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Letter from the Editor

This is the last issue of Volume 17. It is definitely time to renew your subscription if you have not already done so.

This entire issue is devoted to a detailed account of the July 1989 BAS meeting and David Moran's extensive work on loudspeaker measurements. The first issue of Volume 18 will feature the Winter CES report and Al Foster's article on his Audio Control spectrum analyzer.

July 1989 BAS Meeting

Analysis of Horizontal Dispersion: A Useful Way of Measuring and Understanding—and Evaluating—Loudspeaker Systems

[It will be more enlightening, I hope, to put forth even a rambling memoir of my experiences in this field rather than simply to summarize my less well-organized and much less complete BAS meeting presentation. Those averse to opinionated personal yarns should turn to the curves. This report, supplemented with considerable new data since the meeting, is part of my slow-going history of New England loudspeaker companies.—Publisher]

In the Beginning

At least in its first part, my tale must hardly differ from that of any American audio enthusiast in my post-war generation. As amateur pianist/organist, wannabe rocker and music critic in college in the '60s, I found altogether compelling the understated ad copy, technical articles, elegant science, and independent reviews (by Julian Hirsch and by *Consumer Reports* among others) about the latest generation of acoustic-suspension speaker systems coming out of the Cambridge area. Not the only consumer making this decision at the time, I purchased, at various stages of building my stereo and according to my budget, AR3s, then 3as, and KLH 6es and 5s. Indeed, a significant part of the thrill of transferring to college in Boston was knowing I now listened to the same broadcasts and went to the same concerts as the inventors of those speaker technologies: Edgar Villchur and Henry Kloss and their associates.

I found their speakers' low-bass performance quite as claimed provided the cabinets were happily placed in my dorm or apartment room and provided it was happily proportioned, two subjects about which I knew little. Other than this, I thought the systems sounded okay or better but hardly did full justice to, for example, violins. I became a scholar of measurements and specifications, such as they were at the time and such as I understood them. Audio was the entry into physics for this thoroughgoing liberal-arts major. I also knew enough not to rely completely on, and often to distrust, my ear; and for loudspeakers I didn't have a very educated one in any case. Plus I mistrusted perception, or at least knew something about human fallibility, gullibility, and suggestibility.

In the fall of 1968, following its rave reviews, I went to hear this pathbreaking new development the Bose 901, taking my Serkin/Szell Brahms Piano Concerto No.1 LP to Tech HiFi in Waltham. I heard a literally unbelievable, and extremely stimulating and pleasing, improvement in orchestral string reproduction and in the scale of the stereo stage. Still, I thought something wasn't right about either its low bass or the stereophony—the breadth and texture of the spread. But whatever it was that the 901 was doing was sure worth pursuing in some respect or other. Years before, I'd liked my KLH 11 when I turned its pair of simple, equalized, single-driver speakers toward the wall, as the manual strangely suggested. But I wanted that *and* its speakers facing me, I felt. So I did not buy these new 901s, and stuck with my AR3as.

A couple of years later—by now having unsuccessfully tried to get a job at AR (this after learning their customer-service guy was also the text translator for a Nonesuch set of Bach chorales!), having been fired as a laidback stereo salesman, and at last working as a newspaper music critic and prep-school English and music teacher—I wound up sonically more satisfied with large Advents front and rear (L-R) and the increased spaciousness afforded by the configuration. Nonetheless, I sought out Amar Bose's articles in MIT's popularizing *Technology Review* on the conceptions behind the 901. In his two papers Bose goes on about unrevealing speaker measurements, their poor correlation with perceived sound quality, and his discovery of the importance of increased reflections; it was provocative in an oddly smoky, hand-waving kind of way, but unconvincingly argued and supported, especially for an academic. It suffered all the more if you compared it with the formal, droll, understated rigor in prose of Villchur, Kloss, and newcomer Roy Allison.

Eventually I sold my Advents and bought the new products of the last designer. I thought the Allison One and Two signified an easily audible improvement in the speaker art for having a rich and full—lifelike—mid-bass/lower midrange, as well as in their string reproduction, which was much more spacious due to the uniquely wide dispersion of the tweeter. But the stereo stage, which by this time was beginning to be labeled imaging, still was diffuse. Studying Allison's research into room reflections, specifically the serious ripple in the 100-1kHz decade they can cause in recombining with the direct speaker output, and also his development of that tweeter, I bravely called and asked him to rewrite some of his scholarly essays for audio supplements to the newspaper where I had just become an editor.

I also got peripherally involved in the new local audio society, just a couple of years old.

Questions Formulated

At the *Boston Phoenix* I solicited work from the most prominent local audio freelancer (along with, in time, many of his Boston Audio Society acquaintances). For one audio supplement Peter Mitchell and I put together a panel discussion featuring most of the area's many leading speaker designers, Amar Bose declining to participate. Comprising Kloss, Allison, the late Victor Brociner of Avid, Andy Petite (then still with Advent), Win Burhoe (just departed from EPI), Daniel von Recklinghausen (still at KLH, I believe), Victor Campos (then with AR), it turned out to be an interesting discussion of speakers, design decisions in behalf of fidelity, and marketplace considerations. But nothing, really, about why speakers sounded as they did above, say, 500Hz, or why similar designs sounded so different from one another.

Indeed, none of my experience and study in this 1965-77 period made the complex speaker/sound quality/imaging relationship make sense. It almost seemed as if designers knew how to quantify everything but this relationship. All save Bose were devoted to amplitude (frequency) response at some distance or other on some axis or other, or in toto (a power response), or both. The leading designers espoused smooth off-axis responses too, and had for years, but always added how you could not have axis and off-axis output both be "flat." Not ever? I wondered. Yet Bose's "direct/reflecting" approach—what a phrase, as if speakers could do anything else—hardly seemed to be the solution either, although it sounded like a step forward. Still, *why did* similar-looking forward-facing speakers sound different? Within another year or two, a terribly expensive new gadget that produced one visual slice (snapshot) of a speaker's wideband response to a jumpy signal—the Ivie 1/3-octave real-time analyzer with pink noise and calibrated mike gave fascinating, awfully ratty-looking results, and answers of mostly unclear usefulness except to its confident owners.

Answers Formulated

Finally, in the spring of 1978, I read in *High Fidelity* a well-reasoned and fairly well-supported article by one Mark Davis, a doctoral student in electrical engineering/psychoacoustics at MIT, consulting designer, fellow BAS member, and inveterate common-sense tinkerer in audio experimentation and simulations. The *HF* piece purported to explain the real reason why speakers sounded different, apart from their frequency responses either on some axis or in aggregate. From tests he and colleagues had done, Davis believed the answer principally to be the pattern, or shape, of their output—how it changes—at all angles and all frequencies above those we localize (i.e., >150-200Hz). In particular, the decisive factor was said to be horizontal radiation pattern, or radpat, horizontal since our ears of course are so much keener to lateral sounds than to those over or under.

Now speakers started to make sense to me. You could make systems sound similar if you made their horizontal radpats similar in shape and then amplitude. And if similar-seeming systems had different horizontal radpats, they would sound different.

Hmm.

Davis repeated and embellished some of these premises and conclusions about the salient importance of horizontal radiation pattern in a speaker-designer/researcher panel he was on after a 1980 AES convention, set up by and published in *High Fidelity*. With his usual common sense he also gently corrected some of the other panelists' misconceptions, this panel including, among others, psychoacoustician Daniel Queen, AR's Tim Holl (now at Bose), Raymond Cooke of KEF, John Wawzonek from Bose, and Allison.

What all that meant seems to me even today not widely or deeply understood. You can still read interviews with speaker designers and researchers, as in a recent *Stereo Review* panel about trends for the '90s, with no mention of radpats. (The coming multichannelism of home stereo deflects scrutiny from the subject, perhaps somewhat justifiably.) You can still read occasional articles for audio beginners stating that conventional forward-facing 2-ways and 3-ways can be just about sonically equivalent, although by definition they cannot. [Any system with different-size drivers or different enclosure dimensions or different crossover points would have different radpats.—Ed] Indeed, you can finely equalize 1-ways, 2-ways, 3-ways, and 9-ways to have the same power response at some distance in the same room and they'll still sound very different—because their horizontal radpats are. And you still read in the subjective mags the usual pseudoscience about "fast" drivers and "transient" response as the decisive factors. Finally, all of these many years I have been going to BAS meetings, I have rarely heard the many speaker manufacturers invited to give presentations really get into the issue.

dbx and the Soundfield Imaging Venture

In early 1982 I chanced upon the opportunity to work in the engineering department of an audio company as the technical editor/writer. What a windfall for me, or any writer like me. In checking out dbx before I took the job, I discovered that, in addition to everything else their engineers did in a uniquely broad and deep range of audio fields, they had just hired Mark Davis! When I started there I discovered he was working on, among ventures in signal processing, an altogether new speaker design.

So. It was, of course, in trying to explain to the lay and end-user world—such being among the general charges of my new job—the Davis work on "optimized wide-listening-area stereo imaging" that I came to understand what was truly pathbreaking about it. It wasn't his empirical deriving of correct distance/intensity-trading values *(not* time/intensity trading, it turns out, for

speakers in rooms; for details see the Davis 11/87 *Journal of the Audio Engineering Society* paper) for constantly centered mono and stereo way off-center. It was the very idea of a horizontal radiation pattern where the frequency response is mostly the same at all angles and for all frequencies above 150Hz. This is omni broadband sound—but not equi-omni (the conventional meaning of omni), for it favors a rather wide inward angle, being louder in one horizontal direction than in others. (In later versions the design distilled to only the forward half of the output-shape goal, and relied on nearby front-wall reflections: pop muscling out classical.)

As so often happens in nature, it turned out the first property, optimized wide-listening-area imaging, is a subset of the second, uniformity of horizontal response. Finally I was able to gain a deeper appreciation of the subject. We did not publicize it, but if the breadth and depth of the Soundfield "stereo everywhere" imaging was not to your taste, you could simply turn such a speaker so its loudest output now faced you, and it would behave more similarly to, but sound better than, almost all conventional speakers, which narrow and then flare by frequency band.

On a polar or overhead plot, amplitude-consistent horizontal dispersion means the circular shape we're used to seeing for the low-frequency range, overlaid with narrowing, beamier groups of increasing frequencies, would now be, above the equi-omni lows, a repeated overlay of similar shapes, yielding a buildup showing all localizable audio frequencies. Like so: the first pair of images below show one of many possible consistent horizontal radiation patterns, in this case of pre-DAK dbx Soundfield in its full, 360-degree execution, in contrast to the second pair, which shows a typical forward-facing multi-driver/one-driver-per range system (this is of the similar-radiating AR9LS, KEF 105.2, or JBL L250; I have forgotten which one). The third set is the novel, wolfish radpat of a Bose 901. All are 10dB per division, and all are bundled by octave except for the 1/3-octave detail of the conventional model.

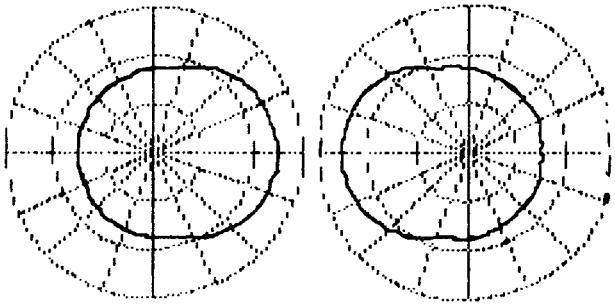

Fig. 3. Desired complete horizontal radiation pattern, after Fig. 2.

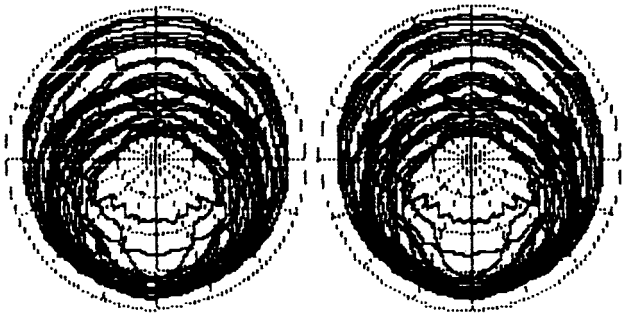

Fig. 4. Measured horizontal radiation pattern for conventional (forward-facing) multiway loudspeaker pair. One-third octaves, 20 Hz to 20 kHz.

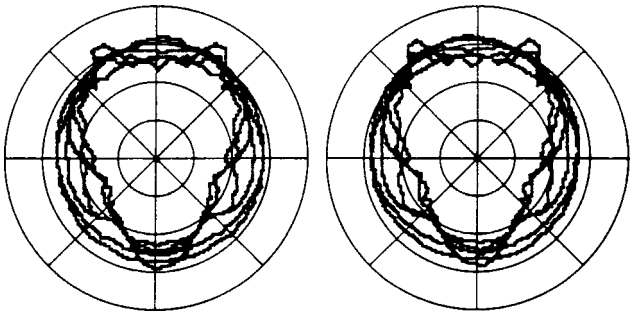

Fig. 6. Measured horizontal radiation pattern for predominantly reflective (8 of 9 identical drivers facing rearward) equalized loudspeaker pair. Octaves, 20 Hz to 20 kHz.

Audition Lessons

Over the years between the Soundfield One launch, in the spring of 1984, and the company's decline and fall, last spring, when there were still five strict dbx SF models in production under the tutelage of design engineer Michael Chamness, Davis's former assistant, we made perhaps a dozen prototypes for evaluation of sound and imaging. To get to the starting point of satisfactory tonal balance and imaging with the line was hard enough; it got easier over time. I still vividly recall an evening before SCES 1983 I spent with Fred Goldstein, the fine cellist (and Longy School of Music president) and audio marketing executive (Advent), who died too young only a few years afterward. He had invited me to accompany him to *a hauskonzert* of former Bostonians and friends, one of them a CSO violinist, now living in the outskirts of Chicago. Goldstein and they read for hours through a range of Brahms and Haydn and Mozart chamber pieces while I listened with the usual chills, but more and more ashamed in the presence of such gorgeous, fierce, loud, bright, biting, and above all airy and enveloping sound to be working in the audio business with its poor, almost always overhyped, often fraudulent efforts. Yet over the next days dbx showed off to the press and industry a

prototype Soundfield One, still rough in balance, and hot up top, and demoed in mediocre, cubical-tending motel rooms ... and on chamber music it had some of that "they are here" snap and jolt; so I felt better.

Of SF designs and variants alike, measurements were made with broadband impulses FFT-analyzed as well as with other means. The dbx RTA-1 was a ways off, though, and the Ivie, as noted, gives a tiny, unhelpful or at least crude picture. For tonal balancing we used music, noise, 1/3-octave pro equalizers, and hours of auditioning by perhaps a dozen listeners, singly and in groups, in rooms good and bad, to rock, jazz, orchestral, chamber, opera.... Systems were hauled to more than a dozen real living rooms for making longer acquaintance. It was a huge amount of work.

What was to my mind as fun as anything else were the purchase, rental, and borrowing of numerous other speakers, expensive as well as modest, all subjected to similar scrutiny, sometimes at length. These included Allison Ones and Sixes; AR9s and 9LSes and old 4Xes; old Large Advents; ADS 1530s, 1290s and others; B&W 802s; KEF 105.2 and 104/2; a couple of Boston Acoustics models; Bose 901s, 10.2s, 8.2s, 301s and other models; a BES, Dahlquist, DCM, and Magnepan model; Polks both conventional and crosstalk-canceling; the Snell A-3; JBL L250s and others; various Japanese speakers; and a few I have forgotten.

We made some surprising discoveries about the design, execution, manufacture, and tonal balance of many of these speakers, some of which were enviable, and many dubious, even contemptible. About fundamentals of sound, measurement, and imaging—horizontal radiation patterns—we made mostly confirming discoveries, as I recall, and no particularly upsetting ones, although we always learned something. Good sound correlated over and over with smooth room-power response, the smoother the better. And good imaging was to be had from smooth off-axis responses reflecting usually off treble-absorptive room surfaces. The slightly delayed reflection from the front wall enhanced image depth, notably so with bidirectional designs; strong treble sidewall reflections often smeared imaging, especially when asymmetrical in tonal balance or unbalanced.

Consistently, and often by a margin that startled and worried those of us given to self-skepticism, we preferred the best executions of the evolving Soundfield design to anything else.

Blind listening, using opaque veils and/or our own newly purchased ABX box, was always fruitful, and most of the time so was fussy persnicketiness about tonal balances. The Allison room-loading conclusions remained "operative": cubic-distance placement of the driver or drivers operating below 500-1kHz—cubic with respect to the floor, the front wall, and the side wall, that is, placement with the same distance from driver to boundary—produced considerable ripple in the response, due to reflections badly combining at the same time and place (the same frequencies) with the direct sound. (The same holds for your listening ears; they will be three feet from the floor, most likely, so they ought not to be three feet or close to it from the back wall and one of the side walls.) Finally, we confirmed that the more cubic the room the worse, too, and the least-cubic the better (fewest, or broadest, or smoothest peaks and dips). However, I now think we never achieved complete understanding of the mechanisms involved.

Digression on Rooms and the Magic of Least-Cubes

Allison has recently compiled data on the acoustically most pleasing distributions of domestic-room resonances (standing waves, eigentones) as discovered by M. M. Louden (1971) and L. W. Sepmeyer (1965), and has analyzed them and related subjects in a typically precise and thorough series of articles on room resonances and speaker placement, currently running in *HFN/RR*.

If those two researchers' measurements and conclusions can be viewed as an overall sample that surely must be a continuum, then I offer the following generalizations.

The best-sounding non-large listening rooms should have a length which is 140-230% (139-233% exactly) of their height (which for most of us can be normalized at 8' ±, more precisely 7.5'-9'), and their width should be within 5% (±5%, that is, or 93-110% exactly) of the geometric mean of length and height. The geometric mean, you will recall, is figured by $W^2 = HL$, or $W = \sqrt{HL}$ (also $= \sqrt{L}$ when H is made 1). The venerable 1:1.26:1.6 ratio (cited most recently by Ralph Hodges in *Stereo Review) is* included in this continuum, of course, although it is not specifically cited by Louden or Sepmeyer [Such proportions distribute the modes and nodes the most evenly.—Ed].

For an 8' ceiling, then, ideal length ranges from 11.1' to 18.6' (say 11-19') and width, provided it meets the geometric-mean (which I now dub least-cubes") restriction, from 8.8' to 12.8' (say 9-13'). Within these limits, the larger the properly proportioned room, naturally, the more pleasing also its reverberation time below 500Hz-1kHz.

Audition Lessons continued

As noted earlier, the importance of smooth and consistent response on and off axis to several reproduced-sound characteristics has been espoused, and sometimes moderately achieved, for two decades or more by Allison and Kloss among many others. During this mid-'80s period, then, it was ever amusing, if also gratifying, to see professor Floyd Toole and his Canadian National Research Council colleagues exhaustively document their rediscovery of this wheel in several *AESJ* and lay-press articles, even while, I felt, they did not quite home in on the variables (driver and baffle width, crossover point, etc.). But quantification is essential to scientific progress and must thus be ever welcome: by golly, acute listeners do prefer smooth sound and smooth reflections to their opposite.

At dbx, all this listening, checking, measuring, recalibrating, making changes one at a time and then listening all over again was exhaustive and exhausting. I usually hung out and learned from my sharp-eared marketing colleague, show manager Gary Soprano, although there were many such acute listeners in marketing and engineering. The process was rigorous and often blind enough for us to be confident about our conclusions but never enough so to be publishable except for Davis's *AESJ* Soundfield paper and an essay I did for *Stereo Review* on imaging, crossovers, and beaminess. Besides, who had time? And of course all the while we were producing speakers for market that got their own unprecedented raves—with occasional less-than-positive reaction to their overall balance, usually to how much treble these Soundfields put out in that newly bright CD era, but also sometimes about excessive spaciousness and lack of pinpoint focus and punch to the image.

I thought, and still think, that the SF line comprised genuinely superior speakers. But the weird extravagance of the reviewer response seemed to me to be at least partly due to generally poor (unlifelike) performance by current speakers, especially in the treble and high treble, which in turn partly stems from inadequate measurements and measurements of the wrong things (and unimaginative design and engineering goals). I mean, canny blending of frequency band and angle by phased arrays to achieve more-uniform overall horizontal dispersion represented only extremely clever and novel thinking, engineering and computer manipulation on the part of Mark Davis and colleagues. And his achievement is brute-force engineering in any case.

Once you get clued in to it, its small imperfections of (inconsistencies in) imaging stability show up, just at a finer and higher level than with most designs. Better execution (round cabinets, for starters) would have helped, but a phased array is not the most elegant way to do it.

The RTA-1

Within a couple more years the dbx RTA-1 real-time analyzer was developed. For my current *CD Review* work it is essential, owing to its uniquely powerful "forever averaging" capability (along with the 16 arithmetically manipulable memories, extreme accuracy, stereo pink noise, and so on). I had come by now to see that properly employed 1/3-octave-pink-noise analysis is plenty adequate for vanishingly fine speaker work, given how terribly far from even their own alleged design goals and ideals most speakers are, and also given what the ear is capable of resolving. I wonder if those who maintain otherwise have spent much time subtly fiddling day after day with 1/3-octave EQ while listening to music over speakers in a room. To me it certainly is clear that you don't need all the incredibly detailed, uninterpretable amplitude and especially phase and time-domain data the exquisite-resolution pulse- and sweep-based FFT-analysis systems give.

I did observe once that when you looked at pulse-response curves plotted out on other than the standard 1/3-octave centers, shifted up or down 1 /9 octave, they could differ a bit. So 1/9-octave spatially averaged pink-noise analyses would be very nice to have. Averaging over space, however small you choose the space to be, is the key, even the *sine qua non;* the Ivie and its peers give such ragged and virtually useless, inconclusive results only because of this spatial/forever-averaging limitation. (Peak-hold doesn't do what you want either—too high because too jumpy, and still not averaged in space even if you move through space with the mike.) A year ago in an article in *Stereophile* VMPS speaker designer Brian Cheney played the old joke of comparing four rather different-looking speaker frequency responses, praising some and damning others, only to inform us at the end, surprise, that these were all measurements at various spots of the same speaker. With the dbx RTA-1 this is not possible; the data are repeatable under a range of circumstances, and truly descriptive.

Indeed, to continue in this pulpit, I don't know where it has been demonstrated that the exquisite-resolution technologies delving into timing and phase behavior reveal speaker properties that matter to the human ear and to our perception of sound quality *which 1/3-octave-pink-noise analysis also misses.* The kind of measuring I am doing does ignore timing/phase information which doesn't affect amplitude response. Fortunately, with speakers playing in rooms, the ear is demonstrably deaf to these behaviors, all the more when compared with its acuity to small changes in amplitude and lateral position. (I'm not referring to frontal milliseconds-long reflection delays, which I think we do sense. And naturally my room power curves do not show anything of source scale or size or direction.)

