Audio

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ANNUAL DIRECTORY ADDENDA

THE AUTHORITATIVE MAGAZINE ABOUT HIG • JANUARY 1980

47425

KILL FM INTERFERENCE WITH TWO ANTENNAS

TONEARM GEOMETRY AND CARTRIDGE SETUP DEMYSTIFIED

THE IMPORTANCE OF DYNAMIC RANGE

AND IT'S WHAT GOES INTO HPM SPEAKERS THAT MAKES THEM SOUND GREAT ON EVERY PART OF THE MUSIC.

HPM 60

HPM 100

HPM 150

HPM 40

Most speaker companies try to impress you by describing the "wonderful" sound that comes out of their speakers.

At Pioneer, we think the most believable way to describe how good HPM speakers are is to tell you what went into them.

THE HPM SUPERTWEETER: SPEAKER TECHNOLOGY RISES TO NEW HIGHS.

In many speakers, you'll find that the upper end of the audio spectrum is reproduced by an ordinary tweeter.

In HPM speakers, you'll find that the high frequencies are reproduced by a unique *super*tweeter.

The High Polymer Molecular Supertweeter. So incredible, we named a whole line of speakers after it.

It works by using a single piece of High Polymer Molecular film, (hence the name HPM) that converts electrical impulses into sound waves without a magnet, voice coil, cone, or dome.

And because the HPM supertweeter doesn't need any of these mechanical parts, it can reproduce highs with an accuracy and definition that surpasses even the finest conventional tweeter.

As an added advantage, the HPM film is curved for maximum sound dispersion. So unlike other speakers, you don't have to plant yourself in front of an HPM speaker to enjoy all the sound it can produce.

You'll never hear a sound out of these die cast aluminum speaker frames.

MID-RANGE THAT ISN'T MUDDLED.

For years, speaker manufacturers have labored over mid-range driver cones that are light enough to give you quick response, yet rigid enough not to distort.

Level controls that let you adjust the sound to your listening area.

Pioneer solved this problem by creating special cones that handle more power, and combine lower mass with greater rigidity. So our HPM drivers provide you with cleaner, and crisper mid-range. Which means you'll hear music, and not distortion.

WOOFERS THAT TOP EVERY OTHER BOTTOM.

Conventional woofers are still made with the same materials that were being used in 1945.

Every woofer in the HPM series, however, is made with a special carbon fiber blend that's allowed us to decrease the weight of the cone, yet increase the strength needed for clarity. So you'll hear the deepest notes exactly the way the musician recorded them.

And because every HPM woofer also has an oversized magnet and long throw voice coil, they can handle more power without distorting.

OTHER FEATURES YOU RARELY HEAR OF.

Every HPM speaker has cast aluminum frames, instead of the usual flimsy stamped out metal kind. So that even when you push our speakers to their limit, you only hear the music and never the frames. In fact, our competitors were so impressed, they started making what look like die cast frames, but aren't.

HPM speaker cabinets are made of specially compressed board that has better acoustic properties than ordinary wood.

Their speakers have level controls that let you adjust the sound of the music to your living room.

And these features are not just found in our most expensive HPM speaker, but in *every* speaker in the HPM series.

All of which begins to explain why, unlike speakers that sound great on only part of the music, HPM speakers sound great on all of it.

At this point, we suggest you take your favorite record into any Pioneer Dealer and audition a pair of HPM speakers in person.

If you think what went into them sounds impressive, wait till you hear what comes out of them.

PIONEER®
We bring it back alive.

WHAT COMES OUT OF A SPEAKER IS ONLY AS IMPRESSIVE AS WHAT GOES INTO IT.

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January 1980

Audio

Vol. 64, No. 1

"Successor to RADIO, Est. 1917"

Feature Articles

Equipment Profiles

Record Reviews

Audio in General

About the Cover: These days, tuner circuit design is a high art, which pushes the limits of the medium, as is symbolized by our impressionist cover photo by Photographic Illustrations, Philadelphia; model, Sue Greco.

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Pictured to the right, is the Stanton Dynaphase 35, a headphone offering top performance at its price. With an adapter plug. *$45

The top-of-the-line Stereo Wafer Model XXI is as fine as they come and featherlight for comfort. *$70

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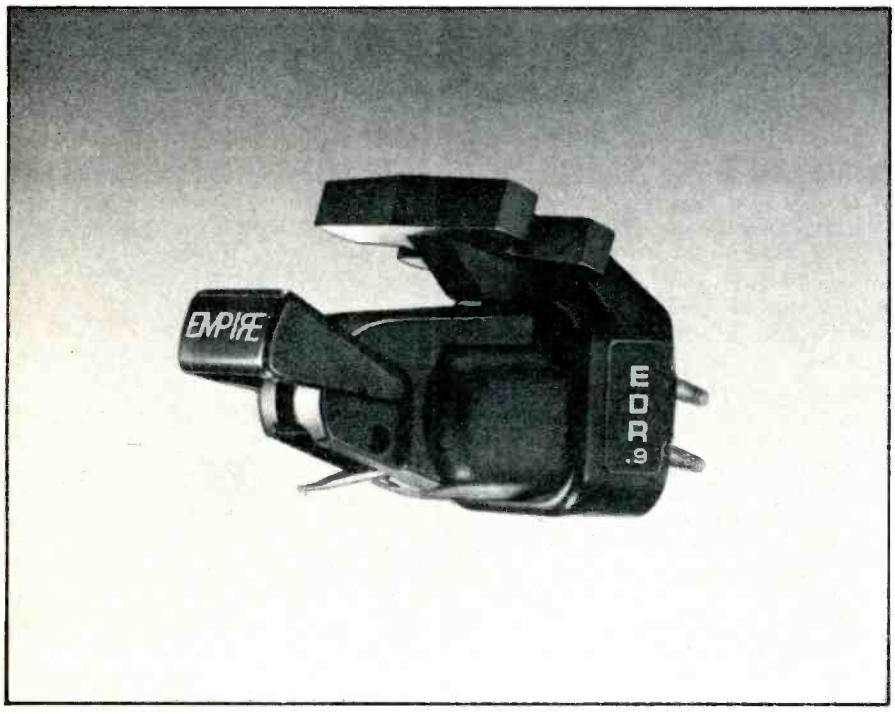
Empire's EDR.9
The Phono Cartridge Designed for Today's Audiophile Recordings



Direct-to-Disc and digital recording have added a fantastic new dimension to the listening experience. Greater dynamic range, detail, stereo imaging, lower distortion and increased signal-to-noise ratio are just a few of the phrases used to describe the advantages of these new technologies.

In order to capture all the benefits of these recordings, you should have a phono cartridge specifically designed to reproduce every bit of information with utmost precision and clarity and the least amount of record wear.

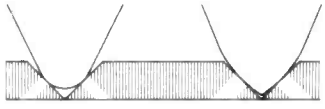
The Empire EDR.9 is that cartridge. Although just recently introduced, it is already being hailed as a breakthrough by audiophiles, not only in the U.S., but in such foreign markets as Japan, Germany, England, France, Switzerland and Sweden.

What makes the EDR.9 different?

1.

Within the cantilever tube, we added a mechanical equalizer. It serves two purposes: (1) to cancel the natural resonance of the cantilever tube, and (2) to improve the overall transient response of the cartridge. The end result is a stylus assembly that has a mechanically flat frequency response. The frequency response extends from the 20Hz to 35Hz with a deviation of no more than ± 1.75 dB. No other magnetic cartridge has that kind of performance. We call this stylus assembly an "Inertially Damped Tuned Stylus," the refinement of which took over 6 years.

2.



Contact area of ordinary Elliptical Diamond.

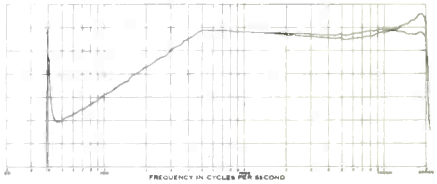
Large contact area of LAC Diamond.

In order to reproduce a groove containing extreme high frequency musical overtones, the stylus tip must have small enough dimensions to fit within the high frequency portion of the groove. Yet, the smaller the stylus tip, the greater the pressure applied to the record surface and the more severe the record wear. In the EDR.9, we have responded to these conflicting requirements by developing a stylus that has the proper dimensions from side-to-side, a much smaller dimension from front-to-back, and a very large, low pressure degree of contact between stylus and groove top-to-bottom. The net result of this large contact area, which engineers call a "footprint," is that the stylus of the EDR.9 can track musical signals to the limits of audibility and beyond, yet has the lowest record wear of any cartridge presently available. The stylus shape of the EDR.9 is called L.A.C. for "Large Area of Contact."

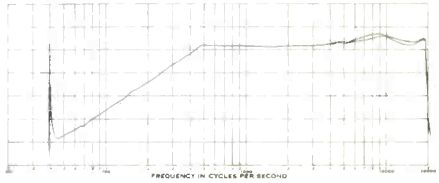
3.

Conventional cartridges exhibit radical changes in their frequency response when connected to different preamplifiers. This is because the load conditions – the amounts of capacitance and resistance provided by the preamp – vary tremendously from one preamp to another, and from turntable to turntable. Consequently, most phono cartridges, even expensive ones, have their frequency response determined essentially by chance, depending on the system they are connected to.

But the electrical elements of the EDR.9 have been designed to remain unaffected by any normal variations in load capacitance or resistance. Thus, the EDR.9 maintains its smooth frequency response and accurate transient-reproduction ability in any music system, irrespective of loading conditions.



A conventional cartridge's frequency response changes when connected to different preamps.



EDR.9 is not affected by changes in loading conditions.

4.

Then, as a final test of performance, we listen to every EDR.9 to make certain it sounds as good as it tests. At $200, the EDR.9 is expensive, but then again, so are your records.

For more detailed information and test reports, write to:

Empire Scientific Corp.
Garden City, NY 11530

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Tape guide

Herman Burstein

Wire You're At It...

Q. I have a tape recorder with an amplifier not worth repairing. I also have a 30-watt power amplifier and a preamplifier. I would like to take the tape transport, power amplifier, and preamp and construct a nice little tape machine. The preamp is equalized for tape-head playback. I want my machine to be able to record from a microphone and also from my music system. Now, when I wire this stuff together, will I need any extra equalizers and, if so, where? Using block diagrams, can you indicate how I should wire the system? — Nathaniel Stelton, Chicago, Ill.

A. To be able to record, you need an oscillator circuit of about 80 kHz or higher to power the record and erase heads, a circuit with sufficient gain and proper treble boost to supply audio signal to the record head, a circuit to drive a record level indicator to proper indication at a reference recording level (one that causes the meter to read 0 VU for a 400-Hz signal that produces one percent harmonic distortion on the tape), and proper switching facilities to go between recording and playback and to choose between low-level and high-level inputs. This is a tall order, and the Tape Guide is not able to perform such a design service. I would suggest that you search for articles on tape amplifiers and write to manufacturers of replacement heads, who sometimes provide circuits to go with their heads.

Decodering De Deck

Q. I am considering the purchase of a four-channel decoder. What function would my tape deck assume with such a unit? — Roy Clark, Chicago, Ill.

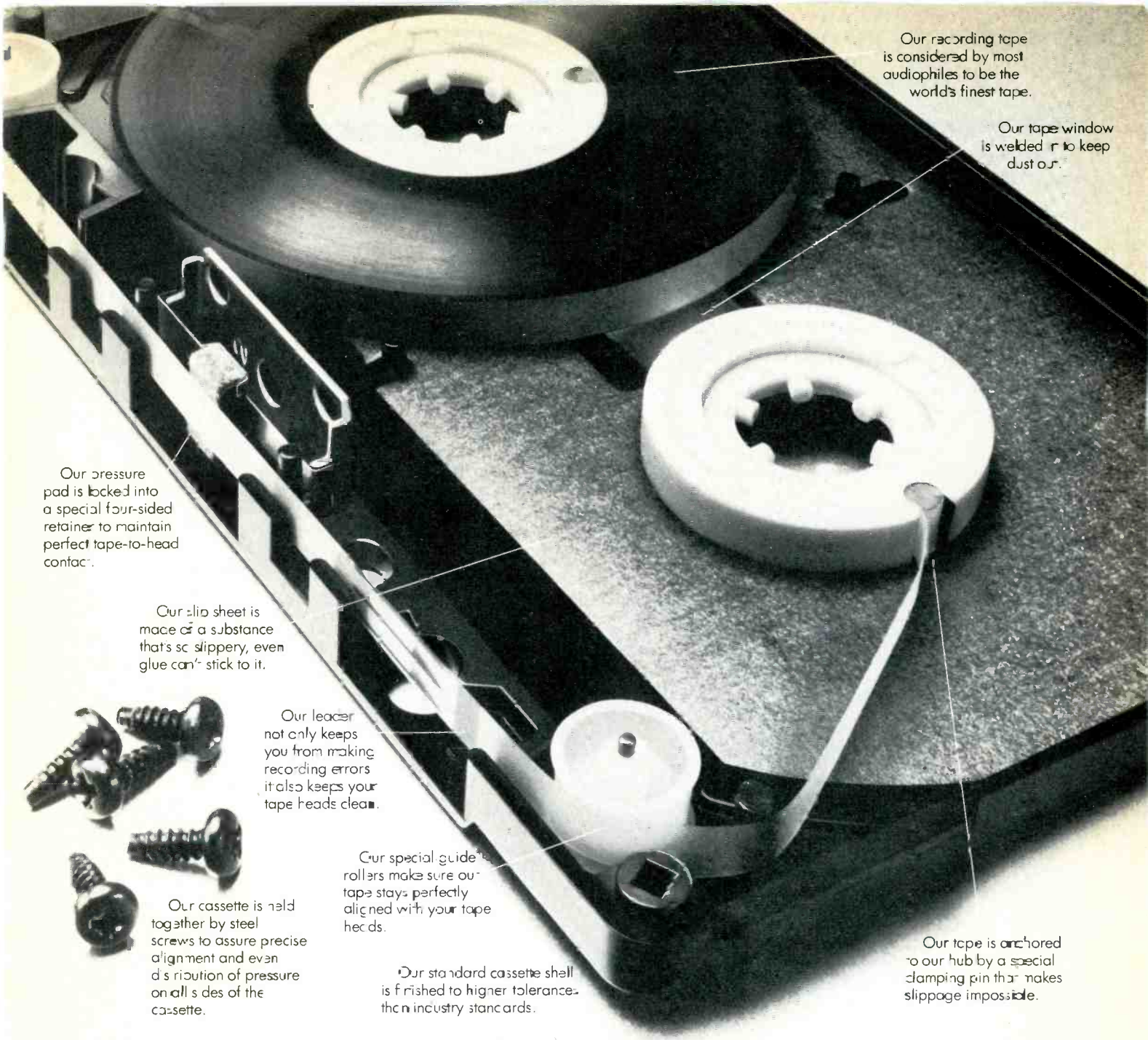
A. The purpose of the decoder is to convert signals on two channels into four-channel sound. Assuming you have a program source with encoded signals — such as a phono disc or tape — the decoder would perform the above function. Thus, if you have an encoded tape, you would play the tape into the decoder and the output of the decoder would go to your audio system. I do not know at what point the decoder is connected to your system; consult the decoder's instruction manual on this. Often the decoder is meant to go between the preamp and power amplifier, and in this case, the tape output would go to your audio system input (preamplifier) and thence to the decoder.

Level Compatibility

Q. I am concerned about the compatibility of tapes produced on "new generation" cassette decks with my original Advent Model 200. I have been considering the purchase of a new cassette deck because of its low wow and flutter but have been troubled by the lack of a calibration oscillator within such decks. Advent says that for each type of tape the input must be adjusted so that the output of the tape yields the standard Dolby level at 400 Hz. Without the internal oscillator it is not possible for the user to adjust the input level, and taking the deck to a service center for this adjustment consumes too much money and time. How much degradation of performance could be expected when making the change from standard tape to chromium dioxide and other new tapes if one doesn't change the original setting of the Dolby level? Will a tape made on one of these decks perform adequately on my Advent 200? — Ivan Ross, APO San Francisco

A. Tapes do differ in their output characteristics, and Dolbyized tape machines should therefore be properly adjusted for the tape to be used. I would imagine that being about 2 db or so off proper adjustment would make only a minor difference, probably an unnoticeable one. This is based on Advent's statement for its Model 100 Dolby unit that the expectation when calibrating is to come within 2 dB of correct level. However, different tapes may have outputs more than 2 dB apart, so that readjusting the tape machine for the particular tape to be used does become important. Accordingly, I have to advise you to acquire a cassette deck which has suitable calibration facilities for your use and does not require you to go to a service technician when you change tapes.

If you have a problem or question on tape recording, write to Mr. Herman Burstein at AUDIO, 401 N. Broad Street, Philadelphia, PA 19108. All letters are answered. Please enclose a stamped, self-addressed envelope.



There's more to the world's best tape than the world's best tape.

Our reputation for making the world's best tape is due in part to making the world's best cassettes.

In fact, we put more thought and more work into our cassettes than most manufacturers put into their tape.

We do all this, because at Maxell we believe in a simple philosophy.

To get great sound out of a cassette takes a lot more than just putting great tape into it.

maxell

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Video scenes

Bert Whyte

Projection TV continues to be one of the more controversial areas of the current video boom. While "bigger is better" has been a watchword in many aspects of consumer merchandising in this country, big-screen projection TV has been a slow-starter in the video marketplace. Some of the reasons cited for buyer resistance are that "the projection systems are too big and bulky," "the picture is big, but it's not sharp enough," "the picture isn't bright enough," and "the projection systems are much too expensive." One could be very cynical and state that if John Q. Public had the money to afford a system, the other objections would miraculously disappear.

Cynicism aside, there are many people who feel that their objections are well-founded. The desirability of big-screen projection TV is self-evident to most people. The question is can they get a system which they feel will satisfy the criteria most important to them? I think it pertinent to define what I mean by "big-screen projection TV." My reference is to units like the Advent Videobeam models, the Sony 60- and 72-in. systems, the Panasonic/Quasar 60-in. models, the GE Wide Screen 1000, and the forthcoming Henry Kloss Novabeam. I most definitely do not mean the "gimcrackery" systems which comprise some sort of lens and mirror assembly kit which purport to turn your TV set into a projection system. Most of these are notorious for their low brightness levels and poor picture resolution, and they probably have turned more people off projection TV than anything else.

Projection TV is a highly specialized product, appealing (at least at present) to a restricted specialized market. It is not a casual product for the average TV dealer. The systems must be set up precisely and demonstrated properly. The idea is to educate, not intimidate, and I regret to say that such enlightened selling is the exception rather than the rule.

Of all the objections to projection TV systems, their sheer size and bulk apparently are the major reasons why people develop sales resistance. Depending on the size and layout of the available rooms in their homes, when they find they may have to devote a room or a major portion of a room to accommodate a projection TV system, many consumers' enthusiasm for big-screen TV is considerably dampened. Of course, there is the other side of the coin, where in many homes the den or playroom is used principally for TV viewing, so the transition to projection TV is relatively painless. Nonetheless, in either case, size is a definite factor governing the purchase of a projection TV system. At this point, General Electric Co. enters the picture.

General Electric has been in the industrial area of large-screen projection TV for a long time. In fact, if any of those Texas oil barons or Saudi sheiks want to live it up a bit, for a mere $50 or $60 thousand, they can get a GE Eidophor projection TV system with an 8- by 10-ft. screen (!) with picture quality that will "blow their mind." For impoverished mortals like us, GE has come up with a very clever projection TV system they call the Wide Screen 1000 Home Television Theatre.

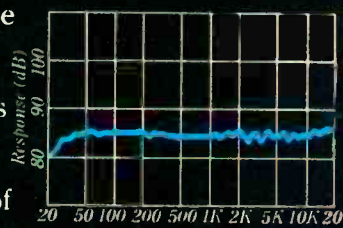
GE designates this model Wide Screen 1000 because the total screen area is 1000 square inches. The screen is 45 inches measured diagonally. Now, there have been some snide remarks that at 45 inches this is only a Mickey Mouse type of big-screen TV, but you can look at this two ways. It's only 5 inches less than the standard screens offered by Sony and Panasonic/Quasar, or it's 20 inches more than the biggest tube size (25") on the market. But, in any case, 1000 square inches is a helluva big picture! The Model 1000 is an imposing piece of equipment, almost 70 inches wide and standing 49.5 inches high. However, it is designed so that the screen area is 47 inches wide, then the cabinet drops 26 inches and becomes a 22.7-inch platform made to accommodate a video cassette recorder. Most importantly, the total depth of the Model 1000 is 24.4 inches, and you must understand that this is a totally self-contained system. The screen is *not* a separate item, placed above the projector unit, but is within the furniture cabinet structure and at eye level when seated. Furthermore, unlike the curved screens of other projection systems, the Model 1000 employs a flat picture screen.

The reason why a flat screen can be

ACCURACY. JBL LAYS IT ON THE LINE.

Why do so many stars and studios use JBLs? And more discos* than any other speaker?

Accuracy is the answer. The music as performed. That's the sound the pros insist on. No wonder 7 of the 10 top albums in 1978 were recorded, mixed or mastered on JBLs.**



On-axis frequency response, L212 system.

And that's the sound we demand in every speaker in our line. JBL speakers are designed to match the music as played. Clear and lifelike.

We can state this with some pride since we create our speakers from the ground up. Concept, design, individual components—all are created at our plant and tested against stringent engineering specifications. Rigorous quality control is applied every step of the way.

We could go into more technical detail but we want to keep our message short and sweet. The reason so many stars, studios and professional installations prefer our speakers is JBL accuracy. Their living depends on how good they sound. So if you question your own ears, trust theirs.

James B. Lansing Sound, Inc., 8500 Balboa Boulevard, Northridge, CA 91329.

JBL

FIRST WITH THE PROS.

*Billboard Disco Survey, 1978.
**Recording Institute of America Survey.

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Sound has color. All kinds of wild and way-out and wonderful color.

That's why Sony is introducing audio tape with Full Color Sound.

To reproduce every shade, every tone, every tint of color that's in the sound itself.

Sony tape with Full Color Sound has such a full frequency spectrum it can actually record more sound than you can hear.

If your tape recordings don't sound the way this ad looks, switch to Sony audio tape. And be up to your ears in bright brilliant beautiful color.

Sony Tape.
Full Color Sound.

used, and why the system can be integrated within the cabinet, is that the Model 1000 is a *rear* projection device. Underneath the VCR platform, actually at right angle to the picture screen, a single-gun color picture tube furnishes the TV image, which, through a complex series of mirrors, is finally projected on the rear of the plastic viewing screen. This screen is akin to a Fresnel flat-lens system, which has the capacity of increasing brightness. The single-gun picture tube avoids the color convergence problems associated with three-gun tubes, which naturally would cause alignment anomalies with the mirror system.

With our present 525 lines-to-the-inch TV system, even with the most perfectly tuned closed-circuit system, picture resolution leaves something to be desired. On most big-screen projection systems, picture resolution is inevitably degraded. Further, every big-screen picture I have seen up to now suffers in varying degrees from a cyan (blue/green) cast overlaying the picture. This should be correctable; a color tint control should in essence introduce more red into the signal, and, since red is the complement of cyan, the cast should disappear. Whatever the case, either those demonstrating the particular projection TV are not bothered, are not really aware of the cyan cast, or they don't know how to make the tonal correction. All this is leading up to the fact that the Model 1000 does not suffer from this malady. The picture resolution and screen brightness are the best I have seen on any big-screen projection system thus far. Like all projection TV systems, maximum brightness is obtained when viewing the picture directly on axis. Even slightly angled viewing causes a rapid fall-off in brightness. Another point in favor of the Model 1000 flat screen is the even distribution of brightness and picture resolution over the entire screen area, a good deal better than with other systems.

The Model 1000 uses digital circuitry for push button electronic tuning of channels. There are controls on the set and a hand-held remote control (of the high-frequency sonic signal/sensor type) which works on both UHF and VHF services and can turn the Model 1000 on and off, adjust volume levels, and activate a muting switch. There are push buttons numbered one through nine, and a zero, and another push button designated as "enter." In use, the desired channel number is selected, then the "enter" button is pushed to activate the channel change. The channel selected is displayed on an illuminated digital readout. When another channel is selected, a tiny red indicator dot lights up, showing the sensor received a change command. Because of the electronic tuning, it is possible to go directly from one channel to another, i.e. "2" to "11," rather than through all successive channels as is the case with rotary mechanical tuners. On the control panel on the set are rotary controls for brightness, contrast, sharpness, and an off and on switch for VIR (vertical interval reference). There are *two* sets of color (intensity) and tint (hue) controls. One set is for standard manual adjustment; the other is for use when the VIR switch is on, and the VIR signal is being broadcast as indicated by a red signal light. The VIR feature is of help in maintaining correct color balance from scene to scene and from channel to channel, but I can get the most accurate color balance when I use the manual controls.

The Model 1000 is a nice-looking piece of furniture of fine walnut veneers, with contrasting beige-colored suede VCR platform and control panel fascia in the same material. The optimum viewing distance is about 12 to 14 feet from the screen and, as noted previously, directly on axis. The impact of such a large bright picture with well-saturated colors, good clean whites, and good contrast ratio is dramatic. All kinds of programs benefit from the big screen but, needless to say, football, baseball, and all other sports furnish a greater sense of action and become much more exciting.

Refinements I would like to see on a "Mark Two" model? I'm old-fashioned enough to want the facility of fine tuning each channel. It is an automatic function now, and I must confess there are no picture anomalies, no vertical rolling, etc., but I want to see if I can beat the automatic control and get an even better picture! The remote control is great, but it should be made full function, capable of changing color and tint and brightness and contrast. As you can imagine, the VCR platform invites you to do the obvious: Mate this big-screen projection TV unit with a good video cassette recorder. At a list price of $2,895.00, the Model 1000 is the least expensive of what I choose to call the "legitimate" projection TV systems. Evidently a lot of people are as impressed with the Model 1000 as I am, since over 30,000 have been sold — far more than any other system. After months of use, the delights of big-screen TV haven't palled on me, and so far this unit has proved to be utterly reliable.

Technics RS-M85 MK2 with metal tape. We pushed performance to a new high. But kept the old price.*

Last year you could get the precision of direct drive and the unparalleled accuracy of quartz with Technics RS-M85. The cassette deck *Audio* magazine (June '79) said "had the best tape speed characteristics ever measured in a cassette deck." This year you can get that same accuracy with the RS-M85 MK2. Along with the additional benefits of metal tape. Yet we didn't add a cent to the price.

What we did add is more dynamic range, a wider frequency response and sendust-formulation heads that easily handle the difficult jobs of recording and erasing metal tape.

One more difficult job the RS-M85 MK2 easily handles is keeping wow and flutter down to a microscopic 0.035% while maintaining excellent speed accuracy. But that's not surprising. At least not with Technics quartz-locked direct drive. This servo system compares the rotation of our direct-drive motor with the unwavering frequency of a quartz oscillator, and instantly applies corrective torque whenever the slightest speed deviation is detected.

Another one of the RS-M85 MK2's bright spots is its two-colored fluorescent (FL) bar-graph meters. A device attack time of just 5 millionths of a second proves they're fast. While no more than 0.1dB deviation from the 0 VU level proves they're accurate. And that's proof enough.

Still, the RS-M85 MK2 has even more: Like a separate, coreless DC motor for reel drive. Dolby† NR. A low-noise, highly linear amplifier section. Full IC logic controls. A 3-position bias/EQ selector with bias fine adjustment. And an optional full-function infrared, wireless remote control (RP-070).

Technics RS-M85 MK2. We pushed the performance up. Not the price.

FREQ. RESP. (Metal): 20-20,000 Hz. WOW AND FLUTTER: 0.035% WRMS. S/N RATIO (Dolby in): 69 dB. SPEED DEVIATION: No more than 0.3%.

*Based on Technics recommended price for RS-M85 and RS-M85 MK2.
†Dolby is a trademark of Dolby Laboratories.

Technics
Professional Series

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Audio etc.

Edward Tatnall Canby

1980! There's nothing like another round-number year to make us think back into the deciPast, and all those amazing things that have happened in those brief units we call decades. That is, those of us who are equipped with a deciPast. And to heck with you kiddies who don't even have a dP yet. So to herald 1980, I am going back 6 dP and more, before I turn again resolutely forward into the great Future of audio.

6 dP. Yeah. I recently had to throw out an old empty cardboard shaker can for cleanser, bright metallic green, which had on its side in large letters *NEW 1950 BAB-O!* Every year it got to look sillier. *Ou sont les cleansers d'enten?* Down the drain, where else. Where are the hi-fis of yesteryear? Up in my attic. One of our ex-*offici* named Charlie recently asked to explore my attic for possible antiques; I said no. Wait awhile, for a better deciPast. In 1940 I remember worrying about what to call the new car models; my family had a '39 and it seemed funny to speak of a Forty-Ford. Don't remember a thing at the moment about 1960, and nothing of any great importance about 1970, but 1930 was the Winter of the Great Depression and we bought a Thirty-Ford right in the middle of it. That was the "A" I sold when it had run up a mere 0.5 dP. Now I know better. I could have me around $14,000 for it. So I guess I'll preserve my attic hi-fi. Come see me around 2001, Charlie.

One does indeed eventually get to know better my kind of enquiring mind, if by hook and crook and mini-increments. I am frankly shocked (NOW we get to the point) by my own writing in this magazine some dPs ago. I fear it just wouldn't do today. I had thought I might rerun a few superbly classic early Canby columns, just as an historical comment on our brief audio span of years; when I got back there — no thanks! Not a chance. I had some right ideas, all right. But I wouldn't want you to read the way I talked about them. Makes me cringe to read the stuff. Famous last words.

After three long years (beginning with issue No. 7 of *Audio Engineering*, November of 1947) in the infinity of my new wisdom I wrote, for instance, two columns entitled "How I Fell into Audio." That heading so amused our audio fraternity that most of them never got beyond the title itself to read the articles. For months people kept greeting me with fatuous remarks, such as, "Hi ETC, still falling?" Yes, I was. And still am. Even so, I have managed occasionally to fall first, in my mildly crackpot way, at least in print. Who the heck was writing obscurely about the future belonging to digital, back quite a few years ago when you hadn't even thought about it? And who stumbled and fell all over Dolby — 1964? — right in this space, the very first who ever did, according to Ray Dolby himself?

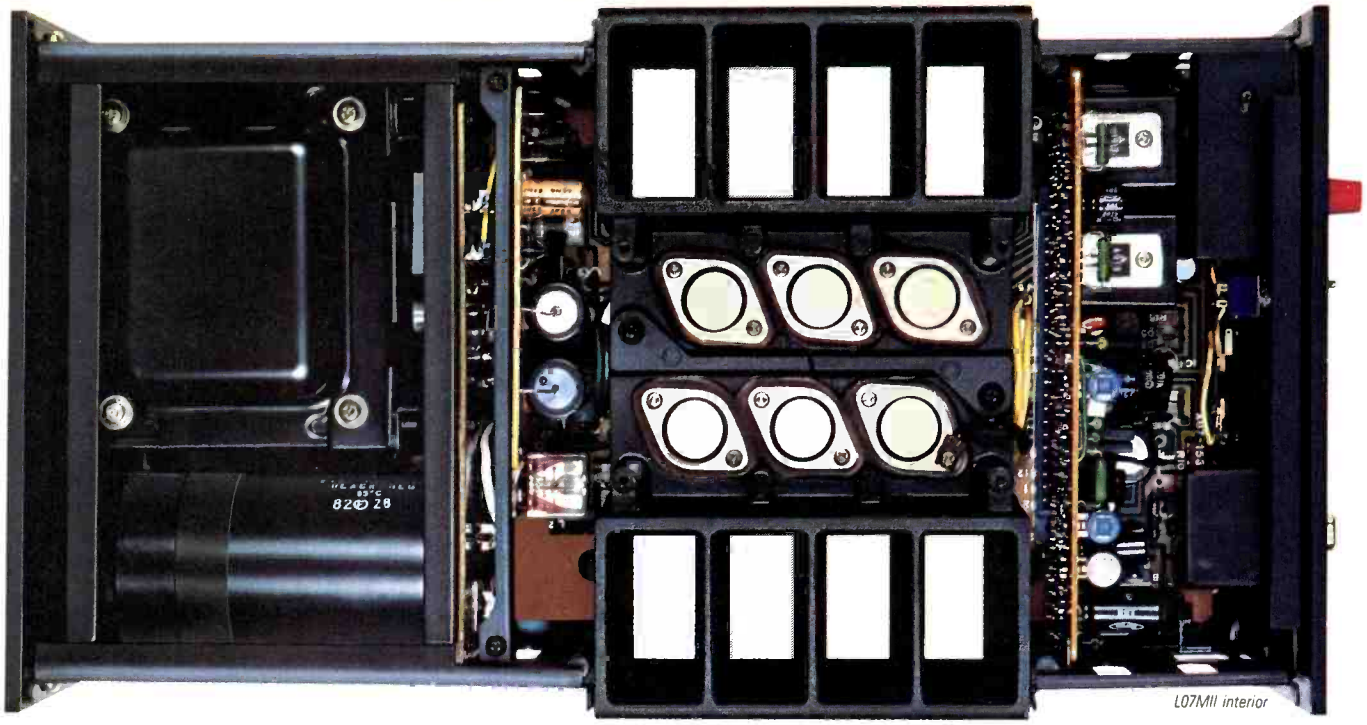
So my present task is to extract a bit of sense out of how I did indeed fall into audio, a music lover, musician, and non-engineer out of a very literary and unscientific family. It was no more then a microcosm of the way that our present and much larger world of audio and hi-fi began. As every older audio engineer knows, there was no such thing as audio, officially, until after WW II. Audio sort of fell together out of many parts and areas. Even our magazine was once called *Radio*.

