in a depressed economy, video games are selling like hotcakes and the profit margins are very comfortable.

In the less frenetic world of the videodisc, second- and third-generation players are part of a concerted effort to revitalize this segment of the video industry. RCA now offers four models of its CED videodisc player. The top-of-the-line SGT-250 features stereo playback with CX noise reduction and such refinements as infrared remote control for visual search (16x normal speed, with picture but no sound), rapid access (120x normal speed, with no picture or sound but with a digital display indicating elapsed playtime), and a pause control. The unit is priced at $449.95. The Model SGT-200 also features stereo playback with CX noise reduction. It too has visual search, rapid access and pause, but no remote control. Price is $399.95. There is an updated version of the original model, the SGT-100, now at a price of $349.95, and finally, what RCA calls a "leader" model, the SGT-075 with visual search ($299.95). Stereo CED discs available include "The Jazz Singer," "Popeye," "Eubie" and "Pippin" and music with such groups as Pink Floyd and The Who. As further support for CED, Toshiba introduced its new player, which also features stereo playback with CX noise reduction. It is reported that the CX encoding improves signal-to-noise ratio by about 14 dB, which certainly is worthwhile. While it would appear that though sales of both the players and the discs have not met RCA's expectations, new lower prices for the players have helped, and RCA now claims CED discs are selling at a very satisfactory level. In fact, RCA expects to sell over 10 million CED videodiscs by the end of 1982.

The optical videodisc forces, although plagued by quality control problems with their laser discs, appear to have weathered the "glitch" storm with some drastic disc manufacturing realignments and the acquisition of new disc manufacturing facilities. Now Magnavox is out with a new Model 8010 laser disc player equipped with CX noise reduction, priced at $750, while Pioneer has two new models, the top-of-the-line LD-1100 ($800) and the lower-priced model LD-660 ($600).

One of the optical videodisc's boasts is the degree of control possible with this system. The remote control included with the LD-1100, for example, selects left and/or right audio channels (both for stereo, either for bilingual discs), and has random-access frame or chapter search, forward (60x) and reverse (30x) fast scan, slow motion (forward and reverse), plus freeze-frame and single-frame advance—not to mention the play, pause and reject controls. Most of these controls, except for the random-access keypad, are duplicated on the player itself. In addition, the player has controls for slow-motion speed adjust and for the CX noise reduction system.

The LD-660 has many of the LD-1100's control functions, but no remote control facilities. However, it does have CX noise reduction. Pioneer is making much of the S/N capabilities of the CX equipped units, claiming 70 dB (IHF A wtd.). They also quote frequency response as 40 Hz to 20 kHz ±3 dB. Both models have new, slimmer styling and smaller overall packaging. For those who own the original Pioneer Laservision player, there is now an add-on CX decoder, the R-1000. This $80 unit has a switchable input level to make it compatible with Magnavox or any other brand of laser-disc player.

JVC's VHD videodisc, as you probably know, has been delayed several times, but it was supposed to finally debut at this SCES. However, disappointing overall sales of the competing videodisc systems and the current poor economic climate have delayed VHD's introduction once again, this time to the summer of 1983. Some trade papers unkindly reported that this decision was "somewhat of a relief," but strangely, the VHD system garnered much interest at McCormick

Illustration: Cameron Wasson

"Videodiscs have come of age, with second and third generations common."

Place. At the McCormick Inn, I was given a special showing of the VHD disc's capabilities, including chapter and frame-by-frame display. Interestingly, a European PAL-system VHD disc could be played directly on our NTSC player and vice versa. This, of course, would obviate the need to import PAL tapes and process them to NTSC discs in this country.

I must honestly state that there are more than a few people who feel that *all* videodiscs will ultimately fail in the marketplace. This opinion is based on the fact that the videodiscs are a playback-only medium and historically, the playback-only tape formats fell by the wayside. But the VHD player's ability to also play the AHD digital audio disc, may yet prove a strong survival factor.