In any case, the RTA-1 generally is congruent with FFT-based measurements, and in my experience, and that of others, its measurements always correlate closely with what is and can be heard.

The End

With the assistance of both BSR and Carillon, dbx slowly collapsed, and today all of this intellectual and other history lives on primarily as that only: stimulating, fond memory, with some exciting products remaining—and with the low comedy, too vulgarized and adulterated by CTI really to be comic, of the current DAK catalog and its bogus "Soundfield" products.

What I Learned

Some of what I came to know in my bones, both on my own and with the vast help of and ongoing dialectic with so many wise engineers and other listeners, were the following:

- Small amplitude changes have an extremely subtle effect on perceived sound *quality*. Why would anyone worry about 1/10-octave or finer resolution

when speakers regularly fall so short in the cruder view?

- The flatter the sound (as 1/3-octave-measured in listening areas) the more pleasing, provided you can tilt down the overall balance and/or the treble according to the brightness of the source.
- Reflections, when their spectra are inconsistent, have a strong smearing and/or imbalancing effect on image location.
- Even though there are perception thresholds, the precedence effect—that the ear is captured by the initial arrival of a sound—seems to me to be a continuum. Otherwise we would have none of this floaty, broad-stage imaging at all, I think; everything would come from its earliest-arrival source, the speaker. And wall surfaces would not matter to imaging: with a given speaker pair, a tile room would deliver the same sound stage and localization as an anechoic chamber. (This is one reason common audiophile usage of the term near-field seems to me so misleading: we're always listening in some far field or other. Think how close you'd have to be to a pair of speakers playing for it not to matter whether the room was tile or was heavily draped and carpeted. Yet earliest arrivals also count, not just a power total. Think how far you'd have to be sitting from a pair of speakers for it not to matter to the sound and imaging whether the speakers were facing out toward you or facing each other, or elsewhere. A favorite recommendation of mine to owners of conventional speakers is to face them toward each other and turn up the treble—not for any Soundfield Imaging effect in particular, as you might assume, but because doing so invariably adds air, reduces midrange honks and deepens the image, etc.)
- Yes, a pleasing listening room has walls that roll off the reflections' highs, with pretty severe rolloff being not a bad thing (a dead-end room). But this doesn't mean you want the reflections spectrally imbalanced—rolled off on their own—to start with, much less inconsistent in response. Even if a speaker pair's off-axis outputs rolled off absolutely evenly, without lobing, as in Figure 2A, imaging still would vary with frequency and hence with instrument: mono soprano would still be much wider than mono cymbals and brushes, and mono male announcer wider yet. Mono piano would still expand and contract in width as you go up and down the scale.
- Asymmetrical treble-absorbent materials have subtle and not-so-subtle effects on imaging and tonal balance: a bare wall on the left vs a drape or stuffed chair on the right, for example.
- Slap and flutter echoes and ringing evidently have little effect on reproduced music, except maybe to indicate general brightness in a room.
- Wide treble dispersion correlates with airiness and spaciousness, while treble beaminess and irregular beaminess correlates with constricted, all-too-often honky (chesty, nasal, barky, squawky, etc.), old-style "hi-fi" sound. Roy Allison summed it up succinctly at my presentation: it is important to get as much treble as possible into the reverberant field. (Note that Bose followers would not disagree with this notion, although most of us don't think the midrange and lower treble—with most Bose products there being little high treble-should be splashed about a room with so little guidance.)
- The more cubic the room, and the more cubic the placement of drivers with respect to floor and two nearest walls, the more unpleasant is the resulting roughness and severe ripple. Down with stands! At first this lower-midrange/upper-bass suckout which stand placement almost invariably produces enhances clarity and imaging, or seems to, by putting into relief everything above it. But it's seriously unrealistic and it aggravates that honk most speakers are prone to.

Nothing in my testing and listening experiences in the two years since the Carillon takeover has modified these conclusions.

A Digression on the Mainstream Reviewers

Being a marketing manager sending products out to review during that time, I also learned firsthand the discrepancy between what the dbx speakers were really doing/probably doing and what the various reviewers' measurement systems and techniques "reveal." We probably measured our products' amplitude outputs more variously and thoroughly, both in rooms (lots of rooms) and anechoically (via pulses and the mathematical manipulations thereon), than other manufacturers, including even in final test. Of course, with so many drivers and surfaces, and with those crossovers, we had little choice—we had more to measure.

Let me discuss for a few paragraphs the reviewers in the large American consumer magazines. I do not mean for this to sound like an invidious comparison session and occasion for taking shots; I just wish to pose questions about the reasoning behind their measurements and techniques developed over the years.

Consumer Reports runs frequency-response graphs in hard-to-interpret sones, showing some totality or other of response, with the advisory that accuracy differences of less than X percent hardly matter or do not matter. Nothing about dispersion.

The late *High Fidelity* was the only one of the old trio of large American audio books to run conventional frequency-response graphs. Ed Foster's work, founded with the help of AR, supposedly subtracted the room's effects above 500Hz or so, but was still always mislabeled something like Room Response Curve. It gave dispersion out to all of 30 degrees. Below 500Hz the curve was called room-dependent, but almost always showed the dip due to cancelation from the floor bounce. Foster, and reviewers Michael Riggs and David

Ranada (and Bob Long) as well, never did seem to get what that was about, about how you can fill in that notch with simple least-cubes placement calculations (and, in the case of Foster's technique, by taking wider-spread measurements about the room).

Stereo Review's Julian Hirsch seems to go all over the map with his fine-resolution pulse-based measurements, but nary a curve shown. Worse, very little is comparable from review to review. His prose and adjectives are generous, often extravagant, albeit toned down in the past few years; still, you have to know dozens of his reviews before you can reliably tell that something is no good. Several times in the last couple of years, Hirsch has measured the lowest low-bass distortion he has ever seen. (This problem is real in terms of the tone of one's prose: I often think my *CDR* reviews reread too nice. You want not to be particularly mean to any company, and also want to be more than fair when possible, and responsible, but also communicative to the reader. Plus the copy is edited.) And like Foster, Hirsch has made a significant technical mistake or three, more than you would expect from someone who has ably done this for a living to influence millions of readers over the decades.

Dispersion is looked at similarly to Foster's much too narrow angle. And Hirsch often doesn't get the consequences of the measurements he does believe in. In a recent review of an expensive Snell 3-way with an 8" woof, a 1" tweet, and a rearward-facing tweeter (main woof/tweet crossover just under 3kHz, which is not such a great thing to make so wide a woofer do), Hirsch measured and observed the predictable power suckout above 1k (5dB or so), but that was all, otherwise stressing the extreme and exemplary neutrality of the sound. Uh ... Now, I have not heard or measured this product, but think it likely one might want more power fill as the woofer beams in its struggle to reach up to the forward tweeter. And one would hear it.

The recent *Audio* speaker crowd, David Clark, D.B. Keele Jr., E.M. Long, is to reduce to Keele alone. This Crown/Techron sales engineer has a reputation as an informed speaker person, and like the other two he continues but improves on the arcane time-based work of the late Richard Heyser, who developed the methodology. (From the magazine and even the pages of the *AESJ* one would conclude that Heyser was the recent great thinker in the history of audio, so allow me to quote a very eminent acoustics researcher with a somewhat different opinion: "Heyser's reviews were either incomprehensible or wrong.") I myself never really recovered after Heyser wrote years ago that the woof-mid crossover in the Allison One was at 1k (off by over an octave); when confronted with this serious error—I mean, if you don't get that, you don't get anything—he and editor Eugene Pitts III refused to do anything but defend the "finding."

Clark, Keele, and Long, in refining and usefully elaborating the Heyser methods—with Keele in particular running radiation plots, albeit rather inscrutable ones, in topographic-farmland style, may show things that are of direct audible helpfulness, such as more than a couple of frequency responses. (Of course, with *Audio* magazine, you never know—and they never say or even suggest—what's true or helpful or plausible. With *Audio,* the reader is always on his or her own; this in the guise of editorial honesty or neutrality. I call it not editing: we won't help you figure out what you're reading, or its worth.) For his part, the clever ABX engineer Clark has been an excitable boy, going on about a Velodyne subwoofer (an achievement on a level with Dolby B, he felt; had he never heard clean low bass before?) and the Cambridge SoundWorks 3-piece (perhaps the best value in the history of etc.). Clark also wrote of the extremely insensitive but wonderful-sounding Ohm 5 how impressive it was to see a speaker system that could take hundreds of watts of input in the very low bass. (Like praising cars according to fuel consumption, commented Steve Owades.) Clark did go out of his way to be fair to the Soundfield Ten, a type of design and sound he (with some others) admittedly was not disposed toward. At dbx's urging he even measured it with pink noise. The resulting snapshot looked not terribly smooth, alas, but it was a first (and presumably last) in the history of *Audio* speaker reviewing.

In his sole recent speaker review, E. M. Long discovered the extreme insensitivity of the costliest Apogee (in the low 70s), its amazingly high IMD at almost any level, and its apparently peaky response (not spatially averaged, however). Most interesting to me was a selective HR polar plot Long ran, showing that the Apogee evidently does have deep sideways-output "nulls" below 1kHz (but not at 5kHz—!?). Hmm. I would like to measure one of those babies, as well as some of its bidirectional competition.

Post-dbx

After leaving dbx I worked up a speaker-measurement protocol to propose to magazines. My intent was to follow (to quote from a recent essay in the *New York Review of Books)* "a well-known guideline in scientific inquiry—start with what you judge to be important, relatively simple, and capable of being explored by available methods of investigation." I wanted thoroughly to measure properties that would correlate with how the speaker sounded (in any room) and would be graphically depictable and comprehendable without undue effort from the reader. What I would do is transform polar (overhead) plots of horizontal radiation into a drying-mop set of the familiar frequency-response graphs, thus showing dispersion as full-band output by horizontal angles. And I would keep constant half-space or 2-pi loading (floor reflection).

(I have never understood why audio journalists have said over and over for decades that "Of course no measurements can tell you how a speaker will sound in your room." Why not? What needs to be measured? I mean, this stuff is knowable, and where not, it's calculable. Worse is the statement along the lines of "Room acous-

tics will of course vastly influence the sound *you* hear, so much so that there is virtually no predicting..." etc. Well, of course room acoustics will have influence; but there is predicting, I suggest)

So 1 drew up a regimen. With the RTA-1 and a superb AKG microphone ensemble (compensated within the RTA-1 to match two different 1/4-inch B&Ks), I would first do the more or less conventional stuff: a room response in a couple of rooms in my house. One of them is a fairly dead 13' x 8' x 24' living room, opening at one end into a study on one side and into the front hall (and rest of the house) on the other—a typical center-entrance-colonial layout. The other is more live, a so-called family room, open on one side upward into a kitchen but otherwise 18' x 19' (ugh) with an 11' peaked ceiling. I would feed the pairs of speakers stereo and mono pink noise from the RTA-1 itself (accurate within 1/4dB) or from the Carver/Foster test CD, one of the very few with pink noise that are accurate and come in two uncorrelated channels ("stereo").

The speaker pair would be sited either as the manufacturer recommends or according to my best judgment and calculations for optimal sound. The mike would gather its data around where an audiophile might have his or her head when listening—at the tip of an equilateral triangle whose other two tips were the speakers (in other words, the mike about as distant as the speakers are apart). The mike would accumulate its readings, moving for 1/2-1 minute, within a cubic rectangle 3' wide and deep and 32"-40" high or so. It would be a reliable and repeatable sonic sample.

The Great Outdoors

Much more informative and interesting, since I am blessed with a large and often profoundly quiet back field, was the idea of measuring a speaker at all horizontal angles in a 2-pi or half-space environment, with the ground (a perfectly reflecting floor) the only constant. Depending again on its maker's wishes, the speaker would be floorstanding or on a stand. And if the manufacturer was one of the handful who specify a front-wall-loading distance, I would then create a pi or quarter-space, simulating a perfectly reflecting front wall by placing the speaker's mate directly behind it (at twice the specified wall distance), facing backward, playing the same pink noise and behaving as the ideal phantom image, as in a mirror.

In these outdoor half-space measurements the mike would again gather its pink-noise data over a suitably long time interval, at 0 degrees (axis), 30, 60, 90, 135, and 180 degrees (directly behind the speaker). If the speakers are asymmetrically mounted on the front of the cabinet I necessarily do both "sides" heading toward the 180 back; otherwise doing only one half-rotation around would suffice. If the situation were quarter-space, I would measure at 0, 30, 60, and 90 degrees only, moving around one side or both sides depending again on driver mounting.

In all cases the mike and RTA-1 would "forever-average" while moving 7-10 feet away, to achieve a well-integrated audiophile-listening-distance window; 32-40" off the ground, to achieve a good seated-ear-height window; and ±15 degrees horizontally from the nominal center value, with a bit more for the 135- and 180-degree takes. The temperature would always be 50-90 degrees F, and in the lower part of that range I would let the drivers warm up with moderate pink noise for some minutes. The mike itself would always be at or just out of room temperature. About humidity I do nothing, although I never work when it's raining, of course; with otherwise high humidity the treble rises markedly (bone-dryness does the same thing) although the sound seems sodden nonetheless. The pink noise would always be 12-20dB above any background noise.

I also employ the extremely high-damping-factor and high-power (and heavy) dbx BX1 amp, so as to forestall charges about load-variant response. In making this decision I did discover, not too surprisingly, that three very different transistor power amps from different countries, decades, and designs all had no-load 20Hz-20kHz frequency-response accuracy at or below the ±0.2/0.3dB resolution of the RTA-1.

With this family of horizontal-radiation curves I also wished to derive a predicter of imaging qualities. I determined to do this by normalizing the axis response of the speaker, making it in other words ruler-flat (all 0s), and then looking at the new off-axis responses, which now show only change or deviation (delta) by angle. The RTA-1 makes this easy to do, so you can see solely the *differences* between and among the various outputs going out into the room toward the walls and thence reflected to our ears.

It's worth noting that the pi-space measurement, with a perfectly reflective front wall simulated, probably is not as accurate a predicter of imaging for speakers more than, say, a foot from the wall (2' from the reflection speaker), because the measured amplitude curve shows nothing of the few milliseconds of delay produced by such placement. Many feel this delay, cherished by most imaging addicts, serves to "unmask," in Mark Davis's term, ambience contained within the recording. But Stanley Lipshitz has insisted to me that this cannot be so, that the delay—4-12ms would be the range in virtually all domestic cases—is too short either to do this or to create its own sensation of ambience.

My method, whether in half or quarter space, also indicates in its discrete angular curves nothing about timing or, indeed, about whether one curve is in or out of phase with another. For example, a bidirectional planar speaker, whose rearward output is out of phase with the frontward output, might look similar to two in-phase conventional speakers back to back—although in the room response you will see stronger bass from the latter.

I ran my entire protocol by my fine friend the shrewd dbx engineer Gary Hebert, and other colleagues of his whom I regularly consult; by Roy Allison; and by the good Dr. Davis. All concurred in its fundamental rea-

sonableness and usefulness. Suggestions were to add measurements of reactance and bass (and perhaps other) distortion, which I shall get around to.

No magazine responded to the scheme until one day Danny Kumin, the able writer and technical editor at *CD Review*, called me out of the blue about doing an audio column. I proposed speaker reviewing in addition, and he and his bosses went for it, to appear every other month or so. (The column has yet to materialize.)

Thus, with the gratefully acknowledged help of *CDR*, AKG/dbx, Carillon, PR maven Fran Dym, illustrator Dave Lail, and above all my many brightly illuminating former dbx associates (db-exers, they're called), I have proceeded. Here are some of the ensuing measurements, with comment. Included also are some other interesting speaker/room measurements and curves. Unless noted, all are plotted out at 5dB per division and taken under the conditions described above; any driver controls are all the way up. Prices are per-system retail but hardly reliable. Apologies for crooked pasteup. The 1/3 octaves are 20, 25, 31.5, 40, 50, 63, 80, 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1k, 1.25k, 1.6k, 2k, 2.5k, 3.15k, 4k, 5k, 6.3k, 8k, 10k, 12.5k, 16k, and 20kHz.

— *David Moran*
(Massachusetts)

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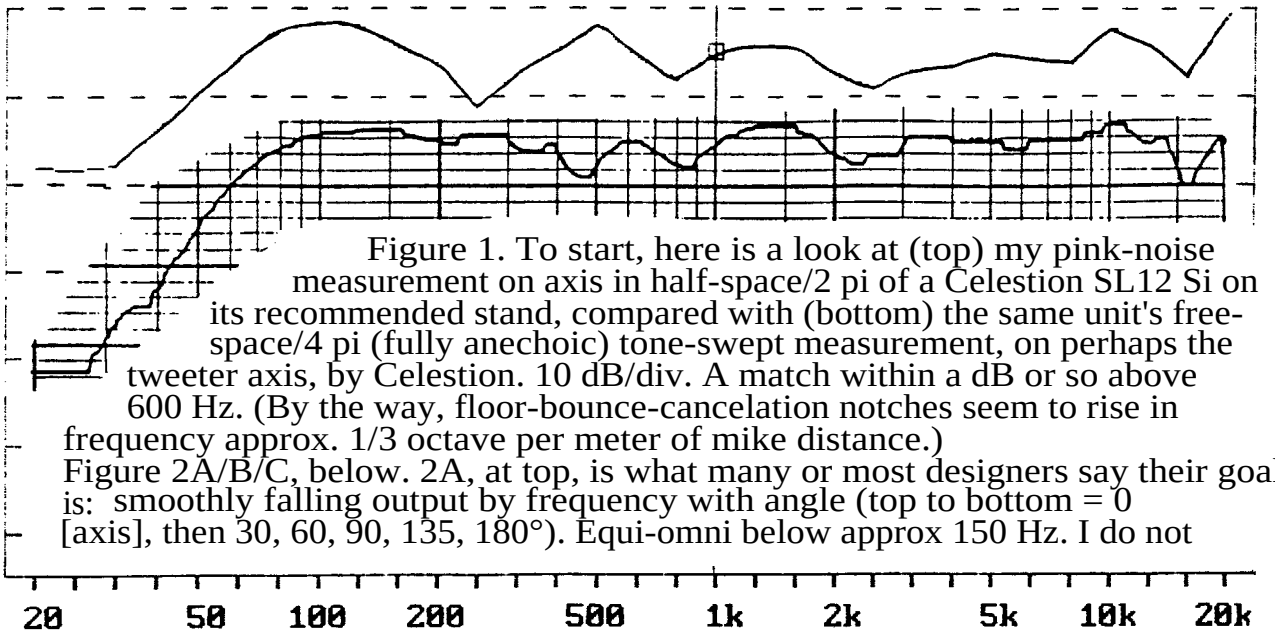
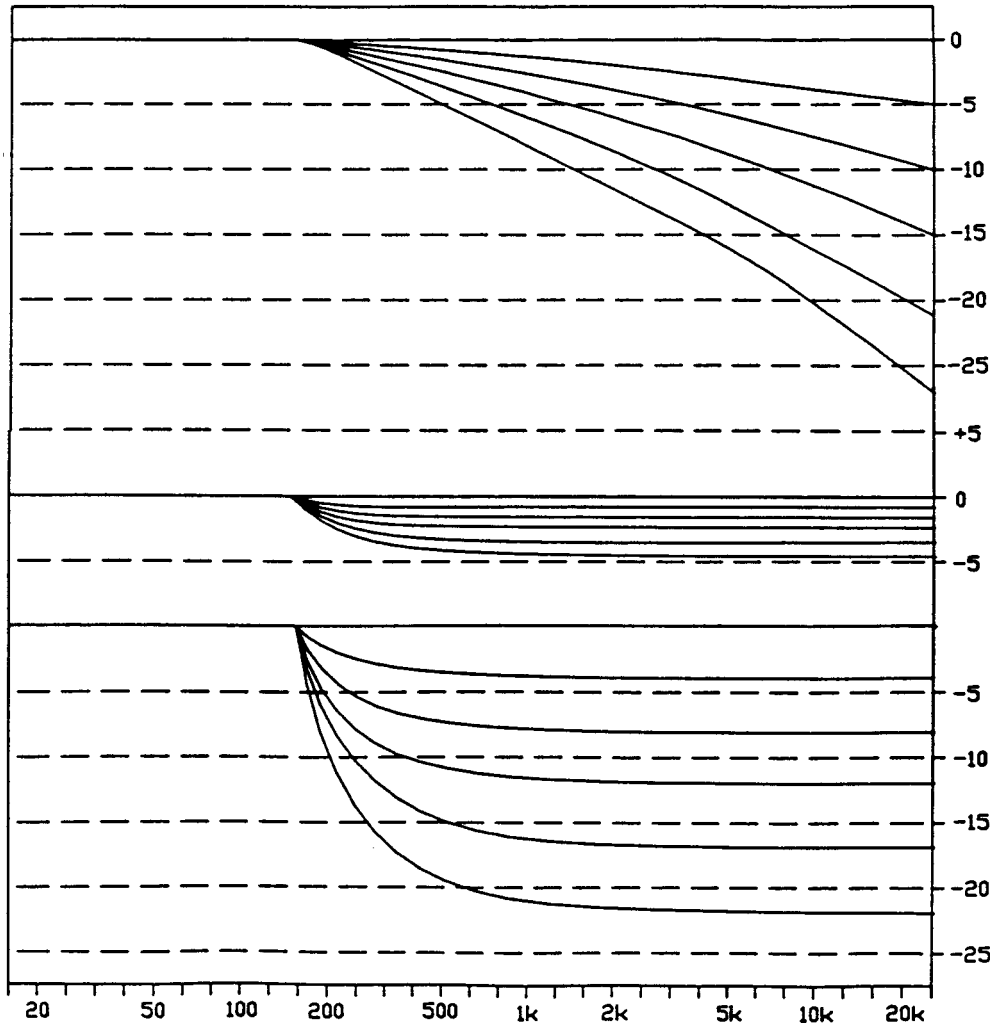


Figure 1. To start, here is a look at (top) my pink-noise measurement on axis in half-space/2 pi of a Celestion SL12 Si on its recommended stand, compared with (bottom) the same unit's free-space/4 pi (fully anechoic) tone-swept measurement, on perhaps the tweeter axis, by Celestion. 10 dB/div. A match within a dB or so above 600 Hz. (By the way, floor-bounce-cancelation notches seem to rise in frequency approx. 1/3 octave per meter of mike distance.)