The main business of this fallen-together audio, as I have often said, is music and has been since the turn of the century, in and among those earlier areas and in spite of billions of spoken words of one sort and another. The phenomenon that has put us on the map as a vast, refined industry of technological and artistic superlatives is simply the fact of *reproduced music*, contrasted with the earlier normal experience of music in the flesh, the only sort that had previously existed.

The slow discovery and unfolding of this new experience, music detached from its origin, music in hitherto unlikely places, music for anybody, anywhere, anytime, music at our personal command to start and to stop at will, is indeed the very history of audio—for without the musical aspect the rest would have been nothing much. No, I am not denigrating those areas where speech is important! Good job done, right along. But without the sound of music, audio would be pretty dull stuff, you'll have to admit. Even in broadcasting, where speech is of the essence. Not to mention commercial messages.

0.1 dP

My generation was the one that made the transition into this new world of music and we could not help it. We fell into it in spite of ourselves, pros and amateurs alike. We began when recorded music was Caruso singing *Over There* in WW I, plus a passel of tiny tidbits of opera and a lot of



L07MII interior

The Ultimate Amp. 0Hz to 600,000Hz (+0-3dB).

For the past several years, a special team of top Kenwood engineers have been re-inventing the amplifier using their most sophisticated innovations in circuit design.

This is the result: The L07MII Hi-Speed™ DC direct-drive amplifier system.

Our research determined that long speaker cables seriously degrade sound quality: Total harmonic distortion doubles, damping reduces by 40%, and there is discernible "ringing." In locating the amplifier close to the speaker by using a special 1-meter cable, THD and damping are not affected and "ringing" is eliminated.

L07MII rear

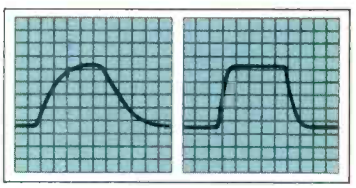
L07MII front

In fact, everything in this amplifier has been engineered to reproduce an input signal audibly free from distortion and coloration. And to achieve a frequency response previously unobtainable. Our DC amplifier improves ultra-low frequency phase shift and transient response. Even the pin plugs of the input cables and locking connectors are gold-plated to insure no signal loss.

HI-SPEED™

Even more remarkable is the inclusion of Kenwood's exclusive high speed circuitry. By allowing the amplifier to react faster to dynamic changes in the musical input, Hi-Speed produces a more accurate sound. This is especially critical in the mid-to-high frequency transients where conventional amplifiers lose their imaging and detail. The L07MII separates individual singers in a vocal group or individual string players in a symphony orchestra with equal ease.

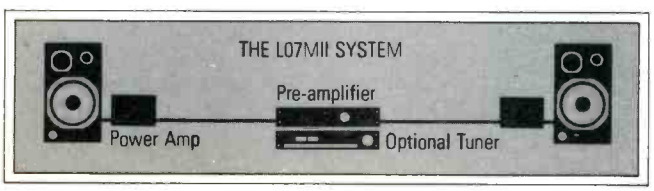
Of course, to appreciate the many design innovations requires much more space than is available here. Please write for full technical data at the address below. Or better yet, audition this remarkable amplifier system at a Kenwood Audio Purist Group dealer. If you have the ears to appreciate what the Kenwood engineers have accomplished, the L07MII system will take your breath away.



Typical "square" pulse waveform of conventional amplifier.

Pulse waveform of High-Speed amplifier.

Significant specifications: 150 watts one channel minimum power RMS at 8 ohms from 20 Hz to 20,000 Hz with no more than 0.007% total harmonic distortion. S/N 120dB. Rise time 0.55 μSec. Slew rate ± 170 V/μSec.



AUDIO PURIST GROUP

KENWOOD®

Not all Kenwood dealers carry these products. For the Audio Purist Group Dealer nearest you, write Kenwood, P.O. Box 6213, Carson, CA 90749.
In Canada: Magnasonic Canada, Ltd.

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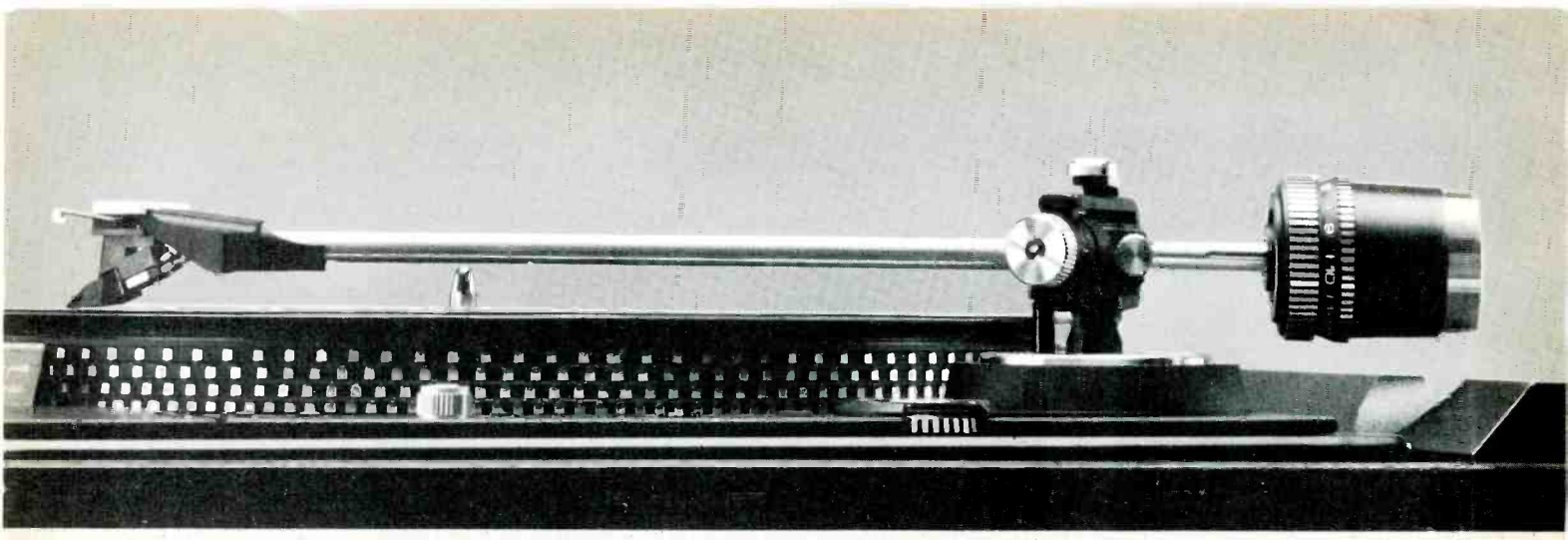
scratchy humor stuff, miraculously intelligible. When radio was something you had luck with if you "got" a few distant scrambled words here and there. I fell into this a bit early, perhaps, because I was more aware of what I heard than some others around me. But what happened to me, early on, was what happened to US, all of us, later and on a much grander scale. I could not avoid it; I mirrored audio and hi-fi in advance, aspect after aspect. I was of course blissfully unaware of this, at least until several dP ago when I wrote those "How I Fell" articles for the magazine.

The Year One for me, in this rewritten history (which will continue from time to time) was d— early. I must have been age six. I was given a toy phonograph as a pacifier. It was a big, circular "Victrola" (registered trademark, though at that time it applied to almost any piece of reproducing equipment). It was in orange enamel and with vertical slots around the sides to let the sound out. You'll find this model in all the history books and museums. Mommie gave me Mother Goose records from the Five and Ten, and I played Popular Favorites too. Yes, I knew the mechanism and could make it go all by myself, including windup when the sound began to droop. But I broke some of the records and scratched more, until one day Mommie got annoyed and said that if I kept on being a bad boy the Victrola might *play the wrong tune* for me, and wouldn't *that* be too bad.

Kids take things seriously. That threat had me in a state of terror for days. I was deathly afraid to put on a record, for fear of some ghastly sonic reprisal. Something HORRIBLE might come out. I screamed if I saw the machine. Finally, it had to be put high on a kitchen shelf out of my way, but the thought continued and so did the threat — all too effectively. I remember the feeling! I haven't ever forgiven Mommie for that ploy, because, you see, I had not the foggiest idea of what *reproduced music* meant. A Victrola was a thing that talked by itself, or made its own music. For years I called it just "Victrola music" without any idea that what I heard had an earlier and outside source in some living performance. Mommie was just playing tricks on me, out of her own continuing amazement that a mere machine could sound intelligent, right out loud. That was the general feeling.

What I find absolutely astonishing to this day is that ever since, and throughout the history of our present hi-fi sound, we have been moving steadily towards this very concept in all our musical audio. We know, of course, that there are often "live" performers behind a recording. But the sound we hear, and the sound we try for, is ever less and less "the original" and more and more a sound in itself, for itself, existing in its own terms. Curiously, that idea of "Victrola music" has shaped my entire writing life, as it has shaped the enormous software of audio sound.

From the age of six onwards I became schooled in what the artists (and the opera people) call *verismo* — factual realism. Don't we all? Pretty soon, I knew what every schoolboy knew, that Santa Claus might be a myth but Caruso was a big fat MAN who actually existed and ate large quantities of spaghetti. When he died, more or less in the middle of a performance, we kids made fun — we would let out portentous opera noises, then suddenly produce strangling gargles and fall flat on the ground, stone dead. So I knew! Everybody knew. It was the beginning of the people's awareness. And it led very shortly to big things including Amos & Andy, King George



All your records will sound better with Dual's new ULM tonearm and cartridge system.

Even if they look like this.

Although none of your records may be in such bad shape, many are probably warped enough to present serious problems to conventional turntables.

The high inertia of a typical tonearm and cartridge combination, with approximately 18 grams total effective mass, causes the stylus to dig in riding up the warp and to take off on the way down. Tracking angle and tracking force vary widely—as much as 30 percent. And a warp as small as 1.5mm (which is barely discernible) can generate harmonic distortion of 2.7 percent. That's audible!

These problems have now been solved by Dual's new Ultra Low Mass tonearm and cartridge system.

The potential for this solution has existed ever since the development of Dual's dynamically-balanced tonearm with its gyroscopic gimbal suspension and straight-line tubular design.

Dual's research into the effects of mass on record playback led to a collaboration with Ortofon. A cartridge was developed with substantially less mass than any in existence. It weighs just 2.5 grams, including mounting bracket and hardware.

At the same time, the mass of the Dual tonearm was further reduced so that a perfectly matched tonearm and cartridge system emerged. Its total effective mass is just 8 grams. That's less than half the mass of conventional tonearm and cartridge combinations.

Tracking a record with the same 1.5mm warp, the ULM system reduces harmonic distortion to only 0.01 percent. That's 270 times less than that produced by the conventional tonearm and cartridge.

Not only is the overall sound audibly improved, but stylus and record life are significantly extended.

To experience the demonstrable advantages of ULM, bring a badly warped record to your Dual dealer. Listen to it played with the ULM tonearm and cartridge. (All nine new Dual turntables feature this system.)

You will hear the difference that ULM can make on all your records.

For the complete ULM story, please write to United Audio directly.

ULM.

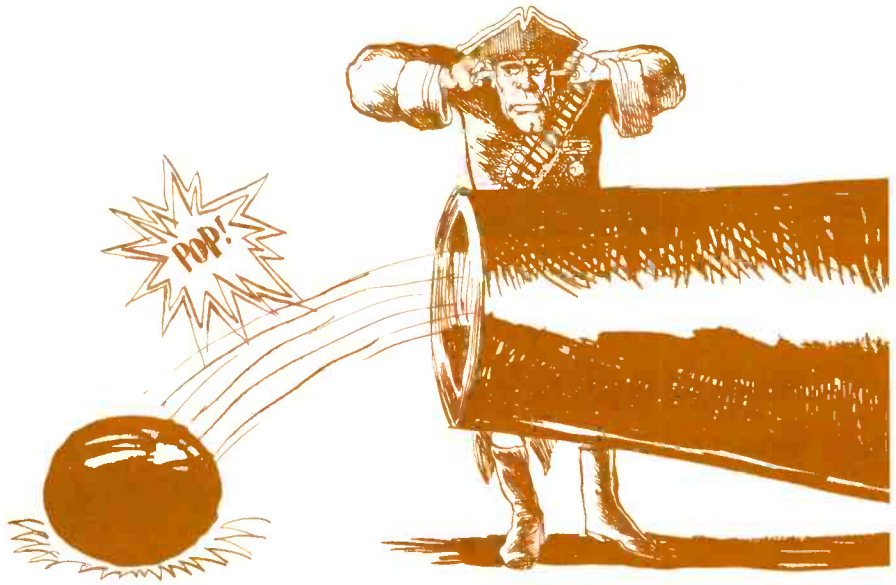
A major breakthrough in record playback technology.

Dual

United Audio
120 So. Columbus Avenue
Mt. Vernon, New York 10553.

Behind the scenes

Bert Whyte



It seems that dynamic range continues to be one of the most misunderstood aspects of modern recording among audiophiles and, unfortunately, among some technical types who should know better. In my column in the July issue of *Audio*, I explained that no matter whether a "super-duper" analog tape, direct-disc cutting or digital tape master was the source used to cut a standard analog lacquer, under absolutely ideal conditions the maximum dynamic range obtainable will be on the order of 62 to 64 dB.

Well, just to prove that not everybody reads my column (harrumph), in the past few weeks I have read a newsletter issued by a fairly prominent manufacturer of esoteric loudspeakers, wherein he touts several of his models as being able to cope with the "tremendous 90-dB dynamic range of the new direct-cut and digital discs." Then a few days later a well-known audio writer in a very famous newspaper goes on at length about the "90-dB dynamic range of the fabulous new digital discs." No wonder the audio consumer gets confused and, chock full of misinformation (and brist'ing with questions), descends on his hapless audio dealer. Let's try to get the record straight (pun intended) once more. No direct-cut disc, recorded by me or anybody else, has a dynamic range of 90 dB. Secondly, you can't play back a digital disc with 90-dB dynamic range, for the very simple reason that there are *no digital discs presently on the market!*

The only digital discs in existence are the experimental prototypes of the laser optical, mechanical, and capacitance types some of us have had the opportunity to hear at recent shows and conventions. At the present time, none of the competing digital discs has been accepted as a standard, and unfortunately it may be quite some time before this problem is resolved. What is on the record market, and beginning to appear in increasing numbers, is the digital/analog hybrid long-playing disc. This is the same 33⅓-rpm, PVC, microgroove disc we have been using for the past 29 years, except that the master lacquer was cut from a digitally recorded master tape. The fact that the digital master does indeed have a 90-dB dynamic range does not confer this range to the analog disc cut from this tape.

Who Needs It?

To many, it is pertinent to ask, why all this fuss about dynamic range and the apparent desirability of 90 dB of dynamic range? The obvious answer is that wide dynamic range is one of the major factors in the sense of realism of the concert-hall listening experience. In fact, the dynamic range of a full symphony orchestra does exceed 90 dB, but this is somewhat dependent on the dynamic scale of the work being performed. To understand the emotional impact of truly wide dynamic range listen to a Mahler symphony in a concert hall, with a triple pianissimo passage followed immediately by a triple fortissimo outburst from the full orchestra. The full weight of strings and woodwinds, the brazen blare of trumpets, trombones, tubas, French horns . . . the thunder of tympani and bass drums. This is to know the searing, ecstatic, quintessence of the glory of music! Who indeed would not strive to simulate this experience in the home listening situation?

All right, so among other factors in our quest for that elusive concert hall, realism in our home playback systems we agree that wide dynamic range is a high priority consideration. One of these days we will have a true digital disc with that vaunted 90 dB of dynamic range and, sad to say, few audiophiles will have equipment capable of accurate, high-quality playback of such recordings.

In fact, however, it is presently shocking quite a few audiophiles to find that their playback systems can't cope with the 64-dB dynamic range of the present digital/analog hybrid discs! A good case in point is the new Telarc recording of that old warhorse, Tchaikovsky's *1812 Overture*. As is now standard practice with Telarc, they used Dr. Tom Stockham's Soundstream digital recording system for mastering this recording. First, the actual music of the *1812* was recorded in the Cincinnati Music Hall, with the Cincinnati Symphony Orch. under the baton of conductor Erich Kunzel. Then the recording crew went to nearby Mariemont, Ohio, where they recorded the bells of the Emery Memorial Carillon. Finally, the crew traveled to Baldwin-Wallace College in Berea, Ohio, where the Fifth Virginia Regiment (an antique arms group) fired off 24 different charges from three different and authentic 19th century cannons which were recorded on the digital equipment. Shades of the old Mercury Records days when they recorded the ancient cannon at West Point for their *1812 Overture!*

At the Soundstream facility in Salt Lake, the three recordings were edited and a composite made of the music, plus carillon bells, and the requisite 16

THE PHASE 7000 SETS OPTIMUM BIAS/LEVEL/EQ AUTOMATICALLY.

LAB-TESTS EACH TAPE, INCLUDING METAL, AND STORES DATA IN MEMORY

The Phase 7000 is the cassette deck that can get the best out of every tape, because it has a microcomputer that works like a lab technician, testing each tape and making precise recording adjustments.

Every type of tape varies by manufacturer. So each tape needs a different bias, level and equalization setting to minimize distortion and flatten frequency response. Metal tape is so new that bias standards haven't even been set. So the ordinary 3-position bias controls can't possibly do it justice.

To make proper adjustments for recording, you'd have to put each tape through a lab test—the same test that's automatic in the Phase 7000!

MICROSCAN: A MICROCOMPUTER WITH 9 MEMORIES

MicroScan automatically determines optimum bias/level/EQ, and stores this data for 9 different types of tape in its memory. Like a technician, MicroScan applies a test tone to the tape, then varies the bias current over 64 possible steps. It then scans the tape in playback to determine optimum bias with an accuracy of ±0.2dB. It sets optimum level and EQ the same way. You get the most out of Metal, STD, CrO_2 and Fe-Cr tapes. *And it takes less than 45 seconds.*

Once MicroScan has determined the best settings, you can store this data in memory, ready for instant recall. No further scanning is necessary.

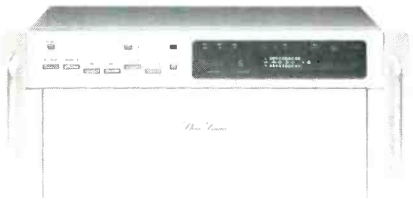
ADVANCED TAPE TRANSPORT SYSTEM

To avoid pitch variations, tape must travel at a constant speed. Most cassette decks have just one capstan, and a pressure roller to apply tension to the tape. But tape irregularities cause tension to vary in this system, increasing wow & flutter.

The Phase 7000 solves this problem with two direct drive capstans. The "drive" capstan and the "tension" capstan are looped, so they rotate at precisely the same speed. Tape slack is automatically eliminated before the dual pinch rollers engage. The tape is isolated between the two rollers, so it's free from external vibrations. This helps keep your music free from pitch variations. And it reduces modulation noise to extremely low levels.

The "drive" capstan's speed is regulated by a quartz-phase lock loop system that detects any speed variations, and instantly corrects them. Speed drift is less than 0.02%. *And wow & flutter drops to an amazingly low* −0.03% *WRMS.*

SPECTACULAR SPECS



The 7000 out-performs all other cassette decks, and rivals the best reel-to-reel. Signal/Noise with Dolby* on is −70dB. Double Dolby allows you to record with Dolby, while monitoring it with Dolby. The 3-head system with Uni-Crystal Ferrite heads achieves a frequency response of 20Hz-20kHz, −20dB with metal tape. The fluorescent meter gives you 24-segment resolution for easy readings from −30dB to +8dB.

If you like the look of these numbers, wait until you hear how they sound. Contact your Phase Linear audio dealer for a convincing demonstration.

Phase Linear®

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*Dolby is a trademark of Dolby Laboratories, Inc.

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cannon shots in the spectacular finale. There was no doubt that the digital master had a faithful recording of the stupendous energy of the cannon shots. Then it was up to Stan Ricker at the JVC Cutting Center in Los Angeles to transfer the digital master to an analog lacquer. If you look at the record, between the label and the run-out groove, you will see inscribed "A-11," meaning that even a cutting engineer as superbly skilled as Stan Ricker required 11 attempts to produce a satisfactory master lacquer. You can hold the disc of the *1812* at arm's length and easily discern the almost right-angle contortions of the grooves containing the cannon shots. It is a tribute to Stan's skill that close examination reveals grooves so close together there is almost no land visible, yet he didn't overcut. The groove velocity and the low-frequency energy of the cannon shots, centered around 30 Hz, are simply tremendous.

Needless to say, the first question that comes to mind when confronted by this recording is can the cannon shots be tracked? Well, I can tell you that distress flags are flying everywhere, and audiophiles are keeping telephone lines to phono cartridge manufacturers buzzing with their tales of woe. I have tried quite a number of arm/cartridge combinations and can tell you that most cartridges, including some very fancy types, just can't hack it. In many instances, the arm just violently jumps out of the groove! What did work? The combination of the Technics EPA-100 arm and the Shure V-15 Type Four, utilizing its brush and viscous damping system, at a tracking force of two grams, reproduced the violent transients without distress. The unlikely combination of an old Pickering 4500 CD-4 cartridge and the arm on the superb new JVC Professional QL-10 turntable also tracked the shots, albeit at a somewhat elevated tracking force of 2.25 grams.

64-dB Silence

Let us continue this dynamic tale (ouch!). So you have the record and a Shure Type Four, and now you're ready to start your barrage. Hah! Once again you are going to find out about 64 dB of dynamic range, in very practical terms. You know every note of the *1812*, so in the early quieter sections you set your volume level so that pianissimos are just audible above the ambient level of your listening room. The music unfolds, the drama builds, and finally the French are charging to the brave fanfares of the *Marseillaise*, and the defenders of Moscow are about to put their slow-match to the touch holes of their cannon, and . . . . and instead of a mighty WHUMP! from your loudspeaker, there is a deafening SILENCE! What happened? Well, if you were lucky, dear friend, you just blew the protective fuses (or circuit breaker) on your speaker system. If your speaker system wasn't fused, you may have a woofer that sustained a direct hit. Nothing daunted, you figure you'll turn down your volume level to the point where the cannon shots won't blow your fuses. Well, that is smart, but now if you play the *1812* from the beginning much of it is at too low a level and out of dynamic proportion.

So your playback system has been zapped by 64 dB of dynamic range. Consider this: When the real digital discs do come, whether they be of the laser/optical type or whatever, there will be no tracking difficulties (when everything is working properly) and the disc will furnish you with the 90 dB of dynamic range you've been looking forward to so eagerly.

Sarcasm aside, do I seem to be advocating either an abandonment of digital audio or a restriction of dynamic range? Certainly not me, friends. I can track the cannon shots, Mark Levinson's ML-3 amplifier has the voltage pulse and great current capabilities to reproduce the cannon without clipping, and Bob Fulton's Premiere speakers simply mirror the visceral punch of the cannon shots. However, it must be noted that some highly respected engineers, directly connected with digital recording technology, have been thinking out loud that for the domestic listening situation, some sort of restriction of dynamic range on the digital disc may become necessary. This is as much a consideration of the next door neighbor as it is of the manufacturers of audiophile equipment, especially loudspeaker manufacturers, who will need to produce a new generation of playback equipment to cope with the dynamic demands of digital discs. In a future column, I will report on some conversations (and a visit or two) I've had with some loudspeaker manufacturers on this subject. In the meanwhile, keep your powder dry!

Addendum

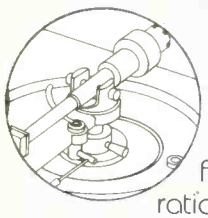
At the SCES I finally heard a demonstration of the British Ambisonic Surround Sound System, which uses the Calrec Soundfield microphone, and I was quite impressed with it. I had promised more on this, but inasmuch as I have been offered the use of this system, I will be making appropriate recordings and will then bring you a first-hand report.

Introducing the ADC 1700DD turntable. The quality begins with the tonearm...

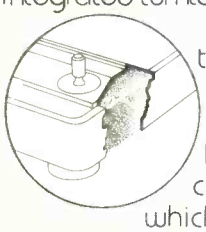
...and keeps on going.

The tonearm you'll find on the ADC 1700DD reduces mass and resonance to new lows. So the music you hear comes out pure and clean.

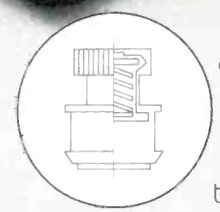
Our engineers have combined the latest advancements of audio technology to create the amazing 1700DD, the first low mass, low resonance turntable.



The famous UMF carbon fibre tonearm was the model for the sleek black anodized aluminum tonearm found on the ADC 1700DD. The headshell is molded carbon fibre, long known for its low mass to high tensile strength ratio. The viscous cueing is a gentle 4mm/sec., and the tempered spring anti-skate adjustment is infinitely variable to 3.5 grams. The pivot system uses stainless steel instrument bearings, which are hand-picked and perfectly matched to both the outer and inner races for virtually frictionless movement. All this makes it the best tonearm found on an integrated turntable.

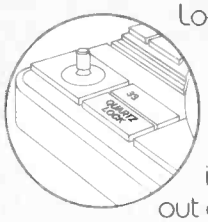


The base on the ADC 1700DD turntable is constructed of a highly dense structural foam which absorbs and neutralizes resonance and feedback. The speed selection control is an electronic microswitch which will respond to your lightest touch.



Supporting this resonance-cancelling base are energy absorbing, resonance-tuned rubber suspension feet. These suspension feet help to stabilize the base while controlling resonance.

The motor in the ADC 1700DD is also present standard of excellence: Direct Drive Quartz Phase-Locked Loop. A quartz crystal is used in the reference oscillator of the motor. An electronic phase comparator constantly monitors any variance in the speed, making instantaneous corrections. Even when out of the Quartz-Locked mode, the optical scanning system keeps drift at below 0.2%. Wow and flutter are less than .03%. Rumble is an incredible -70dB Din B.



The result of all these breakthroughs is pure, uninterrupted enjoyment.

We invite you to a demonstration of this and the other remarkable ADC turntables at your nearest franchised dealer.

Or write for further information to: ADC Professional Products, a division of BSR Consumer Products Group, Route 303, Blauvelt, N.Y. 10913. Distributed in Canada by BSR (Canada) Ltd., Ontario.

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A BSR Company

ADC. We build breakthroughs.

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Audioclinic

Joseph Giovanelli

Electrostatic Speakers and Amplifiers

Q. Do electrostatic tweeters require a special type of amplifier? —Name withheld.

A. Electrostatic tweeters may or may not require special amplifiers. This depends on the equipment included with the tweeter. Some tweeters — at least one type — can be purchased as nothing more than the diaphragm and the two fixed plates. Such a tweeter operates at very high impedance and requires an external polarizing voltage. Both the polarizing voltage and audio were often derived from a direct connection to the output stage.

The more common electrostatic tweeter is equipped with internal polarizing power supply and a step-up transformer. This transformer generates the high voltage needed to drive the tweeter. Such units are connected to the amplifier in the same manner as a conventional woofer or tweeter.

The major problem with this latter type of tweeter is that it presents a high capacitance load to the power amplifier. This load can cause either or both of two reactions: The amplifier can become unstable and break into oscillation, or the high-frequency response can become impaired because of the shunting action of such a high value of capacitance.

When buying an amplifier suitable for use with such electrostatic tweeters, or full-range electrostatic speakers for that matter, be sure to select one designed to remain stable when used with high capacitive loads.

Controlling Extension Speakers

Q. I would like your comments on the design of an on/off switching circuit, determining proper load to be put in the line when one speaker in a main/remote system is off, a recommended type of cable from the amplifier to the speaker and controls, and the selection of volume controls. — Arthur P. Darrow, Troy, N.Y.

A. As far as controlling the volume of individual speakers is concerned, I recommend the use of L or T pads at each speaker. These pads will serve to turn the speakers off — merely by turning the pad down all the way. This eliminates the need for special on/off switching. Of course, by using the pad in this way, you will draw power from the amplifier because the pad is across the circuit.

As far as the kind of cable to use, this is a matter of the length of the run between speaker and amplifier. Some of the speaker wire I've seen should never be used at all. This is often 22-gauge or smaller wire, and it is never suitable for high-fidelity installations. For fairly short runs, I recommend No. 18-gauge wire. If the run is greater than 15 ft. or so, use No. 16-gauge line. If the run is more than perhaps 40 ft., I would suggest No. 14-gauge line. For really long runs and where the wiring is put into the wall, then I would suggest that you use No. 12 wire, perhaps in the form of BX or romex cable. You should use electrical outlet boxes at each end of such an installation so that you can feed the speakers with more flexible cable.

Reducing Bass Leakage

I live in a high-rise apartment complex, with neighbors on all four sides. To keep bass vibrations from annoying them, I placed my loudspeakers on 12-in. thick styrofoam boxes in which frozen meats were shipped. They appear to be doing the job, for I have received no complaints.—Merritt E. Tilley, III, Syracuse, N.Y.

"Pops" Revisited

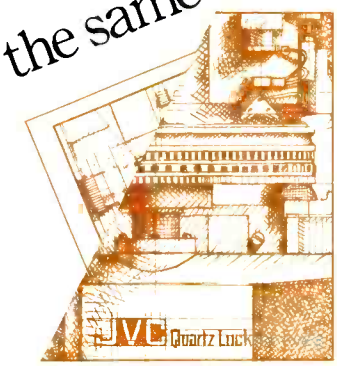
I am writing about a letter in your November, 1976 column from Mr. Krehbiel who expressed concern about a "popping" noise in his component system. I have had this problem from two sources and have solved them both.

One was a "popping" resulting from other circuits in the house being turned on, i.e., the furnace and the refrigerator. A 0.01 μF, 600-volt d.c. capacitor across the circuit of the motors or thermostats of these units worked well to eliminate that problem.

Static discharges occurred in my system regularly, but only on "phono." This was corrected by the use of a room humidifier. —Greg Herring, Toronto, Ontario, Canada.

If you have a problem or question about audio, write to Mr. Joseph Giovanelli at AUDIO Magazine, 401 North Broad Street, Philadelphia, PA 19108. All letters are answered. Please enclose a stamped, self-addressed envelope.

The best records you own were probably cut on our Mastering System. Now you can get the turntable and cartridge designed by the same engineers.



Reason discs from labels like Telarc and Mobile Fidelity sound good is also the reason JVC's finest limited production turntable and cartridge are showing up in prestigious salons alongside Winn, Linn-Sondek, Denon and Coetsu: JVC research.

The JVC Lathe Drive. At our Cutting Center in California, we discovered that even in a state-of-the-art mastering lathe, such as the Neumann, its turntable revolution is slowed slightly when cutting deep grooves, an effect considerably magnified by the demands of digital masters and half-speed mastering.

This hesitation of even the massive Neumann platter—and the resulting wow—were corrected with a JVC logic-controlled DC drive motor which assesses its rotational speed five thousand times per second, and then compensates instantly.

The JVC Turntable Drive. The same rotational drag is again encountered in playback of heavily-modulated grooves. While *no belt drive* is capable of compensation, the Phase Comparator logic system in the QL-10 virtually eliminates these instantaneous pitch variations and the audible textural colorations which result, while still allowing variable pitch in 1Hz increments *without defeating* the quartz monitoring circuitry.

The JVC Cutting Stylus. To complement our lathe drive system, we developed a special cutting stylus made from solid diamond, a first in the industry. The stylus has an extremely sharp cutting point (one micron radius) with highly polished facets. The result is extended high frequency response, better definition and reduction in distortion and surface noise.

The JVC Cartridge. The MC-1 moving coil cartridge brings an equally fresh approach to playback. Instead of a cumbersome coil, the MC-1 employs a tiny "printed circuit" weighing less than 1/100th of a typical wound inductor, enabling it to be placed considerably *ahead* of the pivot, just millimeters from the diamond Shibata stylus.