As we have come to expect at almost every CES, videocassette recorders continue to proliferate and are continually updated with ever more features and refinements. The big excitement at this SCES was the provision of stereo record and playback facilities, usually combined with Dolby noise reduction. Akai started the stereo ball rolling in this country, and more recently JVC incorporated Dolby B stereo on its new HR-7650 VCR.

At this SCES, there were stereo-equipped VCRs from the likes of GE, RCA, Hitachi, Panasonic, and Quasar. A number of portable VCR's offered stereo facilities, and in fact, portables in general are being accorded most of the engineering and desirable convenience features of their big brothers. Full function infra-red wireless remote control is particularly favored.

Virtually all stereo equipped VCRs are VHS models, and the more than 200 stereo prerecorded videocassettes now on the market are available only in the VHS format. The one exception to the VHS stereo domination is Marantz's new VR-200 Beta format VCR which not only features stereo recording, but uses Dolby C noise reduction as well.

Early next year Marantz will have a Beta portable with stereo and Dolby C. Marantz admits to the lack of Beta-format stereo prerecorded video-cassettes, but counters this with a special input on the VR-200 which permits the recording of simulcasts from FM stereo tuner and stereo cable broadcasts. The VR-200 is priced at $1295.

Two of Japan's photographic giants, Pentax and Canon, chose portables for their entries into the VCR market. It was an obvious move, since video color cameras are usually a part of the portable package. Pentax's portable unit has a four-head recording drum and a companion tuner/timer, which can program eight events over a three-week period. Canon has gone "all out" to field a particularly complete system. Their VC-10A color video camera features an f/1.4, 11- to 70-mm zoom lens with auto focusing. The VR-104 is a full-function VCR, weighing only eight lbs. The VT-10A tuner/timer has 105–channel capability and 8–event, 2–week programmer. There's even an adaptor which can convert 35-mm color negatives (via a reverse polarity switch on the camera) to positive colors for viewing on the TV screen. This ability to convert 35-mm color negatives to color positives is also a feature of a new GE color camera and a particularly versatile new Sony Trinitron camera and HVT-3000 Photolab adaptor not to mention an Akai camera introduced last year. As a long-time photography buff, I once had my own color photo lab with the ability to make large C-type and dye-transfer color prints. This negative to positive color reversal process, I feel, is a very exciting development. It has been around a while, but now is much easier to accomplish.

Sony is also offering an HVS-2000 special-effects and character generator which, among other things, has a number of color filters. These can be interposed with the color negative to provide some degree of color correction. I am going to test one of these units, and see if there is some way of using this system to determine the correct printing filters for color negatives. The price of the Sony Photolab unit is $179. Next month, a look at the new TV component systems and some other interesting items.