Figure 2A/B/C, below. 2A, at top, is what many or most designers say their goal is: smoothly falling output by frequency with angle (top to bottom = 0 [axis], then 30, 60, 90, 135, 180°). Equi-omni below approx 150 Hz. I do not concur, but a speaker that measured like this (tonal balance curve group = imaging curve group) would sound and image spectacularly, far beyond what we have now. But there is still, as always, too much mid-range, not enough treble.



2B & C. Here are theoretical speakers that should have faultless imaging and sound reproduction by my criteria. (Goals: no changing of images, and audiophile-acceptable (tight enough] imaging with acceptably balanced sound and [better] airy sound.) 2B would be very spacious-sounding (bunched curves), 2C tight and focused and concentrated (spread curves). These would sound and image like nothing ever heard before. (A Soundfield curve set would be something like the top set mirrored around, that is, flipped above, 0, with the louder parallel curves streaming above it.) Achieving such 2B or 2C uniformity would not be as hard as it might seem provided one turns to truly constantly directive horn/lens structures, which no one to my knowledge is actively pursuing. But you read it here first: engineers associated with Carillon/ADC/dbx, Dolby, JBL/Ford, Aerial Acoustics, and KEF have all delved into the matter.

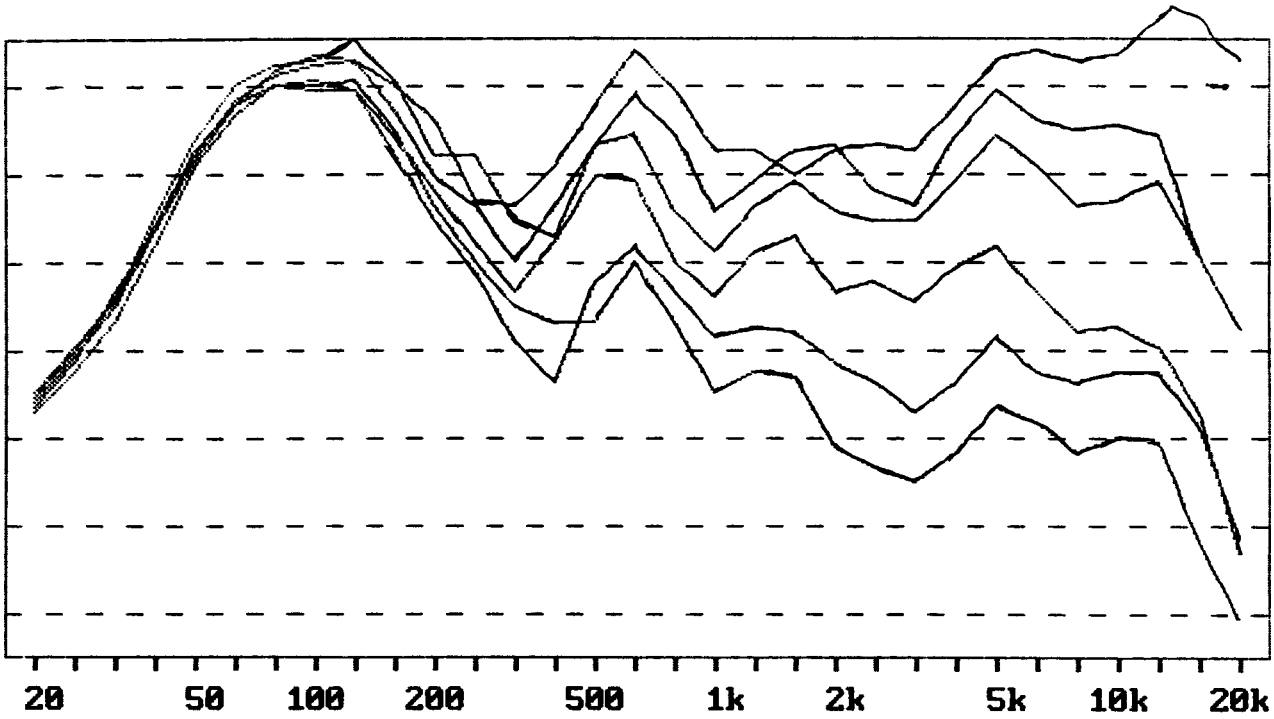
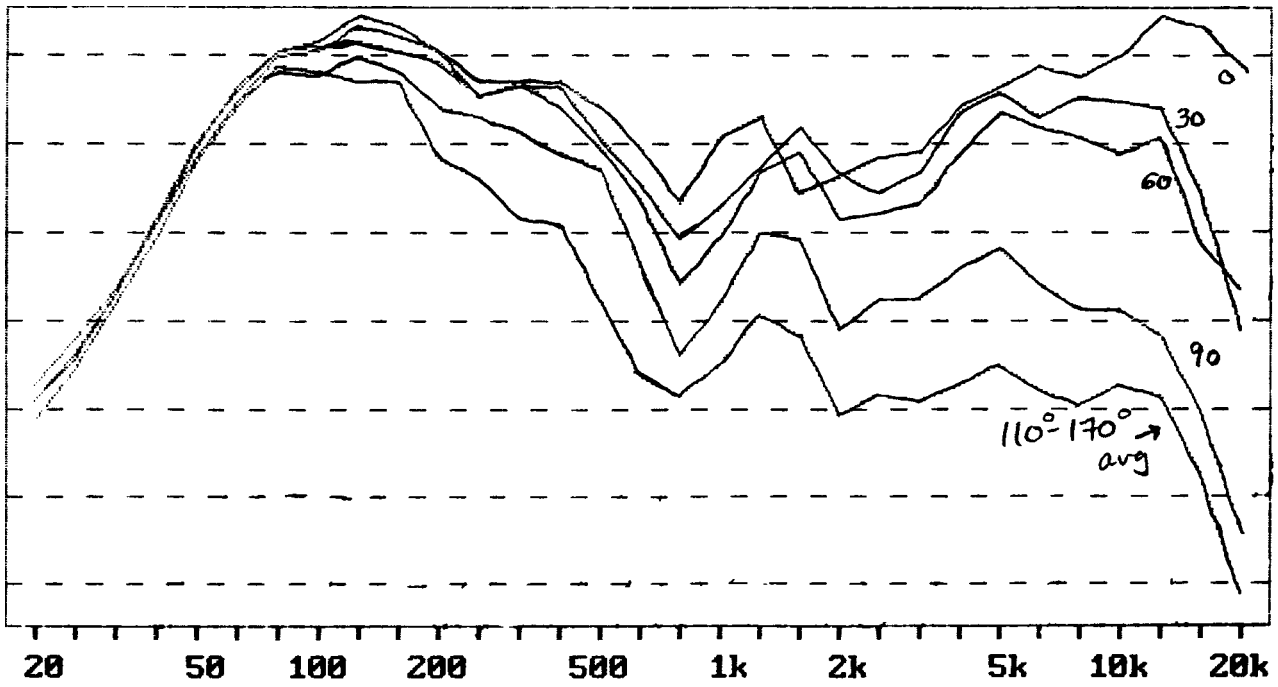
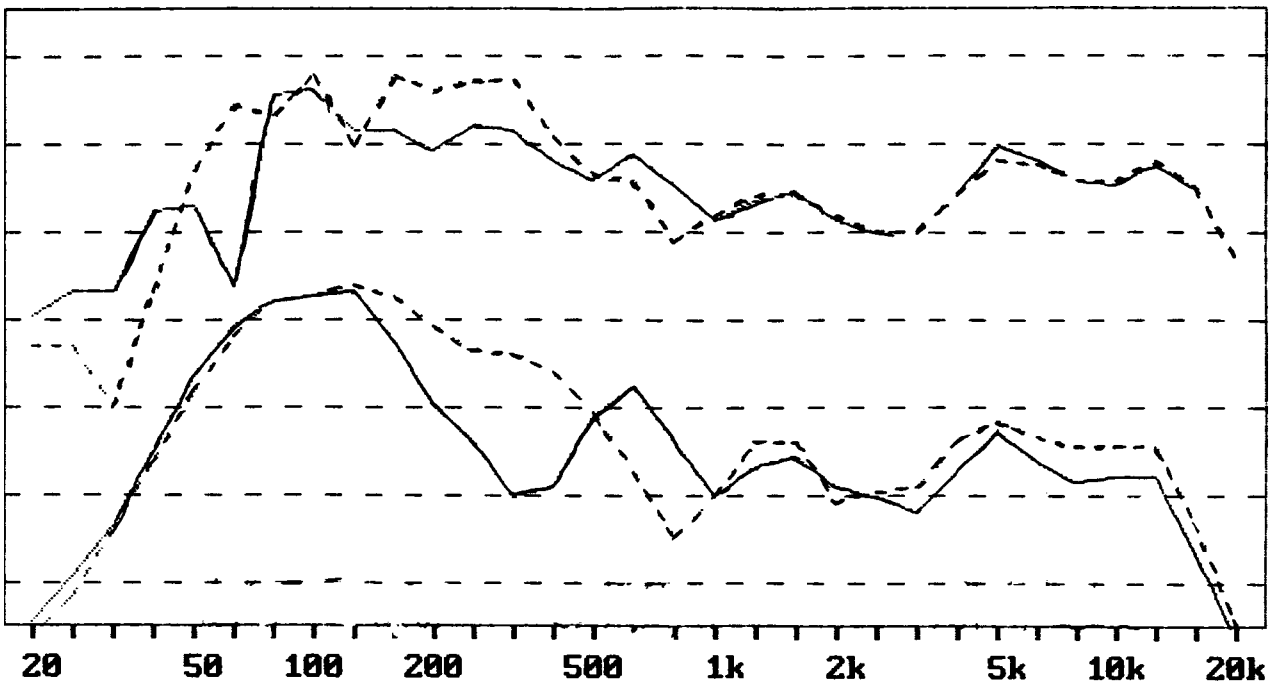


Figure 3A, above. The Altec-Lansing 205 3-way (8" woofer, 1" tweeter, $600/pr), as conventional a design as it gets. The mid output is depressed relative to woof and tweet, even from the back. Here on a stand, as designer Tommy Freadman recommends. (Putting almost any speaker on a stand is asking for trouble, the worst thing you can do to it, because you really have to work to stagger the other two distances, to front and side wall, in order to fill in the notch a Ia the least-cubes geometric mean discussed earlier. It is <u>much</u> better to put the thing on the floor, still least-cubing the distances; perhaps tilt it backward a bit to aim up toward you; and then ear-tune out any excess bass with a cheap ADC or equivalently quiet octave graphic equalizer.

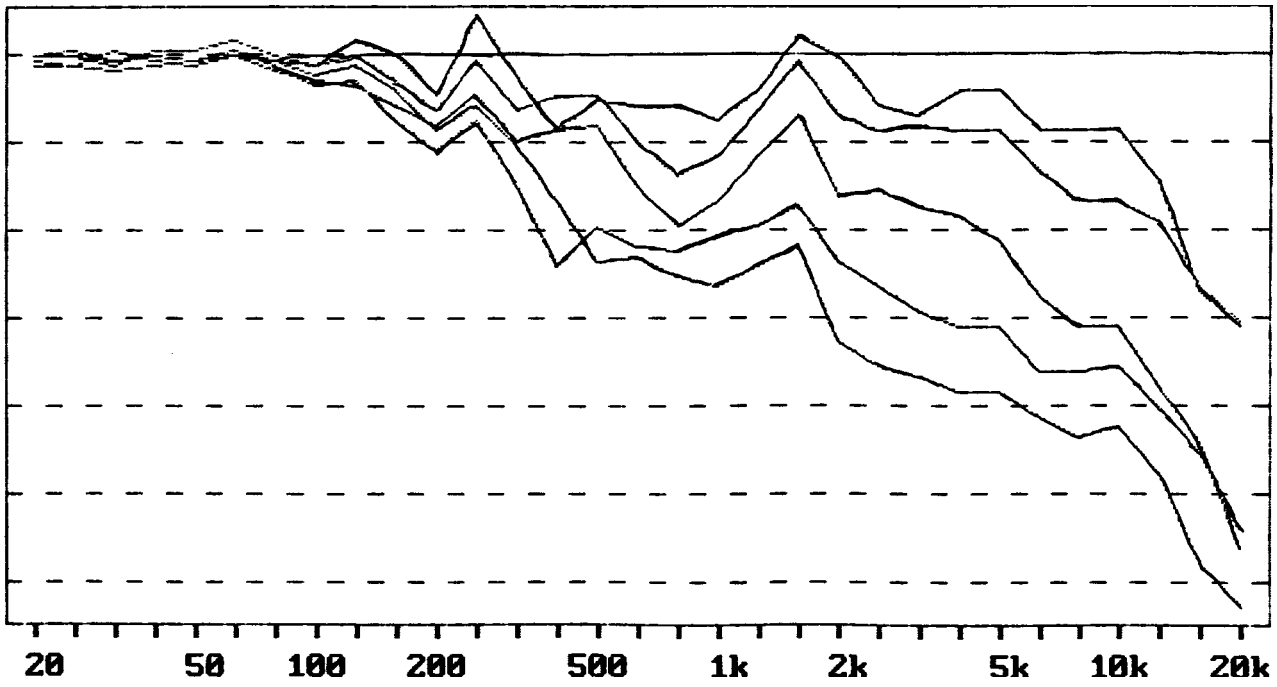
Figure 3B, below. The same only on the ground, and the bottom curve is a 110-170° degree average. (I had run out of memory space in the RTA-1.) However the 205 was placed, it sounded as though someone had turned up the bass and treble tone controls.





Figures 3C (above) and 3D (below). 3C is the same Altec in a room (top). The solid curve at top is stereo room response with stand placement (after much least-cubes experimentation on my part -- otherwise the half-space notch shows up where you listen in your room, much to the detriment of cellos, voice, and virtually all else). The dashed curve at 3C top is room response with the 205s on the floor, showing more upper-bass lower-mid and also more low bass. 3C bottom is the averaged total horizontal output or radiation (HR total) in half-space. Solid curve is the total of 3A (on stand) and dashed is total of 3B (floor).

Figure 3D, below, shows the differential family or imaging-curve set. Beamy, nice enough imaging for the type. This normalized curve set always makes crossover notches stark, as one driver narrows into a beam and the upper one flares in. In some designs the notches are not always where the designer thinks the crossover point is.



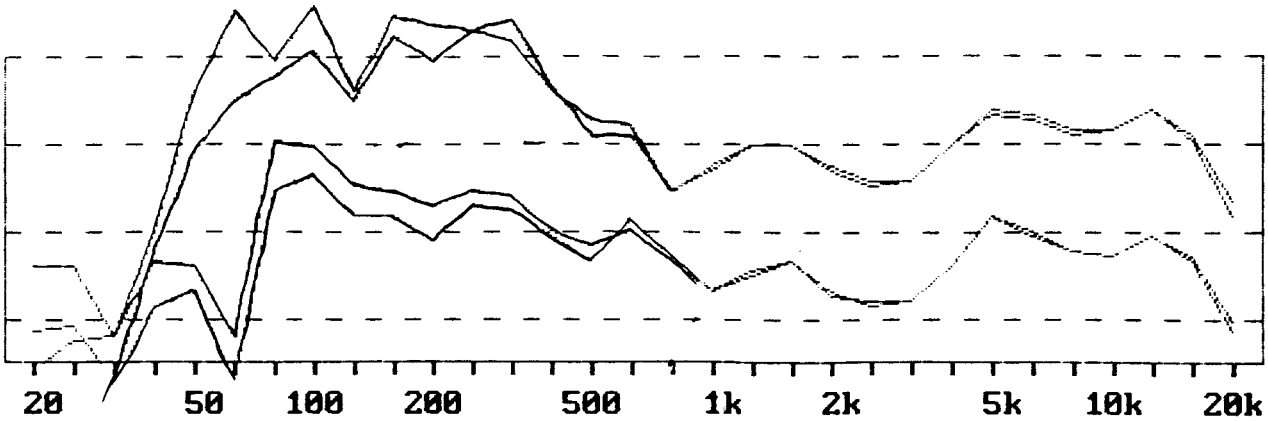
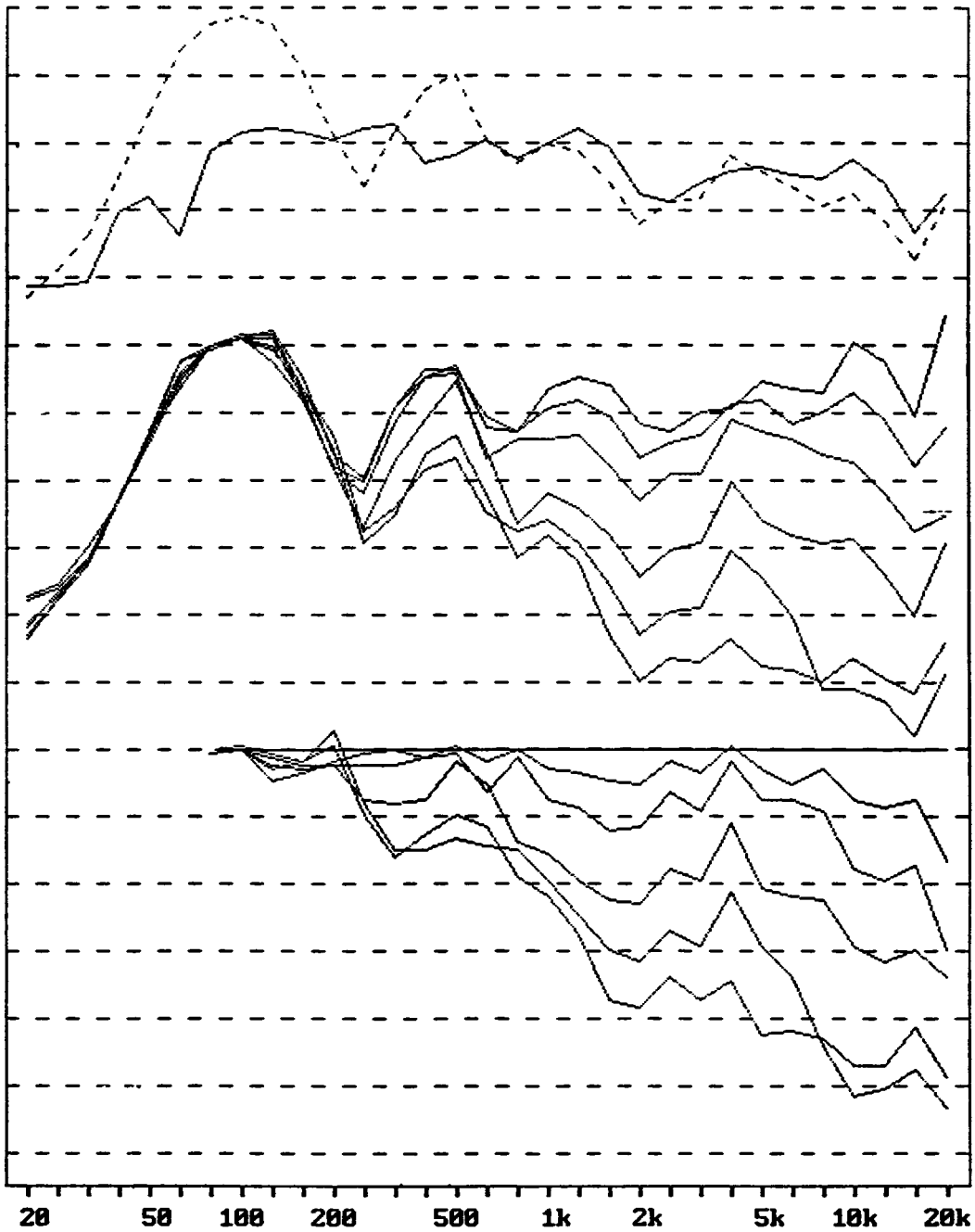


Figure 3E. The Altec 205 pair again in a room, playing mono vs stereo pink noise, stereo being the leaner (lower) of the curves. Mono pn often makes for less-smooth (spikier) as well as louder bass response. Top curve pair is speakers on floor, boundary distances well-staggered; bottom curve pair is speakers on 16" stands, also well-staggered, differently of course.

Figure 4. The Celestion SL12 Si on its stands ($1800!): two 6" woofs (one going up higher than the other) and a 1" tweet. Top, dashed, is averaged half-space HR, and solid is room response after <u>much</u> least-cubes experimentation. The middle set is half-space, the lowest set shows the fine imaging. Beamy, though not quite as much as the Altec (which is very odd given the driver widths). Insensitive. Sound is solid, dulled, back-of-hall. Note famously fretted-over (and utterly inconsequential) tweeter resonance, which even cabinet does not shadow out fully.