Reductions in cantilever whipping, ringing, resonances and crosstalk have led us to the conclusion that the MC-1 is simply capable of extracting more music from well-cut grooves.

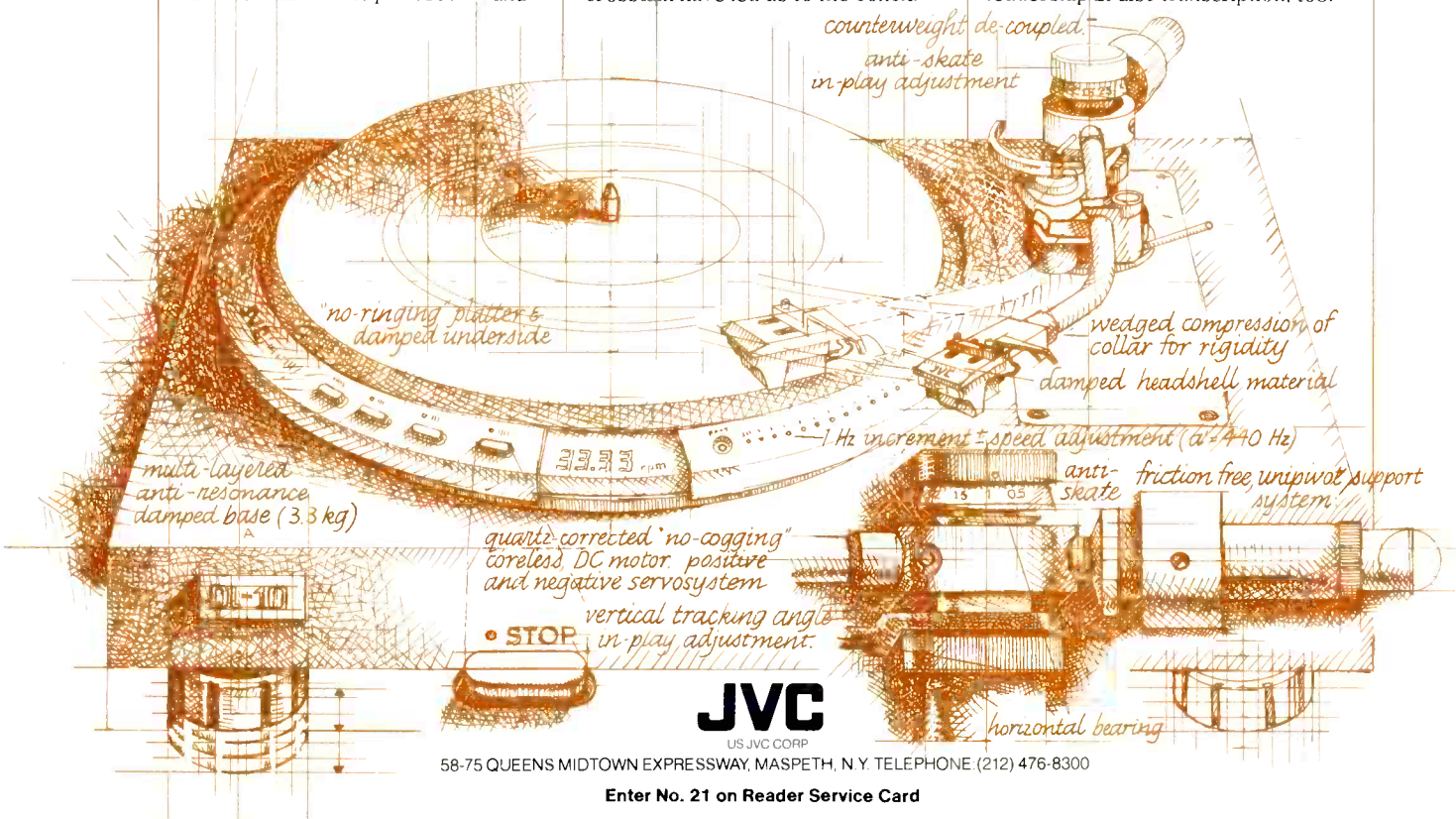
The JVC Laboratory. Only a company with a research facility large enough to undertake the redevelopment of mastering technology could have undertaken such a dramatic rethinking and execution of disc playback technology as well.

Yet, our size is so *inversely proportional* to the number of QL-10's we can laboratory fabricate that it may very well be the *rarest* production turntable on the market. A "spare-no-expense" indulgence enabled by our sheer size!

The Selected JVC Dealer. We invite you to audition the QL-10 and MC-1 alongside the best turntables and cartridges in the world. While subjective comparisons are inappropriate for us, *you* are free to test our somewhat bold assertions at selected audio salons across the U.S.

If you feel you'd appreciate such a comparison—and the price hand-built technology demands—call us for the location of your nearest JVC Professional Audio Representative.

Then call or write Vic Pacor, Pro Audio Sales Manager, who is personally interested to hear how you feel about our assertion that being the undisputed leaders in mastering technology will ensure our future leadership in disc transcription, too.



JVC

US JVC CORP

58-75 QUEENS MIDTOWN EXPRESSWAY, MASPETH, N.Y. TELEPHONE (212) 476-8300

Enter No. 21 on Reader Service Card

what's new

Sansui Tun

Model TU-
tuner that inclu
tuning as well
Through the use
reference oscillator,
try automatically lock
station. A station will s
even if the tuning knob is
bumped because of patented
recting circuitry. Distortion is s
at 0.03 percent in mono and 0.0
cent in stereo, with S/N at 86 dB
capture ratio at 0.8 dB. The unit's IH
sensitivity is 1.5 μV. Price: $585.00.

Enter No. 101 on Reader Service Card

Audio Electronic Systems Loudspeaker

Model AES 50T is a floor-standing, three-way air suspension system weighing 100 lbs. It features four speakers: a 12-in. woofer, two 2-in. soft dome midranges, and a 1-in. soft dome tweeter. Stated nominal impedance is 4 ohms, recommended amp power is from 50 to 125 W rms, frequency response is from 25 Hz to 20 kHz, and crossovers are at 600 Hz and 2 kHz. Price: $399.00.

Enter No. 100 on Reader Service Card

Hegeman Preamp/Control Unit

Model HAPI Two, for relay rack mounting, uses op-amp techniques with flat gain and passive equalization to assure equal time delay from all elements in the musical spectrum. In the preamp section, gain and transient response are controlled over a spectrum 10 times the nominal bandwidth of 20 Hz to 20 kHz. The control section includes selection of three high-level inputs, gain and balance controls, and mode selection for either channel. Also provided are tape monitor, loudness compensation, rumble filter, and time delay. Price: $900.00.

Enter No. 102 on Reader Service Card

Custom Audio Electronics Gooseneck Lamps

Littlites illuminate audio components and control panels in dimly lit areas. Offered with a black finish in 6-, 12-, and 18-inch lengths, the lamps have bayonet-type bulbs and 360-degree swivel bases (detachable for storage). Various mounting brackets, power supplies, and dimmer controls are available. Prices: $15.30 to $19.65, plus accessories.

Enter No. 103 on Reader Service Card

Koss
Digital Delay System

Model K/4DS utilizes a patented single-circuit conversion unit capable of storing nearly 17,000 bits of information. Switchable settings allow the user to recreate the ambience of a small club, theater, concert hall, or auditorium. An EQ switch for signal balance and an isolated stereophone function with twin jacks and stereophone amps are also included. Price: $500.00, with 15-watt/channel amplifier.

Enter No. 104 on Reader Service Card

Polk Audio
Loudspeaker System

Model R.T.A. (Real-Time Array) 12 was designed to create an acoustic transducer system capable of recreating live musical experiences in listening rooms at 120-dB levels and above. It is a three-way system with a computer-derived fourth-order electrical filter network between the two bass midrange drivers and the moving-coil soft dome tweeter. A fourth-order acoustic crossover is between the bass midrange drivers and the molded foam subwoofer. Impedance is specified at 6 ohms with a frequency response of 27 Hz to 20.5 kHz, ±2dB. Recommended amplifier power is 10 to 500 watts/channel. Price: $374.95.

Enter No. 105 on Reader Service Card

Bang & Olufsen
Cassette Recorder

The Beocord 1900, a compact cassette deck with two heads, accepts metal-particle tape. The cassette tray is located on the top of the unit, and touch controls and push buttons have been placed on an angled front panel for easy access. Microphone input and channel balance controls are housed beneath a sliding panel adjacent to the main controls; additional features include illuminated VU meters and a tape counter. Specified frequency response is 30 Hz to 15 kHz, with wow and flutter at 0.15 percent W rms. Price: $495.00.

Enter No. 106 on Reader Service Card

Dear editor

Of the Listener, By the Listener, And For the Listener

Dear Editor:

I have read with interest Lawrence D. Swift's letter in Forum on p. 6 of the May, 1979, issue of *Audio* and Curtiss R. Schafer's Letter to the Editor in the July, 1979, issue. Being a DX-er (one who listens to distant radio signals) of both medium-wave (AM broadcast band) and short-wave signals, I would like to give my view on the matters.

Regarding the AM clear-channel proposal, while the FCC proposal does not strike me as deliberate jamming of Canadian and Mexican medium-wave signals, it will act to severely clutter up the band and cause problems for both those who DX and those who regularly listen to clear-channel stations.

Mr. Swift gave the example of station WWL interfering with WKAR. Up here in Calgary, the same thing happens. CHRB, a 10,000-watt station in High River, Alberta, is interfered with by KTLK, a 5,000-watt station in Denver, Colorado.

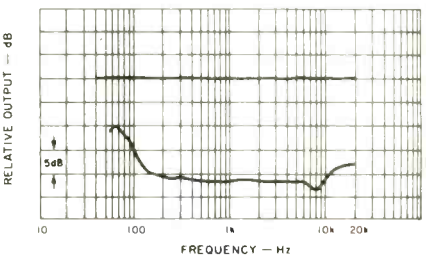
Medium-wave signals are also capable of crossing oceans. Europe and Africa can be heard, as well as Australia and New Zealand, when conditions are right. Some countries operate external radio services to neighboring countries on medium wave, such as Britain's BBC and All India Radio. Trans World Radio operates a 500,000-watt station on Bonaire in the Netherlands Antilles. Their signal coverage extends up the East Coast of the U.S. into Canada, and far into South America. Radio Nacional of Venezuela has acquired a million-watt medium-wave transmitter and plans to use it for international broadcast in several languages. It should have no trouble getting into the U.S. and parts of Canada if its frequency is clear. Thus, I am opposed to the FCC proposal as it would cause severe congestion of the medium-wave broadcast band and would also cause reception problems for listeners in neighboring countries.

As for short wave, I have experienced interference as described by Mr. Schafer. While I don't have a directional antenna and don't know the origin of the interference, stations interfered with include Radio Tirana (Albania), All India Radio, and Voice of Vietnam. This is undesirable, making reception very difficult not only in the countries where the signals are being jammed but also in areas many miles away. Such practices should be stopped since it is the listener who should decide if he wants to hear these broadcasts or not.

William Dang
Calgary, Alberta
Canada

Errata

In the "Equipment Profile" of the Ortofon MC-30 moving-coil cartridge in the November issue, Fig. 2 was incorrect. Herewith, the correct chart, showing left-channel frequency response and separation of the MC-30:



The following photograph is of the Bauman Research Pro-400 stereo preamplifier, reviewed in the November issue:

For the "Workbench Profile" of the Crown RTA-2 real-time analyzer, also in the November issue, the captions for Figs. 3, 4, and 5 should read:

Fig. 3 — Response to a 500-Hz tone. (Vertical scale: 10 dB/div.)

Fig. 4 — Tape recorder setup. Top: Response before head alignment. Middle: After alignment, but before bias and EQ adjustment. Bottom: After adjusting bias and EQ. (Vertical scale: 5 dB/div.)

Fig. 5 — Display of sound-system response. (Vertical scale: 10 dB/div.)

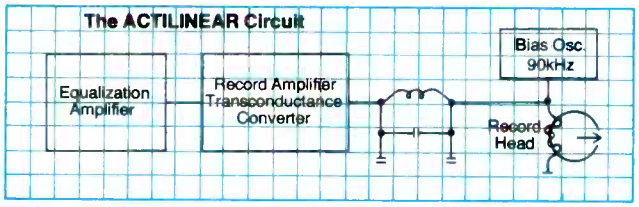
ACTILINEAR
(Patented)

DYNEQ
(Patent Pending)

Two of the most important new words in tape recording

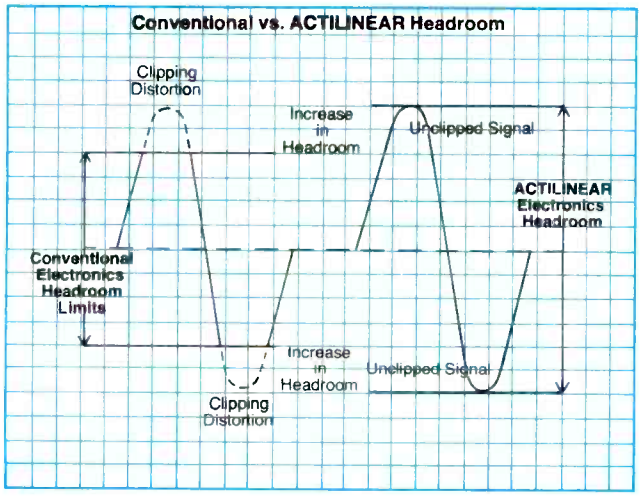
Problem:

Traditionally, tape recorder electronics have had insufficient headroom to fully exploit the greater performance capability of the new high coercivity tapes, such as metal tape. The goal of Tandberg engineers was to improve the headroom of tape recorder electronics by 18-20 dB so it can be used with metal tape.



Cause:

In conventional recording systems the summation of record & bias current in the record head is done through passive components, leading to compromise solutions which have their distinct and pronounced weaknesses—primarily a limited headroom for the signal.



Solution:

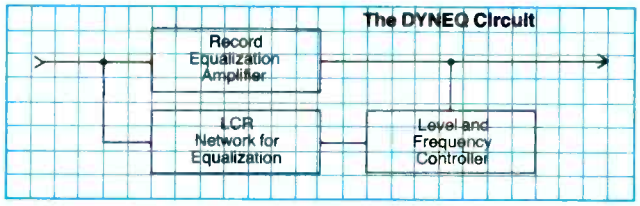
Tandberg engineers developed & patented a new recording technology without these compromise solutions (See curves above). In the new ACTILINEAR system, featured in our TD 20A open reel and TCD 340A & TCD 440A cassette recorders, the passive components have been replaced with an active Transconductance amplifier. Among the benefits of this new recording system are:

- Up to 20 dB more headroom.
- Less Intermodulation due to Slew Rate limitation.
- Improved electrical separation and less interference between bias oscillator and record amplifier.
- No obsolescence factor—usable with any type of tape available now or in the years to come.

Problem:

High frequency limitations inherent in the cassette (i.e., low speed) medium. Tandberg engineers have developed an exclusive, Patent-pending circuit that is not just a technical refinement, but a fundamentally new approach to the matter.

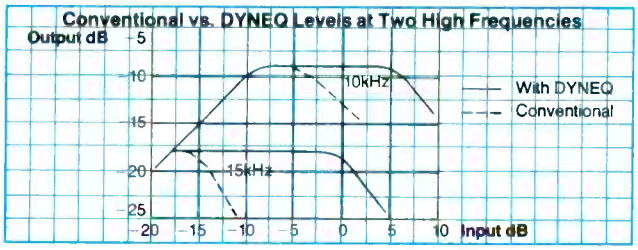
Whereas ACTILINEAR overcomes the limitations of electronics at *any* speed, DYNEQ overcomes tape limitations at *low* speeds.



High frequency saturation (overload) is of particular importance with today's new direct-to-disc and digitally-mastered recordings as they deliver more energy in the high frequency range than ever before.

Cause:

The high frequency overload—i.e., "the cassette sound"—of which tape recording purists complain is not simply a question of reaching a point where the tape can hold no more signal. At high frequencies, excessive input levels not only produce enormous amounts of distortion, but actually lower the signal level played back from the tape. In other words, once you have reached the saturation point on the tape, the more signal you try to put in, the less you actually get out.



Solution:

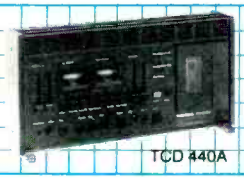
If, just at the point where high frequency saturation (overload) begins to occur, you could automatically lower the amount of record treble boost supplied by the equalization circuit, you could increase the high frequency output of which the tape is capable, and drastically lower high frequency distortion (See curves above). In brief, this is precisely what Tandberg's exclusive new dynamic equalization circuit does.

Yet another benefit is that the DYNEQ circuit, featured exclusively in Tandberg's TCD 440A cassette deck, not only gives improved performance with the new metal particle cassettes, but also delivers a *significant* improvement in performance with today's better premium tapes.


TD 20A

TANDBERG

Setting the standards in tape recording for over 30 years


TCD 440A

Perhaps *the* most important word in tape recording.

Tandberg of America, Inc., Labriola Court, Armonk, NY 10504.

ADDENDA

ANNUAL EQUIPMENT DIRECTORY

Each year, despite mailings, telegrams, and telephone calls, we are unable to make contact with a number of manufacturers, so that their equipment does not receive a listing in our October Annual Equipment or July Car Stereo Directories. The reasons for this are varied, e.g. changes of personnel or facility location, Directory forms lost in the mail, etc. Our experience indicates that we must not list data from the previous Directory, as it is almost certainly outdated, and that to attempt to make up data from our files would lead to further error. Thus, we present the Addenda to our Directories.

A

ADS
1 Progress Way
Wilmington, Mass. 01887

AIKO
See: TZL International

Adcom
11A Jules La.
New Brunswick, N.J. 08901

Anglo-American Audio
P.O. Box 653
Buffalo, N.Y. 14240

Audio Electronic Systems
101 N. Park St.
East Orange, N.J. 07017

AudioMobile
Div., Avnet
3221 W. MacArthur Blvd.
Santa Ana, Cal. 92704

Avid Corp.
10 Tripps La.
East Providence, R.I. 02914

B

Belles Research Corp.
P.O. Box 65
East Rochester, N.Y. 14445

Bose Corp.
100 The Mountain Rd.
Framingham, Mass. 01701

R.T. Bozak
P.O. Box 1166
Darien, Conn. 06820

Bryston Mfg.
R.F.D. 4, Berlin
Montpelier, Vt. 05602

C

Canton
See: Adcom

Clarion Corp.
5500 Rosecrans Ave.
Lawndale, Cal. 90260

Consortium of British Audio
652 Glenbrook Rd.
Stamford, Conn. 06906

Craig Corp.
921 W. Artesia Blvd.
Compton, Cal. 90220

Custom Craft
819 Kraemer Blvd.
Placentia, Cal. 92670

D

Dimension
See: Custom Craft

Dynaco, Inc.
110 Shawmut Rd.
Canton, Mass. 02021

E

Evadin
See: TZL International

F

Fisher Corp.
21314 Lassen St.
Chatsworth, Cal. 91311

G

General Sound
2334 N. 32nd St.
Phoenix, Ariz. 85010

Genesis Physics Corp.
Newington Park
Newington, N.H. 03801

Grundig Electronic Corp.
635 Madison Ave.
New York, N.Y. 10022

H

Hartley Products
620 Island Rd.
Ramsey, N.J. 07446

L

LS R & D
100 Hiawatha Dr.
Mt. Pleasant, Mich. 48858

Lirpa Labs
Corner of Main & Elm
Anytown, U.S.A.
483712260

M

Magnepan, Inc.
1645 Ninth St.
White Bear Lake, Minn.
55110

Marantz
20525 Nordhoff St.
Chatsworth, Cal. 91311

Mayware
15 Heather Walk
Edgware
Middlesex HA8 9TS
England

Meridian
See: Anglo-American Audio

Keith Monks Audio Ltd.
See: Consortium of British Audio

N

Neal-Ferrograph
See: Consortium of British Audio

P

Philmore Mfg.
40 INIP Dr.
Inwood, N.Y. 11696

Pyle Industries
501 Center St.
Huntington, Ind. 46750

S

Sanyo
P.O. Box 51777
Compton, Cal. 90220

Sherwood
8116 Deering Ave.
Canoga Park, Cal. 91304
(Note: This firm moved since the Oct. Directory)

Sonax
See: Anglo-American Audio

Sound Source
1435 Jacqueline Dr.
Columbus, Ga. 31907

Stanton Magnetics
175 Terminal Dr.
Plainview, N.Y. 11803

T

TZL International
2020 W. 16th St.
Broadview, Ill. 60153

Tusk Speaker Co.
Suite A-22
1760 Monrovia St.
Costa Mesa, Calif. 92627

Z

Zenith Radio Corp.
1000 Milwaukee Ave.
Glenview, Ill. 60025

PREAMPLIFIERS

MANUFACTURER	Model	Type of Unit — Kit-K; Wired-W; Tube-T; Phono Stage Only-P; Mono-M	Frequency Response, HZ to kHz, ± ? dB	Maximum Output, V	% THD	% IHF IM Distortion	Rated SMPTE IM, ? Percent	Phono Sensitivity, ? mV For 0.5 V output at 1 kHz	Phono Overload mV	Phono S/N, "A" wtd. re: 5 mV input, ? dB. (IHF A202)	High Level Sensitivity ? V	Tone Controls ?	Phono Input Capacitance, ? pF	Phono Input Impedance, ? Ohms	Moving Coil Input ?	Does Unit Invert Phase?	Weight, lbs.	Price	Notes
BRYSTON MFG.	1B		1-150	9	0.001	0.001	0.001		150	85		No					20		
MERIDIAN	101		5-50 ±0.5		0.01	0.01	0.01	1.4	160	80	0.45	No	100	47	Yes		4	465.00	

TUNERS

Letter Code
"F" indicates FM only;
"K" indicates kit price

MANUFACTURER	Model	Type of Unit, See Letter Key	Mono IHF Sensitivity, μV / dBf	Stereo IHF Sensitivity, μV / dBf	Capture Ratio, dB	Alt. Chan. Select., dB Wide/Narrow	Mono Signal Strength for 50 dB Quieting, μV / dBf	Stereo Signal Strength for 50 dB Quieting, μV / dBf	Separation, dB, 1 kHz	Separation, dB, 10 kHz	THD, Mono/Stereo, 1 kHz, 100% modulation	THD, Mono/Stereo, 6 kHz, 100% modulation	S/N, Max., dB, Mono/Stereo	Switchable De-emphasis	Net Weight, lbs.	Price, $
MERIDAN	104		2.5	22			1.0	22	50	50	0.1/0.2		67	No	4	555.00

RECEIVERS

Letter Key:
"F" indicates FM only
"K" indicates Kit

MANUFACTURER	MODEL	Unit Type, See letter code	Ave. Watts/Chan., 8 ohms	% THD	% IHF IM	Rated Power Bandwidth, Hz to kHz	dB S/N, "A" wtd., Phono ref 5mV	Phono Overload, mV	Dynamic Headroom, ? dB	Mono IHF Sensitivity, μV/dBf	Stereo IHF Sensitivity, μV/dBf	Capture Ratio, dB	Mono Signal Strength for 50-dB Quieting μV/dBf	Stereo Signal Strength for 50-dB Quieting μV/dBf	% THD, 100% Modulation, 1 kHz, Mono/Stereo	Alt. Chan. Select., dB Wide/Narrow I.f. bandwidth	Max. S/N, dB, Mono/Stereo	Net Weight, lbs.	Suggested Price
FISHER	MC2500	F	18	1.0		60-20		100		2.8/14.1	5.5/20.0		5.0/19.2	45.0/38.3		50	65/60	15	229.95
	RS1035A	F	35	0.2		20-20	75	110		1.9/10.8	4.6/18.5	1.0	2.8/14.2	38.0/36.8	0.3/0.4	68	70/66	22.9	299.95
	RS2002	F	20	0.09		20-20	76			1.9/10.8	4.6/18.5	1.0	2.8/14.2	38.0/36.8	0.15/0.2	68	70/66	17.9	279.95
	RS2003	F	30	0.04		20-20	76			1.9/10.8	4.6/18.5	1.0	2.8/14.2	38.0/36.8	0.15/0.2	68	70/66	21	379.95
	RS2004A	F	45	0.04		20-20	76	150		1.9/10.8	4.6/18.5	1.0	2.8/14.2	38.0/36.8	0.15/0.2	68	70/66	28.5	429.95
	RS2007	F	75	0.03		20-20		180		1.7/9.8	4.3/17.9		2.5/13.2	34.0/35.9		75	75/70	31	549.95
	RS1058	F	90	0.1		20-20		180		1.7/9.8	4.3/17.9		2.5/13.2	34.0/35.9		75	75/70	32.4	549.95
	RS2010	F	100	0.03		20-20	76	200		1.7/9.8	4.3/17.9	0.8	2.5/13.2	34.0/35.9	0.1/0.2	80	75/70	36	699.95
	RS2015	F	150	0.03		20-20	72	220		1.7/9.8	4.3/17.9	0.8	2.5/13.2	34.0/35.9	0.1/0.2	80	75/70	52	899.95
ZENITH	MC7051		40	0.05	0.05	20-20	81	125	1.4	1.8/10.3	5.5/20	1.0	3/14.7	40/37.2	0.3/0.5	70	70/65	27.50	359.95
	MC7041		25	0.08	0.08	20-20	76	125	1.2	1.9/10.7	6.0/20.7	1.0	4/17.2	50/39.2	0.3/0.5	60	70/65	19.58	279.95
	MC7030		15	0.4	0.4	20-20	71	125	2.0	1.9/10.7	6.0/20.7	1.0	4/17.2	50/39.2	0.3/0.5	60	70/65	19.36	229.95

TURNTABLES

LETTER CODE FOR SPEEDS
A—33, 45, 78
B—33, 45
C—33, only
D—16, 33, 45, 78
E—16, 33, 45
F—Cont. variable

MANUFACTURER	Model	Speeds—See Code	Wow & Flutter, %; 33-⅓; DIN 45-507	Rumble, -dB, DIN 45-539	Motor Type	Drive System	Speed Accuracy, ± %	Speed Adjustment Range, ± %	Speed Accuracy Indicator If Yes, Give Type?	Overall Arm Length, Inches	Pivot-Stylus Dist., Inches	Multi-Play? If Yes, # Discs	Auto. Cue = C; Auto. Off = O;	Max. Track. Error, deg./in.	Anti-Skate Adjustment	Tracking Force Range, gms.	Total Cable Capacitance, pF	Damped Cueing?	Dimensions, Inches	Price
FISHER	MT 6115	B	0.08	55	4-Pole A.C. Sync	Belt	1			7.6		No	O	3	Yes	0.7-3.5		Yes	17⅜x13¾x5⅛	119.95
	MT 6310	B	0.04	68	D.C. Servo	Belt	0.8	3	Strobe	8.7		No	O	2.0	Yes	0.6-3.5		Yes	17⅓x14½x6	119.95
	MT 6211	B	0.05	60	D.C. Servo	Belt	0.8	3	Strobe	8.7		No	O	2.0	Yes	0.6-3.5		Yes	17¾x14¼x5⅛	149.95
	MT 6320	B	0.035	68	D.C. Servo	Direct	0.5	3	Strobe	8.7		No	O	1.8	Yes	0.6-3.5		Yes	17⅓x14½x6	169.95
	MT 6330	B	0.035	70	120-Pole A.C. Servo	Direct	0.5	3	Strobe	8.7		No	O	1.8	Yes	0.6-3.5		Yes	17⅓x14½x6	189.95
	MT6224	B	0.04	68	120-Pole A.C. Servo	Direct	0.5	3	Strobe	8.7		No	O	1.8	Yes	0.6-3.5		Yes	17¾x14¼x6	199.95
	MT6225A	B	0.03	70	120-Pole A.C. Servo	Direct	0.5	3	Strobe	8.7		No	O	1.5	Yes	0.6-3.5		Yes	17¾x14¼x6	249.95
	MT6335	B	0.035	70	120-Pole A.C. Servo	Direct		6	Strobe	8.7		No	O	1.5	Yes	0.6-3.5		Yes	17⅓x14½x6	249.95
	MT 6250	B	0.03	70	120-Pole Quartz	Direct		6	Strobe	8.7		No	O	1.5	Yes	0.6-3.5		Yes	17¾x14¼x6½	300.00
SONAX	500/10	B	0.04	60	24-Pole Hys.Sync.	Belt	0.02		No			No							17x13x5½	295.00
	100	B	0.04	60	24-Pole Hys. Sync.	Belt	0.02		No	11½	9¾	No	O	1.5	Yes	¾-4		Yes	17x13x5½	395.00
STANTON	8005 A	B	0.07	70	24-Pole Sync.	Belt	0.3							1.7	Yes	0-4		Yes	16⅞x13½x6¼	300.00, Cart. Opt.
ZENITH	MC9050	B	0.03	70	D.C. Servo	Direct		3	Strobe	11½	8¾		O	1.5	Yes	0-4		Yes	6x19x15	249.95
	MC9035	B	0.08	60	24-Pole Sync.	Belt	2.9	3	Strobe	9¼	7½	Yes	O	2	Yes	0-4		Yes	7x16x15	139.95
	MC9030	B	0.20	50	4-Pole Induc.	Belt	2.9			9½	7½	Yes	O	2	Yes	0-4		Yes	7x16x14	149.95
	MC9025	B	0.08	60	24-Pole	Belt	2.9			9⅝	7½	Yes	O	2	Yes	0-4		Yes	7x16x15	109.95
	MC9020	A	0.28	46	4-Pole Induc.	Rim	2.9			9¼	7¼	Yes	O	2	Yes	0-5		Yes	8x16x15	99.95

TONEARMS

MANUFACTURER	Model	Overall Length, Inches	Pivot-Stylus Distance Inches	Cueing?	Damped Cueing?	Removable Headshell	Maximum Tracking Error, degrees/inch	Anti-Skating Adjustment	Tracking Force Range, gms.	Total Cable Capacitance, pF.	Cartridge Weight Range, gms.	Vertical Bearing Type	Lateral Bearing Type	Price	Notes
MAGNEPAN	Unitrac 1	11.41	9.5	Yes	Yes	Yes	1.77	Yes		110	3-12	Unipivot		295.00	
MAYWARE	Formula 4 MK III	11	9	Yes	Yes	Yes		Yes	0-3	116	2-11	Unipivot	Unipivot	175.00	
KEITH MONKS AUDIO	M9 BA Mk3	11½	9	Yes	Yes	No		No	½-2½	80	3-8	Unipivot	Unipivot	197.95	No wires through pivot point.

PHONO CARTRIDGES

LETTER CODE FOR STYLUS TYPE
C—Conical
S—Spherical
E—Elliptical
Q—For CD-4 use (Shibata, etc.)

MANUFACTURER	Model	Frequency response, Hz to kHz ±dB	Principle? Moving Iron=MI; Moving Magnet=MM; Moving Coil=MC; Ceramic=C	W. Individual Response Curve	Channel Separ., 1kHz, dB	Channel Separ., 10kHz, dB	mV Output, 1 kHz, 5 cm/Sec. rms Lateral Velocity	Recommended Tracking Force Range, gms.	Recommended Load Resistance, Ohms	Recommended Load Capacitance, pF	Stylus Type—use code	Stylus Radius (radii), mils	Is Stylus User or Factory Replaced?	Weight, gms.	Price	Replacement Stylus Price	Notes
MAYWARE	MC-2C	10-50	MC	Yes	25		0.2	1.8-2.2	47k		C		Fact.		150.00	75.00	Titanium cantilever.

AMPLIFIERS

Letter Key: K = kit; W = wired;
T = tube; P = phone stage only;
M = mono.