BERT WHYTE

CES: THE LULL BEFORE DIGITAL

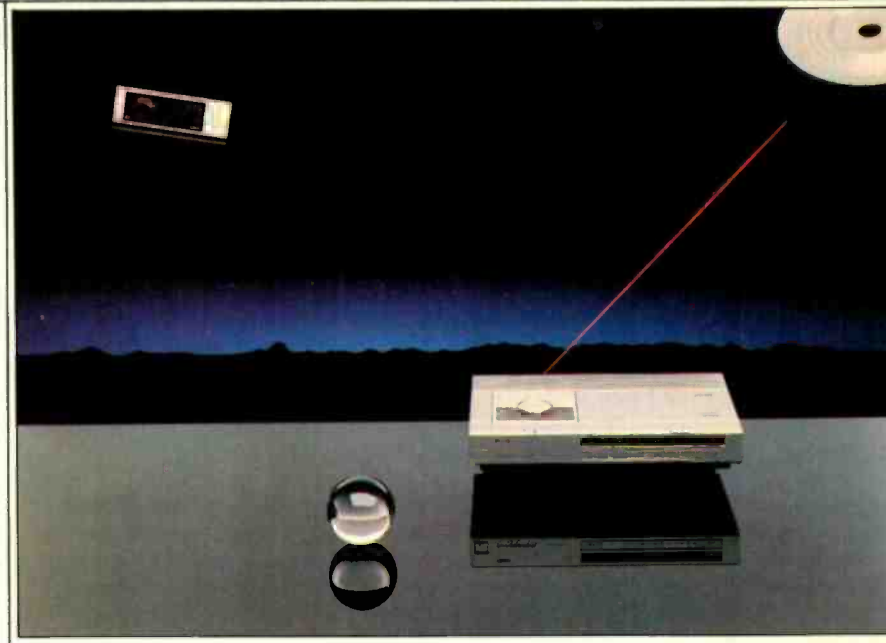
The 1982 Summer Consumer Electronics Show in Chicago opened on June 6th, and by the time the Show closed on the 9th, over 70,000 attendees had filed into the cavernous spaces of McCormick Place, and the exhibit rooms at the McCormick Inn and the Conrad Hilton hotel—or so claims the EIA, which states that this is a new high in attendance, some 19% above last year.

However encouraging these attendance figures may appear, I heard considerable grumbling from manufacturers who said they didn't see many dealers and thought there was a particular dearth of West Coast dealers. After the opening day, more grumbling (especially among audio manufacturers) was generated by the obvious concentration on video in general, video games in particular. There was little doubt that video games were proliferating like the proverbial rabbits, and there was a Klondike frenzy to get to the video-game gold fields. Many feel this product category hasn't even begun to reach its high-water mark; more than a few also believe the boom will prove to be a short-lived phenomenon and go the way of CB radio. I dunno, fellas—there are an awful lot of kiddies with indulgent parents in this country.

Quite a number of the audio contingent in the Conrad Hilton (new headquarters for "high-end" audio) complained about the small size and the generally atrocious acoustics of their demonstration rooms. This reporter can certainly confirm both. I went into demo rooms where speakers I know to be of excellent quality sounded like screechy caricatures of their usual selves.

As a general observation, the Show was not a gloomy reflection of a recession, but neither was it an upbeat Show with a lot of buying activity.

There were no technological breakthroughs that might have stimulated the industry. Oh, yes—there is the promise and undoubted potential of digital audio. Some people thought a few maverick companies might jump the gun and make an unscheduled early foray into the digital lists, but such was not the case. There were indeed DAD (digital audio disc) player prototypes from most of the larger Japanese manufacturers. There even was a working demonstration of the Sony/Philips DAD unit playing Phonogram (Decca, DGG and Philips) digital compact discs. On Sunday, June 6th, Sony gave a special briefing on the status of the DAD for some members of the audio press corps. They had on hand such luminaries as Mr. A. Suzuki, General Manager of the Consumer Digital Audio Project in Tokyo, several other audio department heads from Tokyo and Mr. Roland Martin, Senior VP of Sony of America. Although a bit disappointed in the briefing's limited scope, we were made privy to some interesting points about the DAD. For one thing, Sony and its licensees have all made successful DAD players in modest quantities. Sony/CBS in Japan is scheduled to set up DAD "cutting"(it is really a photo-etching process) and pressing plants by September of this



Philips flashed its compact system for digital discs.

Sony showed off its DAD.

year. Phonogram is said to be stockpiling DADs in its new plant in Hanover, Germany, drawing on the hundreds of digital tape masters in their Decca, DGG and Philips catalogs.

The official launch of the Sony/Philips DAD is September of this year in Japan. Sony stated there will be many models of the DAD players, plus software, at the Japan Audio Fair in October. European introduction will be roughly the same time, with the U.S. market to be opened early in 1983. Although it would appear that Sony could market the DAD systems much sooner than the above schedule, they are acutely aware that the DAD system must work *flawlessly* from "Day one, Play one." Any form of the glitches which so plagued the laser videodiscs would be disastrous.