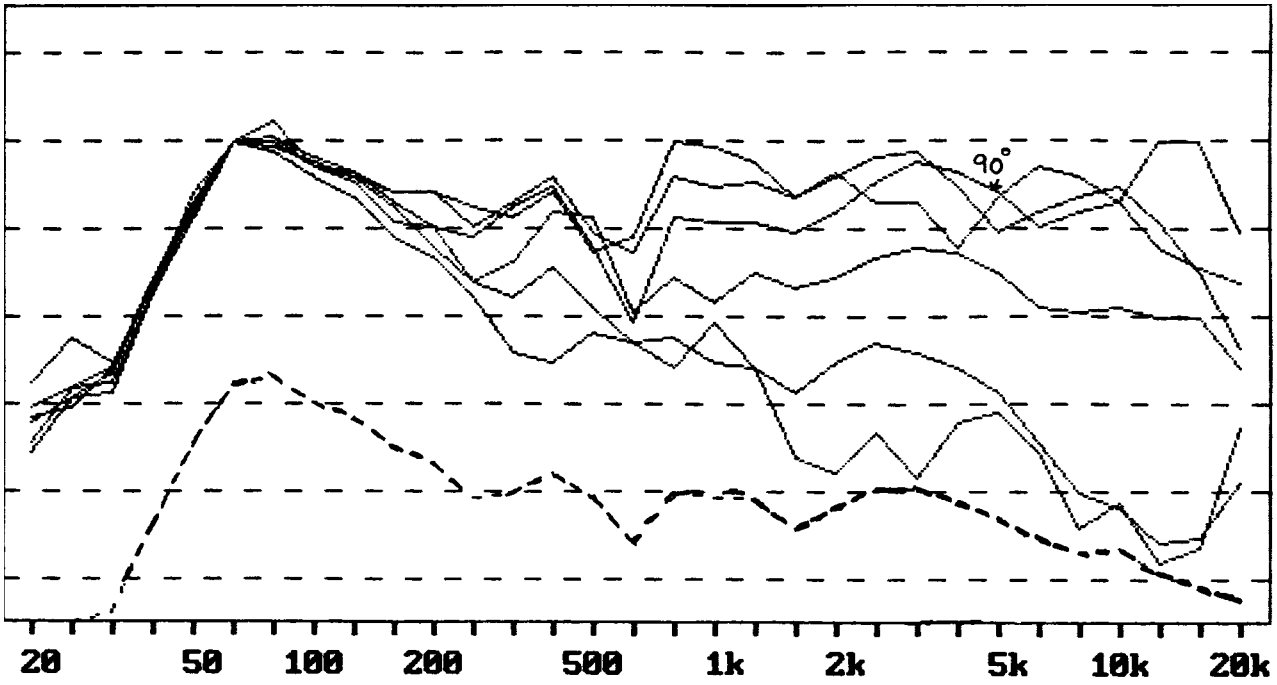
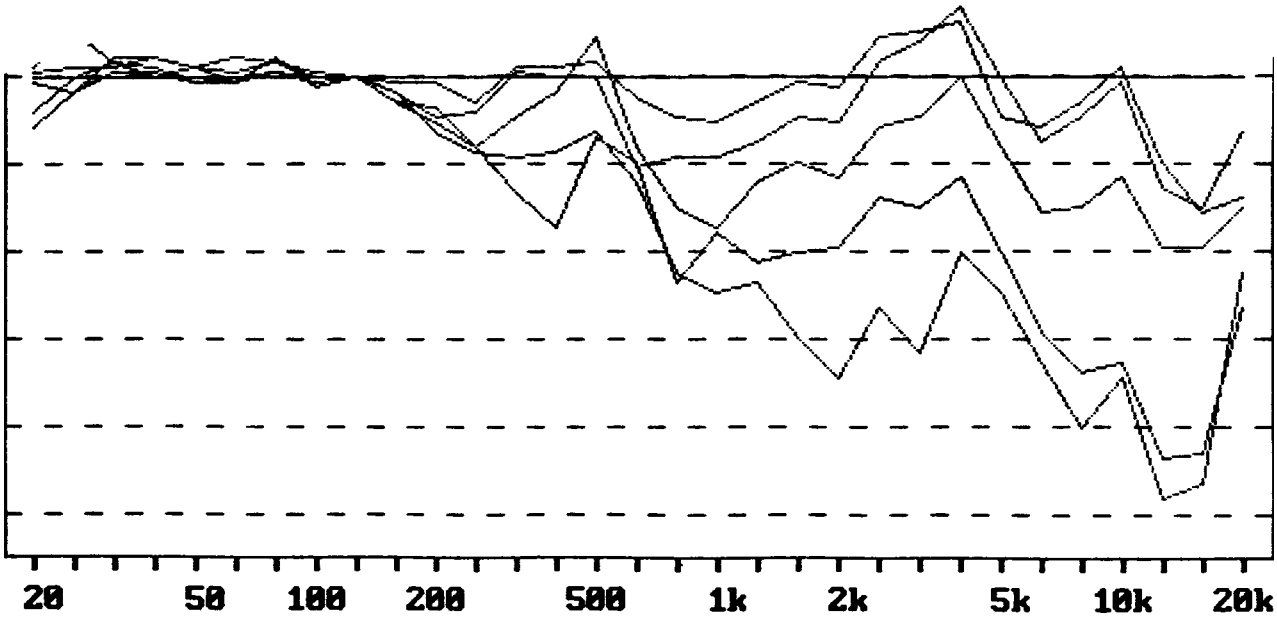


Figure 5A, above. The new Allison AL 120, another $600 system, floor-standing, with two 6.5" woofs (inversely mounted this time) and the famous tweeter with its uniquely (and amazingly) wide dispersion. Top, the solid curve set is half-space HR (note 0-75° overlap); dashed is averaged HR total. With a bit of bark centered on 1 kHz this is not the smoothest Allison, but it has sounded very good at BAS meetings with improper loading (on a table) and a bit of bass and treble turnup (which help swamp the bark). This is the one that J. Hirsch mismeasured by assuming the woofs extended up to the same frequency. In top set also note 2-4 kHz output that is greater sideways than frontally.

Figure 5B, below, is the imaging curve set, vividly showing the reason for the Allison spaciousness, and that comparatively extra output centered on 4 kHz. Note also above 16 kHz the tweeter dispersion to side and back of cabinet.



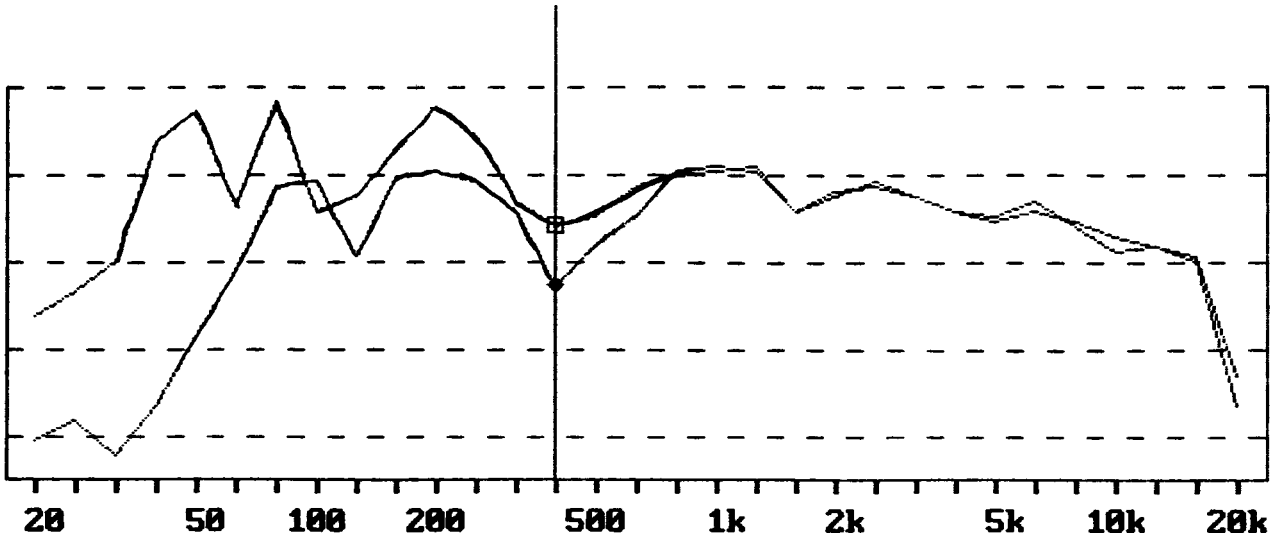
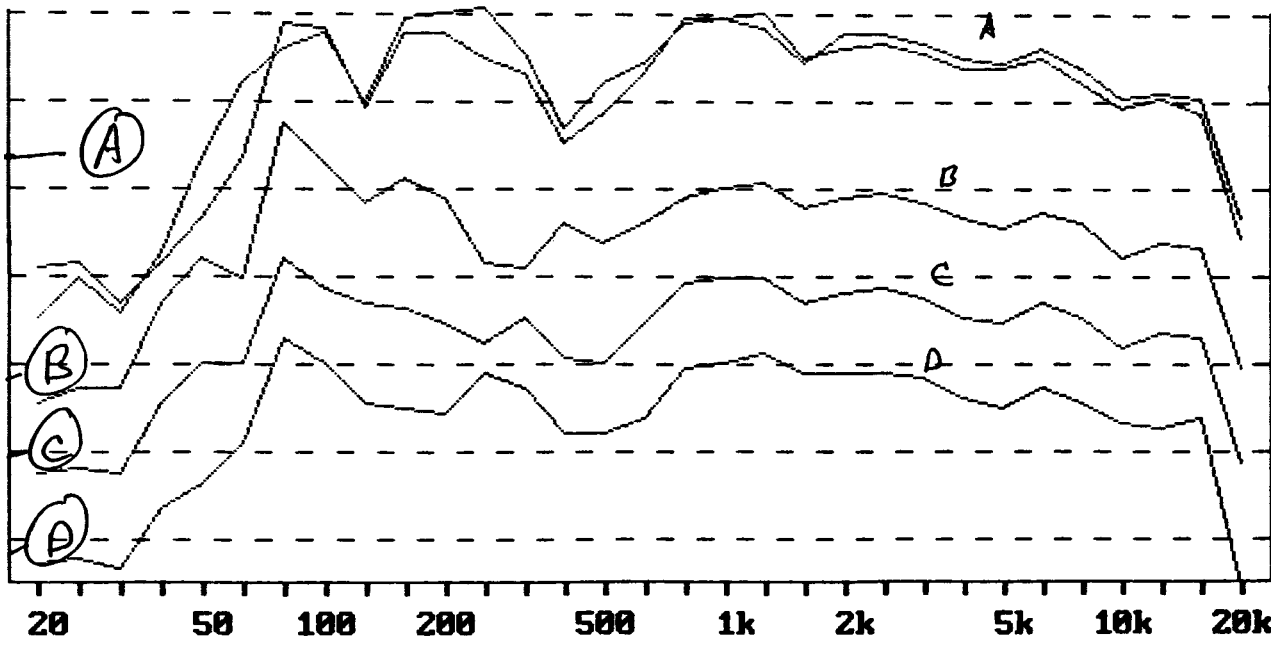


Figure 5C and 5D. Same speaker over a range of room responses. Above, 5C, at top, is good-sounding and goes the lowest: 1' from front wall, 3-4' from side, as recommended by manufacturer after an error in early manuals (consequence of which is shown as 5C lower curve: 3' from side wall, 5' from front; note how 40 Hz dropped 15 dB).
Below, 5D: the top two (scrawl-labeled as A) repeat 5C lower only at different times (a month apart). Then "B," 5' from sides and 3' from front'; "C" 4' x 3+' (thinner-sounding, obviously); "D" 2' x 4', which sounded fairly good too.



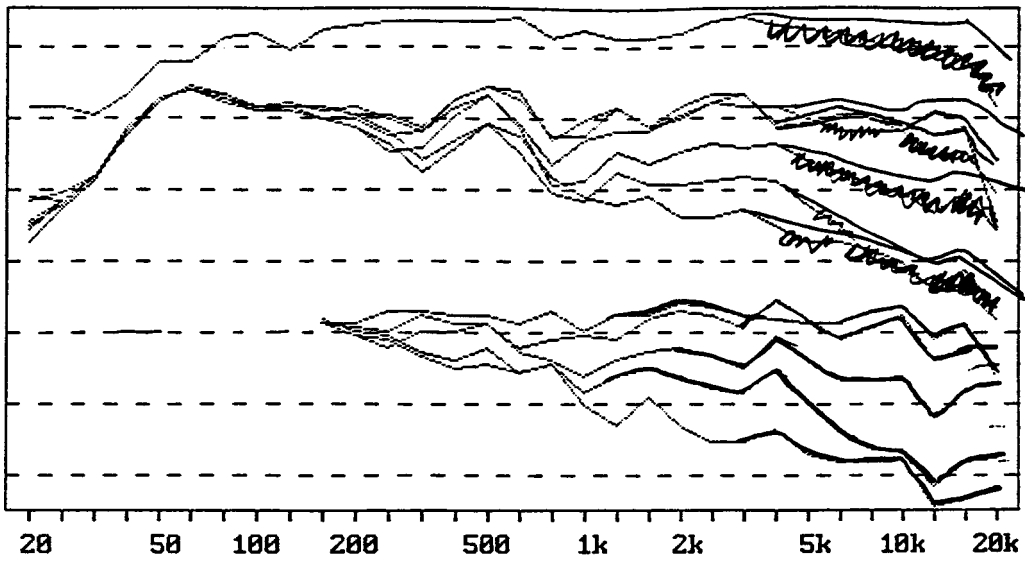
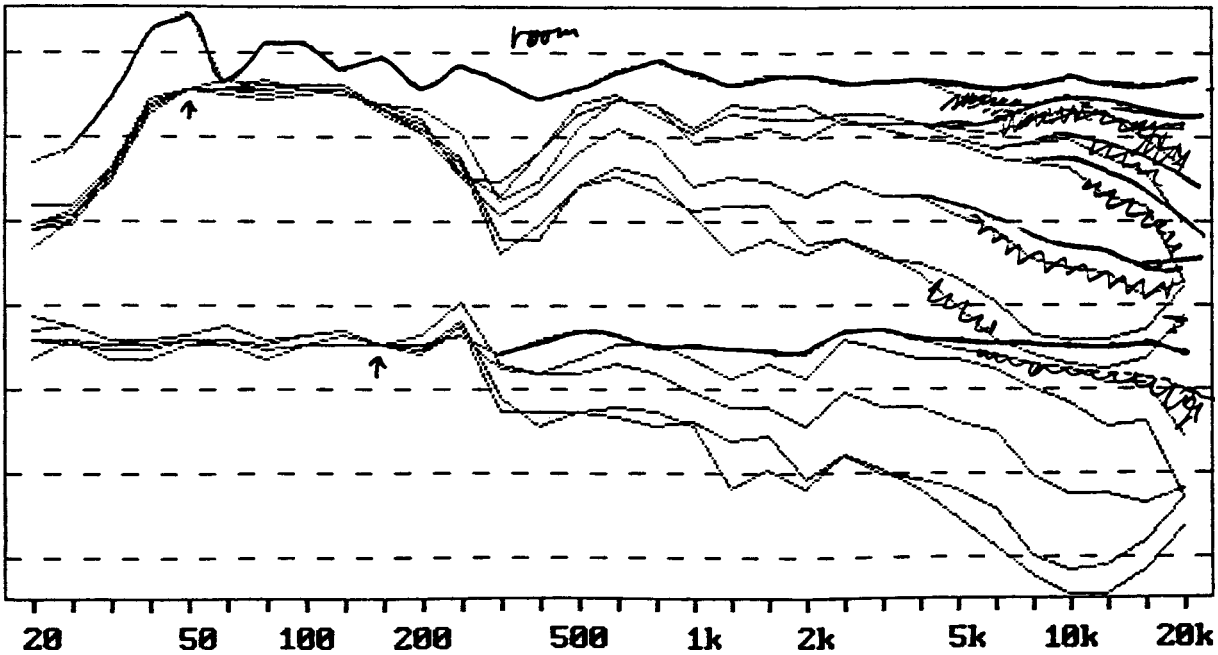


Figure 6, above. The Allison AL 125 ($900): two inversely mounted 6.5" woofs, the Allison mid (also extra-wide-dispersion), and that tweeter. Note: I made a very stupid computational mistake in my internal RTA-1 "correction" math, an error not corrected before now in print, and have tried to rectify it here with pencil scribbles. These curves are not 5 dB/div but 8-9 dB/div, and before the pencil were also, and for the same reason, soft about 1 dB/octave above 3-4 kHz or so. So the shape is accurate but unduly smooth. Above at top is room response; the middle set is HR half-space (again note incredible overlap 1k-16k Hz); the bottom set is spacious but consistent enough imaging, which was probably okay without any error-fixing. Sound is very good, smooth, and lower-midrange is wonderfully full (accurate); potent clean bass; very occasionally a tad hot (see 3 kHz rise).

Figure 7, below. Same dumb error as above, pencil-corrected here, for the Meridian D600 ($5500), a powered and equalized floorstanding vented system (also includes DACs, potential preamp hookup, remote, potential intercomponent communication) with 6" x 2 woof/mids and the ubiquitous 1" tweet. Room response at top (euphonious 40-Hz excess in my room); then BR; then imaging. Goes pretty low; well-crossed-over too. Not too beamy, considering, until you're into the cabinet shadow; smooth sound and good imaging. Designed with KEF help but not using KEF drivers, I believe. Nice what electronic EQ/crossovers do.



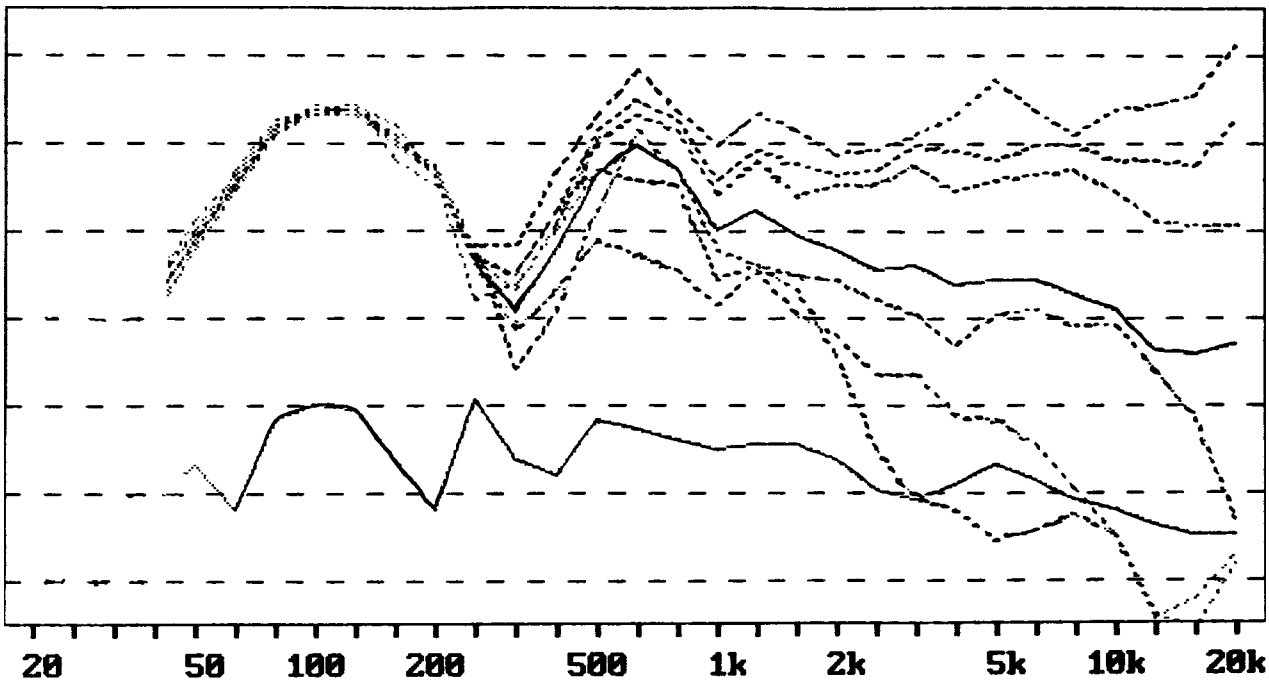
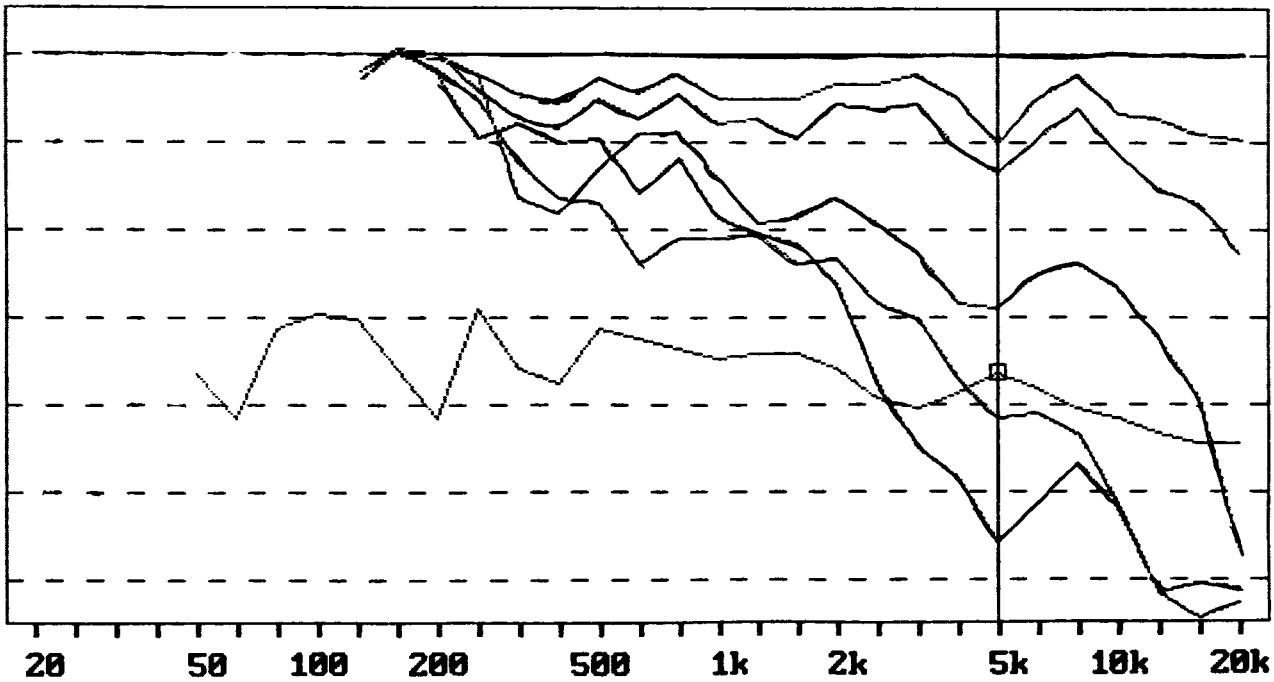


Figure 8A, above. The Celestion 3 ($250/pair), a good, light 2-way (5" so-called woof, 1" tweet). The dashed set, above, is half-space HR, on a stand, with the solid curve, averaged HR total, stuck in the middle; and below them is pretty fair room power response, with the speakers up and (I believe) fairly close to the front wall, bookshelf-style. A new designer's first effort.

Figure 8B, below. The same: imaging curve set, quite beamy (more than driver-diameter theory would predict), with the room response repeated. The 5" unit is pretty smooth.