MANUFACTURER	Model	Unit type — Basic=B; Kit=K; Integrated=I; Tube=T; Mono=M	Cont. Ave. Watts per Chan. into 8 Ohms	Freq. Resp. at Rated Power, Hz to kHz	Rated THD, Percent	Rated IHF IM, Percent	Rated SMPTE IM, Percent	S/N, "A" Wtd., Phono re:5 mV, dB (IHF A-202)	Phono Sensitivity, mV	Maximum Phono Input, mV	Rated Slew Rate, V/μS	High Level Sensitivity, V	Class of Output Operation	Dynamic Headroom, dB	Does Unit Invert Phase?	Weight, lbs.	Price, $	Notes
BRYSTON MFG.	2B	B	50	20-20	0.01	0.01	0.01				60		AB	6		20	525.00	200 watts mono.
	3B	B	100	20-20	0.01	0.01	0.01				60		AB	6		38	900.00	As above.
	4B	B	200	20-20	0.01	0.01	0.01				60		AB	6		55	1,400.00	800 watts mono.
FISHER	CA2120	I	35	20-20	0.02		0.02	80	2.5	230		0.15	AB			20		5-band graphic EQ, power meters.
	CA2220	I	50	20-20	0.02		0.02	80	2.5	230		0.15	AB			22		As above.
	CA2320	I	60	20-20	0.02		0.02	80	2.5	230		0.15	AB			20		Moving coil phono input.
	CA2420	I	80	20-20	0.02		0.02	80	2.5	230		0.15	AB			24		As above, with 5-band graphic EQ and power meters.
LS R&D	The Leach Amp	B	160	20-20	0.1	0.1	0.1				70	1.8	AB		No	40	799.00	
MERIDAN	103	B	35	20-20	0.1	0.1	0.1	90								12.3	485.00	
	103D	B	45	20-20	0.1	0.1	0.1	90								26	699.00	
	105	B, M	100	20-20	0.1	0.1	0.1	90								13	449.00	

HEADPHONES

MANUFACTURER	Model	Operating Principle (dynamic, electrostatic,)	Frequency Range, HZ to kHz	Impedance, ohms	Sensitivity, dB SPL for 1 mW Input	Maximum Input, mV	Cord Length, feet	% THD at 95 dB SPL	Cord Style Flat—F Coiled—C	Weight, ounces	Price	Notes
NEAL-FERROGRAPH	Electrostatic	ES	20-20 ±3	130k	95		9.9		F	13	134.00	With adaptor box and carrying case.
	Dyna-X	Dyn.	20-20 ±5	120			9.9		F	13	64.00	With carrying case.

HEADPHONES

MANUFACTURER	Model	Operating Principle (dynamic, electrostatic)	Frequency Range, HZ to kHz	Impedance, ohms	Sensitivity, dB SPL for 1 mW input	Maximum input, mV	Cord Length, feet	% THD at 95 dB SPL	Cord Style Flat—F Coiled—C	Weight, ounces	Price	Notes
ZENITH	839-32	Dyn.	20-19	8	104 ±3	500	10		C	11	49.75	
	839-49	Dyn.	20-18	8	110 ±3	200	6½		F	11	23.75	
	839-50	Dyn.	20-20	8	108 ±3	200	6½		F	12	47.95	
	839-52	Dyn.	20-20	8	90 ±3	700	10		C	16	53.25	
	839-54	Dyn.	20-16	8	100 ±3	300	9		C	13	54.25	
	839-55	Dyn.	30-18	8	90 ±3	200	10		C	8	26.50	
	839-56	Dyn.	10-25	8	100 ±3	300	8		F	13	74.95	

OPEN-REEL TAPE DECKS

LETTER CODE FOR SPEEDS
A—7½, 3¾, 1⅞
B—7½, 3¾
C—7½, 3¾, 1⅞, 15/16
D—1⅞
E—15, 7½, 3¾
F—15, 7½
G—15, 7½, 3¾, 1⅞
H—15/16

MANUFACTURER	Model	Speeds — see letter code	Maximum reel size, inches	Number of heads	Number of tracks	Number of channels	Number of motors	Drive motor type	Drive to capstan	Freq. resp. Hz-kHz ±dB with best tape at highest machine speed	Wow & Flutter, DIN 45-507, %	S/N, dB	Output level at 0 VU, mV	Dolby N/R included	Mike mixing	Mike input Z, ohms	Record level indicator(s): Type and quantity	Dimensions, inches, W x H x D	Weight, lbs.	Price, $	Notes
NEAL-FERROGRAPH	Logic 7	E	10½	3	2 or 4	2	3	Sync.	Stepped Idler	20-20 ±2	0.08	60	1.27V	Yes	Yes	200-1k	2 VU Mtrs.	20¼x17½ x10	58	1,950.00	Cont. var. wind control, record cancel, opt. remote control; opt. power amps and speakers, 300.00; opt. Dolby NR, 400.00.

CASSETTE & 8-TRACK TAPE DECKS

MANUFACTURER	Model	"X" = cassette; "8" = cartridge	Auto Off?	Frequency Response, Hz-kHz ±dB with Best Tape	Top Load=T; Front Load=F	Number of Heads	% Wow & Flutter, W rms	S/N, dB, without Dolby	S/N, dB, with Dolby	Number of Bias & EQ Settings	Mike Mixing: If yes, no. inputs.	Locking Pause Control	Limiter	Memory Rewind	Peak level indicator(s)	Dimensions, inches	Net Weight, lbs.	Price	Notes
FISHER	CR 5120	X	Yes	30-17	F	3	0.05	53	62	3	No	Yes	Yes	Yes	Yes	17⅛x12½x6⅝	22.5	349.95	
	CR 4028	X	Yes	30-16	F	2	0.07	52	62	4	No	Yes	No	No	No	17⅛x12¼x4¾	17	349.95	
(Continued)				30-23			0.06												2 speed, auto search. Specs. here, 3¾ ips.

CASSETTE & 8-TRACK TAPE DECKS

MANUFACTURER	Model	"X" = cassette; "8" if cartridge	Auto Off?	Frequency Response, Hz-kHz, ±dB with Best Tape	Top Load=T; Front Load=F	Number of Heads	% Wow & Flutter, W rms	S/N, dB, without Dolby	S/N, dB, with Dolby	Number of Bias & EQ Settings	Mike Mixing; If yes, no. inputs	Locking Pause Control	Limiter	Memory Rewind	Peak level indicator(s)	Dimensions, inches	Net Weight, lbs.	Price	Notes
FISHER (Continued)	CR 4031	X	Yes	30-16 30-23	F	2	0.07 0.06	52	62	4	No	Yes	No	No	No	17⅛x12¼x4¾	17	349.95	As Model CR 4028.
	CR 5125	X	Yes	30-18 ±3	F	3	0.04	55	64	3	No	Yes	No	No	Yes	17⅛x12¼x4¾	22.5	499.95	Specs. here, 3¾ ips. Wireless remote editing.
	CR 4029	X	Yes	30-18 30-25	F	3	0.06 0.05	52	62	4	No	Yes	Yes	No	Yes	12½x12¼x4¾	17	499.95	2 speeds, bias fine adj. Specs. here, 3¾ ips.
	CR 5150	X	Yes	30-18 ±3	F	3	0.04	55	64	3	No	Yes	Yes	No	Yes	14⅛x11⅞x5½	22.5	699.95	Remote control, clock/timer.
	CR 4015	X	Yes	40-13 ±3	F	2	0.09	50	56	2	No	Yes	No	No	No	15x8⅛x5¾	12	149.95	
	CR 4013	X	Yes	40-12 ±3	F	2	0.1	48	58	2	No	Yes	No	No	No	5½x15½x9	16	169.95	LED level meters.
	CR 4025	X	Yes	40-14 ±3	F	2	0.09	50	56	2	No	Yes	No	No	No	15⅛x11⅞x6	13	199.95	Wireless remote editing.
	CR 4016	X	Yes	40-14 40-18	F	2	0.1 0.09	50	60	2	No	Yes	No	No	No	5¼x17½x9½	16	249.95	2 speeds. Specs. here, 3¾ ips.
	CR 5115	X	Yes	30-16 ±3	F	3	0.07	52	60	3	No	Yes	Yes	No	No	16⅜x11¾x6⅝	13	279.95	
	CR 4027	X	Yes	30-15 30-20	F	2	0.08 0.07	52	62	3	No	Yes	No	No	No			299.95	2 speeds. Specs. here, 3¾ ips.
	ER 8115	8	No	35-11 ±3	F	2	0.15	48		1	No	Yes	No	No	No	12⅝x10¼x5	8.2	169.95	
	ER 8130	8	No	35-12.5	F	2	0.15	44	52	1	2	Yes	No	No	No	14⅜x10x5	8.5	179.95	2 speeds. Specs. here, 3¾ ips.
	ER 8125	8	No	32-12 ±3	F	2	0.15	44	52	1	No	Yes	No	No	No	13⅜x10x5	8.2	199.95	
	ER 8150	X 8	Yes No	40-12 ±3	F	2	0.09 0.15	50 46	56 52	1	No	Yes	No	No	No	20x10¾x6	14.5	329.95	8 track & cassette.
	ER 8155	X 8	Yes No	40-12 ±3	F	2	0.09 0.15	50 46	56 52	3 1	No	Yes	No	No	No	6x20x10¾	14.5	369.95	As above.
NEAL-FERROGRAPH	302	X	Yes	35-15 +1-3	F	2	0.09	55	64	2		Yes	No	No	Yes	18x5¼x9	18	995.00	Opt. remote control.
ZENITH	MC9070	X	Yes	30-15 ±3	F	2	0.08	52	62	3	No	Yes	No	No	Yes	17x9x6	16	249.95	

MICROPHONES

MANUFACTURER	Model	Directional Pattern	Operating Principle	Case Material	Most Commonly Used For	Actual Impedance, 1 kHz, ohms	Operating Range, Hz to kHz	Open-Circuit sens., 1kHz, dB re: 1 V/1 µbar	Connector on mike?	Cable length, feet	Connector on Equipment End of Cable	Dimension, inches; length x diameter	Weight, ounces	Mounting Method	Price, $	Notes
PHILMORE	DC200	Sup. Card.	Elect. Cond.			600	30-15	-60		20†	Phone		6	⅝x32		† Also with 3-ft. curly, ⅛-in. plug.

LOUDSPEAKERS

MANUFACTURER	Model	Enclosure type	Woofer dia., inches	Midrange dia., inches	Midrange type	Tweeter dia., inches	Tweeter Type	Level controls? W=woofer; M=midrange; T=tweeter; ST=supertweeter)	Anechoic freq. response Hz to kHz ± dB	dB SPL/watt/meter	Recommended min. amp. power	Crossover frequencies, Hz.	Impedance, ohms; Nominal/minimum	Dimensions, inches	Finish	Grille Material, Color	Weight, lbs.	Price $
AUDIO ELECTRONIC SYSTEMS	AES28	Bass Ref.	8			2	Cone		50-15	92	5	1.5k	8	10¾x20 x9⅜	Wal. Vin.	Cloth, Blk.	14½	
	AES 31	Bass Ref.	10	1½	Soft Dome	2	Cone		40-17	92	10	700,3k	8	13x23 x10⅞	Wal. Vin.	Cloth, Blk.	35	
	AES 32	Ac. Sus.	12	1½	Soft Dome	2	Cone	T	35-17	94	10	700,3k	8	14½x26 x11⅛	Wal. Vin.	Cloth, Blk.	46	
	AES 42	Ac. Sus.	12	1½	Soft Dome	1	Soft Dome	M,T	30-20	94	25	600,2k	4	15¾x27 x11½	Wal. Vin.	Cloth, Blk.	65	
	AES 50	Ac. Sus.	12	(2) 2	Soft Domes	1	Soft Dome	M,T	25-20	93	50	600,2k	4	16x34½ x11½	Wal. Vin.	Cloth, Blk.	100	
BELLES RESEARCH	Belles 1	Pas. Rad.	8			1	Dome	T	30-20		40	2.7k	8	15x17¼ x33¾	Oil. Wal.	Foam, Blk.	69	445.00
BOZAK	LS200A	Ported	8			1	Soft Dome		60-20 ±3		10	1.5k	8	20¼x 11¾x10¾	Wal. Vin.		34	234.00 Pair
	LS250A	Inf.Baf.	12	4	Cone	1	Soft Dome		45-20 ±3		10	500, 2k	8	23⅛x 14½x12¼	Wal. Vin.		48	390.00 Pair
	LS400A	Inf.Baf.	12	6	Cone	1	Soft Dome		40-20		10	500, 2.5k	8	25½x18 x13¼	Wal.		65	600.00 Pair
	CS501A	Inf.Baf.	12	6	Cone	(3)2	Cones		40-20		15	800, 2.5k	8	32x20 x16	Wal. Ven.		90	900.00 Pair
	CS4000A	Inf.Baf.	(2)12	6	Cone	(8)2	Cones		35-20		50	400, 2.5k	8	44x27 x16	Wal. Ven.		190	1,500.00 Pair
	CS310B	Inf.Baf.	(4)12	(2)6	Cones	(8)2	Cones		28-20		60	400, 2.5k	8	52x36 x19	Wal. Ven.		225	2,500.00 Pair
	CS410CL	Inf.Baf.	(4)12	(2)6	Cones	(8)2	Cones		28-20		60	400, 2.5k	8	52x36 x19	Wal. Ven.		225	2,700.00 Pair
DYNACO	A150	Ac. Sus.	10			1	Soft Dome	T	50-20 ±3	89	15	2k	8/6	12¼x12¾ x22	Wal. Vin.	Cloth, Brn.	36	300.00 Pair
	A250	Ac. Sus.	10	3	Cone	1	Soft Dome	M, T	45-20 ±3	89	15	300, 5k	8/6	14¼x14¼ x25	Oil. Wal.	Cloth, Brn.	39	500.00 Pair
	A350	Pas. Rad.	10	3	Cone	1, 4/5	Soft Dome	M, T	35-25 ±3	89	15	500, 3.5k, 11.3k	8/6	14x14½ x43	Oil. Wal.	Cloth, Brn.	68	7800.00 Pair
FISHER	MS145	Pas. Rad.	8	5	Cone	3	Cone		55-17	91	6.5	1k, 5k	8	24½x14⅜ x11	Wal. Vin.	Cloth, Brn.	20	139.95
	ST420	Pas. Rad.	8			3	Cone		50-16	90	3.5	5k	8	13⅜x9⅜ x21⅞	Wal. Vin.	Cloth, Brn.	19	149.95
	ST430	Pas. Rad.	10	5	Cone	3	Cone		50-17	90	6.5	1k, 5k	8	16x12¾ x25½	Wal. Vin.	Cloth, Brn.	34	219.95
	ST440	Ported	12	5	Cone	3	Dome	M, T	45-18	90	12	1k, 5k	8	16x12¾ x25½	Wal. Vin.	Cloth, Brn.	36	279.95
	ST450	Ported	12	5	Cone	3	Dome	M, T	45-20	91	20	1k, 5k	8	17x14⅜ x29¼	Wal. Vin.	Cloth, Brn.	44	329.95
	ST460	Ported	15	(2) 5	Cones	3	Horn	M, T	40-20	92	25	1k, 5k	8	18¼x14⅜ x29¼	Wal. Vin.	Cloth, Brn.	53	389.95
GENERAL SOUND	421/422/ 423	Ac. Sus.	4			1	Dome		125-20 ±5	86	10	2.5k	4	7⅞x5⅛ x6⅜	Opt.	Cloth, Opt.	6	125.00
	521/522/ 523	Ac. Sus.	5¼			1	Dome		100-20 ±5	87	10	2.5k	4	9x5⅞ x7⅜	Opt.	Cloth, Opt.	7	150.00
	631/632/ 633	Ac. Sus.	6½	2¼	Cone	1	Dome		70-20 ±5	87	10	3.8k, 13k	4	11⅝x7⅝ x7⅜	Opt.	Cloth, Opt.	14	200.00
	1011 Bass Extender	Tuned Port, Satellite	10						32-250 ±5	91	20	200	5.6	19x18x18	Wal.	Cloth, Brn.	54	350.00

MANUFACTURER	Model	Enclosure type	Woofer dia., inches	Midrange dia., inches	Midrange type	Tweeter dia., inches	Tweeter Type	Level controls? W=woofer; M=midrange; T=tweeter; ST=supertweeter	Anechoic freq. response Hz to kHz ± dB	dB SPL/watt/meter	Recommended min. amp. power	Crossover frequencies, Hz.	Impedance, ohms, nominal/minimum	Dimensions, inches	Finish	Grille Material, Color	Weight, lbs.	Price $
GENESIS	3+	Pas. Rad.	8,10	4	Cone	1	Dome	M,T	28-20 ±3	88.5	25	800,3k	6	14½x12 x37½	Opt.	Knit, Brn.	52	389.00
	2+	Pas. Rad.	8,10			1	Dome	T	28-20 ±4	89	15	1.8k	8	14½x10½ x35½	Opt.	Knit, Brn.	44	253.00
	2	Pas. Rad.	8,10			1	Dome	T	28-20 ±4	88.5	15	1.8k	8	14½x11½ x26½	Opt.	Knit, Brn.	37	207.00
	1+	Ac. Sus.	8			1	Dome	T	35-20 ±4	88	12	1.8k	8	12½x9½ x22	Opt.	Knit, Brn.	28	147.00
	V-6	Vented	6			1	Dome	No	52-20 ±4	88.5	10	1.8k	8	10¾x7 x18½	Wal. Grain	Knit, Brn.	18¾	105.00
HARTLEY PRODUCTS	Zodlac Jr.	Inf. Baf.	8			2	Cone	No	50-18 ±4	90	5	2.5k	8	11½x7½ x19	Wal. Ven.	Cloth, Beige	22½	96.00
	Zodlac 1B	Inf. Baf.	10			1	Dome	No	40-25 ±4	92.5	5	2k	8	14⅜x8¾ x21¾	Wal. Ven.	Cloth, Beige	32½	135.00
	Zodlac '78	Inf. Baf.	10			1	Dome	No	35-25 ±4	92.5	5	2k	8	15x11¾ x30	Wal. Ven.	Cloth, Beige	50	180.00
	Concert Jr.	Inf. Baf.	10	3	Cone	1	Dome	No	25-25 ±3	90	15	5k	8/5	15x11¾ x38½	Wal. Ven.	Cloth, Brn.	65	375.00
	Holton Tower	Inf. Baf.	(2)10	3	Cone	1	Dome	No	20-25 ±3	93.5	15	2k	4	20x14 x49½	Wal. Ven.	Cloth, Brn.	105	495.00
	Concertmaster	Inf. Baf.	18	10	Cone	1,7	Dome, Cone	No	16-25 ±3	91	25	250, 3k,7k	8/5	29x18x41½	Wal. Ven.	Cloth, Brn.	150	1,380.00
	Reference	Inf. Baf.	24	10	Cone	7,1	Cone, Dome	No	16-25 ±3	91.5	25	250,3k, 7k	8/5	36x24x50¼	Wal. Ven.	Cloth, Brn.	300	1,725.00
MAGNEPAN	MG I	Bipolar	428 Sq. In.		Planar Strip	68 Sq. In.	Planar Strip		50-16 ±4	87	40	2.4k	5	22x60x2	Oak	Cloth, Ivory	42½	495.00 Pair
	MG II A	Bipolar	500 Sq. In.		Planar Strip	68 Sq. In.	Planar Strip		45-16 ±4		40	2.1k	6	22x71x2	Oak	Cloth, Ivory	50	825.00 Pair
	Tympani 1D	Bipolar	1026 Sq. In.		Planar Strip	96¾ Sq. In.	Planar Strip		40-20 ±3		100		4	(3) 72x16x1	Oak	Cloth, Ivory	80	1,395.00 Pair
NEAL-FERROGRAPH	S23	Ac. Sus. Laby.	4	4	Cone	1	Dome		65-20 ±4	90	10	600	8/6	17⅜x7½x11	Teak / Wal.	Brn.	19½	416.00
SOUND SOURCE	82	Ac. Sus.	8			2	Phen. Ring		50-18 ±3	94	5		8	10x8x20	Vin.	Knit, Blk.	15	
	T-82	Pas. Rad.	8,8			2	Phen. Ring		40-20 ±3	94	5		8	11¼x11¼ x30	Vin.	Knit, Blk.	27	
	103	Vented Ref.	10	5	Cone	2	Phen. Ring		40-20 ±3	96	5		8	13¾x10¼ x22¾	Vin.	Knit, Blk.	25	
	123	Vented Ref.	12	5	Cone	2	Phen. Ring	T	40-20 ±3	96	5		8	15x10½ x24⅝	Vin.	Knit, Blk.	34	
	124	Ac. Sus.	12	5	Cone	(2) 2	Phen. Rings	M,T	40-20 ±3	94	5		8	15x12½ x24⅝	Vin.	Knit, Blk.	36	
	H12d	Vented Ref.	12	4x11	Horn	1	Dome	M,T	35-20 ±3	98	5		8	15x12½ x24⅝	Vin.	Knit, Blk.	36	
	T-123	Vented Ref.	12	5	Cone	2	Phen. Ring	M,T	35-20 ±3	94	10		8	15x10½x35	Vin.	Knit, Blk.	40	
	1020	Vented Ref.	10	5	Cone	2	Phen. Ring	T	40-20 ±3		5		8	13¾x10¼ x22¾	Laq. Wal.	Knit, Blk.	40	
	D-12	Vented Ref.	12	4x11	Horn	2	Cone	M,T	30-20 ±3		5		8	15x12½ x24½	Laq. Wal.	Knit, Blk.	45	
	1220	Vented Ref.	12	5	Cone	2	Phen. Ring	M,T	35-20 ±3		5		8	15x10½ x24½	Laq. Wal.	Knit, Blk.	42	
(Continued)	1240	Vented Ref.	12			2x6	Pz. Horn		35-40 ±3		10	2k	8	15x12½ x24½	Laq. Wal.	Knit, Blk.	42	

LOUDSPEAKERS

MANUFACTURER	Model	Enclosure type	Woofer dia., inches	Midrange dia., inches	Midrange type	Tweeter dia., inches	Tweeter Type	Level controls? W=woofer; M=midrange; T=tweeter; ST=supertweeter	Anechoic freq. response Hz to kHz ± dB	dB SPL/watt/meter	Recommended min. amp. power	Crossover frequencies, Hz.	Impedance, ohms; Nominal/minimum	Dimensions, inches	Finish	Grille Material, Color	Weight, lbs.	Price $
SOUND SOURCE (Continued)	1A	Pas. Rad.	8		Cone	1	Dome		40-22 ±3	94	5	2.5k	8	13x13 x24	Laq. Wal.	Knit, Blk.	30	
	2A	Vented Ref.	10	5	Cone	1	Dome	T	38-22 ±3	96	10	1k, 6k	8	13½x10½ x26	Laq. Wal.	Knit, Blk.	30	
	3A	Time Line	10	5	Cone	1	Dome	M,T	30-22 ±3	96	5	900, 6k	8	15x10½ x34	Laq. Wal.	Knit, Blk.	50	
	4A	Time Line	12	5	Cone	1	Dome	M,T	20-22 ±3	94	20	800,6k	8	16x13 x42	Laq. Wal.	Knit, Blk.	95	
TUSK	The Wedge		10	4½	Cone	1	Dome	No	30-22 ±2	80	100	Var.	6/4.5	12x12x30	Opt.	Opt.	32	800.00 Pair
ZENITH	MC4000	Tuned Port	12	5	Cone	3½	Horn	M,T	30-20	91.5	5	600, 2.0k	8/6	17x13¼ x28	Wal.	Cloth, Brn.	45¼	255.00
	MC3000	Tuned Port	10			3½	Horn	T	40-20	90	5	2.0k	8/8	15⅝x10¾ x24¾	Wal. Vin.	Cloth, Brn.	29	309.95 Pair
	MC2000	Tuned Port	8			3½	Horn		50-15	89	5	2.5k	8/6	14½x9¼ x22½	Wal. Vin.	Cloth, Brn.	18	209.95 Pair
	MC1000	Tuned Port	6½			2	Cone		60-15	88	3	2.5k	8/8	13½x7⅞ x20½	Wal. Vin.	Cloth, Brn.	13⅛	159.95 Pair

BLANK TAPE

MANUFACTURER	Brand	Principal Type of Use	Recommended Bias Level	Cassettes: C-45	C-60	C-90	C-120	Other	8-Track: 45 Min.	60 Min.	90 Min.	Open-Reel: 1200 ft.	1800 ft.	3600 ft.	List Price	Notes
ZENITH	High Performance	General	Normal	X	X	X	X		X		X				2.95 2.99 3.89 5.25 3.63 4.49	
	Ferri-chrome	General	FeCr			X									8.50	
	Budget	General	Normal	X	X	X									1.84 1.99 2.63	

CAR STEREO DIRECTORY ADDENDA

RADIOS/TAPE PLAYERS

MANUFACTURER	Model	Price	Stereo (S), Mono (M), or 4-channel (Q)	FM Sensitivity, µV (for 30-dB quieting)	Selectivity	Average Watts/channel, at rated Distortion	% Distortion @ rated watts	Local/Distance Switch	Pushbuttons (# Yes, Number AM, Number FM	Separate Bass Control	Separate Treble Control	Cassette	8-Track	Auto Reverse	Fast Forward	Tape Rewind	In-Dash (I) or Under-Dash (U)	Dimensions, inches, H x W x D
AUDIOMOBILE	ST770	399.95	S	1.5	70			No	No	Yes	Yes	Yes	No	No	Yes	Yes	I	2x7x4¾
CLARION	PE-958A	419.95	S	1.5	80	Needs Amp		Yes	5 AM or FM	Yes	Yes	Yes	No	Yes	Yes	Yes	I	2.4x7.1x5.5
	PE-751B	389.95	S	1.5	80	10	1	Yes	5 AM or FM	Yes	Yes	Yes	No	Yes	Yes	Yes	I	1.9x7.1x6.3
	PE-550A	279.95	S	1.5	80	4	1	Yes	No	No	No	Yes	No	Yes	Yes	Yes	I	1.9x7.1x6.3
	PE-662C	275.75	S			4	1	Yes	No	No	No	Yes	No	Yes	Yes	Yes	I	
	PE-666B	252.95	S			4	1	Yes	No	No	No	Yes	No	Yes	Yes	Yes	I	
	PE-684A	287.95	S			10	1	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	U	
	PE-838A	243.95	S			10	1	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes	U	
	PE-828A	149.50	S			4	1	No	No	No	No	Yes		Yes	Yes	Yes	U	
	PE-703A	223.50	S			4	1	No	5 AM or FM	No	No	No	Yes	No	No	No	I	
	PE-453A	159.50	S			10	1	No	No	Yes	Yes	No	Yes	No	No	No	U	
CRAIG	T684	336.95	S	4.6	60	12	5.0	Yes	4 AM or FM	Yes	Yes	Yes	No	Yes	Yes	Yes	I	2x7⅛x6
	T686	419.95	S	4.5	60	12	5.0	Yes	5 AM or FM	Yes	Yes	Yes	No	No	Yes	Yes	I	2¾x7⅛x5¼
	T688	279.95	S	6.5	70	12	5.0	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	I	2x7⅛x6
	T681	219.95	S	3.2	65	12	5.0	Yes	No	No	No	Yes	No	No	Yes	Yes	I	2x7⅛x5¼
	T636	359.95	S	5.3	65	4	5.0	Yes	5 AM or FM	Yes	Yes	Yes	No	No	Yes	Yes	I	2¾x7⅛x5¼
	T634	279.95	S	2.4	60	4.5	5.0	Yes	4 AM or FM	Yes	Yes	Yes	No	Yes	Yes	Yes	I	2x7⅛x6
	T638	219.95	S	3.5	60	4	5.0	Yes	5 AM or FM	No	No	Yes	No	No	Yes	Yes	I	2x7⅛x5¼
	T606	239.95	S	4.6	66	4.5	5.0	Yes	No	No	No	Yes	No	No	Yes	Yes	I	2¾x7⅛x5⅞
	T614	169.95	S	4.0	60	4	5.0	Yes	No	No	No	Yes	No	No	Yes	Yes	I	2x7⅛x6
	S686	359.95	S	4.5	60	12	5.0	Yes	5 AM or FM	Yes	Yes	No	Yes	No	No	No	I	2¾x7⅛x5¼
	S683	289.95	S	4.6	71	12	5.0	Yes	5 AM or FM	Yes	Yes	No	Yes	No	Yes	No	I	2¾x7⅛x5¼
	S682	239.95	S	3.6	71	12	5.0	Yes	No	Yes	Yes	No	Yes	No	Yes	No	I	2x7⅛x5¼
	S636	324.95	S	4.5	30	4	5.0	Yes	5 AM or FM	Yes	No	No	Yes	No	No	No	I	2¾x7⅛x5¼
	S606	239.95	S	4.6	66	4.5	5.0	Yes	No	No	No	No	Yes	No	Yes	Yes	I	2¾x7⅛x5¼
	S608	179.95	S	4.6	35	4.5	5.0	Yes	No	Yes	Yes	No	Yes	No	No	No	I	2x7⅛x5¼
	S632	179.95	S	5.0	60	4	5.0	Yes	5 AM or FM	Yes	Yes	No	Yes	No	No	No	I	2½x7⅛x5½
	S609	119.95	S	7.0	50	4	5.0	Yes	No	No	No	No	Yes	No	No	No	I	2x7⅛x4¾
	T639	189.95	S	6.0	60	4	5.0	Yes	5 AM or FM	No	No	Yes	No	No	Yes	No	I	2x6⅜x5½
	T635	359.95	S	5.3	65	4	5.0	Yes	5 AM or FM	No	No	Yes	No	No	Yes	Yes	I	2x7⅛x5¼
GRUNDIG	GCV2700	399.00	S			20		Yes	Opt.	No	No	Yes	No	Yes	Yes	Yes		
	GCM4700	219.00	S			7		Yes	No	No	No	Yes	No	Yes	Yes	Yes		
	GCM4600	179.00	S			7		Yes	No	No	No	Yes	No	No	Yes	Yes		
	GEM5000	139.00	S			7		Yes				No	Yes	No		No		
	WKC2035US	316.00	S	2.5		7		Yes				Yes	No	No	Yes	No		
	GCM 8200	279.00	S			4.5	10	Yes				Yes	No	Yes	Yes	Yes		Built-in EQ.
	GCM 8100	239.00	S			4.5	10	Yes				Yes	No	Yes	Yes	Yes		

RADIOS/TAPE PLAYERS

MANUFACTURER	Model	Price	Stereo (S), Mono (M), or 4-channel (Q)	FM Sensitivity, µV (for 30-dB quieting)	Selectivity	Average Watts/channel, at rated Distortion	% Distortion @ rated watts	Local/Distance Switch	Pushbuttons If Yes, Number AM, Number FM	Separate Bass Control	Separate Treble Control	Cassette	8-Track	Auto Reverse	Fast Forward	Tape Rewind	In-Dash (I) or Under-Dash (U)	Dimensions, inches, H x W x D
SANYO (Continued)	FT489	189.95	S	2	55	4.5	10	Yes	5 AM or FM	No	No	Yes		Yes	Yes	Yes	I	7x6x2
	FT1490A	199.95	S	2	55	2,12	5	Yes		Yes	Yes	Yes		Yes	Yes	Yes	I	7x6x3
	FT646	219.95	S	1.5	60	4	5	Yes		No	No	Yes		Yes	Yes	Yes	I	7x6x2
	FT1490-2	239.95	S	2	60	2.7,14	5	Yes		Yes	Yes	Yes		Yes	Yes	Yes	I	7x6x3
	FT1495	239.95	S	2	55	2.7,14	5	Yes	5 AM or FM	Yes	Yes	Yes		Yes	Yes	Yes	I	7x6x3
	FT690	249.95	S	2	55	4	5.0	Yes	5 AM or FM	No	No	Yes		No	Yes	Yes	I	7x6x3
	FT1670	299.95	S	2	55	2,12	5.0	Yes	5 AM or FM	Yes	Yes	Yes		No	Yes	Yes	I	7x6x3
	FT2400	329.95	S	1.5	65			Yes	5 AM or FM	Yes	Yes	Yes		Yes	Yes	Yes	I	7x6x2
	FT1498	349.95	S	1.5	60	2.7,14	5.0	Yes	5 AM or FM			Yes		Yes	Yes	Yes	I	7x6x3
	FT2200	329.95	S	2	60			Yes	5 AM or FM			Yes		Yes	Yes	Yes	I	6¼x5x2
	FT478	99.95	S	3	45	4	10	Yes		No	No	Yes		No	Yes	No	I	6¼x4⅜x1⅞
	FT479	109.95	S	3.5	50	4.5	10	Yes		No	No	Yes		No	Yes	No	I	7x6x2
	FT481	119.95	S	3.5	55	4.5	10	Yes		No	No	Yes			Yes	Yes	I	7x6x2
	FT642	129.95	S	2	45	4	10	Yes		No	No	Yes		Yes	Yes	No	I	6¼x4¾x1⅞
	FT644	139.95	S	2	55	4.5	10	Yes						Yes	Yes	Yes	I	7x6x2
TZL INTER-NATIONAL	Evadin CR6000	199.95	S			8	5	Yes	5 AM or FM	No	No	Yes	No	Yes	Yes	Yes	I	7x2½x6¼
	Evadin CR3010	159.95	S			6	5	Yes	No	No	No	Yes	No	Yes	Yes	Yes	I	7x1¾x5⅞
	AIKO ACS 8000L		S			5	5	Yes	No	No	No	Yes	No	No	Yes	Yes	I	7x1¾x5½
	AIKO ACS 2200		S			15	10	No	No	No	No	Yes	No	No	Yes	No	U	6¾x1¾x2
	AIKO ACS 4000	99.95	S			5	5	No	No	No	No	Yes	No	Yes	Yes	Yes	U	6¾x1¾x2