Sony revealed that the typical DAD players will retail for about $1,000 with the cost of the discs between $15 and $18—in other words, somewhat on the order of present audiophile discs. One must keep in mind that, with the DAD impervious to most scratches, dust, fingerprints and even gloppy soft drinks, and with the "no-wear" character of the no-contact laser playback, the discs can last forever.

The negative aspect of the Sony meeting was their admission that neither RCA, CBS, WEA nor any American record company had indicated it would set up DAD cutting and pressing facilities. With a depressed record industry, warehouses bulging with unsold analog discs, and a huge capital investment in conventional pressing facilities, the advent of the DAD is not arousing much record-company enthusiasm. I would also point out that the total number of digital tape masters thus far produced by American record companies is fairly limited.

Sony gave me a good demonstration of the DAD via their player reproduced through their Esprit components. Larry Poor, who heads up the Esprit program, played a Phonogram recording of the "Great Gate of Kiev" from Mussorgsky's "Pictures at an Exhibition." The great climaxes came over very cleanly, with huge impact; in rests and quieter spots, not a trace of hiss was heard! However, one must note that the complete lack of noise on the DAD unmasks every detail and makes the excesses of multimiking technique even more objectionable. Still, this is not a reflection on the technical excellence of the DAD system.

There was other digital activity at the SCES. Sony showed their PCM-F1, and Hitachi exhibited their digital audio recorder, priced at $3,500, while Sansui exhibited their TriCode PCM digital audio processor. The Sansui processor uses the standard EIAJ digital encoding of 14-bit linear quantization and 44.056k sampling rate. The TriCode has the unique feature of record and playback of digital tape at one-third normal VCR speed—the EP speed in the VHS format and Beta Three in the Betamax format—without

"Digital recordings, using Sansui's TriCode, might well cost less than recordings made using metal cassettes."

deterioration of the signal. Signal-to-noise ratio and dynamic range is quoted as 84 dB, with d.c. to 20-kHz frequency response and THD of less than 0.007%. Sansui pointed out that at one-third of normal VCR speed, the cost per minute of TriCode digital recording is less than that for metal-particle cassettes and that the price of the TriCode PCM would be "comparable" to some of the other PCM processors on the market.

A great deal of interest was shown in the new Technics SV-100 digital audio processor. This unit also uses the standard EIAJ digital encoding, and it can be used with VHS, Beta or any other videocassette format. It is about the same size as the Sony F1 but is a bit lighter, weighing about 8 lbs. *with battery*. One of the main reasons for the keen interest in this PCM unit is its anticipated price of approximately $1,000. It is said there will be production models at the WCES in January.

JVC again showed its PCM unit which uses metal-particle audio cassettes. Here we have a rather offbeat sampling rate of 33.6k, which gives bandwidth to 16 kHz, with a recording time of 60 minutes. There's no further word on production, yet. Optonica also showed an experimental PCM cassette recorder using metal-particle audio cassettes. This is a multiple-scan system utilizing 18 tracks, a number of which are redundant, that is for error correction. No other details or indications of production of this digital recorder were available.

In the face of all this digital recording activity, the analog open-reel recorder might seem like a dying breed. However, there have been significant improvements in several models of open-reel recorders which make them newly attractive. For example, Tandberg has a new 10½-inch reel unit that, with their Dyneq circuit and running at 15 ips, achieves a signal-to-noise ratio close to 78 dB at 0-VU. Revox has updated their B-77 recorder with more convenience features and with improved circuitry for wider frequency response, less distortion, and better S/N ratio. Teac and Akai also have a number of new open-reel models, some with EE tape capability. While these units can't match the digital recorders in a number of areas, there is one facility the open-reel units have that is likely to keep them on the scene for quite a long while to come: The ability to easily edit via razor blade cut-and-splice technique. This is vitally important to many semi-pro and even amateur recordists. Present digital recorders using videocassettes cannot be edited at all or can be spliced only with great difficulty. The chances of a reasonably priced digital editor appearing on the market are quite remote at this time; pro editors cost around $40,000.