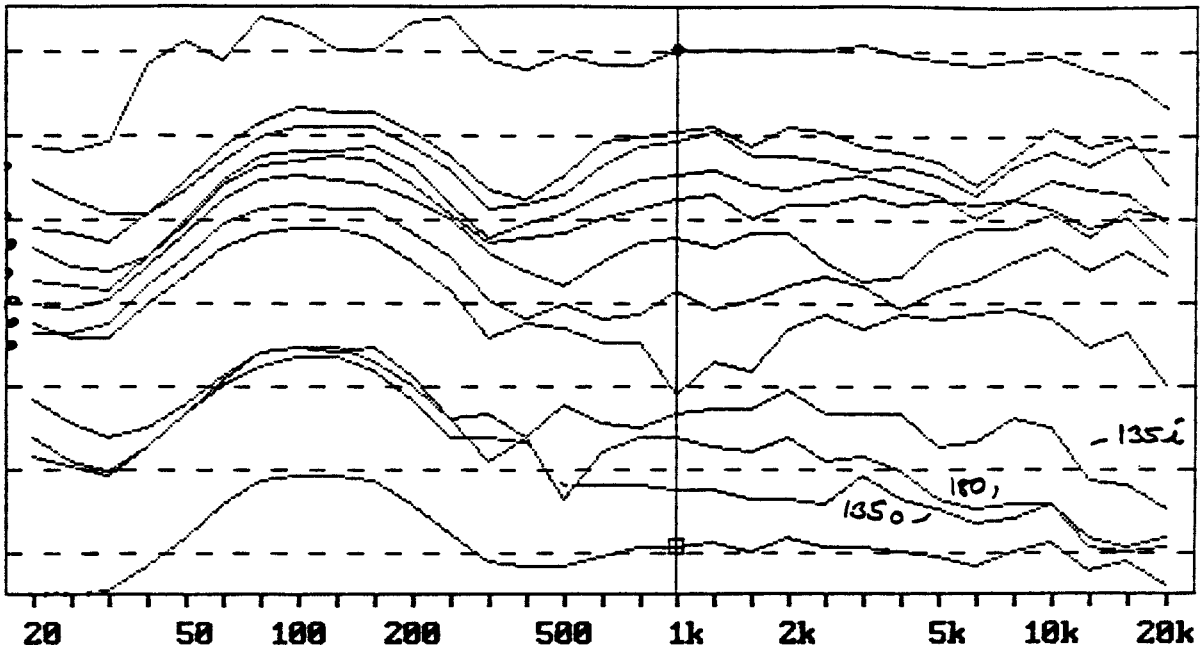
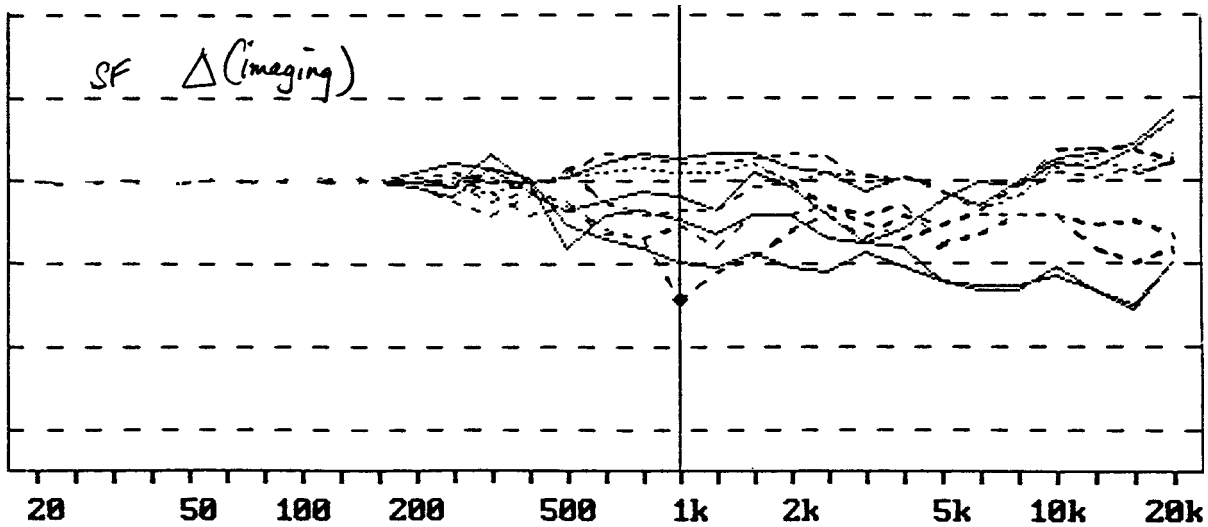


Figure 9A, above. The dbx Soundfield 2500 ($600), floorstanding, 6" woof, 2.5" or so mid, two 1/2" tweets. Essentially a standard 3-way with an extra (phased-array) tweet, fancily cabinet-angled. But an astounding speaker and speaker value, maybe Chamness's foremost achievement (with the help of John Buzzotta, now a chief designer at AR). This SF2500, or two pairs back to back, with a real subwoofer, and you have something truly extraordinary. At top is room response, at bottom is averaged HR total. Check 'em out. These are so smooth I suspect they too may be 8 dB/div and top-end-soft, but I am not sure. Between them -- spread out here for clarity, please note -- is HR, from top to bottom @ 1 kHz: 90, 60, 30 on the inner-firing panel, 0°, then 30, 60, 90 outer-firing panel, then 135 inside, 180 (behind), and 135 outside.

Figure 9B, below: The lack of louder (>0°), Soundfield Imaging-responsible output 3k-6k Hz -- when the curve family otherwise adheres so well to the SF template -- made me realize that for this forward-180° SF design, which depends on there being a wall a foot or so behind it, I perhaps should have used two speakers outside and simulated a pi environment (quarter-space).



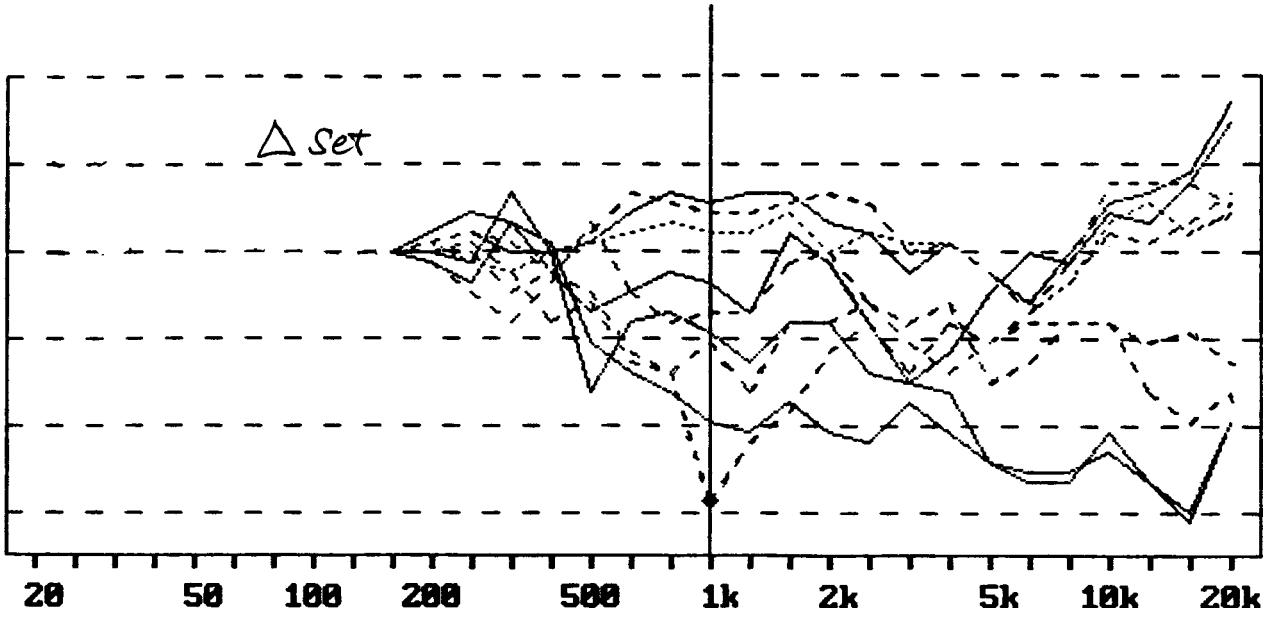
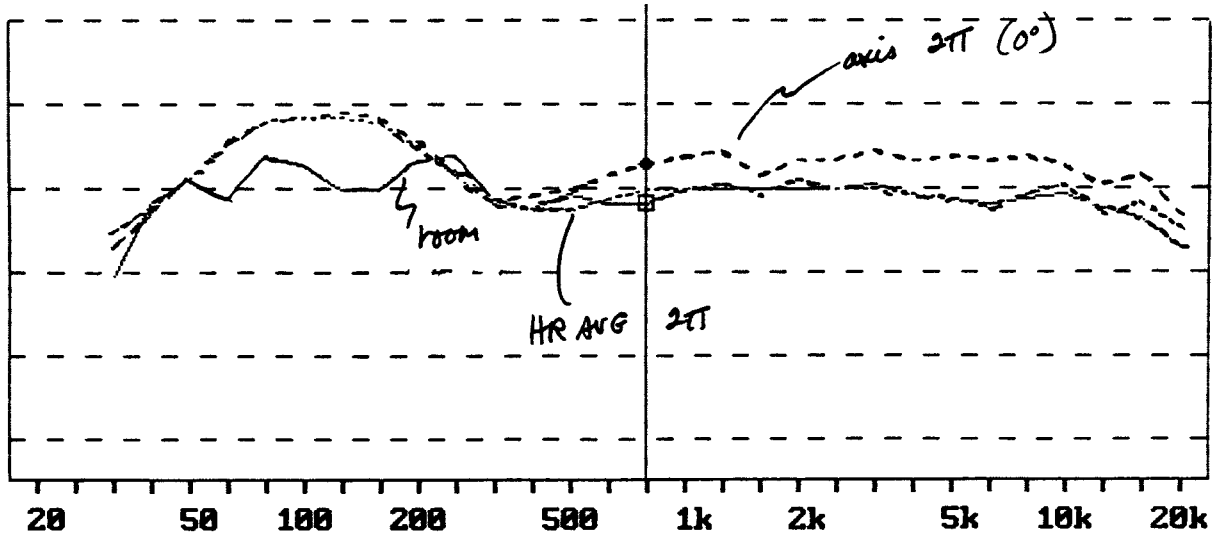


Figure 9C, above. The same only 2.5 dB/div -- maybe -- and properly overlaid (not fanned out) to show actual measured HR behavior. At the 1k rule line, top-bottom, that's 600 inner face, 90 and 30 ditto, 0 (marked only by the 0 RTA-1 grid line), 30 outer face, 135 inside, 180, 60 and 135 outside, 90 outside. At other frequencies the sequence changes because of overlap (in other words, imperfection in achieving the design goal). Not a faultless realization, then, but given the hardware.... And it does almost fully accomplish the SF goal. (You don't need that many drivers if the crossover, driver dispersions, and baffle widths are just right and the cabinet is curved and angled just right; the 1A and its fellows represent design overkill. But now it's unlikely we'll ever know.)

Figure 9D, below. Room response and HR average are repeated (solid curve and short-dash curve), along with 0° ("axial", longer dashes) in half-space. Flat on-axis and flat power indeed.



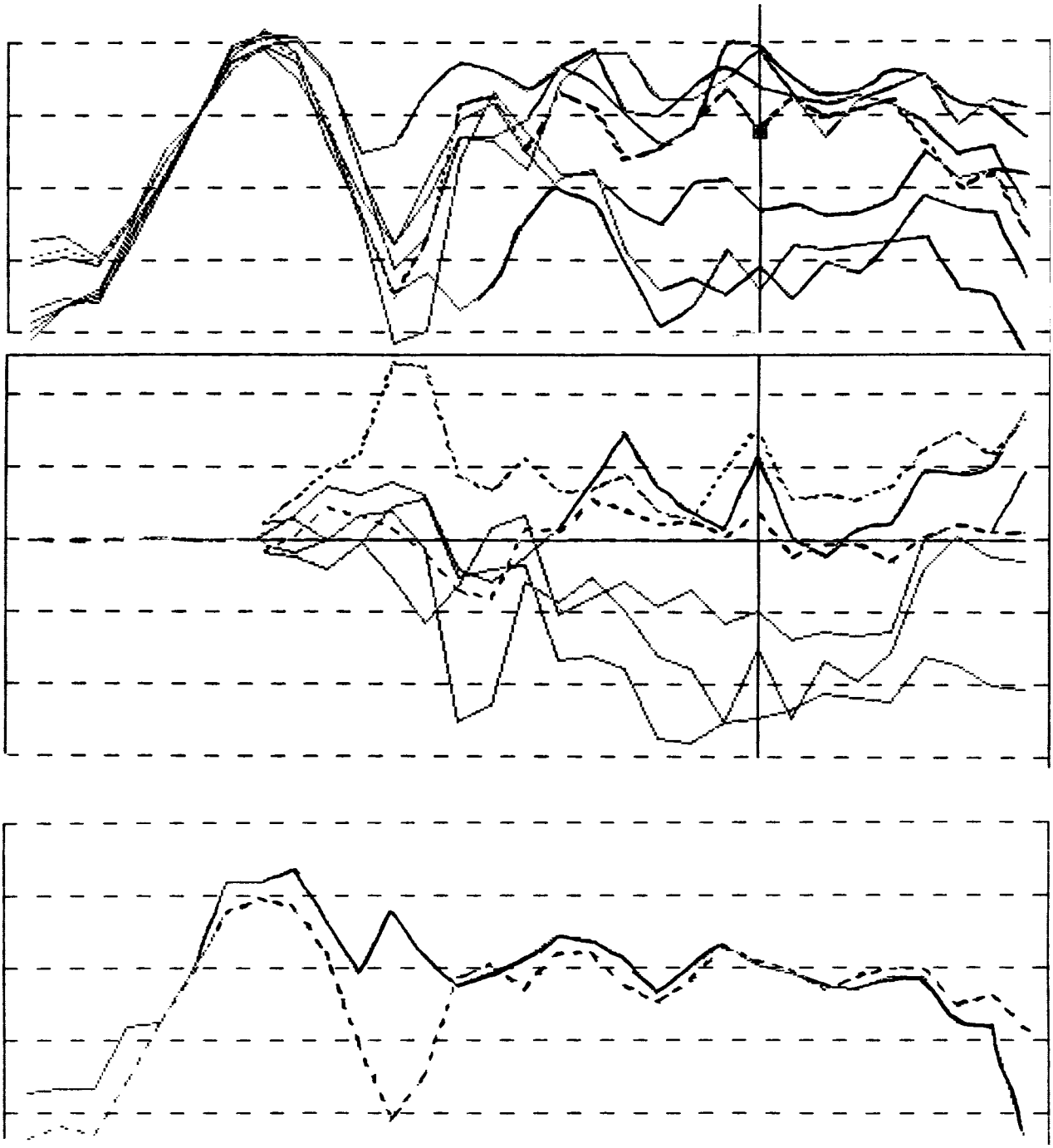


Figure 10A-C. The dbx SF5000 ($450), same driver complement as the SF2500 but less-fine -- cheaper -- crossover. At top, HR on stands in quarter-space (pi), a perfect wall simulated 5" behind. The set may look a bit ratty but the rule at 3.15k (where the ear is most sensitive, remember) reads, top-bottom, inner panel 90/60/30, then 0°, and then outer panel 30/60/90, just as the ideal would have it. Evidently, including the wall the model was designed for does it. The middle curve set is imaging and again is 90/60/30/0/30/60/90° top-bottom, although obviously the image would not stay stock-still. At bottom is a room response (solid curve), off the floor, 5" from front wall, while the dashed curve is averaged HR total. Sounds very nice.

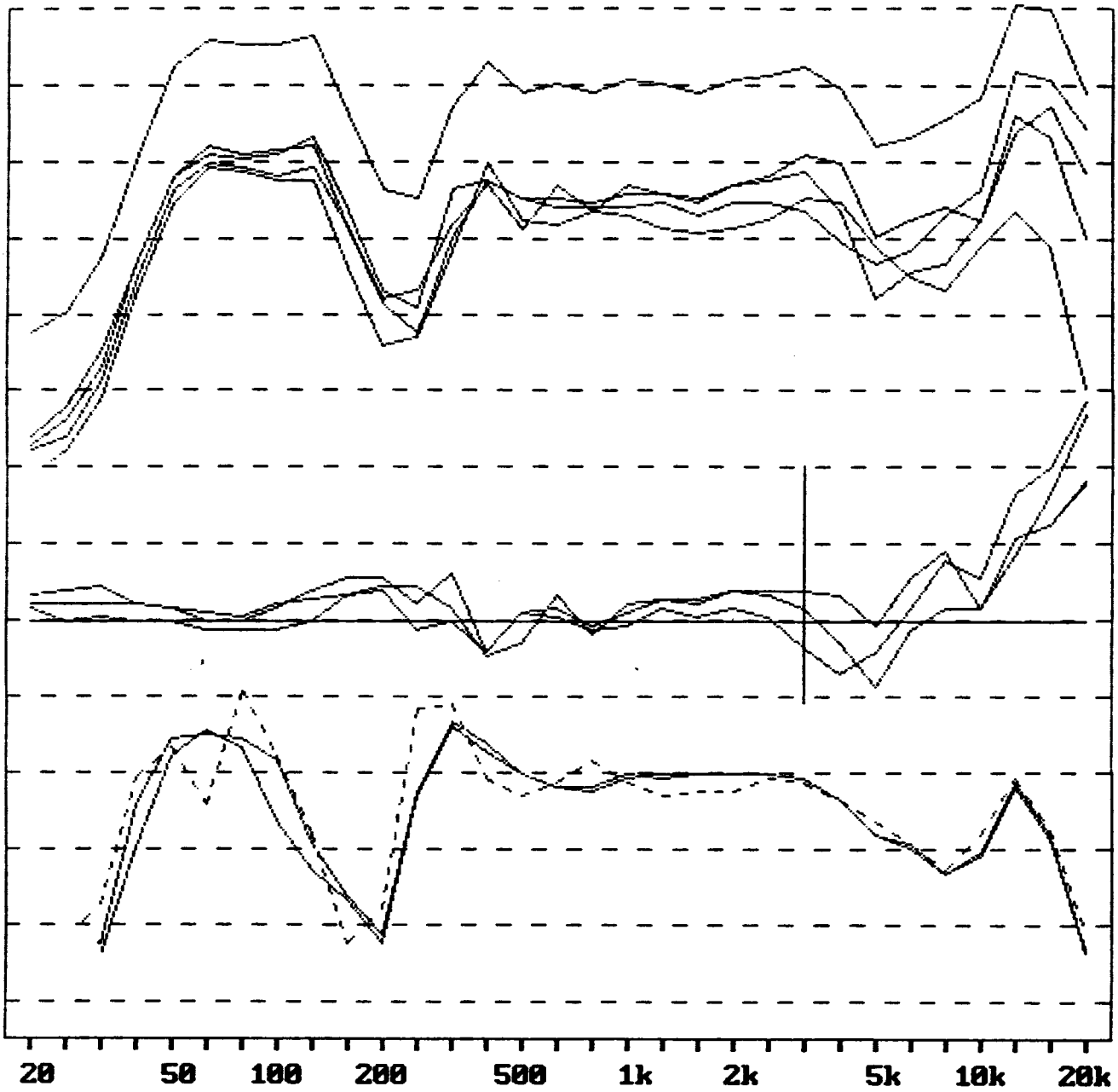


Figure 11A-D. This is the Bose SE-5 3-piece ($799), with a perfect wall 2.5 feet behind its inwardly angled satellites. Bose people admit their marketing is often cynical; is this proof? After you listen to the thing at any length, it's hard to believe this one was let out the door: it sounds like a table radio with footfalls. The infamous hole is 12 dB deep, over an octave wide, and centered on the range below middle C! ("So what?" somebody quipped. "After all, how much music is there at middle C?") At top is average of HR, below that is HR (11B) -- take a look at that pair of midranges -- and next is imaging, 11C. All in quarter space, sat's 3' up and woofer module underneath the front sat, vents outward. Inward-cantered angles are chosen okay for pseudo-Soundfield above 2k-3k or so: the 3k rule goes 30/60/0/900 top-bottom, moving inward; the curves criss-cross higher up. In other words some of the music's harmonics <u>will</u> pull you from the near speaker toward the middle or the far speaker. Equi-omni imaging otherwise. The real test of these Soundfield pretenders, of course, is well-centered off-center <u>Mono</u> Everywhere; stereo everywhere is too easy to fake with widely separated material. Just above this caption, at the bottom (11D), is room response. The dashed line shows response with the sat's against the front wall, the solid lines response well out in the room, with the 80-160 Hz solid-line envelope showing bass-module movement from corner (upper curve) to midwall (lower). Uniquely, none of these curves did the usual 3-dB 100-300 Hz change with woofer-polarity inversion, so little shared output is there. Astonishing OEM midrange, but no real highs despite its weird, tall peak. (Another tweeterless Bose product.)

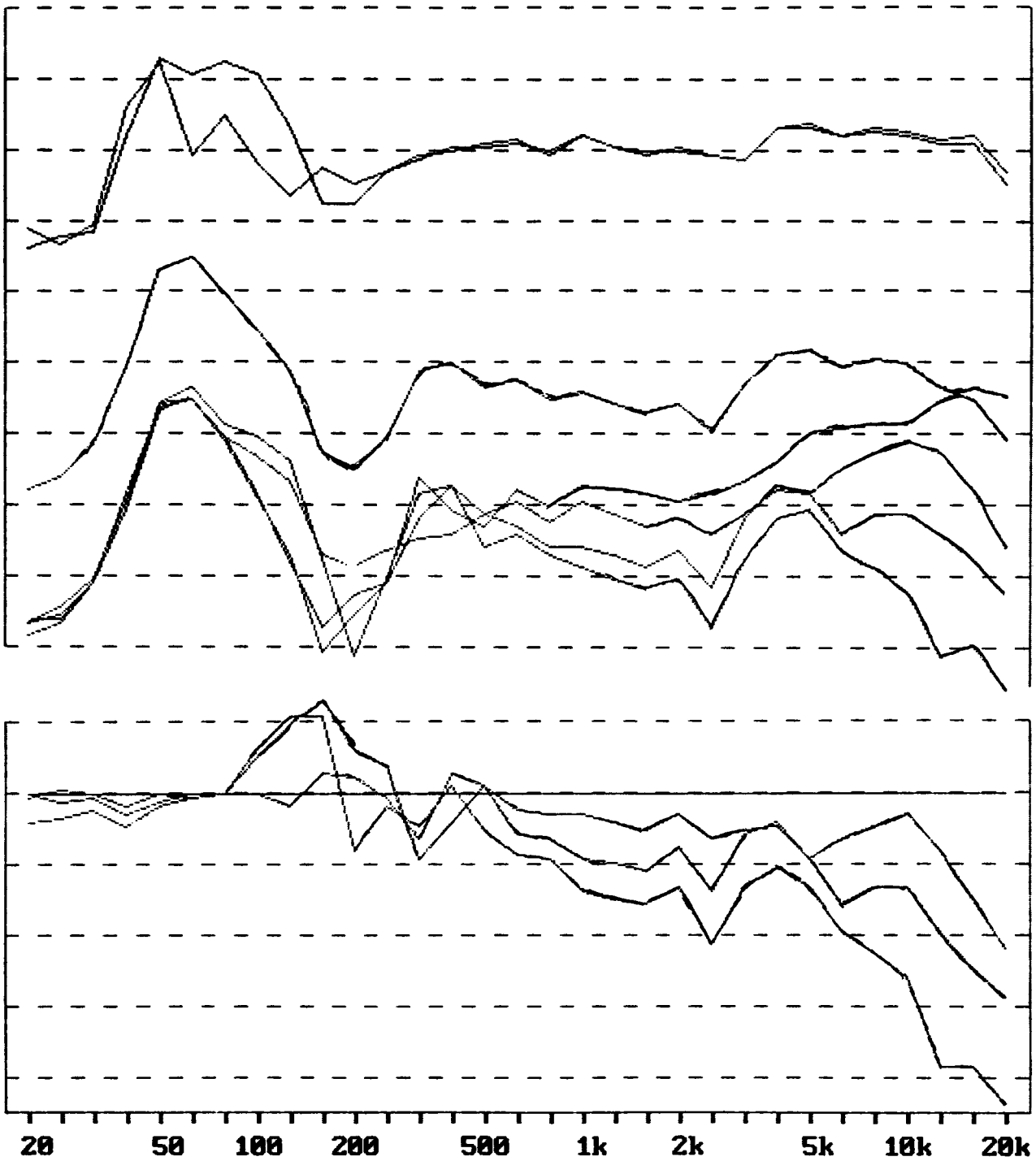


Figure 12A-D. This is the Cerwin-Vega CV 6, a big 3-piece ($599) with a 10" vented internally sited (bandpass) woof and big (6" x 1" drivers) satellites. Somebody there has an ear. At top is startlingly smooth room power, sat's well out as recommended, with fuller bass from the module out from corner, leaner bass from it in corner, believe it or not. Below that set is averaged HR, beneath which is HR, showing how the tweeter is brought in hot (note on-axis rise). Outside conditions same as Bose and other 3-pieces: quarter-space, 2.5' from perfect front wall, 3'+ off floor, woofer directly below front sat. At bottom is imaging, 0/30/60/ 90° as usual, pretty steady except note lobe centered on 3k, where tweeter is broader than any other source. Beamy at 90°. Don't know exactly what the 80-200 Hz excess sideways output is about. The slightly hot top and big bass made this a winner for me. Woofer had totally ripped out of its particleboard in shipping (what a drop test!); I was pleased to fix with lots of caulk and some difficult screwbolting.