SPEAKERS

MANUFACTURER	Model	Price, $ (If sold individually)	Price, $ (If sold in pairs)	Recommended Power, Watts	Driver Size, Inches	Magnet Size, Oz.	Impedance, Ohms	Frequency Response, Hz to kHz, ± dB	Two-way (2) or Three-way (3)	Flush Mount (F) or Surface Mount (S)	Overall Dimensions	Notes
AUDIOMOBILE	SK65HP		129.95	50	6½	25	4 & 8	20-3 ±5		F	6¾x6¾x 3¾	Woofer only.
	SK10		79.95	50	1	10	4 & 8	2k-20k ±3		F	3¾x3¾x1	Tweeter only.
	SK100		159.95	100	10	32	4 & 8	10-1 ±5		F	10¼ x 4½	Woofer only.
AVID	Ten		225.00	5	6½,1	20, 10	4	60-20 ±5	2	S	11⅜x7⅜x1⅝	With cables.
	RD-5		40.00	5	4½	12	8			S	4½	As above.
	Ten-Plus		250.00	5	4½	12		100-10 ±5		S	4½	As above.
BOSE	1401		328.95		4½	9.1		40-17 ±1		F		Price includes booster/EQ (see "EQ/Amps" section).
CANTON	AC-200		300.00		¾, 4⅓			48-25	2	S	7½x5⅔x4¾	Blamped, with x-over.
CRAIG	R771		99.95	50	6x9	20	6	45-17.5 ±6		F	9⅞x6⅞x3½	
	R732		99.95	50	5¼	20	6	50-17.5 ±6		F	6⅛x2¼	
	V480		179.95	40	4,1¼	10,3		120-24 ±6	2	S	10¼x4¾x6¼	
	V180		24.95	8	3x5	3.6		130-16 ±6		S	7⅝x3¼x5⅝	
	V303		39.95	25	5¼	14		80-15 ±6		F	6¼x6¼x2⅛	
	V301		39.95	12	4	8		120-21 ±6		F	5⅝x4⅝x1⅜	
	V360		49.95	25	4x10	10		60-20 ±6	2	F		
	V341		36.95	12	4x6	5.6		85-21 ±6		F	6⅝x4⅝x2⅝	
(Continued)	V350		89.95	25	6x9	20		60-16 ±6	3	F	9⅞x6⅞x3⅝	

SPEAKERS

MANUFACTURER	Model	Price, $ (If sold individually)	Price, $ (If sold in pairs)	Recommended Power, Watts	Driver Size, Inches	Magnet Size, Oz.	Impedance, Ohms	Frequency Response, Hz to kHz, ± dB	Two-way (2) or Three-way (3)	Flush Mount (F) or Surface Mount (S)	Overall Dimensions	Notes
CRAIG (Continued)	V362		69.95	25	6x9	20		60-15 ±6	2	F	9⅞x6⅞x3⅝	
	V451		199.95	40	6x9, 5¾, 3, 2	20, 10, 2.8, 1.5	8	60-20 ±6	4			Separates with under-dash control.
	V102		24.95	8	5¼	3.6	6	90-16 ±6		F	6⅝x1¾	
DIMENSION	MK-I	87.00		30	4½	8	4	44-22	2	S	7½x5x4½	
	MK-IB	99.00		30	4½	8	4	44-22	2	S	7½x5x4½	
	MK-II	110.00		30	4½	8	4	44-22	2	S	7½x5x4½	
	MK-IIB	125.00		30	4½	8	4	44-22	2	S	7½x5x4½	
	MK-VI	149.00		60	6	20	4	36-22	2	S	10¾x7½x5¾	
	MK-VIB	169.00		60	6	20	4	36-22	2	S	10¾x7½x5¾	
	MK-VIII	199.00		75	8	20	4	32-22	3	S	14½x10x6	
GRUNDIG	HF 2025		75.00	20	4½		4	30-20		F		
	HF 2040		110.00	20	4½, 2		4	30-20	2	S	9⅜x4⅞x4½	
LIRPA LABS	Bazoom Aphonic	100.00	99¢	15 kV	82	3	10k	D.C.-10 k rpm	2.0	Yes	82½xcarx 0.003	Sprays on hood, roof or trunk; will not come off in car wash; colors opt. Designed for use in late-model Bricklins, Corvairs, Edsels, Packards, and Studebakers.
MARANTZ	SS169		60.00	30	6x9	20	4	40-13		F	6⅝x9⅜x3¼	
	SS269		70.00	30	6x9	20	4	40-15	2	F	6⅝x9⅜x3⅝	
	SS469		110.00	30	6x9	20	8	40-18	4	F	6⅝x9⅜x3⅝	
	SS569		130.00	30	6x9	20	8	40-20	5	F	6⅝x9⅜x4	
	SS3269		30.00	30	6x9	20	4	40-15	2	F	6⅝x9⅜x3⅝	
	SS3469		110.00	30	6x9	20	8	40-18	4	F	6⅝x9⅜x3⅝	
	SS625		40.00	12	5¼	10	4 or 8	50-13		F	6¼x2	
	SS725		70.00	30	5¼	20	4	50-16	2	F	6¼x2⅝	
	SS825		90.00	30	5¼	20	8	50-20	3	F	6¼x2⅞	
	SS140		40.00	10	4	10	8	60-14		F	4x1⅜	
	SS5000		300.00	250	6½		4	20-20	2	S	7⅜x11x7⅜	
	SS5100		250.00	250	6½		4	20-20	2	F	7¼x11⅜x1⅝	
	SS3357		100.00	30	5x7	20	4	50-20	3	F	5x7¼x3	
	SS3410		80.00	20	4x10	20	4	50-20	3	F	4¼x10x2⅝	
PYLE INDUSTRIES	F52C165-FP	48.25		30	5¼	16	8		2	F	5¼x5¼x2⅞	Pz. tweeter.
	F52C165-FP4	49.15		30	5¼	16	4		2	F	5¼x5¼x2⅞	As above.
	F69C190-FD	70.85		60	6x9	20	8		2	F	6⅜x9⅜x4	Dome tweeter.
	F69C290-FD	81.60		100	6x9	30	8		2	F	6⅜x9⅜x4¼	As above.
	F69C290-FD4	82.50		100	6x9	30	4		2	F	6⅜x9⅜x4¼	As above.
	F410C160-FP	49.90		30	4x10	16	8		2	F	4¼x10x3	Pz. tweeter.
	F52C100-FP	41.60		20	5¼	10	8		2	F	5¼x5¼x2⅞	As above.
	F69C100-FP	49.90		30	6x9	10	8		2	F	6⅜x9⅜x3¼	As above.
	F69C190-FP	58.25		60	6x9	20	8		2	F	6⅜x9⅜x4	As above.
	F69C290-FP	66.60		100	6x9	30	8		2	F	6⅜x9⅜x4¼	As above.
	F410C100-FP	43.25		30	4x10	10	8		2	F	4¼x10x3	As above.
	F35C30-WF	19.15		16	3½	3	8		2	F	3½x4⅜x1⅝	
	F5C99-WF	22.50		18	5	10	8		2	F	5x2⅛	
	F52C100-WF	22.90		20	5¼	10	8		2	F	5¼x5¼x2⅜	
	F6C100-WF	24.90		30	6	10	8		2	F	6½x2¾	
	F57C100-WF	24.90		28	5x7	10	8		2	F	5x7¼x2½	
	F69C100-W	23.75		30	6x9	10	8			F	6⅜x9⅜x3	
	F69C100-WF	25.40		30	6x9	10	8		2	F	6⅜x9⅜x3	
	F410C100-WF	25.25		30	4x10	10	8		2	F	4¼x10x2¾	
	PK52C165-FP		108.25	30	5¼	16	8		2	F	5¼x5¼x2⅞	Pz. tweeter.
	PK69C190-FD		149.90	60	6x9	20	8		2	F	6⅜x9⅜x4	Dome tweeter.
	PK69C290-FD		166.60	100	6x9	30	8		2	F	6⅜x9⅜x4¼	As above.
	PK410C160-FP		109.90	30	4x10	16	8		2	F	4¼x10x3	Pz. tweeter.
	PK52C100-FP		91.60	20	5¼	10	8		2	F	5¼x5¼x2⅞	As above.
	PK69C100-FP		108.25	30	6x9	10	8		2	F	6⅜x9⅜x3¼	As above.
	PK69C190-FP		124.90	60	6x9	20	8		2	F	6⅜x9⅜x4	As above.
	PK69C290-FP		141.60	100	6x9	30	8		2	F	6⅜x9⅜x4¼	As above.
	PK410C100-FP		96.60	30	4x10	10	8		2	F	4¼x10x3	As above.
	PK52C100-WF		61.60	20	5¼	10	8		2	F	5¼x5¼x2⅜	
	PK69C100-WF		66.60	30	6x9	10	8		2	F	6⅜x9⅜x3	
	PK410C100-WF		63.25	30	4x10	10	8		2	F	4¼x10x2¾	
	P-G52N		10.85		5¼					F	6½ rd.	
	G69ND	6.25			6x9					F	6⅜x9½	
	G410ND	5.85			4x10					F	5⅛x10⅛	
	W6C170-F	33.25		70	6	16	8			F	6½x3⅛	
	W69C190-F	38.25		70	6x9	20	8			F	6⅜x9⅜x3½	
	W69C290-F	49.90		100	6x9	30	8			F	6⅜x9⅜x4	
	W69C290-F4	50.85		100	6x9	30	4			F	6⅜x9⅜x4	
	T3PA	14.90			3			3k-30k		F	3⅜x¾	Pz. tweeter.

SPEAKERS

MANUFACTURER	Model	Price, $ (If sold individually)	Price, $ (If sold in pairs)	Recommended Power, Watts	Driver Size, Inches	Magnet Size, Oz.	Impedance, Ohms	Frequency Response, Hz to kHz, ± dB	Two-way (2) or Three-way (3)	Flush Mount (F) or Surface Mount (S)	Overall Dimensions	Notes
SANYO	SP780		89.95	30	6x9	20	8	30-2		F		Separately mounted 2-way, 4-speaker system.
				3.5	3	2.2	8	2k-18k		F		
	SP795		99.95	35	5	20	4 or 8	100-2	2	S	4⅞x7½x4⅛	Self-contained, 2-way system.
				35	3	5.0	4 or 8	2k-20k	2	S		
	SP754		79.95	25	5x7, 6x8	15	4 or 8	70-20	3	F/S		
	SP768		69.95	28	6x9	20	4 or 8	45-16	2	F		
	SP770		79.95	28	6x9	20	4 or 8	60-20	3	F		
	SP777		99.95	30	6x9	20	4 or 8	30-18	3	F		
	SP731		44.95	21	6	10	4 or 8	80-15	2	F		
	SP733		59.95	22	6	10	4 or 8	50-17	2	F		
	SP737		69.95	23.5	6	10	4 or 8	45-20	3	F		
	SP757		54.95	18	5x7	15	4 or 8	80-15	2	F/S	8x6x4	
	SP700		12.98	5	6	3.2	8	100-10		F		
	SP705		16.98	8	6	3.2	8	100-10		F		
	SP708		20.98	8	4	5.4	4 or 8	100-12		F		
	SP710		29.95	12	6	10	4 or 8	90-13		F		
	SP720		39.95	14	4	6.7	4 or 8	10-12	2	F		
SOUND SOURCE	UD-1			100	6,1		8	40-20 ±3	2		7x11½x3	

AMPS/EQUALIZERS

MANUFACTURER	Model	Price	Amp=Amp; EQ=Equalizer; Both=Both	Number of Bands of EQ	Separate Controls for Each Stereo Channel?	Boost/Cut Range, db	Watts into 4 ohms	% THD at Rated Output	Dimensions, Inches
ADS	P100	300.00	Amp				50	0.08	
AUDIOMOBILE	SP300	149.95	EQ	3	No	±15		0.05	4.5x1.6x4.1
	SA400	99.95	Amp				36	0.25	4¾x5½x2
	SA2000	399.95	Amp				200	0.20	7¾x7⅝x4¼
BOSE	1401	See "Speakers" Section.	Amp				50	0.09	10x4½x1½
CRAIG	V501	59.95	Amp				12	1.0	7¼x2x5¼
	V502	84.95	Amp				24	0.5	8½x5½x2½
	V503	199.95	Both	4	No	±12	36	0.1	Two units: 7x1¾x4¾, 9x3x5½.
	V504	119.95	Both	2	No	±10	12	2.0	6x2¼x5¼
	V505	144.95	Both	4	No	±12	24	0.5	Two units: 7x1¾x4¾, 6½x2¼x5½.
GRUNDIG	GAA7000	72.00	EQ	5		±12		0.5	6½x3½x1⅞
	ESO 70	178.00	Amp				35	0.2	6x5½x2½
	ESO 70EQ	376.00	Both	3	No	±15	35	0.2	Two units: 6x5½x2½, 4½x3½x1½.
MARANTZ	SA2040	150.00	Amp				10x4	0.5	2x3⅝x9¾
	SA2415	250.00	Amp				30x2, 15x4	0.05	2x5⅛x10¼
	SA230	70.00	Both	2		±12	10	0.5	1⅝x4¾x7¼
	SA247	160.00	Both	7		±12	15	0.5	2⅛x6¾x5¾
SANYO	PB3000	34.95	Amp				15	1	6x4x2
	PB5050	59.95	Amp				25	1	6½x2¼x5
	PA7000	99.95	Biamp				5,23	3	Two units: 3x9x7, 1½x2½x4½.
	PA6050	119.95	Amp				25	0.05	3x7x7⅝
	PA6100	149.95	Amp				50	0.05	3x7x7⅝
	PA6060	199.95	Biamp				5,25	0.05	3x4½x7¾
	PA6120	249.95	Biamp				10,50	0.05	3x4½x7¾
	EQZ6200	69.95	EQ	7	No	±12		0.1	6½x4¾x2
	EQZ6400	99.95	EQ	7	No	±12		0.1	7½x5x2
TZL INTERNATIONAL	Evadin EQB-60	49.95	Amp				30		1½x4x4½
	Evadin EQB-61	99.95	Both	5	Yes	±12	30		1¾x5⅝x6½
	Evadin EQB-160	39.95	Amp				30		1½x4x4¾
	Evadin EQB-260	69.95	Both	5	No	±12	30		1½x4x4¾

THE ONKYO TX-MKII RECEIVERS... COMMITTED TO QUALITY

Most manufacturers play "take away" when they design a product line. With every cost reduction, there's a quality loss. Onkyo takes a different approach. Each of the five models in the TX-MKII series of receivers represents an exceptional value for price. And vital performance features such as Onkyo's exclusive distortion-free, quartz or servo-locked FM tuning are built into each of the receivers, as is the sophisticated HTS™ (Human Touch Sensor) control. HTS™ senses your touch on the tuning knob and "unlocks" the station. You rough tune to another station, release the knob, and the HTS™ analog comparator circuits automatically find and precisely lock into the most distortion-free station setting.

And aside from the excellent signal-to-noise ratios at all inputs, the Onkyo TX-MKII series provides excellent value-to-dollar ratios at all power levels, starting with the top-of-the-line digital-readout TX-8500MKII rated at 160 watts per channel, with 0.05% total harmonic distortion, both channels driven into 8 ohms from 20 Hz to 20 kHz, to the modest TX-1500MKII at 17 watts per channel and 0.03% THD under the same conditions.

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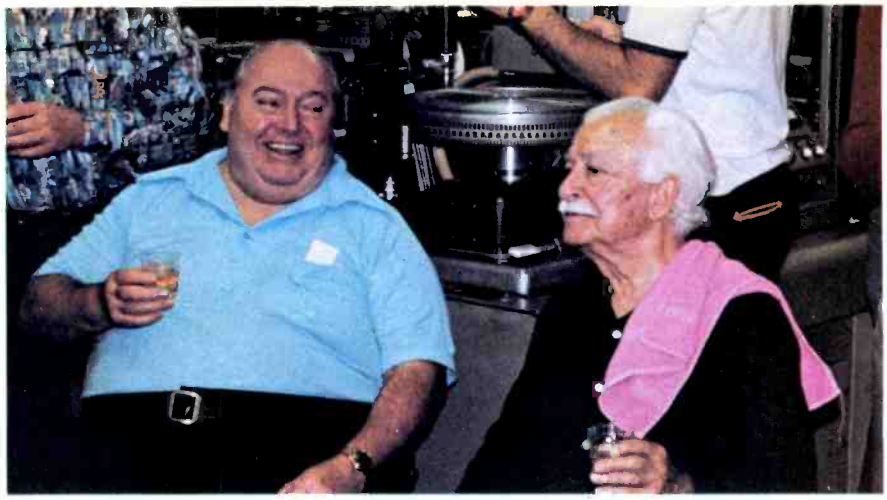
left in the first balcony, as a control room. Into it were crammed two Neumann lathes with SX-68 and SX-74 cutting systems and a Scully lathe with the new Ortofon 732 cutting system. There was an Ampex ATR-102 for straight analog recording, an Ampex ATR-104 for four-channel analog recording, and Dr. Tom Stockham was on hand with his Soundstream digital recording system. With a pair of the big new UREI Time-Aligned® monitoring speakers, we were in business.

Maestro Fiedler approached all this new recording technology with his usual aplomb, and he was quite non-



Bert Whyte with Arthur Fiedler during a playback in the control room.

chalant about my somewhat unorthodox orchestral layout. The players were a little concerned about this new-fangled recording at first, but after the first playbacks they were quite enthusiastic and played like the superb musicians they were. We made a few test cuts so the Maestro could acclimate himself, and were rewarded by hearing him say, "Now, by God, that's how we sound in Symphony Hall!" As we made the first direct discs, we were amazed that the number of "blown" lacquers, from either technical or musical problems was quite minimal. After the first run-through, we were ready for playbacks. Naturally, we couldn't play back the direct-disc lacquers without ruining them, so Tom Stockham gave us a playback of his digital tapes. After a minute or two of listening, the Maestro turned excitedly to me and said, "Listen to that, Bert. No hiss, by God, no hiss. That's marvelous. Marvelous!" Everything went smoothly the following day when we recorded the other side of the disc. Everyone was just bubbling with enthusiasm about the quality of the playbacks. At the end of the session we broke out champagne to toast the occasion, and Arthur said to me, "I'd rather have Schnapps, but what the hell, champagne is all right!"

We played the digital tapes at the AES convention the next day, and they caused quite a sensation. Sadly, although negotiations were in progress for a follow-up recording with the Maestro, his death ended all that. Arthur Fiedler was under no illusions that he was a conductor to test his mettle against a Mahler or Bruckner, but in his particular musical milieu, he had no peer.

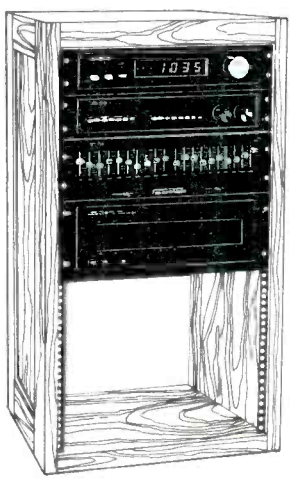
As Tom Morris said to me, "We can get another conductor for The Pops, but we can never replace Arthur Fiedler." Amen.

INSIDE EVERY RECEIVER OWNER IS A SPECTRO ACOUSTICS BUYER

Don't blame the singer if her high notes make your teeth hurt. Or the drummer if his boomy performance threatens to dislodge a kneecap. The rotton sound probably comes from your lack of control over your listening environment not from their lack of talent.

Plain truth is, good sound, like good sailing, is about 90% balance. And your listening room simply scuttles the tonal balance of every piece of music that comes through your system.

Spectro Acoustics™ equalizers are made to let you hear music as it was really meant to be heard. Our Model 2102R has ten silicon damped slide pots for each channel, for a 30dB range adjustment over the entire audible listening range-octave by octave. The 210R offers additional features such as a pair of unity gain adjustments and a full range of tape equalization and monitoring facilities, for creating tapes that are pre-equalized for special listening environments — like your car sound system. A Spectro Acoustics Model 210R or 2102R equalizer is, after loud speakers, the most crucial determinant of the quality of music you hear, and a necessary tool for getting full value from your investment in equipment and records. And beyond that, a Spectro Acoustics equalizer is just plain fun to use.



SPECTRO ACOUSTICS™

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The most generally agreed upon objective of high fidelity is to recreate the realism of live music performances in the home listening environment. Various acoustic characteristics and psychoacoustic phenomena have been identified over the years that appear to be responsible for the emotional impact and excitement that we experience at a live performance. However, past limitations in the tape recording process and software formats for traditional delivery systems, that is records and tapes, have imposed serious restrictions on one of the major factors involved — dynamic range. This article will explore the significance of dynamic range in music and review the use of noise-reduction technology and dynamic range expansion to improve the realism of music reproduction for increased listening pleasure.

Since the late 1890s when Thomas Edison and Emile Berliner first began to record musical performances on cylinders and discs, there has been a persistent disparity between the quality of "master" recordings produced with the performing artist and that of mass-produced copies made from the masters. Steady advances in recording technology, however, have improved every link in the chain of music recording and reproduction, narrowing the gap between live and recorded performances.

A major milestone in the history of recorded music was the introduction of the long-playing microgroove record in the 1940s, which increased the playing time of records so that compositions of considerable length could be recorded uninterrupted. Another major advance followed in the form of magnetic tape recording that provided a means of editing recorded performances and producing a master tape from which an unlimited number of vinyl pressings could be made. Unfortunately, magnetic tape recording of analog signals introduced its own set of problems which detracted from the fidelity of recorded music, the most notable being tape hiss, but also including wow and flutter and other forms of distortion.

The realism of recorded music was dramatically enhanced in the 1950s with the introduction of stereophonic sound, which brought much of the perspective of the hall or stage to the home. The "three-dimensional" character of sound produced by multi-channel signal processing touched off a great deal of research that, in the late 1960s, led to a development that promised an even greater increase in realism of recorded music — quadraphonic sound. But, the audio industry experienced a marketing disaster with quad due, in large part, to its inability to agree on hardware and software standards. The potential benefits of four-channel sound were never fully realized, even though the concept had considerable technical merit and is still being explored.

Over the years, the quality of music-reproduction hardware (amplifiers, record playing equipment, and speakers) has surpassed that of available music software — records, tapes, and radio broadcasts. In response to growing demands for recordings with improved sound quality, so-called "audiophile" records were introduced during the 1970s in the form of direct-to-disc records and digitally mastered records. The major contribution made by these technical innovations was the elimination of tape hiss and the various forms of distortion associated with analog master tape recordings. Their superiority over conventional records was immediately obvious; however, even these fine recordings are too often marred by the presence of record surface noise and restrictions on the dynamic range that could be captured on and retrieved from a vinyl disc.

We are still faced with the challenge that has been the underlying motive for the steady stream of technological advances in sound recording and reproduction — *to recreate the excitement and emotional impact of a live performance in the home listening environment.* Our ability to meet this challenge is certainly enhanced by analyzing and understanding the acoustic and psychoacoustic factors that characterize "live performance" sound, so that appropriate consideration will be given to these characteristics when attempting to make improvements in the music recording and reproduction process.

Characterizing Live Performance Sound

Our appreciation and enjoyment of music, whether live or recorded, is strongly related to three major factors that characterize live performance sound: Tonal balance, spatial perspective, and dynamic range.

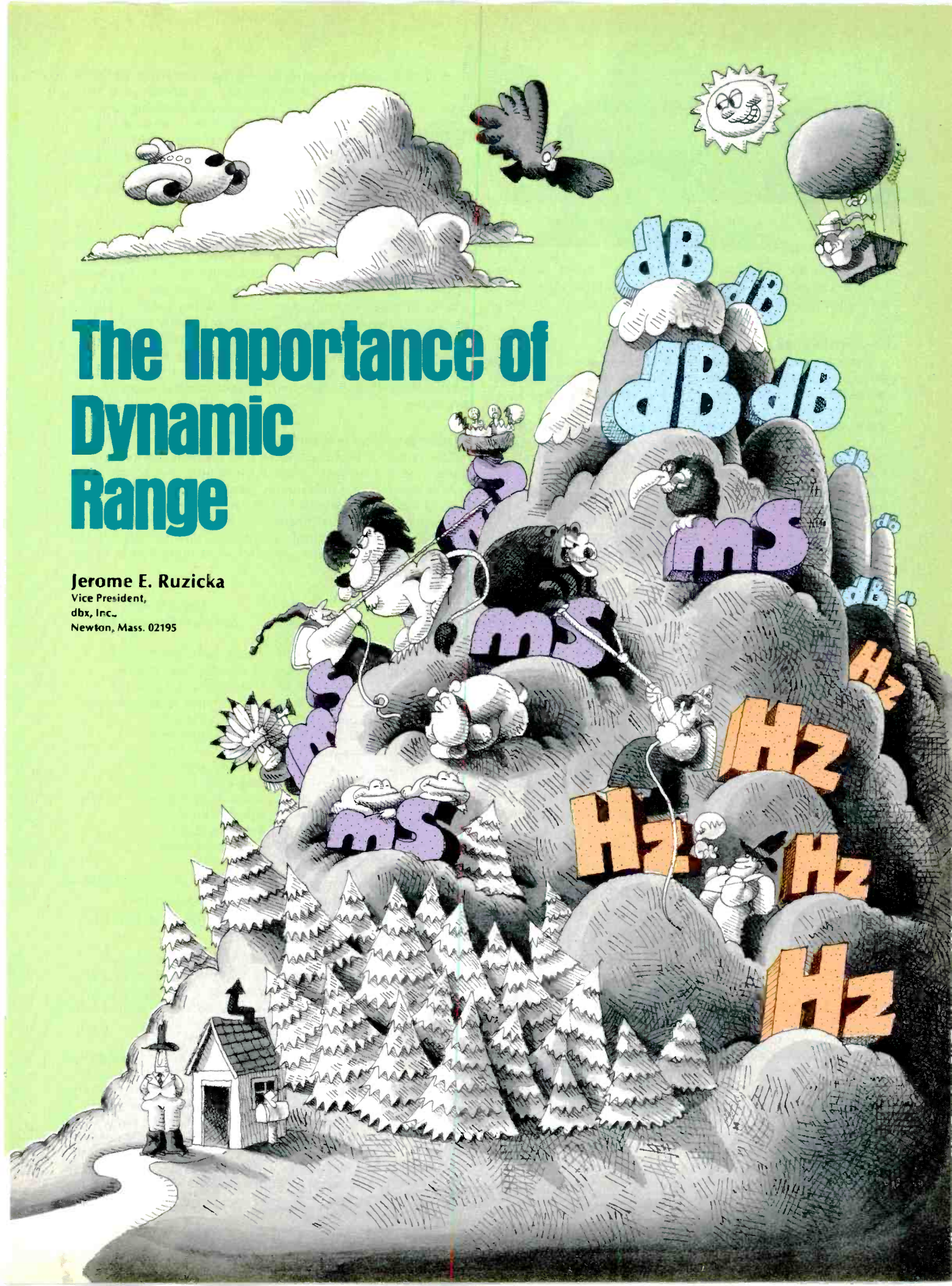
Tonal Balance

The tonal balance of music has received the greatest amount of attention over the years. It has long been appreciated that the low-frequency content of music should be kept in balance with the high-frequency content, consistent with that which occurs in live performance. Today, most recording and reproduction equipment is capable of handling frequencies that extend well beyond the audible range of 20 Hz to 20 kHz. Electronics are readily available that offer responses over this frequency range with variations smaller than those which can be detected aurally. Covering a frequency range necessary for quality music reproduction is no longer a significant technical challenge for records, phono cartridges, and tape recorders. Also, many fine speakers are now available that are capable of uniformly reproducing most all frequencies in the audio spectrum. Further improvements in frequency response characteristics are unlikely to produce greatly significant improvements in the perceived tonal balance quality of recorded music.

Spatial perspective is a somewhat elusive quality of sound involving a complex combination of geometric and temporal factors. In the geometric dimension, our perception of the spatial character of sound seems to center around a *panoramic* sound field in which individual instruments can be localized. Giving breadth to the musical performance, the sense of spaciousness involved is extremely important in creating the illusion of "being there" at a live performance. Stereo sound reproduction represented a major step forward relative to recreating the spatial perspective of live music. Also, special speaker designs have been developed in an attempt to produce a combination of direct and reflected sound similar to that which exists in live performances. Finally, recent developments have resulted in microphones and signal-processing techniques which are claimed to recreate the sound field geometry present during the original performance.

The temporal aspect of spatial perspective is primarily related to what is usually described as a sense of *ambience.* What a listener hears at a live performance is a composite of multiple sound waves, each arriving at slightly different times because of the many different sound transmission paths that are involved. This dimension of live music has been the subject of considerable research and experimentation over the years involving the use of reverberation and delay-line devices to create auxiliary acoustic signals that are delayed in time from the master audio signal. The most recent developments that address the temporal character of sound in music reproduction are electronic "time delay" or "ambience recovery" systems that employ either analog or digital signal processing to create auxiliary signals with variable amounts of time delay. The primary function of such devices is to simulate the ambience of a wide range of acoustic environments — from small, intimate rooms to large, highly reverberant halls.

There is still much to learn about the geometric and temporal characteristics of sound. Some of the approaches taken to introduce spatial perspective in music reproduction have



The Importance of Dynamic Range

Jerome E. Ruzicka
Vice President,
dbx, Inc.,
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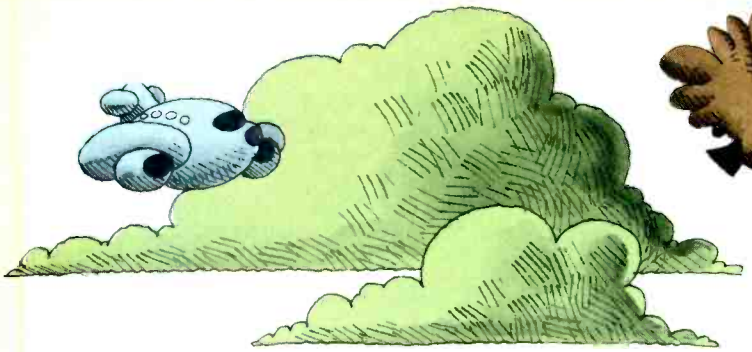


resulted in an unnatural sound quality. Others have improved the sense of realism. More substantial advances in creating a realistic spatial perspective undoubtedly are yet to come.

Dynamic Range

Dynamic range is the difference between the sound levels during the loudest (fortissimo) and quietest (pianissimo) music passages. Giving depth to the musical performance, its existence during a live performance is as apparent to the listener as its absence in a recording. Exposure to the dynamics of live music has caused us to appreciate the extremely large amplitude differential between the whisper of a lone flute and the thunderous finale of a symphonic work. It's not too unusual to experience a 90-dB dynamic range in a live performance but, unfortunately, more than one-third of this range (and its associated effect on realism) has traditionally been lost before the music signal gets through the recording and reproduction process.

In order to store the music information on magnetic tape or vinyl discs, it traditionally has been necessary to compress or otherwise modify the amplitude of the recorded signal so that (1) the signal strength during loud passages stays below saturation and tracing distortion levels for tape recording and disc mastering, respectively, and (2) the signal strength during quiet passages stays sufficiently above magnetic tape noise levels and record surface noise levels. Basically, the problem has to do with the *signal-to-noise ratio* (S/N) limitations of tape and disc recording processes. The S/N ratio has to be greater than the desired music dynamic range if loud music passages are to be recorded without distortion and quiet passages are to be heard clearly above the background noise on the tape or record. Hence, an S/N ratio of 60 dB may be required to provide a clean dynamic range of 50 dB with 10 dB safety margin shared between the top and bottom ends of the dynamic range.

During tape recording, a common method for restricting the dynamic range is to "gain ride"; that is, the recording engineer manually adjusts the levels while the recording is being made — reducing them during fortissimo passages and increasing them during pianissimo passages. This same result is frequently accomplished automatically by using *limiters* that prevent high-level signals from exceeding a preset level or by using *compressors* that gradually reduce level when loud passages occur and increase level during quiet passages. Without the aid of a tape noise-reduction system and excluding allowance for signal peak "headroom," the dynamic range capability of a professional studio tape recorder is typically 60 dB at the 15 ips speed and somewhat higher at 30 ips. The comparable figures for high-quality audiophile open-reel tape recorders operating at 7.5 ips is 50 dB, and for a good cassette recorder, about 45 dB applies. The psychoacoustic impact of such dynamic range restrictions is to make the music sound "flat" or "thin." The sharp edge of percussive attacks is blurred, the contrast between loud and quiet instruments is muddled, and the overall definition is obscured, thereby diminishing the excitement and realism of the recorded performance.