MUCH ABOUT MIKES

Microphones—An Anthology of Articles from the Pages of the Journal of the Audio Engineering Society, Vol. 1-27 (1953-1979) Audio Engineering Society, New York, 1979, $22.00.

This book is one of the continuing series of anthologies published by the AES. Others include *Loudspeakers*, *Sound Reinforcement*, *Quadraphony*, and *Disc Recording—Volume 1*.

Microphones includes most of the important papers that have been published on the subject since 1953. Prior to that year, AES articles were published in *Audio Engineering* magazine which, of course, later became *AUDIO*. A reader interested only in present-day microphone technology will find *Microphones* a comprehensive reference that includes ample historical background. Our file of microphone articles from 1953-1979 shows that *AUDIO* is the best alternate reference source. The *Journal of the Acoustical Society of America* and the IEEE publications have carried relatively few articles on microphones in recent years.

Virtually all of the history of electret microphones, miniature microphones, and microphone electronics is contained in *Microphones*, because recent developments have concentrated in these areas. The reader, who has some interest in microphone history from earliest days to the present, will find that Harry Olson's historical articles in Section C, "Directional Microphones," provide sufficient information. For more details on the microphones of the '30s and '40s, consult the references in the Bibilography. Important papers by such authors as Bauer, Olson, Wente, and Thuras are noted, but the list is too brief. Additional contemporary articles should have been included. For instance, Bob Pacquette's 1979 article in *AUDIO* is an excellent source of information on microphones of the '20s and contains many photographs. The patent literature which provides a 100-year history of microphones shows details of construction and technical descriptions of microphones which may not be found elsewhere. A representative list of patents should have been included in the Bibliography.

The quality of the articles in this anthology is generally excellent. Most of the papers apparently have been refereed and are consistent with the present-day level of articles in the *Journal*. The early articles from 1953 are written in a different style, and probably were not properly refereed. For instance, Souther's article on page 73 contains some remarks comparing moving-coil to ribbon microphones which are written in a style resembling advertising copy, and some of the claims are erroneous.

Present day *Journal* articles are divided into "Papers" and "Engineering Reports." Product development and other less "scholarly" articles appear as "Engineering Reports." In earlier years, this distinction was not made, so there are quite a few "report-type" articles in *Microphones* mixed with the more scholarly papers. For example, the early article by Burroughs is a one-page item that describes how to make a windscreen. Other examples include Kaufman on a wireless microphone, Schulein *et al.* on an amplified microphone, and Burwen on a capacitor microphone system. The Schulein-article format appears to be similar to present day "reports" but is not so labled.

Many readers of *AUDIO* will enjoy the report-type articles because they are less technical and therefore easier to read than the "Papers."

Aside from these few remarks about editorial organization, I find little to criticize in this book. It is the best collection of information on microphones that has been published since Olson's *Acoustical Engineering*. As the latter was published in 1957, *Microphones* makes an excellent companion volume.

Jon R. Sank

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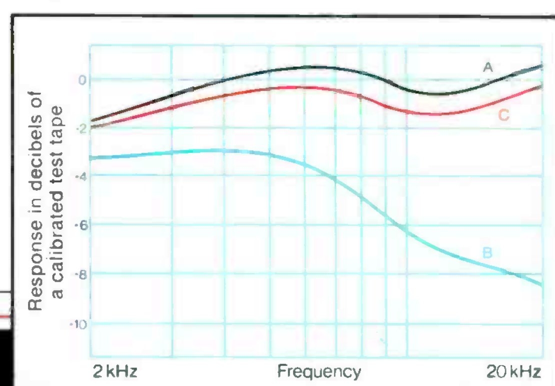

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