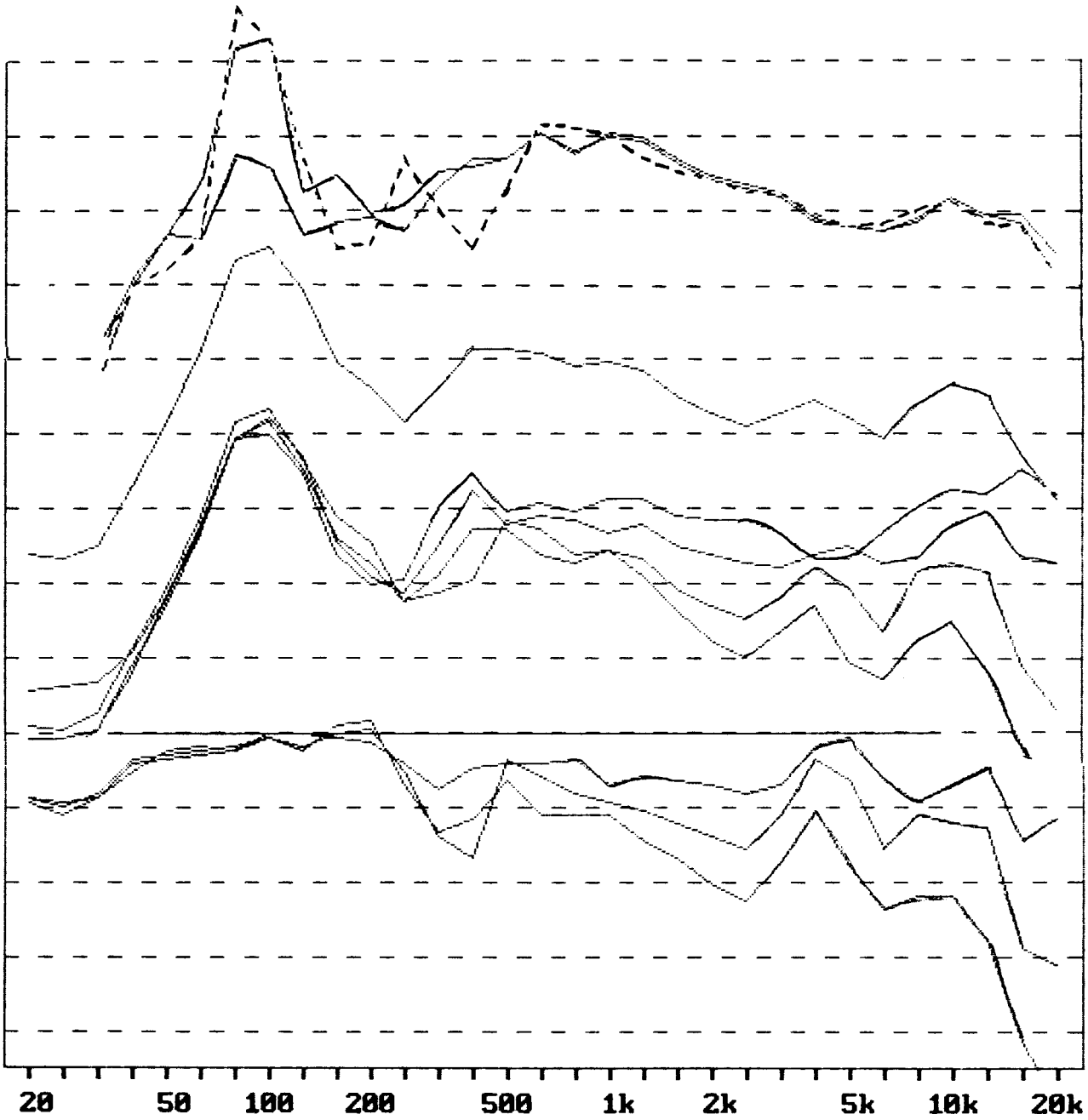


Figure 13A-D. The Design Acoustics PS*3 3-piece ($599), a pretty red-oak (almost unfinished) but honky and boomy system: sealed woof module 2 x 6" fires into slot loading; small sat's with allegedly small-diameter drivers. At top, room responses, with dashed curve showing close-to-wall placement and solid curves showing sat's out in room. 80-Hz boom can be reduced by bringing the woof out of the corner, as attested to by lower solid curve. Turn up the treble control to swamp the midrange excess and you're all set. Below the room power responses are averaged HR total and HR spread, quarter space/simulated wall, same conditions as before. At bottom is imaging, which was okay. Really beamy for such small drivers (look at the midrange); I thought something was wrong with my measurements but Hirsch found something similar, fortunately.

These 3-piece systems almost always have problems (apart from the floor-bounce potential hazard) blending in the 100-300 Hz range, because designers chop the upper output of the woofer module -- never a subwoofer no matter what they say -- too early, out of fear of the consumer (or the salesperson) being able faintly to localize it, I guess.

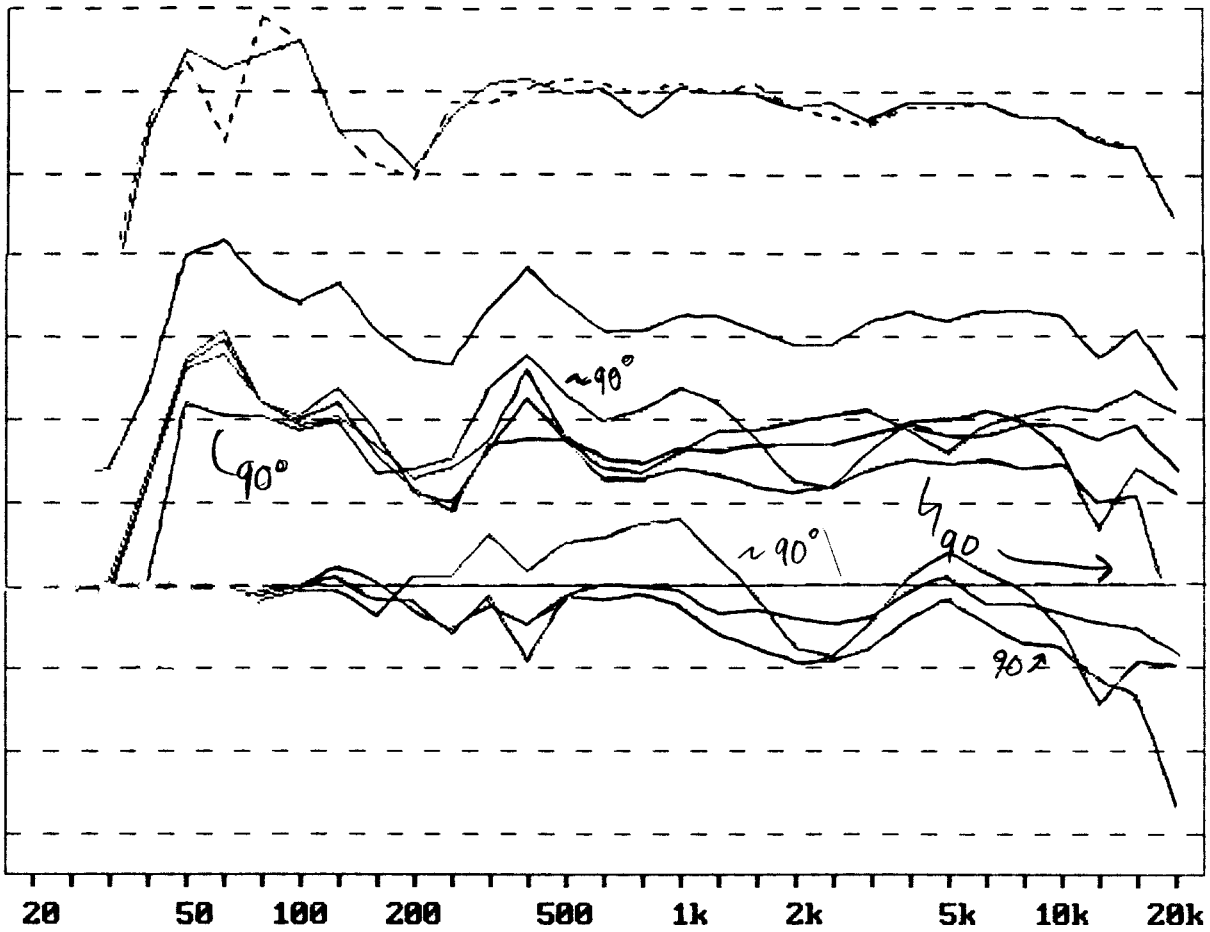
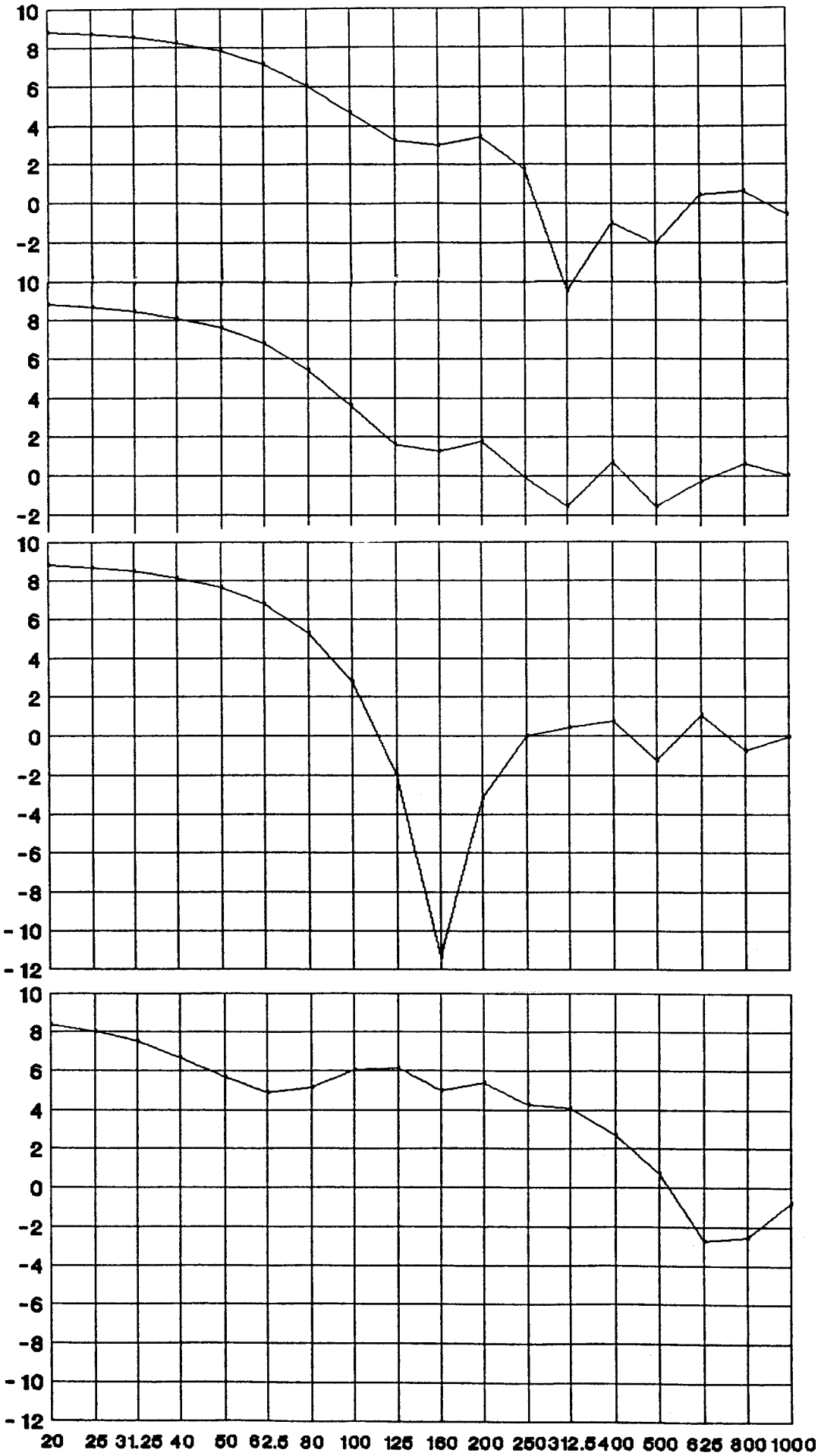


Figure 14A-D. The Boston Acoustics SubSat 6 ($499), a really fine little 3-piece system with superior dispersion due to a broad-firing midrange and good 3/4" tweeter. At top is a room response: solid curve is sat's on 38" stands and woof in corner; dashed is sat's 25" up and closer to front wall, with woof at floor/midwall. Woofer-to-satellite suckout problem is mild. Below this is averaged HR total in quarter-space, and beneath that is HR, top-bottom 0/30/60/90°. Some competitors have commented on chestiness in the sound; I did hear a tad but measured more (300-400 Hz and continuing a little up to 1500 Hz). Whatever, the midrange does put out an awful lot sideways. Very good woofer module (6" x 2, vented, bandpass) goes low; influenced by the Bose design. Note treble bunching/ overlay indicating wide dispersion.

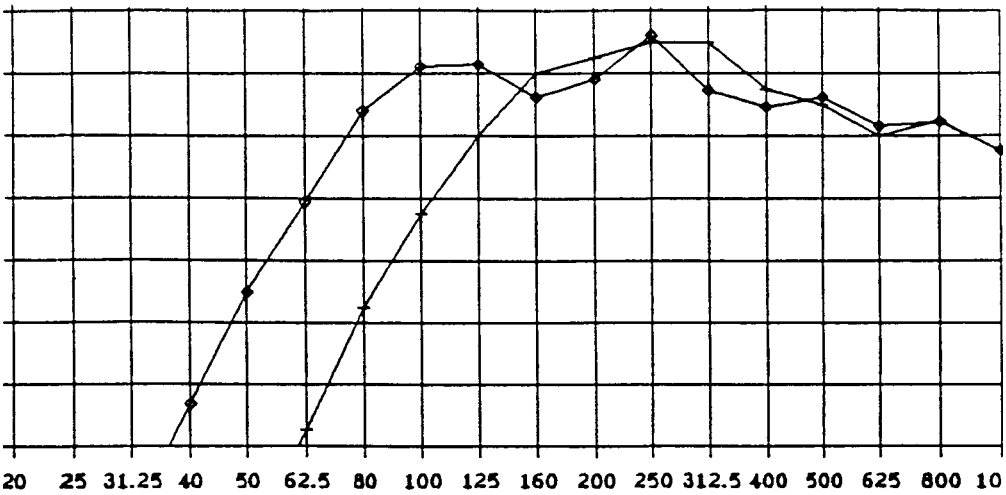
At bottom is spacious imaging (but there's that mid again, firing to the side -- angle these satellites inward, I suggest). And the striking sound overall is similarly spacious. Most modest and tiny 3-pieces are hardly clear winners, are indeed truly mediocre. This one's a winner to my ear. Now I am eager to get ahold of the Allison and the ADC 3-pieces. Other suggestions?

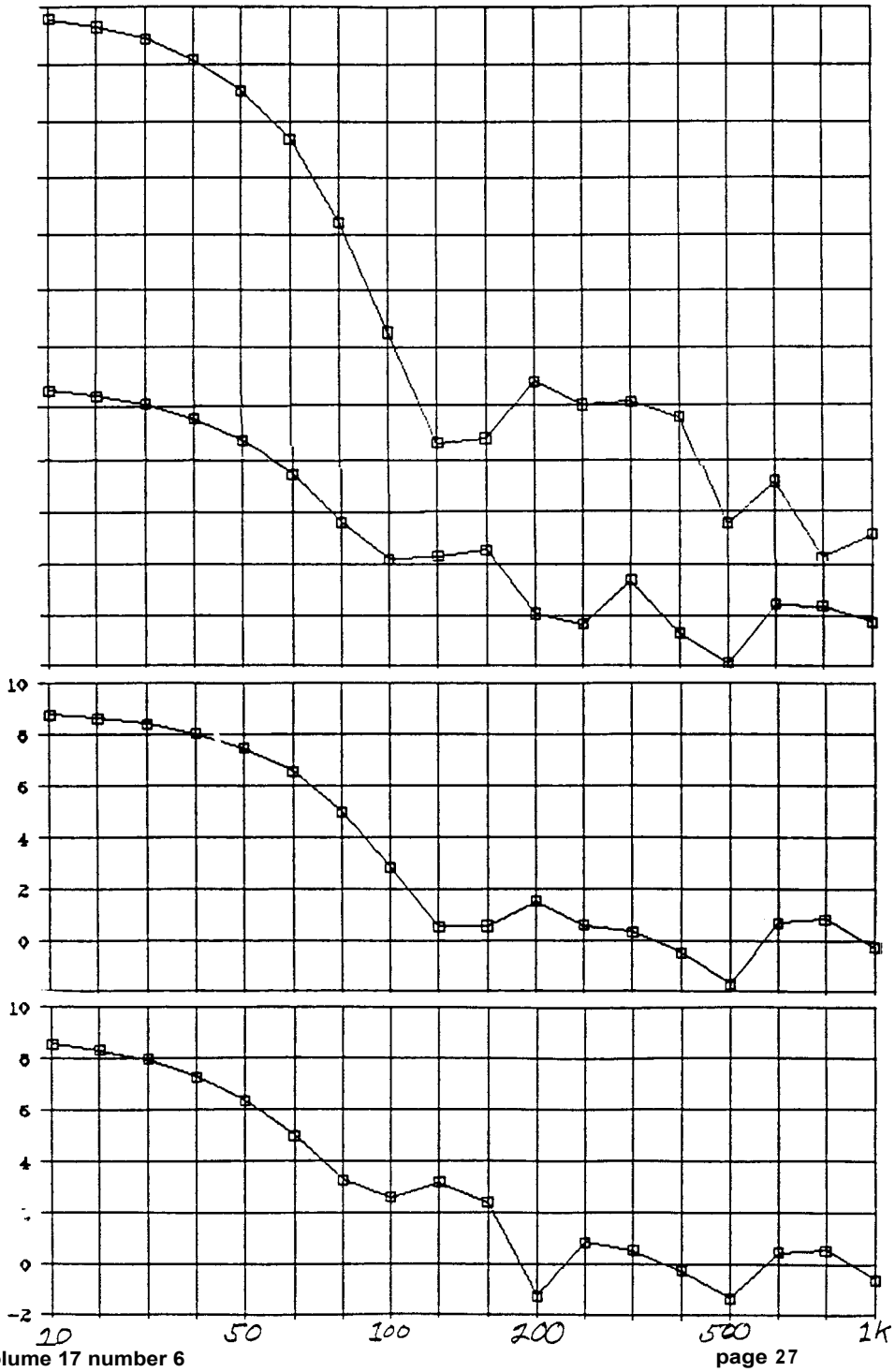
Figures 15 A-D. Some calculated boundary-power-augmentation curves, courtesy of Roy Allison, after R.V. Waterhouse (1955, '58, '65). The "gain" is what the 3 nearest room surfaces do to a driver compared with its behavior in free space (4 pi). Note ripple. 2 dB/div, 20-1k Hz.

Top, woofer center 0.9' (i.e., very close to wall if woofer is on front of cabinet) x 1' x 3'. Second, least cubes (geometric mean): 0.9' x 1.643' x 3'. Third, 2' x 2' x 2', the pits (Brit-style on-stand imaging "improver"?). Bottom, 0.5' x 0.5' x 6' (good augmentation if woof is crossed over low enough to mid well off floor, la Allison CD9, 350 Hz).



Figures 15E-I. Top, what a small satellite, near-field-measured (= half or 2-pi space), does with and without 1.1' x 1.5' x 2.4' augmentation. Second, 0.5 x 2 x 3'. Third, 0.9 x 2 x 3'. Fourth, 0.9 x 2 x 4'. Bottom, 0.9 x 2 x 4.4'. These last two, obviously, begin to approach the exact least-cubes (geometric) mean.