A similar problem occurs during disc mastering, since the maximum dynamic range that can be stored on a vinyl disc is about 55 dB for conventional pressings and up to about 65 dB for the very finest pressings. Again, a substantial loss in excitement, emotional impact and realism results from the dynamic range restrictions of conventional discs — and they are plagued as well by annoying record surface noise, even for the best direct-to-disc and digitally mastered records.

Since dynamic range has a tremendous effect on our enjoyment of music, it should be recognized for its importance and receive more attention in the music reproduction process. Further improvements in characteristics like frequency response are not likely to significantly increase the overall quality of music reproduction. On the other hand, a modest increase in dynamic range will be immediately perceived as making substantial improvements in the realism of music reproduction. Consequently, dynamic range represents very fertile ground to be explored relative to coming closer to our goal of recreating the live-performance musical experience in the home.

Understanding Dynamic Range

The range of sound pressure that humans are capable of perceiving is extremely large. For example, the sound pressure is about one million times greater at a level that causes pain or discomfort (about 120 dB) as it is for the threshold of audibility (0 dB). This means that the human auditory process handles approximately twice the dynamic range in dB (or 1000 times in sound pressure) of a professional studio tape recorder.

Relative Sound Pressure		Sound Pressure Level	Typical Sound Sources or Environments
		130 dB	Artillery Fire (Close Proximity)
1,000,000		120 dB	Jet Aircraft (Close Proximity)
		110 dB	Orchestra/Band (Audience)
100,000		100 dB	Train/Propeller Airplane (Interior)
		90 dB	Bus/Truck (Interior)
10,000		80 dB	Automobile (Interior)
		70 dB	Average Street Noise
1,000		60 dB	General Business Office
		50 dB	Private Office
100		40 dB	Residential Living Room
		30 dB	Suburban Bedroom
10		20 dB	Recording Studio
		10 dB	Sound-proof Room
1.0		0 dB	Total Silence

Fig. 1 — Typical sound sources or environments for a range of sound pressure levels measured in dB as well as indicated relative to 0 dB.

Our hearing mechanism responds to changes in sound intensity (pressure) in a roughly logarithmic manner, rather than in an absolute way. For this reason, and as a matter of convenience, the decibel scale is used to describe Sound Pressure Level (SPL), as follows:

$SPL = 20 \log_{10}(P/P_o)$

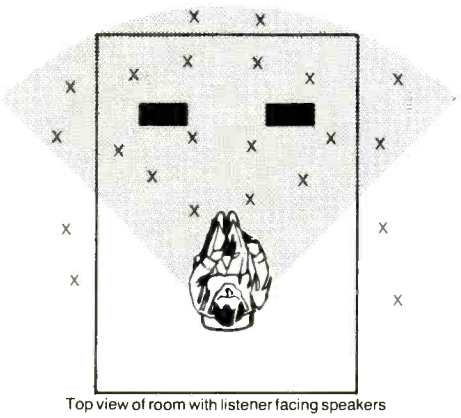
where the reference pressure P_o is defined as the threshold of audibility corresponding to 0.0002 μbar, and a μbar (microbar) is the pressure of one millionth of an atmosphere. Hence, a range of 0 dB to 120 dB covers the entire range of sound amplitude that is of interest, much like the range of 20 Hz to 20 kHz that applies to the audible frequency range of sound.

Typical sound sources or environments are presented in Fig. 1 for a 130-dB range of sound pressure levels. A doubling

SONIC HOLOGRAPHY!

Carver Sonic Holography™ – it is absolutely astonishing.

Sonic Holography ™ technology provides a dimensionally realistic sonic image from any stereo tape, record, or broadcast. Instruments and voices appear naturally and convincingly within a wide and deep sonic stage, behind, in front of, and off to the sides of the two front speakers. This remarkable achievement until recently has been a laboratory curiosity demonstrated with special recordings or in anechoic chambers. Carver research brought Sonic Holography out of the laboratory and into the listening room.



Top view of room with listener facing speakers

The holographic image places instruments in a broad proscenium arc. Primary sound images (x) clearly emerge from beyond the room boundaries each in a fixed and totally natural position. There is no spatial distortion in size or location of the instruments. Such holographic imaging is not possible with conventional stereophonic or time-delay enhanced reproduction.

Here's what the experts said about Carver Sonic Holography:

"The results were positively breathtaking. . . . With the lights out, we could almost have sworn we were in the presence of a real-live orchestra."

Harold A. Rodgers
Senior Editor, *Popular Electronics, May 1979*

"The instrumental sounds, originally heard in a more or less narrow line between the speakers, were suddenly located down the side walls of the room to a point nearly as far back as we were sitting (about 12 feet from the speakers). The sound took on a rich, solid quality . . . "

"The 'miracle' in Carver's technique is that it uses only the two normal front speakers—and that it works!"

Julian Hirsch
Hirsch-Houck Laboratories
Stereo Review May 1979

"My listening experiences leave no doubt that the technique produces a far more plausible sonic illusion of space and localization than is produced by normal stereo. . . . it brings the listener substantially closer to that elusive sonic illusion of being in the presence of a live performance."

Larry Klein, Technical Director
Stereo Review, May 1979

"In sum, listening to the C-4000 in its hologram position was a thrilling sound experience for me. Plain old stereo will never be the same."

Arthur Salsberg, Editorial Director
Popular Electronics, May 1979

Sonic Holography is now available in the Carver C-4000. It is a versatile control console that also includes a sophisticated preamplifier, third generation Autocorrelator for noise reduction, Peak Unlimiter for restoration of dynamic range & Time Delay with built-in power amplification. For copies of the complete reports write to the Carver Corporation or use the reader service card.

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of sound pressure corresponds to a 6-dB increase in SPL, while 20 dB represents an order of magnitude increase. While the levels of SPL are approximate for each sound source indicated, a comparison of relative SPLs is very revealing. For example, the background noise level in a residential living room is 10 times (or 20 dB) higher than the level in a recording studio. Similarly, the noise level that exists in a general business-office environment is 10 times higher than the living room level.

Returning to music, it is possible for peak sound pressure levels to momentarily reach 120 dB during transients. If these peak levels are produced in a studio, concert hall, or home environment, the "noise floor" of 20 dB to 40 dB, depending on its spectral distribution, can reduce the perceived dynamic range of music to about 90 dB. Therefore, a music recording and reproduction system need only be required to handle a maximum dynamic range of 90 dB to properly represent the characteristic of live performance sound.

Noise Sources and Masking Effects

It is important to note that there are two separate and distinct fundamental sources of noise which detract from the fidelity of recordings — those that are introduced while recording a master tape and those that are associated with disc mastering and playback. Direct-to-disc, digital recording, and tape noise reduction applied to conventional analog recording are techniques that address the issue of eliminating (or at least reducing) the introduction of noise prior to disc mastering. Unfortunately, full benefit of these advanced recording techniques is lost to a great extent when the recording is transferred to a vinyl disc.

With the masking effect of tape hiss removed, the surface noise of the record becomes all the more objectionable. It appears that the elimination of a major noise source, such as tape hiss, serves to highlight another — record surface noise generated as a result of the interaction between the stylus and the record groove. Any roughness of the vinyl surfaces of the groove walls causes extraneous stylus motion, creating the familiar record surface noise which is inseparable from the music on conventional vinyl discs. Of course, the opposite is also true. If the surface noise of discs is eliminated, any imperfections in the master tape relative to hiss or other forms of noise and distortion become more apparent. Hence, it is clear that noise in *both* the master tape and the recorded disc has to be eliminated, or at least dramatically reduced, to significantly improve the quality of recorded music.

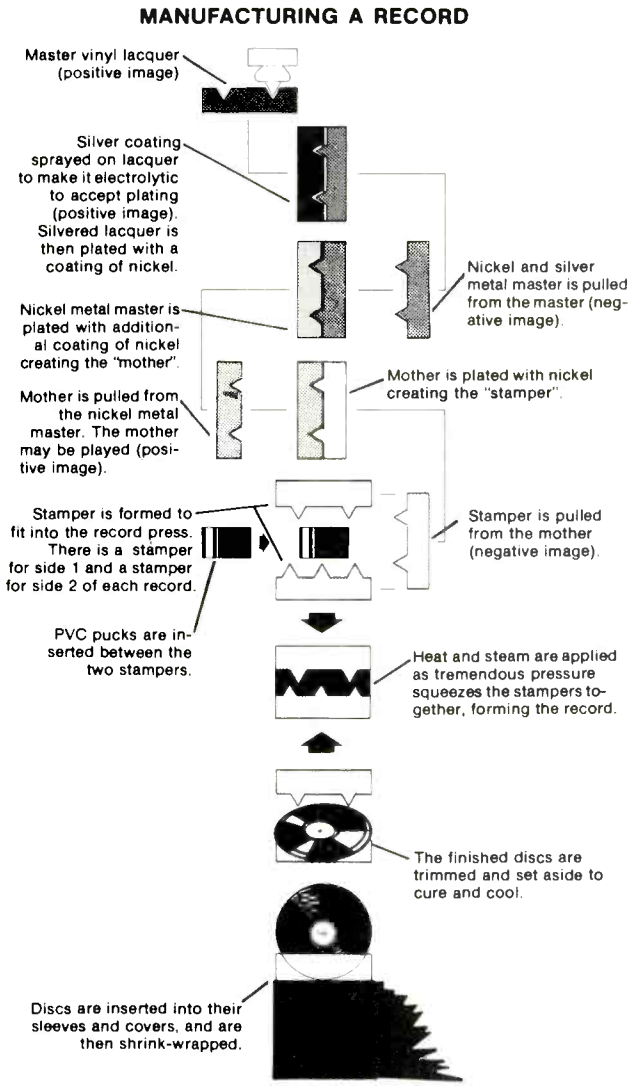

Fig. 2 — Illustration of the various stages of the record manufacturing process. (Courtesy of Nautilus Recordings.)

Evolution of Recording Technology

Since the mid-1940s, there have been major technological advances in sound recording. Prior to the development of magnetic tape recording, records were made in the old 78 rpm format involving the cutting of a single-channel (monaural) groove in the surface of a master recording blank. The fidelity and time per side (four minutes per side on a 12-in. disc) were limited, and any performance errors required recutting the master. With the advent of the long-playing microgroove record came extended playing time per side, improved pressing quality (accomplished by using vinyl instead of shellac), and increased durability — all resulting in a better overall value to the record-buying public.

The Record Manufacturing Process

The beginning point in the record manufacturing process is the production of a master disc or lacquer. This is accomplished by using a master tape recording (or the real-time output of a mixing console in a direct-to-disc recording session) to provide an electrical signal that is fed to a heated cutting stylus which engraves the surface of the lacquer with traces representing the musical waveform. The diagram presented in Fig. 2 illustrates each subsequent step of the process involved. Since the quality of a lacquer may deteriorate if it is not plated shortly after being cut, the multi-stage electroplating process is generally scheduled to occur immediately after the master cutting session. The (positive image) lacquer is plated to produce a (negative image) metal master. Then a (positive image) metal "mother" is made, from which (negative image) metal stampers are made. The stampers are used to press (positive image) vinyl discs that are a replica of the original lacquer.

From each master lacquer, only one metal master can generally be made. The number of mothers available from each metal master is limited, as are the number of stampers from each mother and the number of pressings from each stamper. These limitations are such that only about 20,000 to 25,000 high-quality pressings can be produced from each lacquer. Multiple lacquers, therefore, are necessary to produce larger quantities of quality pressings.

Analog Tape Recording

For the last several decades, it has been common practice in producing records to temporarily store the musical performance on magnetic tape. A typical recording session in-

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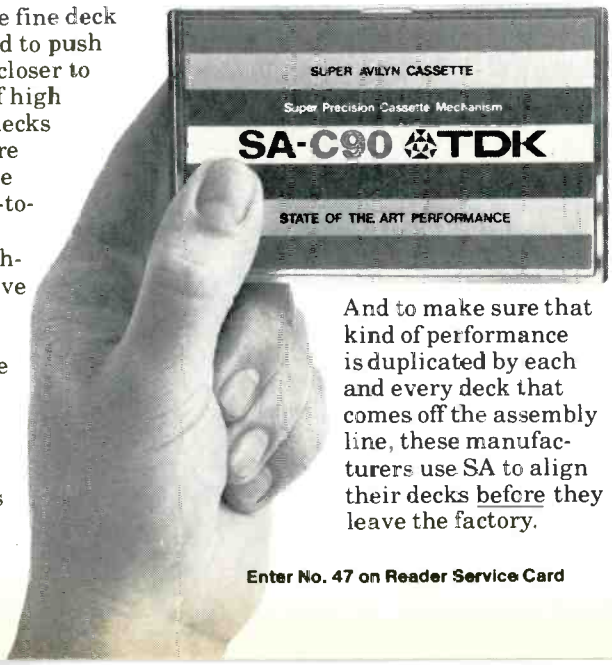
In the past few years, these fine deck manufacturers have helped to push the cassette medium ever closer to the ultimate boundaries of high fidelity. Today, their best decks can produce results that are virtually indistinguishable from those of the best reel-to-reel machines.

Through all of their technical breakthroughs, they've had one thing in common. They all use TDK SA as their reference tape for the high bias position. These manufacturers wanted a tape that could extract every last drop of performance from their decks and they chose SA.



And to make sure that kind of performance is duplicated by each and every deck that comes off the assembly line, these manufacturers use SA to align their decks before they leave the factory.

Which makes SA the logical choice for home use; the best way to be sure you get all the sound you've paid for.

But sound isn't the only reason SA is the high bias standard. Its super-precision mechanism is the most advanced and reliable TDK has ever made—and we've been backing our cassettes with a full lifetime warranty* longer than anyone else in hi fi—more than 10 years.

So if you would like to raise your own recording standards, simply switch to the tape that's become a recording legend—TDK SA. TDK Electronics Corp., Garden City, NY 11530.

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The machine for your machine.

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volves the recording of multiple "takes" of a musical selection in order to provide enough material to create something which approaches "the perfect performance." This is accomplished by an editing engineer who listens to the various takes and chooses the best parts of each one, then combines them together (by physically cutting and splicing the magnetic tape). This results in an edited recording of the musical selection. The practice is so common that few musical selections (notably those recorded "live" before an audience) listened to on a record today represent a continuous performance by the musicians or performing artist. Rather, we generally hear a composite of several performances where any mistake or imperfection is removed in the editing process. Consequently, the ability to edit represents one of the major advantages of using a magnetic tape recorder in producing a record.

Another advantage of tape recording is that the master (edited) tape can be used to cut as many lacquers as are required to meet consumer demand for the record album. Hence, there is no limitation to the quantity of records that can be produced from a master tape.

Although records produced from analog master tapes represent the best sound recordings available until recently, there have been serious technical limitations inherent in the process. Various forms of distortion and noise are introduced into the recording because of the mechanisms that are operative in the recording process. For example, analog tape recording suffers from such problems as tape hiss, wow and flutter, frequency response non-uniformity, modulation noise, multi-channel crosstalk, print-through, and transient distortion. Of particular significance is the background noise that appears as tape hiss in the recording, which ultimately gets transferred to the master disc and vinyl pressings produced from the tape.

As the magnetic tape passes by the recorder head of a tape transport during the recording mode, the electrical signal provided by the microphone pickup of the music performance causes a reorientation of the magnetic particles on the tape to produce a magnetic replica of the music waveform. In the playback mode during the cutting of a master disc, the magnetic tape passes by the recorder head but, in addition to "reading" the music signal, the head also "reads" the random distribution of magnetic particles on the tape and this is perceived as tape hiss. Consequently, during the cutting of a master disc, both music and tape hiss signals are communicated to the cutting stylus, thereby introducing background noise in the master disc and all records that are subsequently pressed. As discussed earlier, the presence of noise in analog tape recording results in dynamic range being restricted to about 60 dB for professional studio tape recorders, while for audiophile reel-to-reel and cassette tape recorders, the dynamic range is restricted to about 50 dB and 45 dB, respectively. A trade-off exists, consequently, between the advantages of tape recording (editing and unlimited production capabilities) and the undesirable restriction it imposes on dynamic range.

Tape Noise-Reduction Systems

A number of techniques have been employed since the early 1970s to improve the dynamic range capability of analog tape recorders. These "noise-reduction systems" process audio signals in various ways to increase the S/N ratio of a tape recording system, resulting in an increase of its usable dynamic range.

Two of the most successful approaches to tape noise reduction have been those developed by Dolby Laboratories and dbx, Inc. Neither one can improve the quality of an existing audio signal, that is, any noise existing in the audio signal is processed unaltered. Their function is solely to reduce the amount of noise added during the recording process. Hence, they might appropriately be called *noise-prevention systems*.

Both Dolby and dbx operate effectively as *companders* — a signal processing system involving *encoding* of the audio signal during recording and *decoding* the signal during playback. However, their operation is based on completely different principles.

The Dolby Type A ("professional") noise-reduction system is actually a dynamic equalization system that operates over four separate bands of the audible frequency range. During recording, increasing amounts of pre-emphasis are applied to the audio signal in these frequency bands as the signal level approaches predetermined reference levels. During playback, complementary amounts of de-emphasis are applied to the signal in the four frequency bands. Recognizing that the behavior of the Dolby system is nonlinear relative to amplitude, the identical reference or "threshold" levels must be employed during recording (encoding) and playback (decoding) to avoid mistracking distortion. The Dolby Type B ("consumer") noise-reduction system operates over a single frequency band in the high-frequency region above 1 kHz where tape hiss is normally encountered. During recording, all signals having high-frequency amplitudes below a reference level are subject to pre-emphasis, with subsequent complementary de-emphasis applied during playback. In the course of attenuating the high-frequency content of the audio signal during playback, tape hiss is reduced.

The dbx Type I ("professional") and dbx Type II ("consumer") noise-reduction systems operate on all frequencies and all amplitudes of the audio signal. The dbx system functions as a linear decibel compressor/expander that is neither frequency selective nor level sensitive, and thus it does not involve the use of reference levels or calibration test tones. During recording, the amplitude of the audio signal is compressed while, during playback, the amplitude of the signal is expanded in a complementary fashion. The basic idea behind the dbx tape noise-reduction system is to keep the music signal level sufficiently higher than the offending noise level (e.g., tape hiss) during recording (encoding) so that, in the course of expanding the signal during playback (decoding), tape hiss is reduced, thus extending the S/N ratio of the tape recording system.

By processing all the frequencies in the audio signal, the dbx system eliminates any anomalies that may be introduced by limiting the companding action to a limited frequency band. Precision level-sensing circuits are used to control both the encode (compression) and decode (expansion) modes of operation during recording and playback, respectively. Employing a voltage-controlled amplifier (VCA) and a level detector in each stereo channel, the compression/expansion gain instructions given to the encode and decode VCAs are equal and opposite (mirror image) as long as the two level detectors track accurately.

All recording systems have some frequency-dependent phase shift which can change waveforms considerably even though the sound is not audibly degraded. This could introduce an error signal that is added to the music signal prior to decoding. The dbx system circumvents this problem by employing wide-range rms (root-mean-square) level-sensing circuits that respond to the signal energies, regardless of their phase relationships, in creating a command signal to drive the VCAs. Using a 2:1 compression during recording and a 1:2 expansion during playback, this linear decibel compander provides accurate results, even with extremely sharp music transients, over a wide (100 dB) range of signal level.

The decode process in tape noise-reduction systems should be a mirror image of the encode process, and the accuracy of the system in providing precise mirror imaging determines the fidelity of the signal processing. Any extrane-

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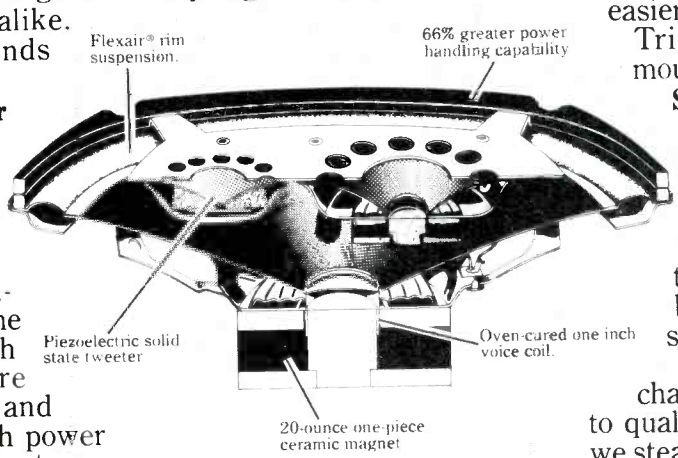

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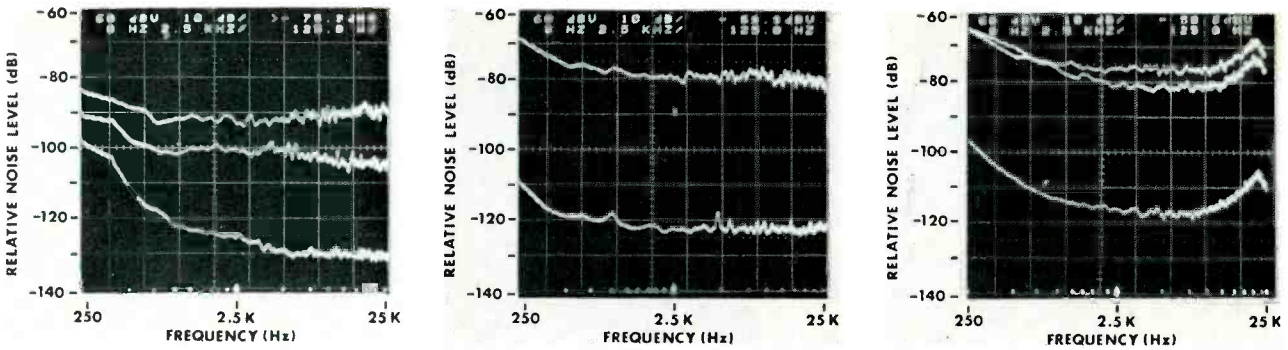


Fig. 3 — Constant 125-Hz bandwidth frequency spectrum of Ampex 456 tape using a Studer/Levinson A-80 professional studio recorder operating at 15 ips. Noise level is shown relative to 0 VU for no noise reduction (upper trace), Dolby Type A noise reduction (middle trace), and dbx Type I noise reduction (lower trace). The total wide-band (20 Hz to 20 kHz) noise level of -65 dB is reduced to -76 dB by the Dolby noise-reduction system and to less than -100 dB (at the limit of the measurement instrumentation) by the dbx noise-reduction system.

Fig. 4 — Constant 125-Hz bandwidth frequency spectrum of Scotch 206 tape using a Pioneer RT-707 audiophile open-reel recorder operating at 7.5 ips. Noise level is shown relative to 0 VU for no noise reduction (upper trace) and for dbx Type II noise reduction (lower trace). The total wide-band (20 Hz to 20 kHz) noise level of -59 dB is reduced to -96 dB by the dbx noise-reduction system.

Fig. 5 — Constant 125-Hz bandwidth frequency spectrum of Maxell UD XL-I tape using a Tandberg TCD-340A cassette recorder operating at 1⅞ ips. Noise level is shown relative to 0 VU for no noise reduction (upper trace), Dolby Type B noise reduction (middle trace), and dbx Type II noise reduction (lower trace). The total wide-band (20 Hz to 20 kHz) noise level of -48 dB is reduced to -56 dB and -84 dB by the Dolby and dbx noise reduction systems, respectively.

ous signal introduced into the system subsequent to encoding but prior to decoding is decoded along with the original audio signal. This, as well as any mistracking errors between the encode and decode modes of operation, can introduce distortion or artifacts in the form of unnatural sounds. The nature of the artifact is different for each type of companding system, but its character is frequently described as a "pumping" sound or "noise modulation." Obviously, one would like the companding system to be totally free of any forms of distortion, but reality is such that a trade-off is frequently involved between the elimination of tape noise and distortion of the companded signal. Fortunately, psychoacoustic masking provided by the music signal itself is generally adequate to make the artifact inaudible. The masking effect of a given sound is greatest upon offending sounds that are of somewhat higher frequency. Hence, a music signal having frequency content that encompasses the frequency range of the artifact will generally be processed with complete fidelity. The enhanced music experience that is provided by increased dynamic range and reduced background noise makes the trade-off heavily in favor of using these types of tape noise-reduction systems.

To illustrate the effect of tape noise reduction on the performance of a range of tape recording systems, background noise spectra were measured with and without Dolby and dbx noise-reduction systems in the circuit. The results are presented in Figs. 3 to 5 for a professional studio, audiophile open-reel, and high-quality cassette recorder, respectively. The frequency spectrum of noise was measured using an automatic spectrum analyzer for a constant 125-Hz bandwith. The noise spectra in the figures indicate the noise level relative to 0 VU for frequencies ranging between 250 Hz and 25 kHz. The total wide-band noise was also measured in each case for all frequencies in the audible frequency range (20 Hz to 20 kHz). Since Dolby noise-reduction systems comparable to dbx Type II systems are not readily available, only noise spectra with and without dbx Type II noise reduction are shown in Fig. 4 (as well as later in Figs. 6 and 7).

A summary of the total wide-band noise levels for professional studio, audiophile open reel, and cassette tape recorders, with and without tape noise reduction, is presented in Fig. 6. The chart also indicates the approximate increase in dynamic range provided by Dolby and dbx tape noise-reduction systems for each type of tape recorder. The information on this chart may be combined with that previously given to tabulate the approximate usable dynamic range capabilities of various types of tape recorders, with and without noise reduction, as presented in Fig. 7. Usable dynamic ranges in excess of 80 dB are possible for each type of tape recorder using dbx noise reduction. Professional studio recorders equipped with dbx noise reduction meet the objective of 90-dB dynamic range and, therefore, they can properly represent the music dynamics of live performance sound.

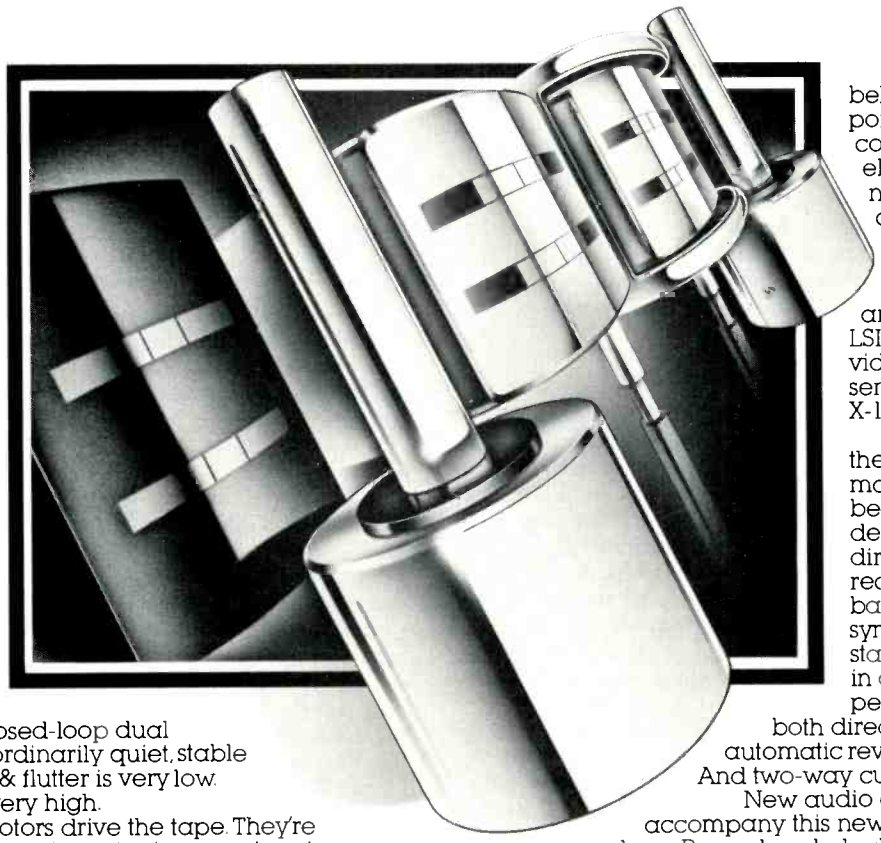
It is interesting to note that, with its wide-band companding action, the dbx noise-reduction system makes the dynamic range capability of open-reel tape recorders approximately equal to that of 14-bit and 16-bit digital recording systems (discussed later). This is a particularly important observation in view of the cost penalty associated with digital recording equipment.

Direct-to-Disc Recording

During the 1970s, a "new" recording approach was introduced for disc mastering. It involved cutting a master disc in real time — the same way that 78-rpm discs were produced from about 1898 until their demise in the early 1950s. Instead of storing the musical performance on magnetic tape, the electrical signal from the mixing console is amplified and fed directly to the cutting stylus of a mastering lathe — hence, a "direct-to-disc" recording.

In the many years since 78-rpm discs were cut direct to disc, advances in the design of disc-cutting equipment have allowed a return to the direct-cutting method to produce recordings that sonically are superior to conventional records produced from master analog tapes. The performance advantages of direct-to-disc records result from the elimination of

TEAC TODAY: THE X-SERIES.



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Three DC motors drive the tape. They're used to keep changes in motor temperature to a minimum under different loads so constant torque is maintained.

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The X-Series transport maintains ideal tape-to-head contact. Audible drop-outs, level and frequency losses are absolutely minimized. Frequency response is wide and flat. And signal articulation is unusually clear.

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Within the X-Series, machines have been specifically designed for bi-directional record and playback. Perfectly symmetrical head stacks (6 heads in all) assure top performance in both directions. There's automatic reverse and repeat. And two-way cue monitoring.

New audio electronics accompany this new transport technology. Record and playback amplifiers are quieter and completely free of audible distortion. The sound is cleaner, more faithful to the source. The fidelity is unsurpassed.

An option previously available only on our professional recorders can now be added to any X-Series machine. Called dbx I,* this noise elimination system adds 30dB to the already high S/N and over 10dB of headroom to give you master-quality recordings.

If your audio perception is critical, your listening standards high, audition an X-Series recorder. The performance is flawless. The sound peerless.

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problems associated with magnetic tape recording, such as tape hiss, channel crosstalk, distortion due to magnetic oxide saturation, print-through, wow and flutter, etc. Records produced in this fashion have greatly increased clarity of complex musical passages, particularly those that involve loud bursts of percussion.

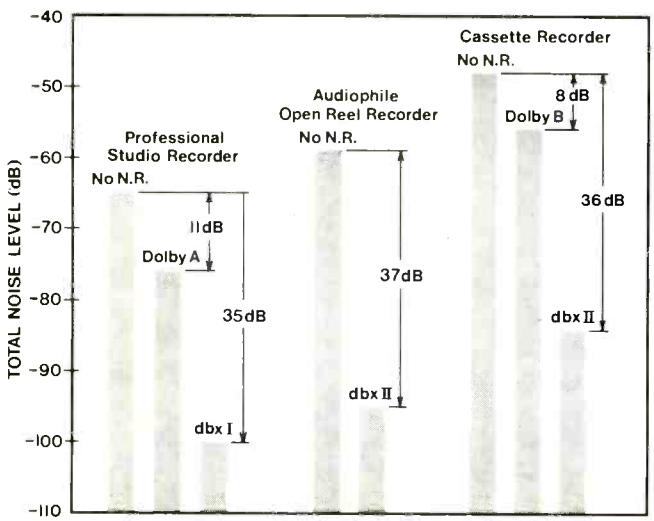
While their sonic superiority over conventionally produced records is immediately apparent, direct-to-disc records must still contend with the dynamic range limitations and surface noise problems of vinyl discs. Furthermore, direct-to-disc records have other potential disadvantages, including (1) inability to edit, since the master disc is cut in real time during the musical performance; (2) decreased playing time per side since the cutting lathe must be controlled manually, rather than by a computer as is normally done, and (3) limited quantity of records that can be produced (since there is no master tape to cut additional master discs as required), which results in a premium price. The trade-offs involved with records produced in this fashion may not be worth it for those who are bothered by the dynamic range limitations of vinyl discs and the annoying record surface noise that may be still present.

Digital Recording

Digital recording involves the storage and retrieval of a musical performance on magnetic tape with the continuous analog audio signal replaced by a series of binary numbers. Basically, when music is recorded digitally, its waveform is sampled electronically many times a second (such as 50,000 times/sec) to produce a sequence of numbers that, as a function of time, represents a piece-wise replica of the original analog music waveform. This sequence of binary numbers (which are comprised solely of a combination of "zeros" and "ones" — the language of the digital computer) are generated by an analog-to-digital converter at the input to the tape recorder.

When the tape is played back (for the purpose of cutting a master disc, for example), the binary numbers are "read" by the recorder head, and the sequence is translated into an analog electrical signal by use of a digital-to-analog converter. One of the most significant aspects of digital recording is that the only information the playback system can recognize is the sequence of binary numbers recorded on the tape. As the magnetic tape passes by the recorder head, the head ignores the random distribution of magnetic particles on the tape which, for an analog recording, is perceived as tape hiss. Only information about the pure music signal is passed on to the master disc, and noise comparable to tape hiss on analog recording is non-existent. Furthermore, digital recording is not plagued by other forms of distortion inherent in the analog recording process, such as wow and flutter, crosstalk, or print through, although it is susceptible to a type of distortion known as quantization noise.

Fig. 6 — Comparison of total wide-band noise levels of tape recording systems relative to 0 VU, with and without Dolby and dbx noise reduction, for professional studio, audiophile open-reel, and cassette tape recorders. The approximate dynamic range increase provided by Dolby and dbx tape noise-reduction systems is indicated for each type of tape recorder.



Noise Reduction	Recorder Type: Professional Studio	Recorder Type: Audiophile Open Reel	Recorder Type: Cassette
None	60 dB	50 dB	45 dB
Dolby	71 dB	N/A	53 dB
dbx	95 dB	87 dB	81 dB

Fig. 7 — Approximate usable dynamic range capabilities of professional studio, audiophile open-reel, and high-quality cassette tape recorders, with and without Dolby or dbx tape noise-reduction systems.

A 16-bit digital system is capable of recording music with a 90-dB dynamic range over the complete audio frequency range when a sampling rate of about 50,000 samples per second is used. Similarly, an 85-dB dynamic range is available from a 14-bit digital system. Editing is accomplished electronically rather than by physically cutting and splicing the tape. Digital tapes are immune to degradation caused by long-term storage of magnetic tape, and they can be duplicated through many generations without loss of sound quality. The only drawback to digital recording at its present state of development appears to be the relatively high equipment cost involved and potential problems caused by lack of standardization. Nevertheless, from a purely technical point of view, the performance capabilities of digital recording are extremely impressive and suggest the degree of sound quality that ultimately may be made available to the listening public when technical standards of delivery systems are agreed upon and digital playback systems of reasonable cost are developed.

Dynamic Range Expanders

Putting aside for the moment the concept of producing recordings with full dynamic range and inaudible background noise, it is appropriate to explore the possibility of enhancing the value of existing record and tape collections by restoring at least a portion of the dynamic range that existed in the original live performance. Since recordings played in the home, or those played in broadcast studios and transmitted to the home, have their dynamic range limited to something generally less than 60 dB (representing a loss of at least one-third of the potential 90-dB dynamic range), it seems logical to introduce some form of dynamic range expansion to counteract the compression that exists in tapes, records, and broadcasts. The general function of such devices, known as *dynamic range expanders*, is to make loud passages louder and/or make quiet passages quieter, resulting in a spreading out or expansion of the dynamic range of the music signal.

Unlike the situation which exists with companders, where the expansion process is a mirror image of the compression process, dynamic range expanders operate in a "single-ended" fashion, processing the music signal according to its particular design or user concept, rather than providing expansion that is the exact converse of the compression process.

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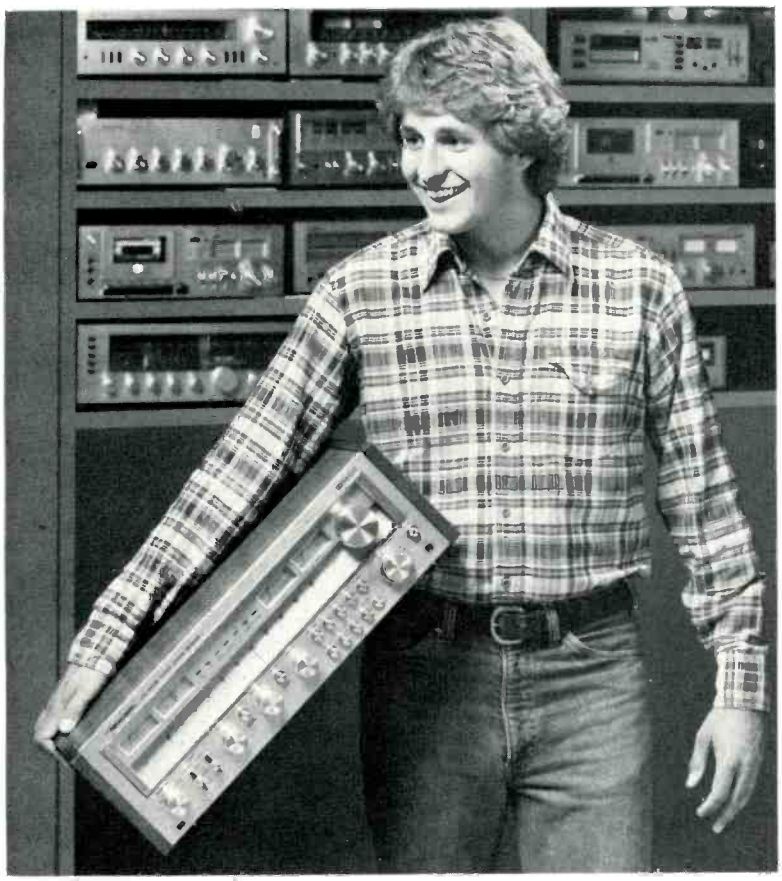

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Since the amount and nature of the compression that existed during recording and/or broadcast is not generally known, dynamic range expanders typically offer a variable range of expansion capability. The user selects the degree of expansion that provides an overall pleasing effect, avoiding excessive expansion that can introduce undesirable artifacts.

Dynamic range expanders based on somewhat different operating concepts are available from companies like dbx and MXR. Most of these devices process the wide-band audio signal by sensing the overall average level of the music signal and increasing the level (making the music louder) when a preset threshold level has been exceeded. More sophisticated expander designs separate the music signal into multiple frequency bands so that the degree of expansion that occurs in a given frequency range depends on the level of signal in that range, thus preserving the integrity of tonal balance and the timbre of individual instruments during complex musical passages.

The amount of expansion that is appropriate will vary according to degree of compression that resides in the audio signal as well as on individual music tastes. Excessive expansion can lead to artifacts frequently described as "pumping" or "breathing" noises. To avoid this situation, expansion should be limited to less than a factor of 1.5 for most popular or rock music, while factors of 1.3 or less are generally preferred for classical music. Properly utilized, dynamic range expanders can restore a significant portion of the original dynamic range that is lost in the recording process, dramatically increasing the excitement, realism, and enjoyment of conventional recordings and broadcasts.

dbx Encoded Discs

The two major problems with vinyl discs that have stayed with us over the years are restricted dynamic range and record surface noise. In cutting a master disc, a signal level that is too "hot" can create a condition that will cause tracing distortion by the cutting and/or playback stylus. If the level of the signal gets too low, it may be obscured by the record surface noise. These two conditions place upper and lower bounds on music signal levels that can be stored on a vinyl disc, resulting in a maximum dynamic range of 50 dB for conventional pressings and up to 65 dB for the very best pressings.

Record surface noise is generated as a result of the interaction between the playback stylus and the record groove. Modulations in the groove cause the stylus to undergo complex motions that are translated by the phono cartridge into an electrical signal representing the musical waveform. The stylus tip is less than one-thousandth of an inch in diameter, yet it must travel up, down, and sideways thousands of times a second to follow the undulations of the groove. Any roughness of the vinyl surfaces of the groove walls cause extraneous stylus motion, creating the familiar record surface noise which is inseparable from the music on a conventional disc.

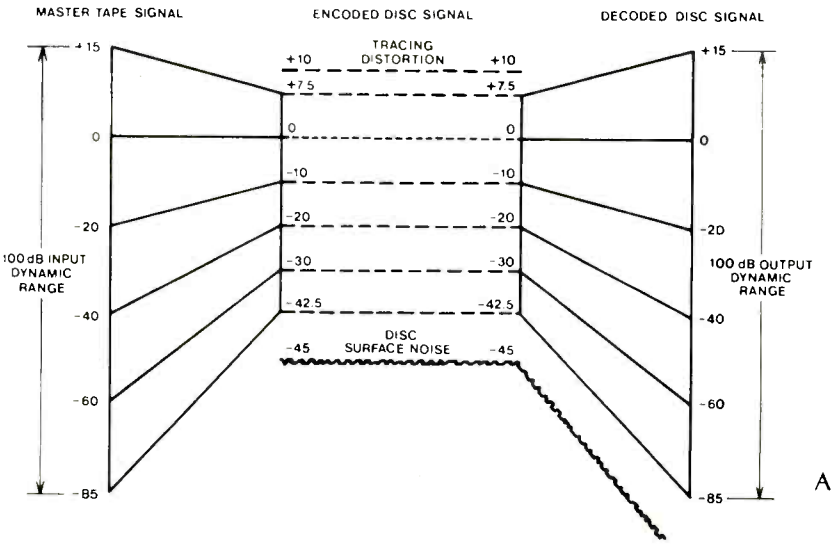
One solution to the problem of restricted dynamic range and surface noise of vinyl discs is available through the application of dbx noise-reduction technology. The dbx Type II noise-reduction system, previously described relative to tape noise reduction, can be employed in record mastering and playback to render record surface noise virtually inaudible, while dramatically increasing the dynamic range of the reproduced music signal. The operation of this noise-reduction process applied to discs is illustrated in Fig. 8 where, for purposes of convenience, a master tape signal having a 100-dB dynamic range is assumed to exist.

The dbx linear decibel compression/expansion (companding) system operates as follows. The music signal from the master tape (or directly from a studio console) is encoded (compressed) during the cutting of the master disc and decoded (expanded) during playback. The dynamic range of the music signal is linearly (in dB) compressed by a 2:1 factor when cutting the master disc, which means a music signal having a 90-dB dynamic range is reduced to 45 dB. This fits comfortably within the maximum dynamic range storage capability of vinyl discs. During playback through a decoder, the signal picked up by the phono cartridge is linearly expanded by a 1:2 factor so that the dynamic range of the original music signal is completely restored. And, as a result of downward expansion during decoding, the surface noise on dbx Encoded Discs is approximately 30 dB lower than on conventionally-recorded discs.

The frequency spectrum of record surface noise for a conventional disc and a dbx Encoded Disc is shown in Fig. 9 for a constant 125-Hz bandwidth analysis. Measurements were made on a disc that was cut with an unmodulated groove (no signal). About 30 dB of noise reduction is provided by the dbx Encoded Disc for frequencies below 10 kHz, which encompasses the frequency band of greatest concern relative to record surface noise. The total wide-band noise of -57 dB is reduced to -85 dB, in this particular case, for an overall reduction in surface noise of 28 dB.

There are a number of side benefits to dbx Encoded Discs. During cutting of an encoded master disc, the compressed signal reduces the demands on the cutting stylus, resulting in

Fig. 8 — Diagram depicting the combination of signal compression during encoding and expansion during decoding that results in surface noise reduction and dynamic range retention on dbx Encoded Discs.



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The total audio experience can't be gleaned from specifications. It must be heard ..felt. Because many Lux original technical developments enhance the experience, they are not easily specified.

The Lux L-11 Integrated Amplifier uses Realtime Processed DC Amplification. In a conventional amplifier, a capacitor is used in the negative feedback loop to eliminate wave form distortion, but it in turn triggers time lag causing phase distortion in the lower frequency and transient distortion in the higher frequency. Lux's approach to this problem as seen in the Model L-11 was to drop the capacitor from the negative feedback loop; thus erasing the time lag causing phase and transient distortion. DC drift was solved by the use of Lux's exclusive DML-IC (dual monolithic linear integrated circuit).

Lux 5K50 Cassette Deck uses our BRBS System. Building a superb cassette deck needs more technology than standard decks. To make the most of the unit's 3-head design, the BRBS variable bias system is provided. This Bridge Recording by Bias Current and Signal Current avoids transient and phase shift distortion.

Lux R-1120A Tuner/Amplifier and our T-12 Tuner both use the Closed Lock Loop Tuning System. Since it's impossible to enjoy mistuned FM, or to relax when you have to jump up and retune, Lux has perfected frequency control.

While most quartz lock systems operate on the front end only, Lux goes further, with Closed Lock Loop controlling the front end, the IF and detector circuits, with strong, instantaneous corrective feedback to the exact center of the desired frequency range. Another locking circuit, Accu-lock™ physically locks the tuning knob at the desired point. Not only does Lux's system deliver perfect tuning, it retains the last tuned frequency even when the power is turned off and on.

Lux PD-277 offers quality and convenience. Using a Lux designed, servo-controlled brushless, slotless motor, wow and flutter is extraordinarily low at 0.03% while signal-to-noise ratio is 60dB.

Other outstanding features are a straight low mass tonearm and vertical pivot construction for minimizing resonance and instability.

Quality and convenience are evidenced by electronic controls for all major functions and a separate motor for the tonearm eliminates noisy, friction-producing linkage.

These and other innovations are typical of Lux's outlook. But none of this shows up on spec sheets. Only listening will prove that all of Lux is for your pleasure.

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11200 Chandler Blvd., North Hollywood, CA 91603 (213) 985-4500
In Canada: Lux Audio of Canada, Ltd., Ontario

Due to the tremendous response from consumers, Lux has decided to extend the Great Rebate Program from December 31, 1979 to January 31, 1980.

Kill FM Interference With Two Antennas

Richard Modafferi

FM listeners often wish to tune in a distant station which is adjacent-channel or co-channel to a stronger local signal. Often no amount of tuner selectivity or capture ratio will enable reception of the weaker signal.

Adjacent-channel reception is particularly difficult, and tuner designs 30 years ago did not permit adjacent-channel reception. Indeed, when the FCC set up broadcast standards for FM transmission, adjacent-channel reception was considered impossible. Today, FM tuners can be built with 100 dB adjacent-channel selectivity.

The improvement in tuner selectivity has unfortunately not been followed by a reduction in the spurious emissions of FM transmitters in their adjacent channels. This interference cannot be tuned out by a selective receiver, since it is already spilling into the desired channel at the transmitter end.

Co-channel interference may also be a problem. You may live between two stations, or in the middle of a triangle of three stations, and wish to receive just one of them. Instead, you get all at once, even when using a directional antenna and rotor.

Hope still exists for the listener facing these reception problems; the solution involves erecting a second antenna.

Method

We call this method a "phase-cancelling" antenna system, and it is often used in military and commercial point-to-point communications systems where interference must be minimized. Two separate receiving antennas are connected such that the desired signals add in phase, and the undesired signals add out of phase. Thus, the wanted signal is reinforced and the interfering one eliminated, or nearly so.

In order for the system to work, the antennas must usually be physically separated in a horizontal direction. Mounting the two antennas on the same mast will not work. Consider first the case where the two stations are at different compass directions from the receiving location (Fig. 1); they may be co-channel or adjacent-channel. Point both antennas at the desired station and adjust their horizontal separation until the undesired signal cancels out.

It is easy to obtain as much as 60-dB rejection of the undesired signal with a phase-cancelling antenna of this type. As long as the two stations are at different compass headings, the scheme will work easily. If the stations are in the same direction from the receiving location, the problem is more difficult. This special case will be discussed later.

Stations on Different Headings

Best performance is achieved using two identical antennas on separate masts. All connections are made with coaxial cable of the same length and type. Arrange the antennas as in Fig. 1. Calculate the distance between the antennas, as

$D \text{ (meters)} = 300 \div 2f \text{ (MHz)}$,

where the frequency, f, is of the undesired station.

For example, if the undesired station is on 100.1 MHz, the distance D will come out to:

$D = 300 \div (2 \times 100.1)$

or about 1.498 meters or 4.92 feet.

It may be easier to measure the distance d between the two antenna masts; this is given by:

$d = D \div \sin \theta$

where θ is the angle between the desired and undesired stations (Fig. 1).

What happens if you do not want to crawl all over your roof with protractors and slide rules, putting up masts, or digging up your back yard and putting in expensive tower foundations? Is there an easier way?

There are some simpler tricks, which won't work as well, but often give adequate results. An existing TV antenna can be combined with the FM antenna, if they are on different masts. You may even use your existing FM anten-

Fig. 1 — Phase-cancelling antenna system. Desired and undesired stations at different compass headings.

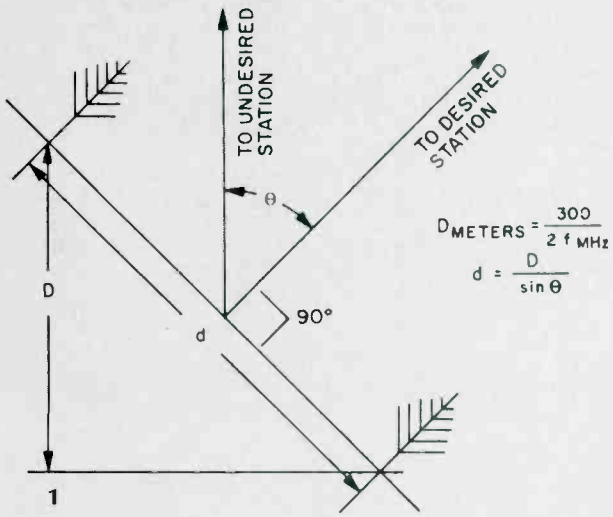
Fig. 2 — Use of an existing TV antenna, or existing TV-FM cable signal, combined with the FM antenna in a phase-cancelling system. Place the attenuator in the cable to the stronger of the two undesired FM signals.

Fig. 3 — Easy, "quickie" phase-cancelling scheme that will work in many cases. Hook the rabbit ears to the splitter with any convenient length of cable, and then walk around the room with antenna while watching signal strength of undesired signal. You may need to place an attenuator in line to the outside FM antenna. Juggle attenuator settings and placement of the rabbit ears for minimum interference on the desired station or minimum pickup of the undesired station. This scheme fails when the attenuator setting becomes large enough to kill the desired signal.

Fig. 4 — Phase-cancelling system using two identical indoor antennas. A pair of B•I•C Beam Boxes should work well, but the author hasn't tried them. Move and adjust the two antennas for best results. Physical spacing of the antennas should be large, at least 10 feet, or on opposite sides of the room.

Fig. 5 — Scheme to try if the desired and undesired stations are in the same direction (zero degrees) or opposite directions (180 degrees). The idea is to obtain vertical spacing of the antennas so both pick up the strong undesired station, but only the big antennas on the tower picks up the weak undesired station. Connect antennas as in Fig. 3 and then adjust the position of the indoor antenna and the setting of the attenuator of the outside antenna for best results.

(a) Layout for phase-cancelling antenna system using two identical antennas.



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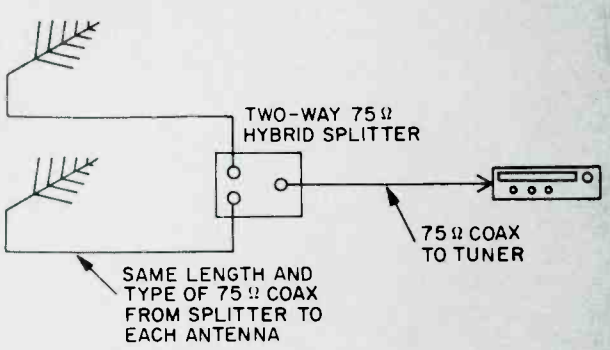
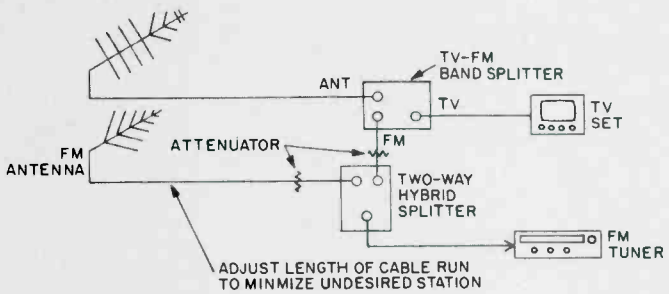
(b) Electrical hookup for the phase-cancelling system shown in (a).





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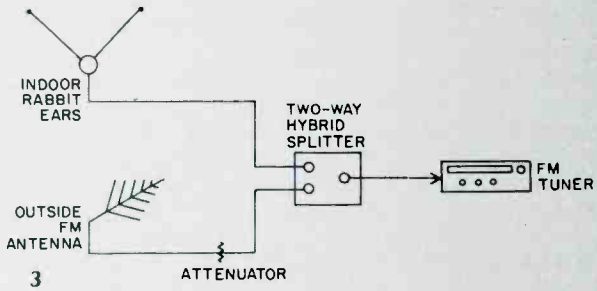

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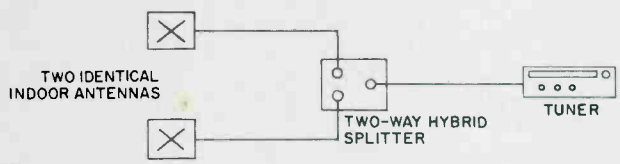

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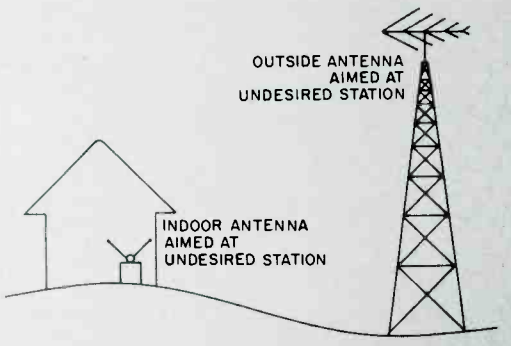

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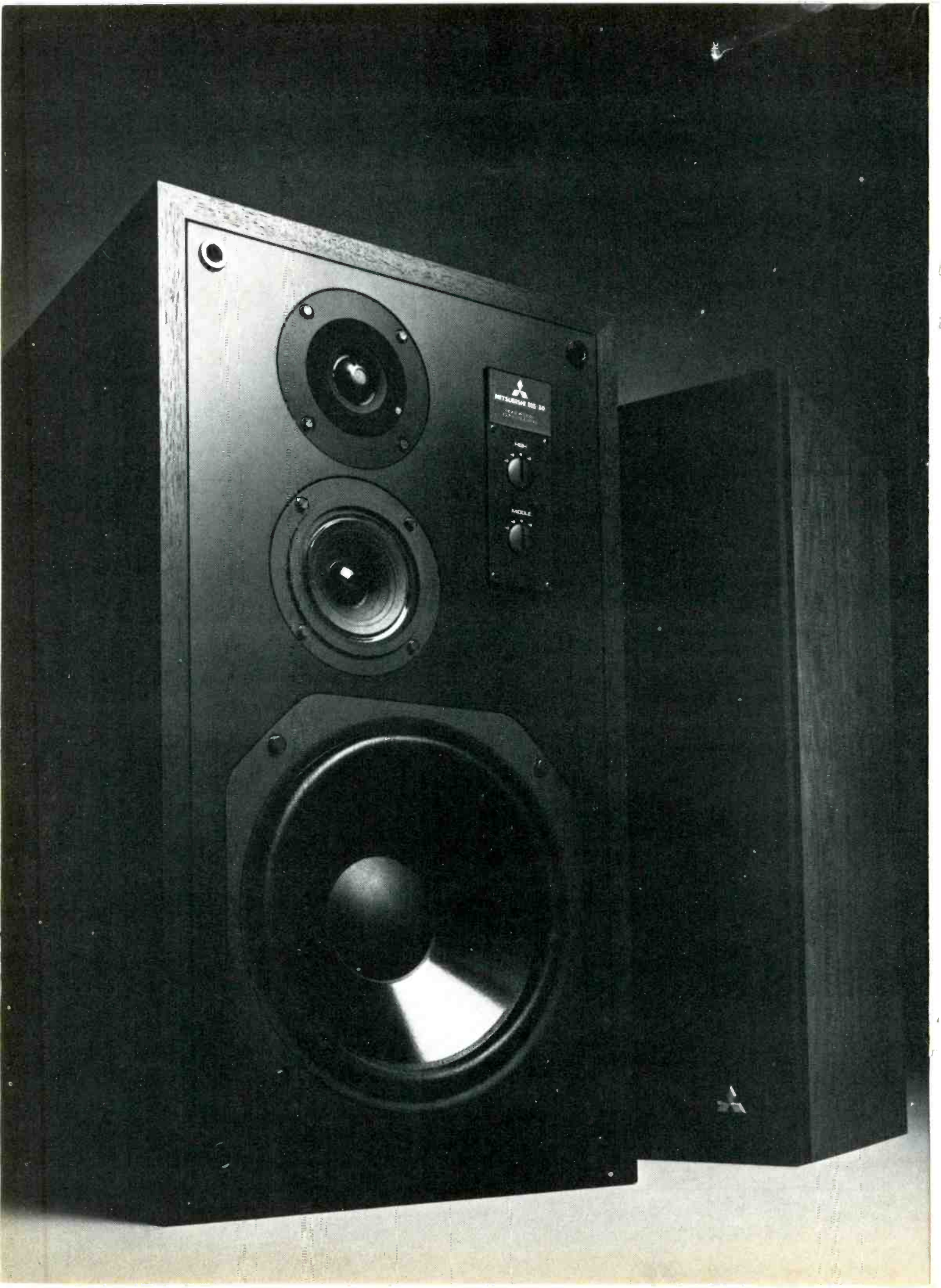
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Stop Listening To Paper.

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Completely free of the spurious vibrations caused by conventional paper cone speakers.

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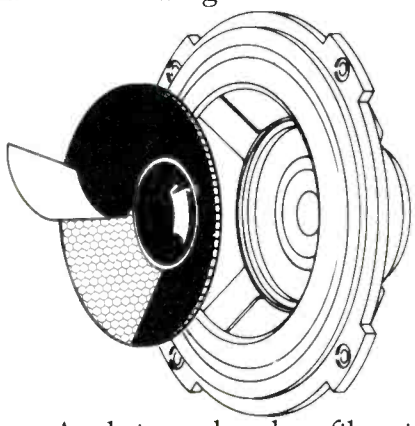

And since the glass fiber is non-porous, it gives our air suspension speakers a perfect seal, and a lower resonance frequency for better bass response.

We've also added a flux normalizing ring that reduces distortion by 20dB. And automatic overload protection.

The end result is a speaker capable of a level of performance literally unheard of until now.

If our honeycomb speakers sound too good to be true, test listen to them and judge for yourself.

It's what you won't hear that will impress you.

MITSUBISHI AUDIO SYSTEMS

Mitsubishi's Honeycomb Speakers. MS-10 10" 2-Way Bookshelf. MS-20 12" 2-Way Bookshelf. MS-30 12" 3-Way Bookshelf. For more information write Melco Sales, Inc., Dept. 40, 3010 East Victoria Street, Compton, California 90221. For the name of your nearest dealer, please call (800) 621-5199 (in Illinois, (800) 972-5855). In Canada, contact: Melco Sales Canada, 900C Denison Street, Markham, Ontario. L3R 3K5.

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na and a piped-in cable FM signal to cancel an unwanted local FM station. Both of these schemes are outlined in Fig. 2. You must be prepared to do some tedious cutting and adjusting of the lengths of the cables from the signal sources to the tuner. Adjust the cable length from one antenna for minimum undesired signal, and then set the attenuator to further minimize the undesired station.

Sometimes simple rabbit ears can be used as a phase-cancelling antenna, as in Fig. 3. This scheme will work well only if both signals are fairly strong. A "quickie" setup that actually worked at the author's home used the method of Fig. 3 to cancel a local station three miles away and allowed the reception of an adjacent-channel distant station 140 miles away.

If you are apartment-bound and cannot put up outside antennas, a scheme using two indoor antennas in a phase-cancelling hookup may work. Set up the two antennas as in Fig. 4, and move them around until the undesired signal is minimized. Cable FM combined with an indoor antenna may also work, as in Fig. 2 earlier.

Stations on the Same Compass Heading

If the stations are on the same compass heading, you are in trouble because the distance d (Fig. 1) becomes infinite as sin θ = zero. Even my back yard on top of a country mountain isn't that large!

Here is a trick that may work when the angle between the stations is near zero degrees, i.e. they are in the same direction. Try a large vertical spacing between the antennas (Fig. 5). This scheme works especially well if the desired station is distant and the undesired station is local. The big outside antenna picks up both stations, and the indoor antenna picks up just the local, allowing cancellation to work. If the desired station is very weak, it may not be possible to effect cancellation with the attenuator; the cancellation may be just right when the desired station disappears into the noise!

Stations located at an angle θ = 180° (opposite directions from the receiving location) are a little easier to handle. If your antenna had an infinite front-to-back ratio, a phase-cancelling system would not be needed, so the first thing to try is a better antenna. If your antenna has the best possible front-to-back ratio and still you have interference, the phase-cancelling scheme of Fig. 5 will work. Results are best if the undesired station is nearby.

Conclusion

While at McIntosh in 1970-1972, I received requests from FM listeners to solve reception problems just discussed. Today letters still come; phase-cancelling antenna hookups do work for those willing to make the effort to try them out.

I purposely avoided too much technical detail here. If you want to try an elaborate phase-cancelling antenna, it is best to work through a local TV-FM dealer experienced in exotic antenna systems. Realize that you must *really* want that distant station, so write that station's management and ask if they intend to keep the program format you like so much. Imagine the frustration after putting up two $1,000.00 towers in your back yard to pick up that elusive classical station 150 miles away, and just as you finish they switch to the same taped disco format that's on the station you were trying to cancel!

Listeners with specific reception problems or questions may write to me for more information, and I will be glad to help. (Note: If I'm flooded with letters, the replies may be slow.) Write to Rich Modafferi, c/o Electroacoustical Labs, Inc., 16 E. 42nd Street, Suite 918, New York, N.Y. 10017.

If you don't have at least $1,000 to spend on an Audiovox Hi-Comp autosound system, read no further.

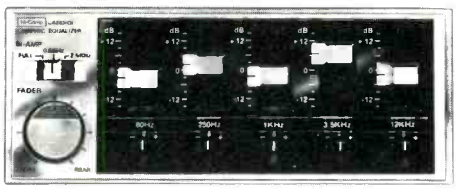
By Robert Harris, Technical Director

There are few things in this world that can take a driver out of the traffic jam or away from a gas line, better than great music, well reproduced.

Audiovox understands this. That's why they engineered the Hi-Comp range of high fidelity stereo components designed to produce exemplary sound in automobiles.

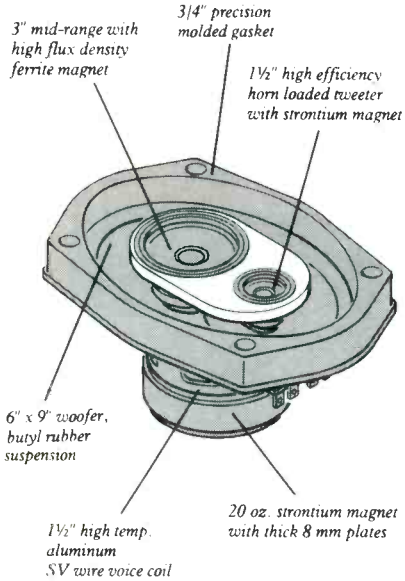
A total range of exotic amplifiers/receivers.

Each model builds on the one before it until you reach the HCM-0010 – the "master system."



HCE-750 HiComp Semi-parametric graphic equalizer

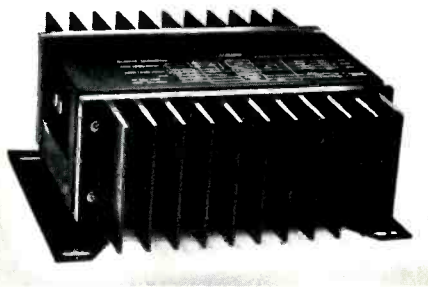
It's an electronically-tuned AM/FM multiplex receiver with a built-in auto-reverse cassette deck. The HCM-0010 has 12-station memory, LED display, built-in quartz clock and an automatic station seek. It also features a CrO_2 switch, Dolby®, FM muting, 4-way stereo balance controls, separate bass and treble controls and a Hard Permalloy tape head. Its looks are straight out of a stereo buff's music room.