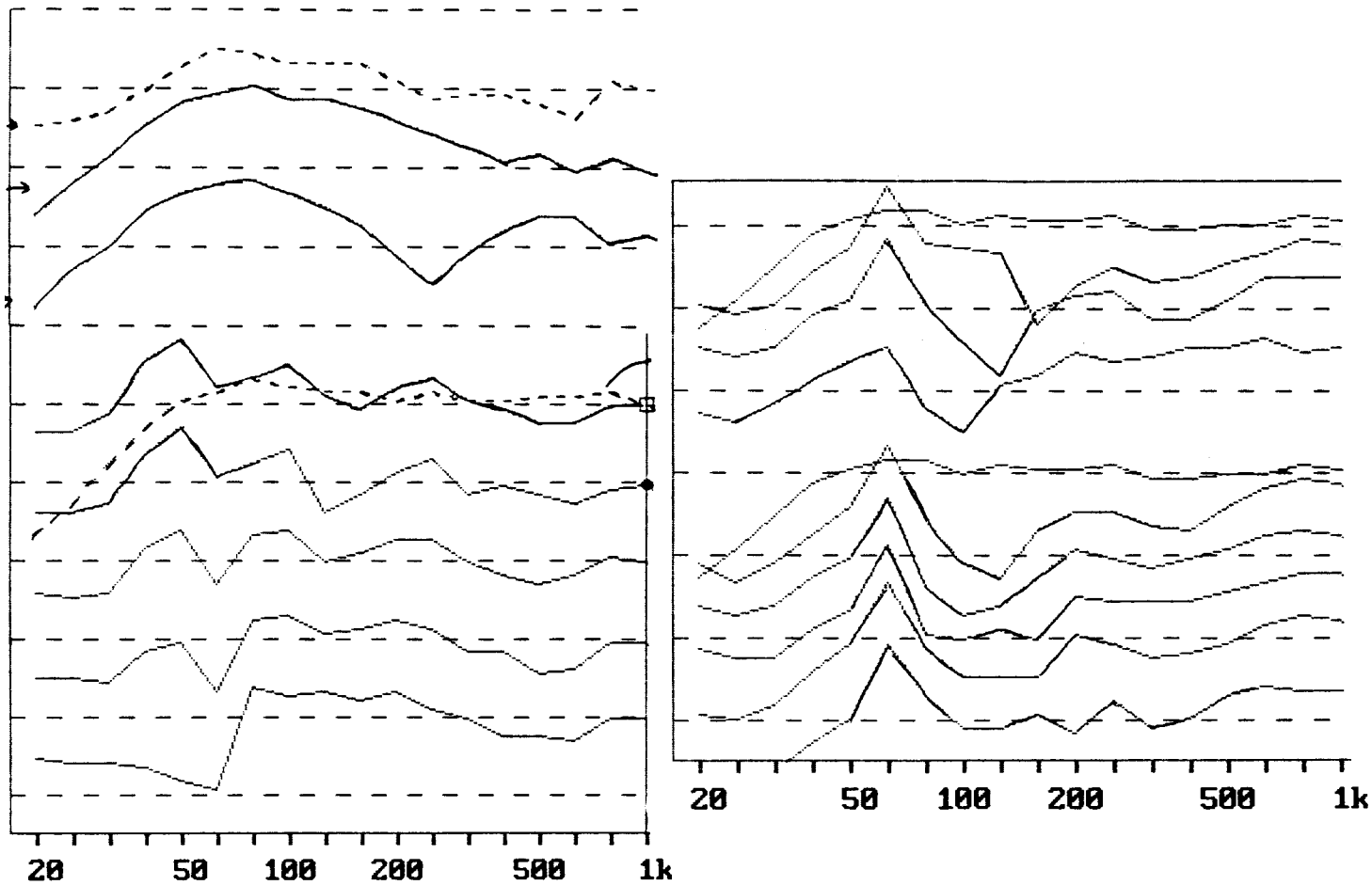


Figure 16A (left) and 16B (right). The old Small Advent <1 kHz, 8-9 dB/div.

16A: At top, dashed, is half-space axis response with unit on ground (spatially averaged with mike 8'+ away and 3'+ high). Second (solid curve) is averaged HR total half-space, and third (solid curve) is same only on a stand.
With the lower set we move inside and look at a single speaker. Dashed is close-miked response (= half or 2-pi space), which theory says should be more similar to top solid curve, I think. Overlaid on the lower dashed curve is response at near-enough listening position with speaker on floor and 18" from front wall (perhaps 6-7' from each side wall). Next, pushed back against wall; note notch. Then 1' out; 2' out; and at bottom is 3' out.

16B: Same, in a partly square room with 60-Hz ripple. At top is close-miked response again (nice driver, and this one was on its very last legs -- nearly rotted surround, as always). Then response of single speaker with mike spatially averaging at listening position near mid-room (ugh). First, on stand so woofer center is 2+' off floor, speaker cornered (centered on corner) 1+' from each wall. Second, same, 2+'; third, 3+'. Note notch moving down in frequency.
Lower set: top repeats close-miked response. Then, with speaker on same stand: 2' from front x 3' from side; 1.5' x 4'; 1.5' x 5'; 1.5' x 3.5'; and at bottom 1.5' x 2+' with speaker turned upside-down on stand, so woofer center is 3.33' off floor. This last is the closest to least-cubes, and it sounded and measured the best. It is still a bit lean 80-400 Hz but the room boom helps make up for that. Such positional inversion is a handy trick for the stand-addicted, sometimes working. Useful in studios too.

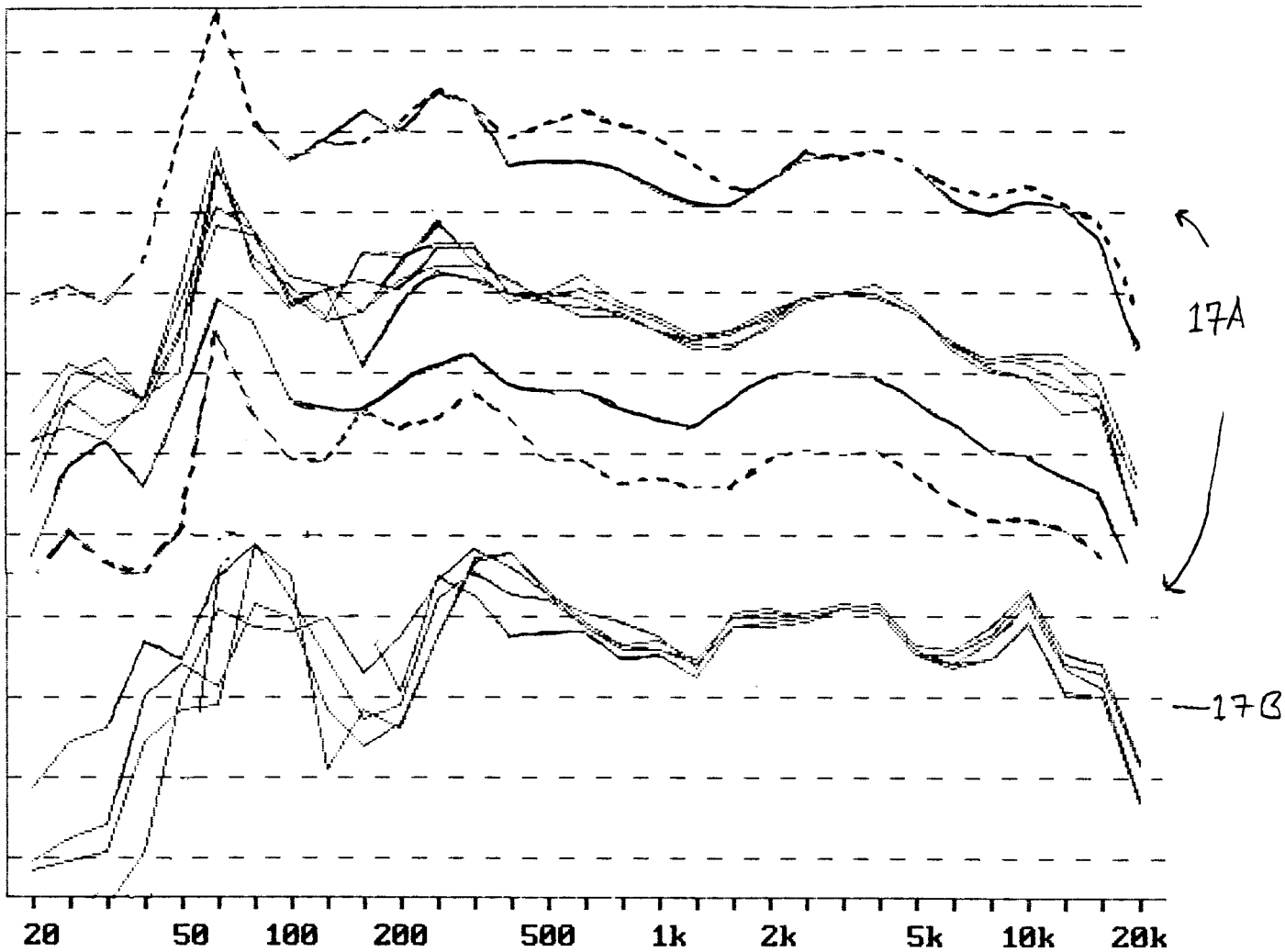


Figure 17A, top set above. The Henry Kloss Cambridge Sound-Works Ensemble ($499), here bass-boosted (+12 dB at 20 Hz) by an Allison Electronic SubWoofer (ESW) in its 48 Hz (+3 dB) setting, believe it or not. These power responses were taken with the sat's and the mike all over the place in two rooms, sat's near front wall and out a bit in room, turned sideways and upside down as well as right-side up (2 8"-woofer modules were left in corners). One of the listening rooms has a resonance at 60 Hz, but this system has a chronic peak of its own at around 70 Hz. Other than that unhappy combination, pretty fair sound, smooth enough, quite old-fashioned in its utterly constricted airlessness due to beamy (1.75"!) tweeter.

Figure 17B, lowest curve set above. NAD/Lincolnwood's Atlantic Technology's new Pattern 3-piece system ($500), "dynamically" equalized and also amplified. Sat's (2 mids each, rotatable) out from walls, woofer (6" x 2) in corner. Power responses in a couple of rooms. E. Brad Meyer assisted in the tonal balancing. The 300-400 bump is mostly remediable with increased out-from-wall placement, as is the dip an octave lower. Bump at 80 Hz is probably real but woofer also goes lower. Impressive sound, value; dispersed highs might be nice.

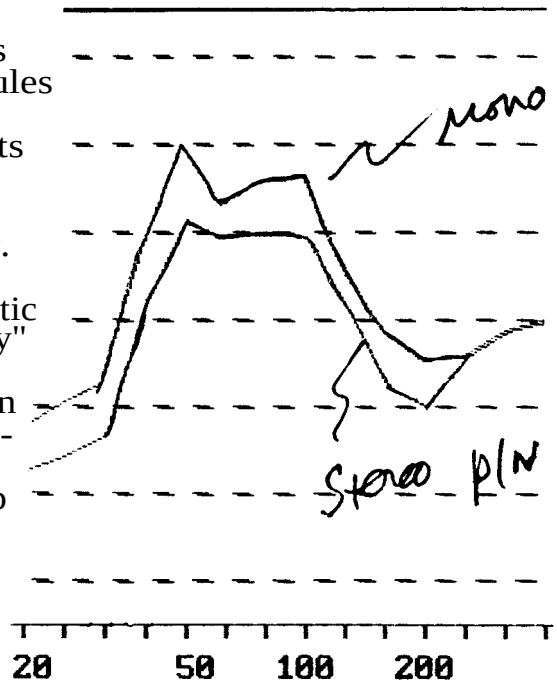


Figure 18, right. Another mono/stereo comparison, this time with a single woofer (stereo inputs to dual voice coil): Cerwin-Vega Sat-6 module, 10", vented, bandpass; pretty consistent-3-dB difference.

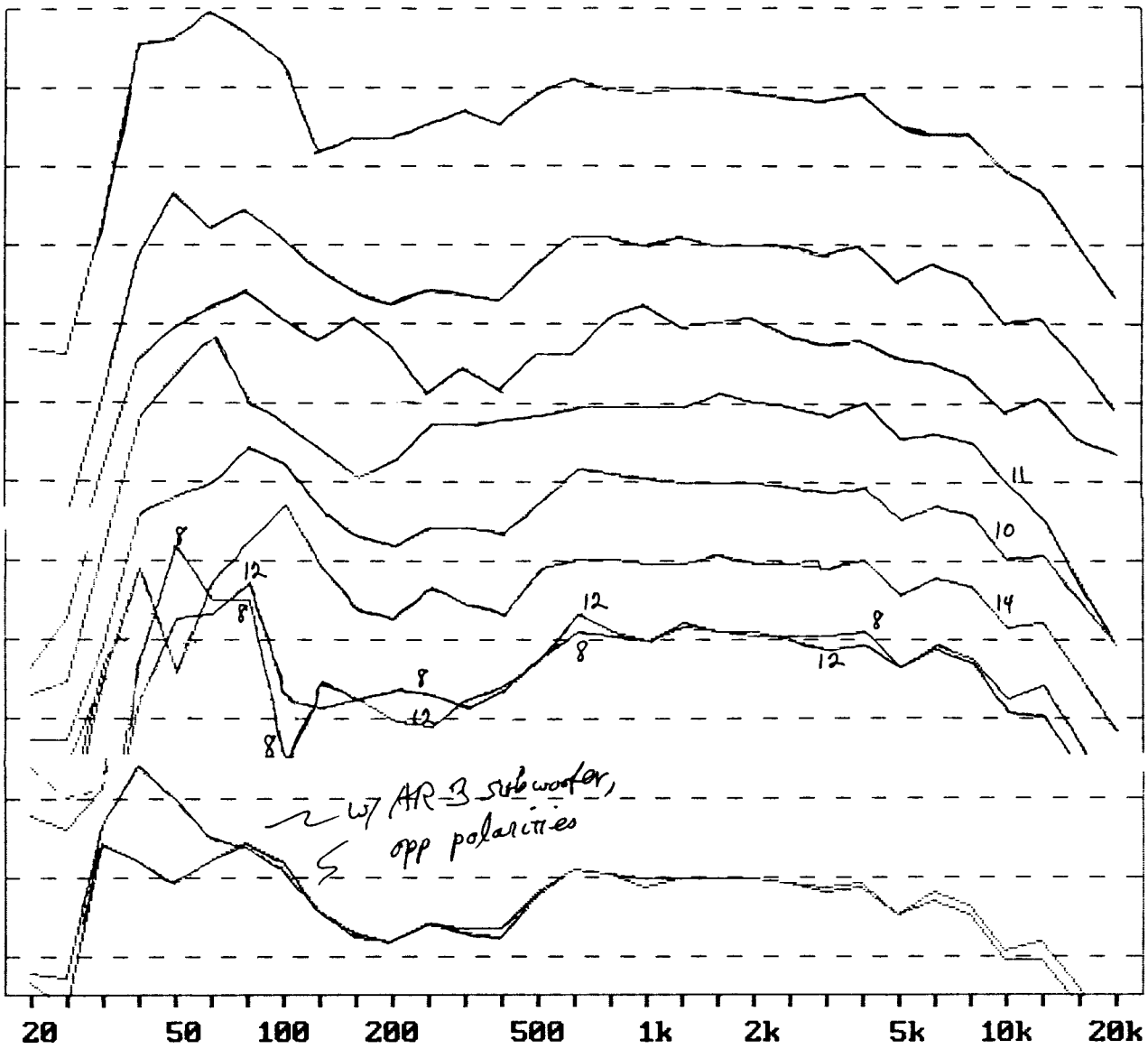


Figure 19. The famous Quad ESL 63, early production, measured in owner's listening room, speakers on 1' stand. Quite something over 3+ octaves (but then so is the Bose 3-piece midrange). Note the rolloff of highs >4 kHz; so much for its being a point source, said one audiophile. Broadly sucked out below 500 Hz at many locations, too.
Top is listening chair near a side wall. Second is the sweet spot, couch centered in front of speaker pair. Third is same only speakers on floor -- a "right out of the box" measurement. Fourth (marked by a tiny "11") is at a higher seat behind the couch, speakers back on low stands. Fifth ("10") is the same as the second only with a large glass sliding porch/balcony door open; down 3-4 dB 125-500 Hz approx. Sixth curve ("14") is right speaker only, seventh ("8" and "12") left speaker only (8 = glass door behind it closed, 12 = open). Finally, bottom curve is with Roy Cizek-modified AR3 woofer (12") added, in opposite polarities.

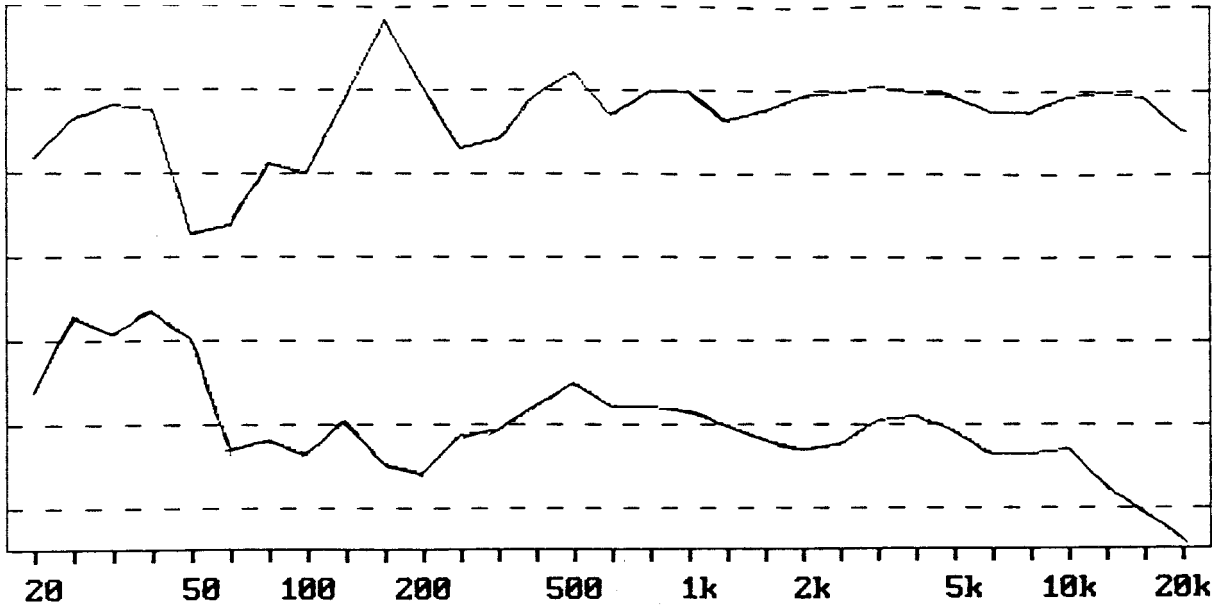
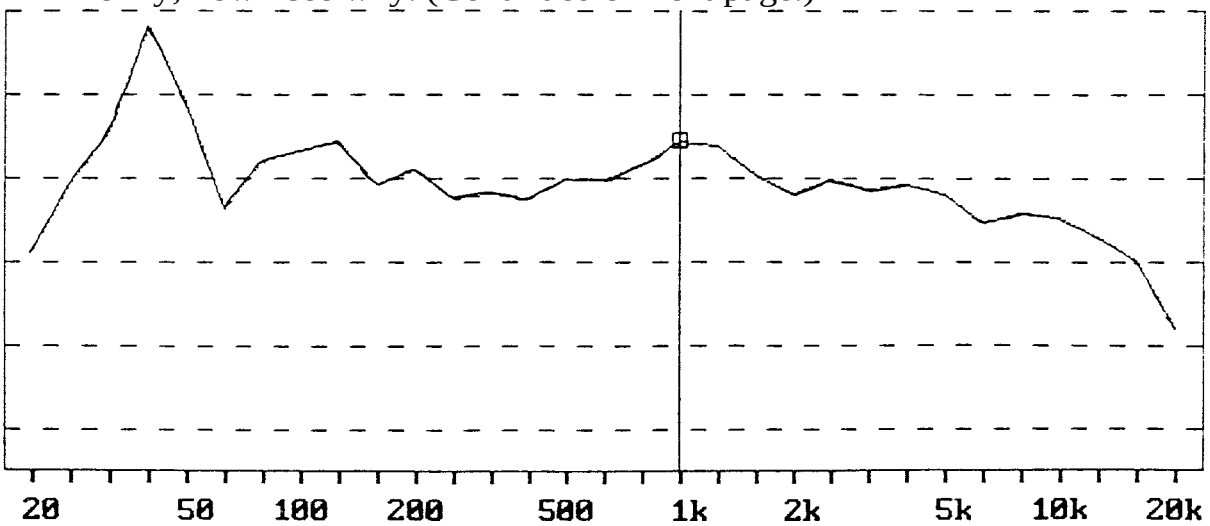


Figure 20, above top: the Snell A-3 ($4500 or so). This pair I got to know well because we rented them for a week at dbx to A/B with SF 1As (very similar balance, tighter imaging, less spacious, a teeny bit boxy-sounding). Sold from one prominent audio journalist to another, these are now sited in a very treble-absorbent, acoustically designed and treated, dedicated listening room with a real sweet sweet spot up close. Upper-bass/lower-midrange ripple aside, the sound is very good and the imaging dead-on if both dry for my taste. Response >500 Hz is maybe the flattest of any conventional forward-firing 1-driver/range design I have measured; I forget if rear tweeter was on, but in this room it would be mostly absorbed in any case. (More attention might be paid to least-cubes boundary positioning, evidently, but this failing remains the most common one in audiophile [and others'] acoustic understanding and sonic achievement with their stereo systems.)

Figure 21, above bottom: the new B&W 801 (Matrix Series 2; $4500 or so). This is one tweaks go gaga over (e.g., musician Lewis Lipnick in 12/87 Stereophile). Here it is in a small shoebox room, near the corners; famous Boston tweak dealer set them up on optional fancy low stands for almost perfectly cubic boundary placement, hence the 5-8 dB lower-mid/upper-bass suckout. Sounds and images good. This pair very woofy even without outboard B&W EQ box.

Figure 22A, below: the old B&W 801 (F?). Placed at the end of narrowish rectangular living room, evidently with some 40-Hz boom (seldom a bad thing). System sounds fairly good and is airy enough because of B&W's very-small-baffle design (more designers should copy). I always thought the old 801 was a little honky; now I see why. (Continued on next page.)



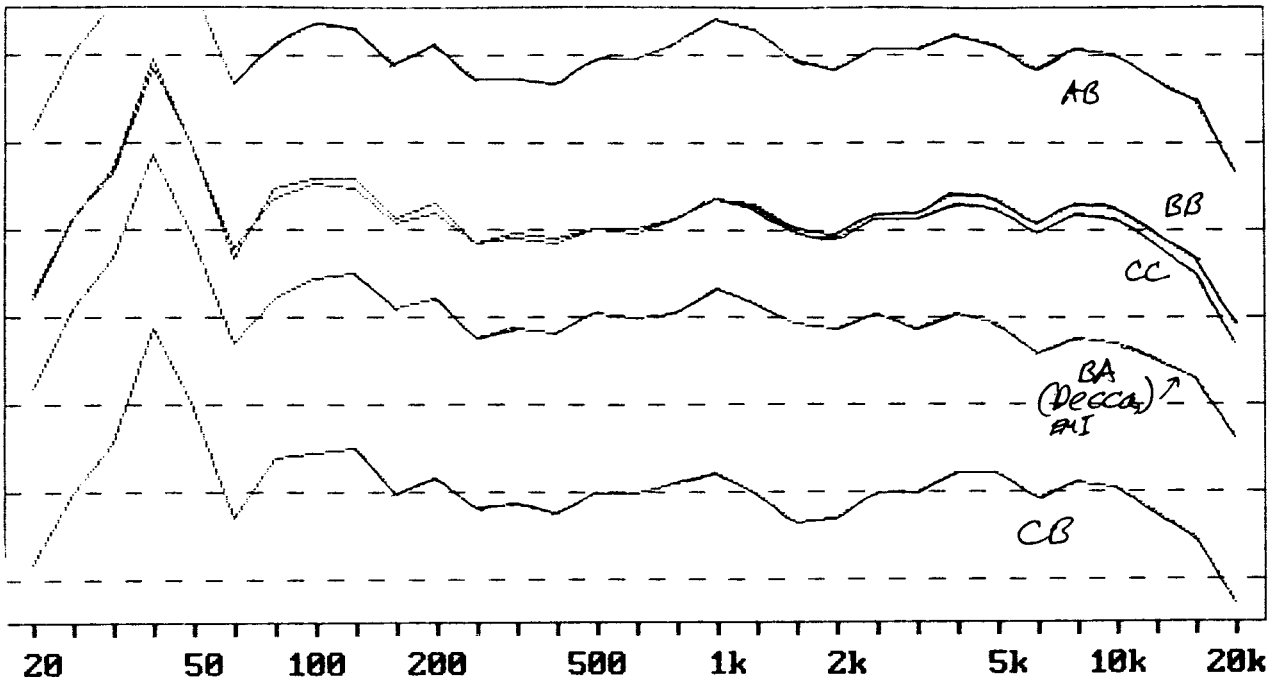
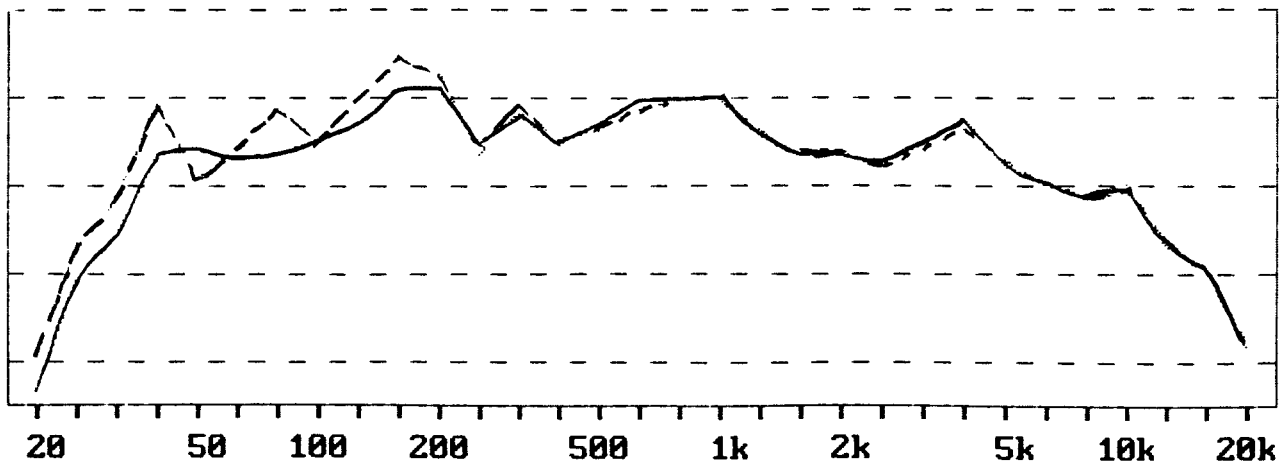


Figure 22B-F (above), same B&W 801, now with various mid and tweet driver-level-adjust EQs shown. Hard to do much about that 1k+ peak and dip, surprising in so expensive and influential a system. (Decca/EMI reference position is fourth discrete curve down; classical monitor indeed.) Best solution may be to leave the mid alone, turn down the tweet, and then turn up the preamp treble control. (Details of crossover-pot settings available to 801 owners; contact author.) This basic B&W design, with golfball-size tweet and grapefruit-size mid housings, has quite nice HR, as we discovered measuring an 802 at dbx.

Figure 23, below. This is an old pair of Allison Twos, ideally loaded in a large acoustical-dream room, although the end wall they're against opens out both sides into the rest of a large ranch house, so treble reflections especially are reduced. Note smoothness 500-1k and swayback above (for a touch of nasality, perhaps); crossover/tweeter flare at 4k (HR swings through lobes here with the two parallel, closely enough spaced mids and tweets); typical, uniquely Allison richness 150-200 (a tad more than you might want, actually); and strong smooth output down to 40 Hz. Dotted line is mono pink noise. Sound is good, imaging diffuse.



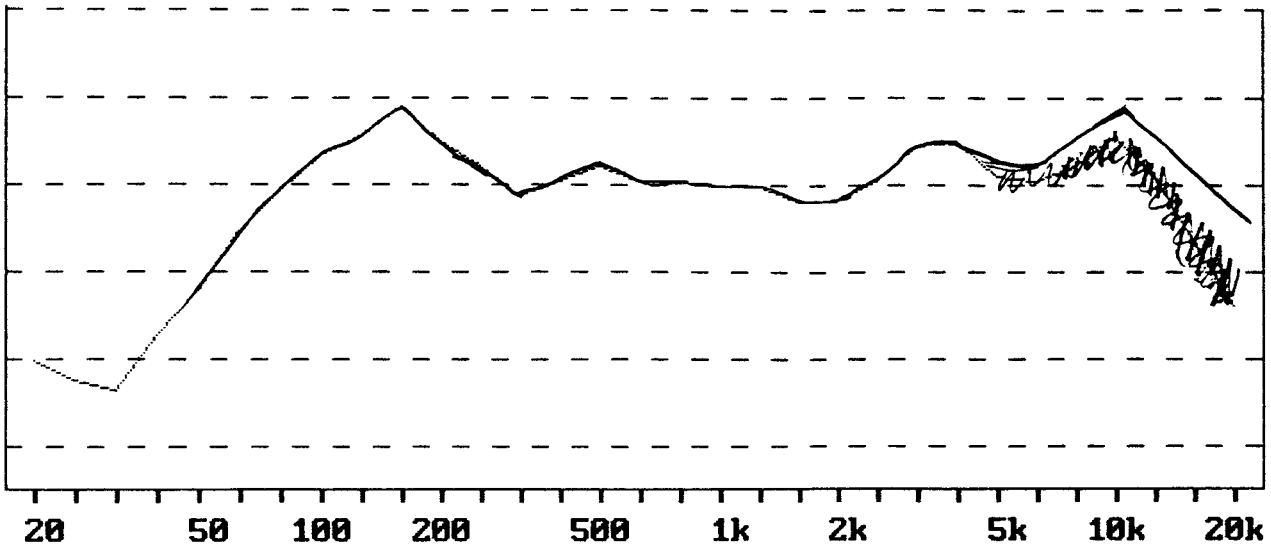
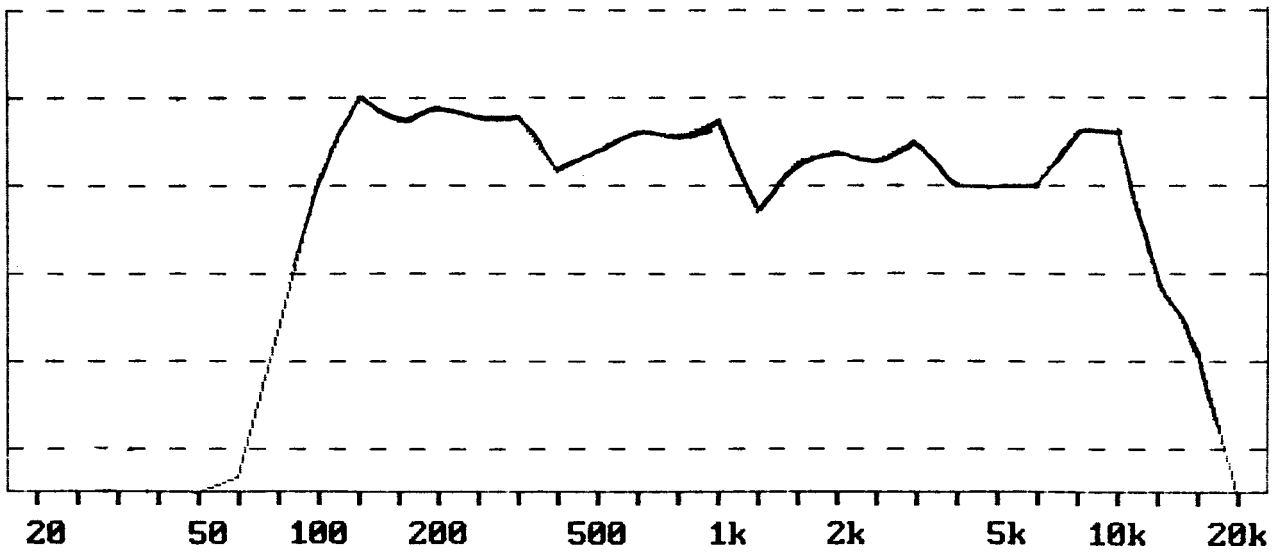


Figure 24, above. The old KLH 11, bass-equalized midranges, essentially; good little driver. 8-9 dB/div with the erroneous treble shyness corrected. Taken about 3' away, speakers close to each other and against the front wall. Not bad at all. Ear-training for many of us 25+ years ago.

Figure 25, below. Thank God for equalization. This is the DAK "Li'l Tiger" GoldStar (Sae Woo) stereo boom box ($180 shipped!). It comes with quite a good CDP (a little hissy) and radio (sensitive) and a 5-slider EQ. Also line in and out; cassette deck (fluttery). You have to push down 1k and 4k all the way and push up 100 Hz and 10k likewise or the honk will drive you out of the room; 400 Hz you adjust according to boundary loading. This curve is stereo-pn room power from a few feet away, the unit against one boundary, so 400 Hz is all the way down too. Sounds great, with noticeable stereo; quite the measurement curve too. Add a powered subwoofer and you're all set.



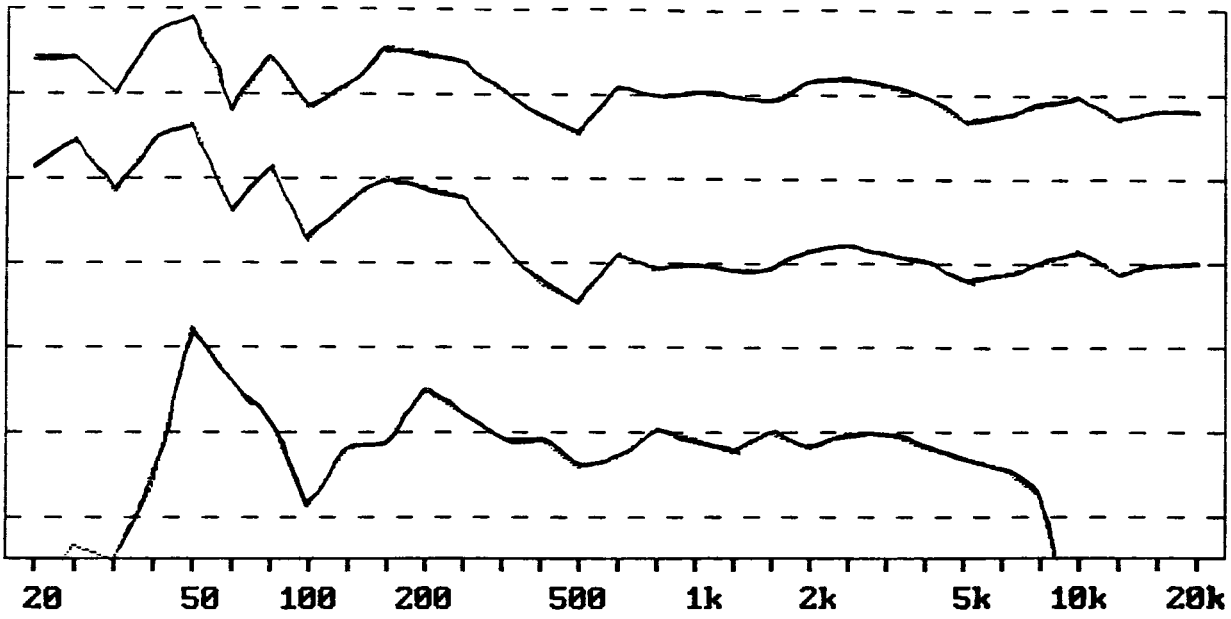
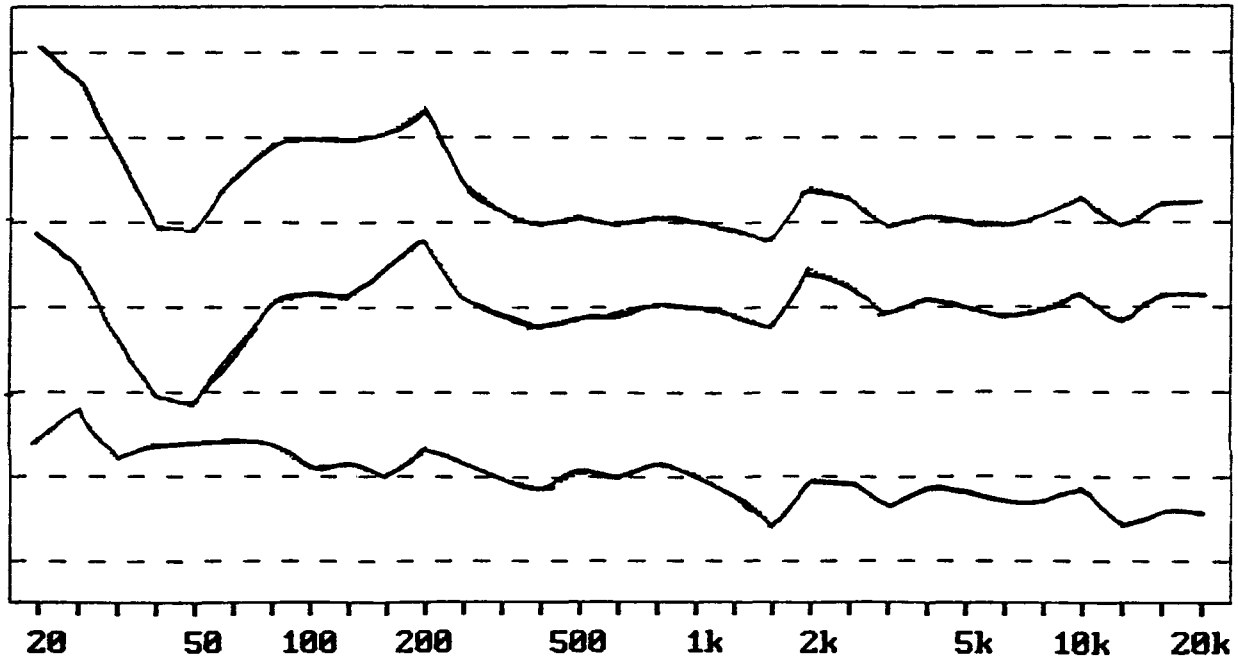


Figure 25A and B, above, top two curves. The dbx Soundfield 1A ($2500-$3000), fairly close power response in a well-proportioned low-bass-lossy living room, speakers pulled out from long wall. First curve is with the preamp's high-shelf bass cut; the one below is the system out of the box. SFC1A controller's HF and LF sliders are at their midpoints.

Figure 26: Third curve is the owner's Allison 110 rear/side speakers (my favorite small 2-way), fed delayed signal through a steep 7-kHz highcut (low-pass) filter. This system, front speakers only or all four, sounds awfully good with deep "listen-into" clarity, especially with that upper-bass richness broadly reduced. Chamber music is very much they-are-here. Rock and choral are formidable, orchestra detailed and close (like leaning over the balcony).

Figure 27, below. Another pair of SF 1As. At top is the out-of-the-box response with the controller's HF slider at midpoint; middle curve includes a high-shelf bass-tone-control cut. Bottom curve is after some further octave EQ (not that much, actually). Sound is again remarkable and complete.

From these two systems it appears that somewhat too much effort may have gone into balancing the system EQ to be sure to eliminate any reduced output in the upper bass/lower mid in real-world usage.



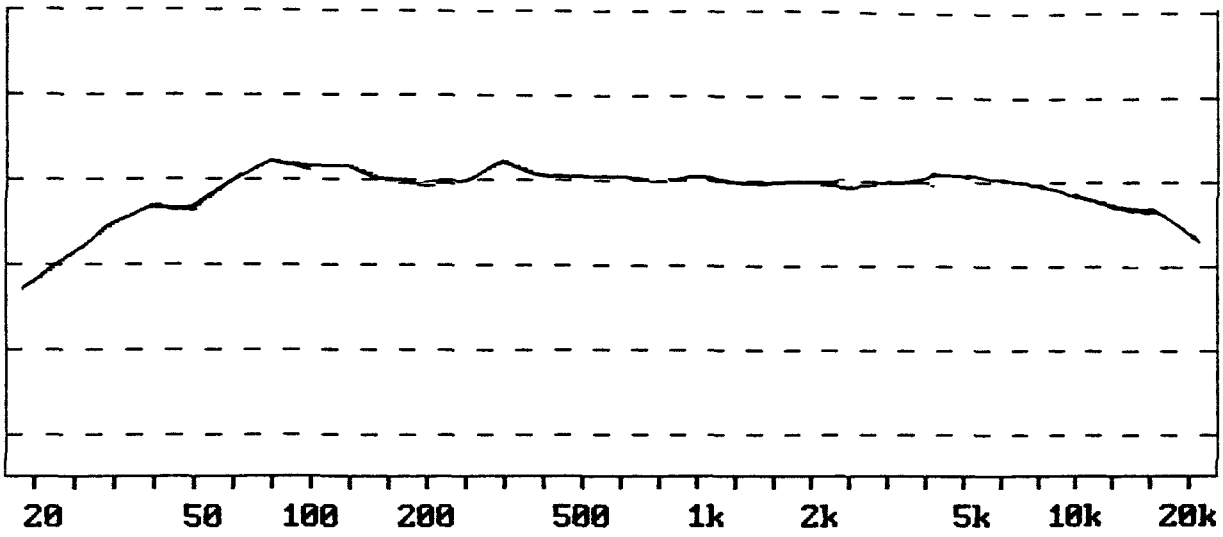
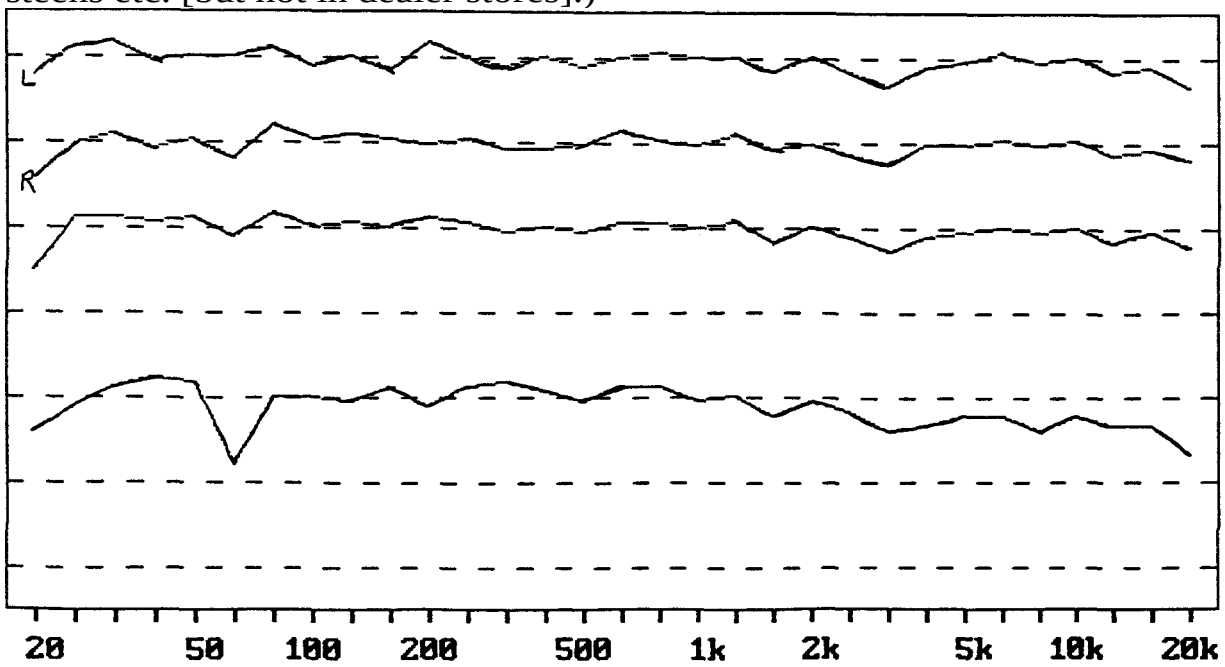


Figure 28, above. The Allison IC20 ($5000), measured in a superior but not unfairly atypical room at the manufacturer; 8-9 dB/div and treble too soft (corrected by hand). Remarkably, the same power response regardless of those HR panel-strength settings for various imaging styles (dbx, Allison, Bose, you will recall). No other comment called for, is there? A great achievement.

Figure 29A-D, below. The author's dbx SF 1A as EQed by the dbx 14/10 (half-octave and octave equalizer), but not through its own automatic computerized routine. Measured moderately far away. At top is the left speaker, second curve is the right, and third is both. At bottom is more conventional, non-SF orientation, with the speakers' loudest axis facing outward toward the room center. Euphonious 60-Hz anti-hum notch is due to placement where one room resonance is least-excited.

The sound is as you might expect, like gigantic electrostatic headphones, "immersive," often enough the best I have heard. Imaging is rather exact but spacious, some might feel spacy.

(Future systems I plan to measure: brand-new KLH 6es, VMPS, Apogee, Klipschorns, two oddly sited Allison One pairs, dbx SF50, Goldsteins, other Snells, Bose 901, Infinity Kappa 9s, Carvers. I am looking for big Polks, KEF 107s, more B&W 801/2s, also Magnepans, Spicas/Thiels/Vandersteens etc. [but not in dealer stores].)