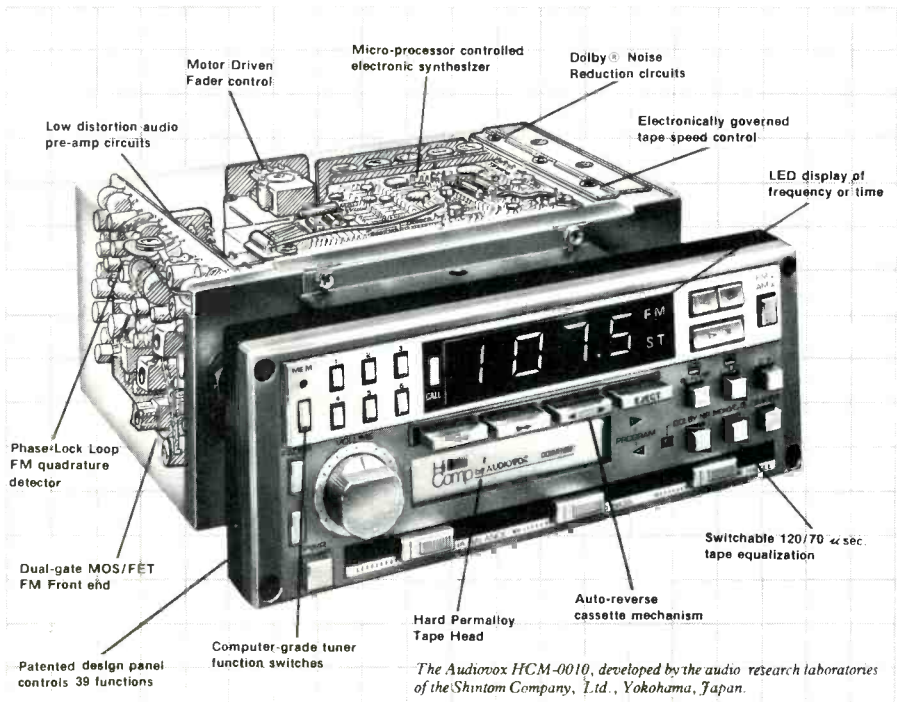
HCS-362 HiComp 6" x 9" 3-way speaker system.

4 power-matched speaker systems.

The ultimate is the Hi-Comp 362 system: 6" x 9" three way speakers with 1½" Strontium horn tweeters, 3" mid-ranges, 20-ounce Strontium magnet woofers, 1½" heat proof aluminum voice coils, and a 70 to 18,000 Hz response range with crossovers at 2,900 and 9,000 Hz, and a power capacity of 70 watts. Hook these up to the HCM-0010 with the Hi-Comp power amplifier, *HCB-830, 120 watts RMS at less than 0.3% distortion*, and you've got enough sound to pop a moon roof.



HCB-830 HiComp 120 watt 4-channel power amplifier



The Audiovox HCM-0010, developed by the audio research laboratories of the Shintom Company, Ltd., Yokohama, Japan.

Now for the equalizer.

Apart from a heavy-duty fader control or a dual slide-bar pre-amp, the only other Audiovox Hi-Comp component you might buy is the HCE-750 semi-parametric graphic equalizer with 5 slide-bar response controls and bi-amp capability.

You spend $1,000 and what do you get?

Probably the finest sound you've heard, *anywhere*. It takes money to get it. But it also takes a lot of specialized dedication. Audiovox only knows how to do just one thing: How to engineer the finest automobile sound systems you've ever heard.

For further information, write to: Robert Harris, Technical Director, Dept. AU , Audiovox, 150 Marcus Blvd. Hauppauge, New York 11787.

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THE RATIONAL AMPLIFIER, FROM CROWN.

Sound reproduction systems of the 1980's will include "smart" components–components that react to their environment, that know how to protect themselves, and know how to keep functioning in that environment. They belong in your future.

The Crown Distinction SA2 stereo power amplifier is a rational amplifier. It analyzes its own behavior in terms of its immediate environment. It protects itself. It keeps on driving your speakers with power reserves that may amaze you. It's available now.

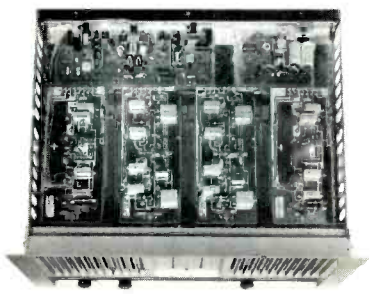
The SA2 has four on-board computers that constantly monitor and control the performance of the amp. The SA2 knows when it can use its full power capabilities, and when it has to cut back in order to prevent damage to itself.

The SA2 is sonically so accurate that its distortion and response levels require highly sophisticated test instruments to measure. However you measure them, the SA2 translates into beautiful music.

The SA2 incorporates new system engineering concepts that won't easily be duplicated. It is unique.

SOA–it's important!

The safe operating area (SOA) of a power transistor is defined by the internal temperature of the transistor. That temperature must be kept below a critical level or the transistor will be damaged, an expensive and bothersome event.



Audio circuit designers have always known that SOA is difficult to measure, since it varies widely depending on what the transistor is being asked to do. Designers have had to estimate arbitrary limits for output voltage or current in order to protect output transistors, leaving much of the capability of the power transistor unused. Such designs are not as efficient as the SA2 has proven to be.

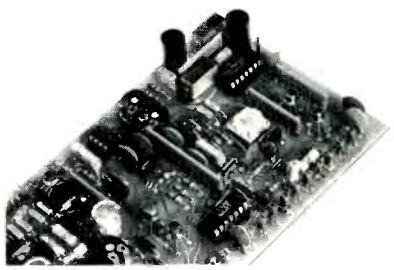
SOA measured by Crown.

Crown's engineers several years ago developed a special test instrument to accurately measure the changing SOA of power transistors under varying loads. To the best of our knowledge, it's still the only such test equipment in the audio industry.

From the work done on this instrument, Crown developed the mathematics of output device behavior needed to design the computer-controlled protection system of the SA2 amplifier. That system makes it possible, for the first time, to utilize fully the capabilities of power transistors in an audio amplifier.

On-board computing.

The SA2 protected-power system starts with the output transistor data developed by Crown, which is now in computer memory at Crown. Analog computer circuits built into the SA2 are programmed from data about the SOA of the output devices. The on-board computers obtain real-time input from sensing devices which report current, voltage and thermal behavior of the output transistors. The computers then describe, in real time, what the transistors have been doing, what they are being asked to do, and compute whether the result of all that could drive them outside their SOA.



If the on-board computers predict operation outside the SOA, the output is limited automatically and immediately. The computers also limit output only to the degree necessary, so that output power is always at the maximum safe level for the existing environment. The limiting is self-correcting, and full output power is automatically restored as soon as the demands on the output devices no longer threaten their SOA limits. All this happens in micro-second time, with the output devices being constantly checked.

Continuing safe output.

Output power is never, in the Crown SA2 system, limited arbitrarily. Your

SPECIFICATIONS

Stereo Output Power:

220 WATTS PER CHANNEL MINIMUM RMS (BOTH CHANNELS OPERATING) INTO AN 8 OHM LOAD, 20Hz-20KHz AT A RATED RMS SUM TOTAL HARMONIC DISTORTION OF 0.05% OF THE FUNDAMENTAL OUTPUT VOLTAGE.

350 WATTS PER CHANNEL MINIMUM RMS (BOTH CHANNELS OPERATING) INTO A 4 OHM LOAD, 20Hz-20KHz AT A RATED RMS SUM TOTAL HARMONIC DISTORTION OF 0.08% OF THE FUNDAMENTAL OUTPUT VOLTAGE.

600 watts per channel minimum RMS (both channels operating) into a 2 ohm load, at 1KHz; rated RMS sum total harmonic distortion of 1.0% of the fundamental output voltage.

Monaural Output Power:

700 WATTS MINIMUM RMS INTO AN 8 OHM LOAD, 20Hz-20KHz AT A RATED RMS SUM TOTAL HARMONIC DISTORTION OF 0.12% OF THE FUNDAMENTAL OUTPUT VOLTAGE.

440 watts minimum RMS into a 16 ohm load, 20Hz-20KHz, at a rated RMS sum total harmonic distortion of 0.08% of the fundamental output voltage.

1200 watts at 1KHz into a 4 ohm load, at a rated sum total harmonic distortion of 1.0% of the fundamental output voltage.

Stereo Hum and Noise:

115dB below rated output, "A" weighted.

Stereo IM Distortion:

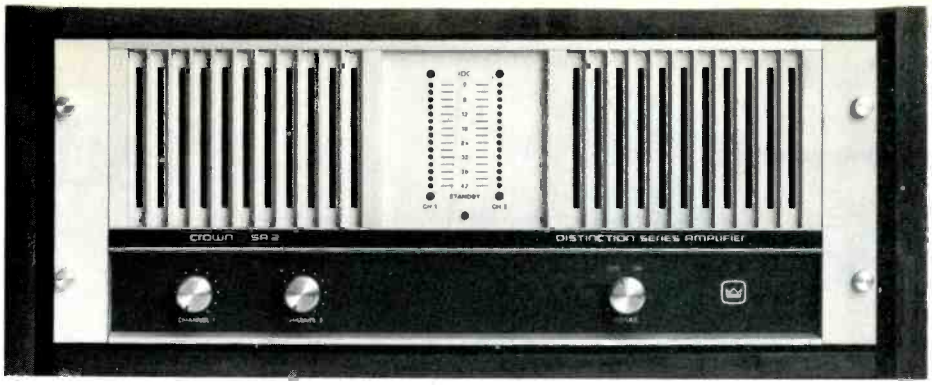
Less than 0.01% from 0.25 watts to 220 watts into 8 ohms per channel.

Stereo Slewing Rate:

Greater than 30 volts per microsecond.

Stereo Frequency Response:

+0, −1.5dB, DC–80KHz.



SA2 continues at full power as long as output transistor safe operating area is not violated. Where other amps would simply thermal out and shut down, the sensing and protection concepts employed in the SA2 keep the maximum safe power flowing to your speakers under any and all conditions.

Unique heat sink design.

The Crown SA2 heat sinks may be new to most home audio system owners. The finned aluminum channels in these Crown-made heat sinks are much more efficient than castings because they rapidly dissipate large amounts of heat to keep the SA2 at its most efficient thermal level. In addition, a rear-mounted fan keeps a gentle flow of air moving through the amp. If the chassis should heat up, the fan automatically shifts to a higher speed until the amp returns to a cooler operating level.

And much more.

When we designed our rational amplifier, we didn't stop with the innovative protection system. The SA2 is built around a carefully thought out circuit design that contributes to immeasurably low distortion. For instance, a junction field-effect transistor (J-FET) input is incorporated into a multiple feed-back design to reduce noise and distortion while offering perfectly controlled transient response.

The main power supplies and transformers for each channel are separate. The SA2 mechanical design emphasizes sensible weight distribution and easy handling. The Crown IOC distortion indicating system notifies you about deviations in output waveform before any kind of distortion becomes audible. Subaudio speaker protection is provided by monitoring the output and turning off the affected channel if necessary.

Indicating dynamic range.

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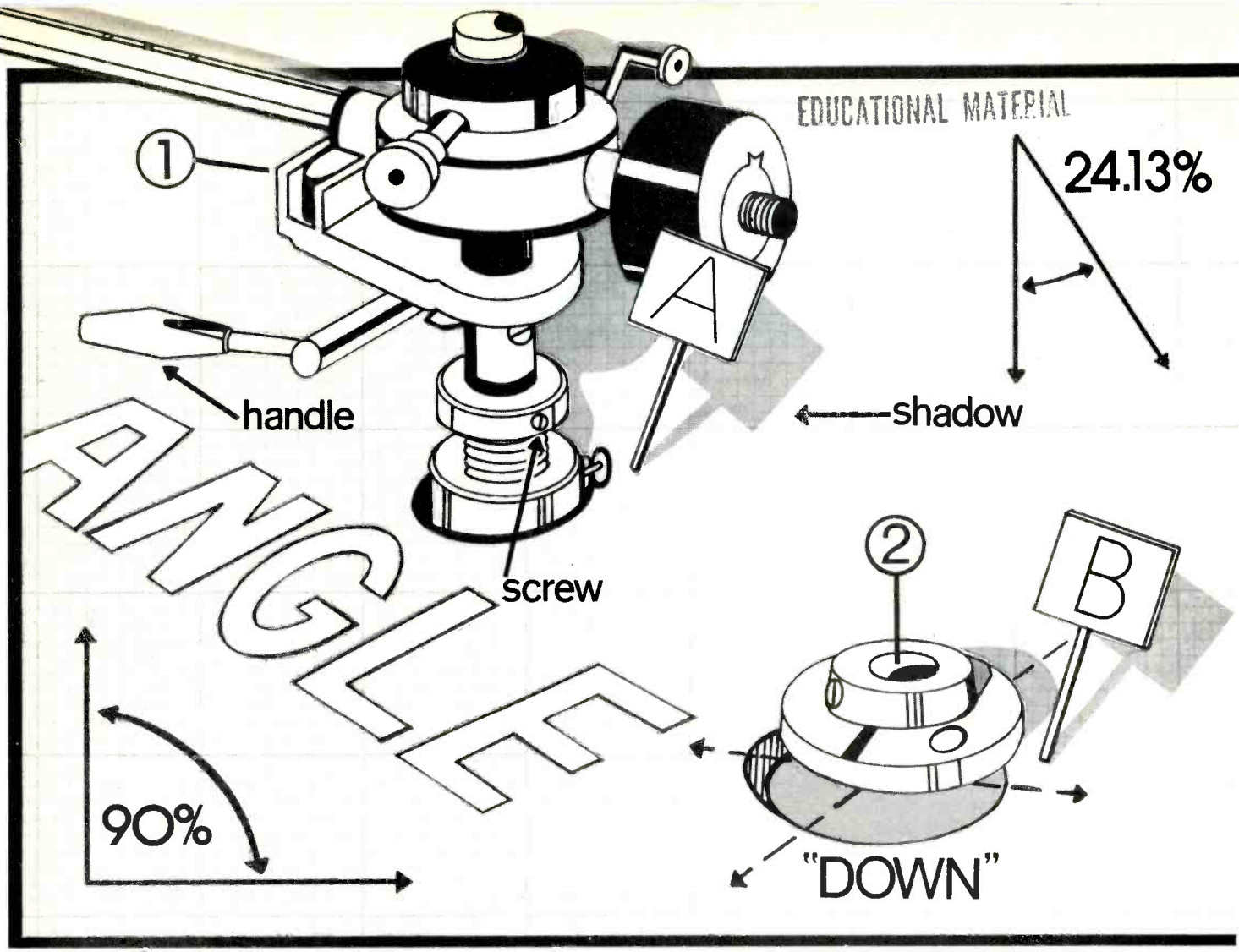
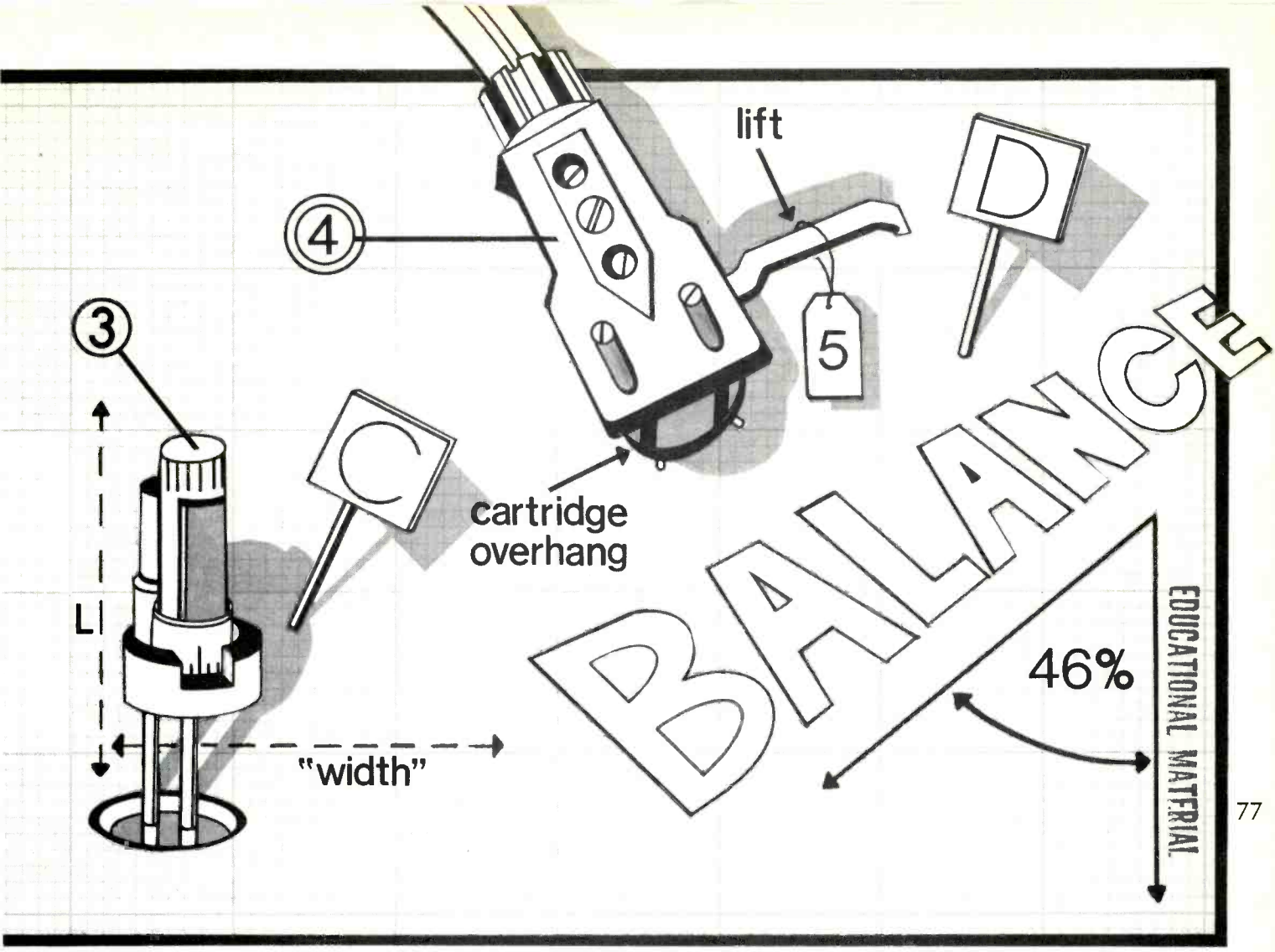


Tonearm Geometry and Setup

Martin D. Kessler and B. V. Pisha

Optimum geometry of tonearms has been the subject of several articles over the past three decades, the earliest complete mathematical study being that of H.G. Baerwald in his paper on optimum geometry in 1941, where an analytical study of tracking error distortion showed that optimum geometry of a tonearm of given effective length will have a corresponding offset angle and overhang. Further, the arm should zero at two positions on the grooved surface of a phonograph record given the minimum and maximum radii where the signal will be encountered. Recently the subject has been brought up by *The Audio Critic*, and in surveying the literature, we found papers on the subject of lateral tonearm geometry by B.B. Bauer in 1945 and John Seagrave in 1956/1957 that presented data essentially the same as that of Baerwald. Seagrave stated in his paper, "Hear, then, the sad facts: Few of the commercially available arms are designed to give minimum tracking distortion on the largest LPs they are supposed to handle!" *Consumer Reports* in 1956 stated in a survey of high-fidelity pickups that "the best performance was often obtained when an overhang other than that recommended by the manufacturer was used." In these "modern" times of computers and high technology, it is interesting to note, according to our calculations, that only a small group of manufacturers of tonearms are utilizing optimum lateral geometry. One would assume there would at least be agreement on this design parameter. Recently, Paolo Nuti used simple trigonometry to present some easy-to-use equations for measuring and calculating lateral tracking error, and provided a program for use on the Hewlett-Packard 67/97 scientific programmable calculators.

Baerwald found "that both absolute and nuisance effects of tracking distortion are considerably greater than commonly assumed, published values usually being underestimates, due to omission of rigorous procedure." Basically, the absolute error of the tracking angle is not important but rather, the weighted error which is the angular error divided by the groove radius. The idea is to reduce the weighted tracking error over the entire grooved surface — minimizing the peak weighted error. Baerwald derived his formulae from a second-order Chebyshev approximation used in electric wave filter design. As angular error increases, so does stylus friction, according to Baerwald, where the vertical component of friction increases in direct proportion to the angular error. The higher the stylus friction (angular error), the greater the skating force. A pivoted tonearm with zero tracking error (tangential type) will maintain a constant stylus friction for a given recorded velocity. In order to get a fixed offset arm (most commonly available) to have as near constant friction as possible, the angular error over the grooved surface would



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Demystified

have to be minimized. With Baerwald's equations, there will be slightly more overall angular error than in an arm optimized for angular error but, for most arms available, the optimal weighted error equations still result in lower overall angular error. With simple signals, for instance a sine wave, distortion is essentially second-order harmonic. This kind of distortion is not a grossly unpleasant sort, but when reproducing music, simple signals are usually not encountered. With the complex signals of recorded music, according to Baerwald, second-order cross-modulation products are the prevalent distortion components. Cross-modulation distortions according to *The Audio Critic* are " time-dispersive and therefore much more audible and disturbing."

Geometric Considerations

Basically, optimum geometry can be summarized in three simple equations — the determination of null radii, the optimum offset angle, and the optimum overhang for a given effective length. The equation derived through a second-order Chebyshev approximation for the position of the null radii by Baerwald is given by:

$$\text{Small null radius} = \frac{2r_1r_2}{\left(1+\frac{1}{\sqrt{2}}\right)r_2 + \left(1-\frac{1}{\sqrt{2}}\right)r_1} \qquad (1a)$$

$$\text{Large null radius} = \frac{2r_1r_2}{\left(1-\frac{1}{\sqrt{2}}\right)r_2 + \left(1+\frac{1}{\sqrt{2}}\right)r_1} \qquad (1b)$$

where r_1 and r_2 are the inner and outer maxima of encountered signal. The equation for optimum angular offset is given by:

$$\text{Sin (a) opt} = \frac{r_1 + r_2}{L\left[\frac{\left(\frac{r_1+r_2}{2}\right)^2}{r_1r_2} + 1\right]} \qquad (2)$$

where a is the angle of the offset for the tonearm in degrees and L is the effective length of the tonearm. The equation for optimum mounting center is given by:

$$\text{Mounting center} = \sqrt{\frac{r_2(L^2+r_1^2) - r_1(L^2+r_2^2)}{r_2 - r_1}} \qquad (3)$$

where L is the effective length, r_1 is the inner null radius, and r_2 is the outer null radius.

From the above equations optimum tonearm pivot-to-turntable spindle distance (mounting center) can also be determined from the law of cosines:

$$\text{Mounting center} = \sqrt{L^2+r_1^2+2Lr_1\cos(90-a)} \qquad (4)$$

where L is the effective length, r_1 is null radius 1, and a is the offset angle in degrees.

The following is an actual numerical example. Given r_1 = 2.375 in. (minimum groove radius) and r_2 = 5.75 in. (maximum groove radius), then

Null radius 1 from (1a) =

$$\frac{2x2.375x5.75}{\left(1+\frac{1}{\sqrt{2}}\right)x5.75+\left(1-\frac{1}{\sqrt{2}}\right)x2.375}$$

$\cong$ 2.6 in.

Null radius 2 from (1b) =

$$\frac{2x2.375x5.75}{\left(1-\frac{1}{\sqrt{2}}\right)x5.75+\left(1+\frac{1}{\sqrt{2}}\right)x2.375}$$

$\cong$ 4.76 in.

The above results are the optimum values for the minimum and maximum signaled grooves encountered on a 12-in. LP.

Given an effective length of 9 inches, calculate the offset angle.

Sin (a) opt from (2) =

$$\frac{2.375+5.75}{9x\left[\frac{\left(\frac{2.375+5.75}{2}\right)^2}{2.375x5.75}+1\right]}$$

$\cong$ 0.4088.

Therefore the arc sine of 0.4088 = 24.13 degrees.

From the offset angle and one of the null radii, calculate the mounting center of the tonearm.

Pivot-to-spindle distance from (4) =

$$\sqrt{9^2+2.6^2-2x9x2.6x\cos(90-24.13)}$$

$\cong$ 8.28 in.

Overhang for the stylus is the effective length minus the pivot to spindle distance (9 in.-8.28 in.=0.72 in.).

Figure 1 shows the relationship of the offset angle to the effective length to the tonearm mounting center to the null radii.

Null Radii

On a record surface a pivoted arm will traverse an arc. Through this arc, with most arms, the stylus will go through two points where the stylus is tangential to the groove — in other words, there will be zero error at each of those two points. In addition, the stylus will encounter maximum error, depending again on the design of the arm, in three places. Some arms have near zero error at the beginning and end of the record, creating a larger error in the middle. To find the radius of greatest angular error between the null radii, given the effective length and the overhang, the equation is:

Radius of greatest angular error between nulls =

$$\sqrt{L^2-(L-OH)^2} \qquad (5)$$

where L is the effective length of the tonearm and OH is the overhang.

Given an arm of 9-in. length and an overhang of 0.5 in., calculate the radius or maximum error between the nulls.

Radius of greatest angular error from (5) =

$$\sqrt{9^2-(9-0.5)^2} \cong 2.96 \text{ in.}$$

Note that the greatest weighted error will not occur at the same point as angular error but will be quite close — its solution is determined by an iterative technique and will not be discussed here.

An arm will have two maximum error points if it is made to zero at or near the innermost groove and somewhere in the middle of the record. Most arms are designed this way. Optimum arm design has the maximum error at three points — the outermost groove, the innermost groove, and between the null radii. Again, it is not angular error but weighted error. With optimum design the weighted error is the same for each peak. As in Baerwald, the tracking distortion is directly proportional to the weighted error and inversely proportional to the groove radius. To find the exact angular error of a given arm, given the offset angle, the effective length, and the overhang for any given groove radius, the equation is:

$$\text{Angular error} = 90\text{-OA-arc cos}\left[\frac{R^2+L^2-(L-OH^2)}{2RL}\right] \qquad (6)$$

where R is the radius for which the error is to be found, L is the effective length, OH is the overhang, and OA is the offset angle.

Given an arm of 9-in. length, an offset angle of 24 degrees, and an overhang of 0.62 in., calculate the angular error for a 4- in. radius.

Angular error from (6) =

$$90\text{-}24\text{-arc cos}\left[\frac{4^2+9^2-(9-0.62)^2}{2x4x9}\right] \cong -2.17 \text{ degrees.}$$

One of the major problems when calculating optimum design parameters occurs with the source itself. What are the minimum and maximum groove radii that will be practicably encountered? A number of years ago this would have been a difficult problem, because the record manufacturers had not standardized on the record sizes. Since 7-, 10-, 12-, and 16-in. records were being produced, arm geometry had to be a compromise. Now that all are using a standard 12-in. format for high-fidelity use, the problem boils down to settling where the inner groove is to be. Practically all records have an outermost groove radius of 5.75 in. (146.05 mm). The innermost groove on some records has run almost to the record label, which is at 2 in. NAB standards call for a minimum of 2.25 in. (57.15 mm). Most records, aimed at the audiophile market, never reach 2.375 in. (60.325 mm), a more realistic figure for high-fidelity use than the NAB standard 2.25 in. Generally, the smaller the area over which the arm is to be optimized, the smaller the peak weighted error will be. So, within the limits of practicality, arms aimed at the audiophile market should be optimized for records whose grooves will end up between 2.375 in. and 5.75 in., as proposed by Bauer. These values give null radius positions of approximately 2.6 in. and 4.76 in. (66.04 and 120.9 mm, respectively).

Effective Length

Effective length of the tonearm is the distance from the pivot of the arm to the cartridge stylus tip. This dimension is almost always determined from the design specifications and is very difficult to measure accurately once the tonearm is assembled and the cartridge mounted. Generally, as effective length increases the tracking error decreases — a pivoted tonearm of infinite length will have zero tracking error. Since it is impractical to make such a tonearm, most manufacturers design their products' effective length with other factors in mind such as effective mass, resonance, the size of the turntable base upon which the arm is to be mounted, as well as decreased tracking error and distortion. From a design standpoint, it is desirable to have the longest effective length practical.

Overhang

Overhang is a figure derived from subtracting the distance from the pivot to spindle center from the effective length of the tonearm. Except for a small number of arms with an adjustable pivot, once the arm is mounted and the overhang set, the effective length is fixed. If the arm is mounted precisely at the correct point, the effective length will be that which was intended.

From equation 3 it can be seen that the mounting center of the tonearm is a precisely determined figure in a mathematical relationship to the other lateral components of the arm. However, our study reveals that most tonearm manufacturers appear to have overlooked this figure in their production of

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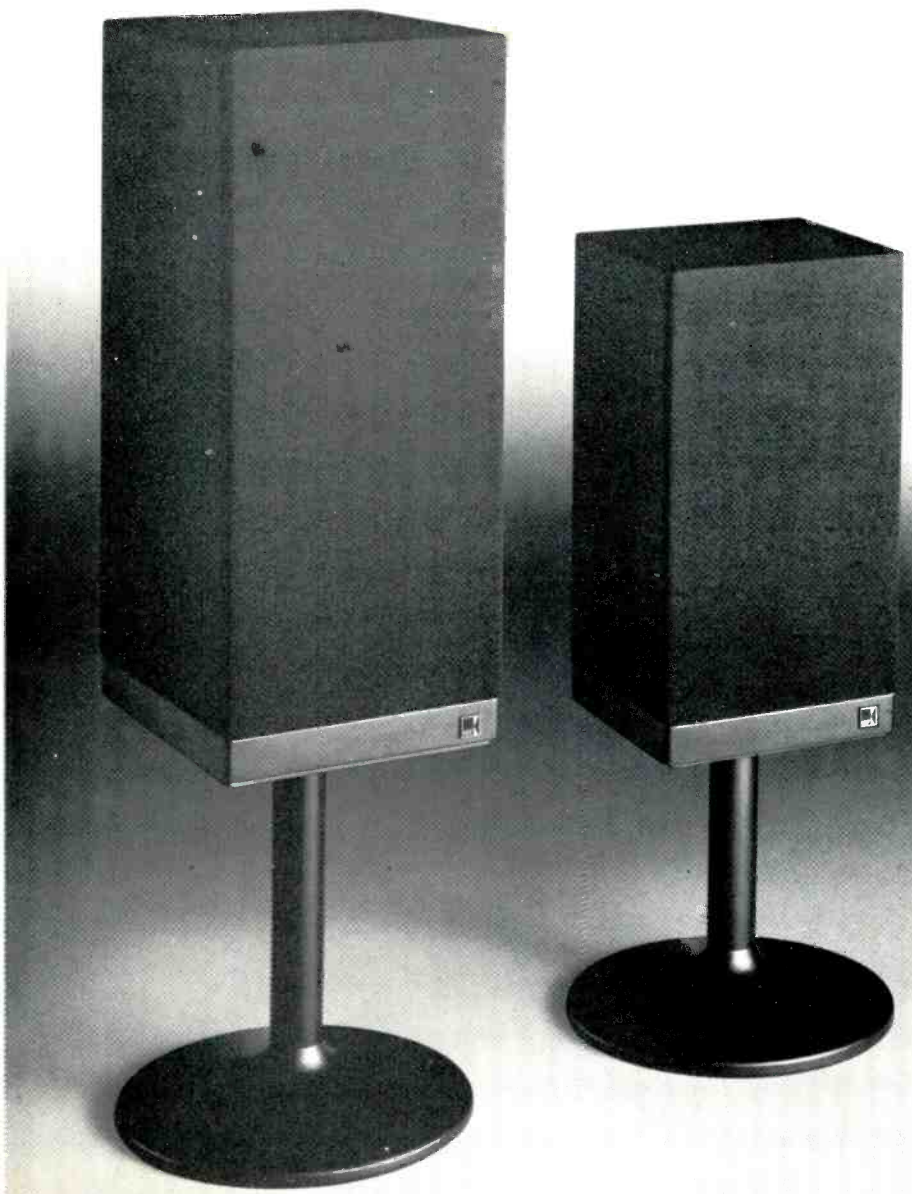

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tonearms. As an example, many of the Japanese arms listed in Table I have a specified overhang of 15 mm. Unfortunately, the only effective length that will optimally have an overhang of 15 mm is 274 mm (10.787 in.), a length larger than many turntable bases can practically accommodate. A major problem is locating the precise pivot position on the turntable base. Most manufacturers of separate tonearms have failed to supply a precise means of locating the tonearm on the turntable base, thus negating the parameters designed into the tonearm. In our opinion, it behooves the tonearm manufacturers to supply a means of precisely locating the mounting center for their tonearm so that the carefully designed parameters are maintained. Therefore, assuming that the tonearm pivot is mounted correctly according to the manufacturer's specification, the overhang template supplied with the tonearm may be valid for the design of that tonearm, though not necessary optimally. Should the mounting hole center be located wrongly, the overhang templates will most probably be invalid for the tonearm. In order to decrease the possibility of imprecisely locating the tonearm pivot, some tonearms are designed with an adjustable pivot that is used after the tonearm is mounted. Generally, a slot is made in the mounting board, located lengthwise along the line extending from the spindle center to allow for maximum range of adjustment. On tonearms whose pivots are fixed the manufacturer has included two mounting slots in the headshell so as to permit sliding the cartridge to the correct position for the desired overhang. The adjustable pivot arms usually have two round mounting holes in the headshell. With these arms, overhang distance is of little concern to the installer, because the arm is usually zeroed in on a null template. With these arms, effective length will vary somewhat according to the cartridge used (most are standard 0.375 in. stylus tip to mounting hole center), but also the offset angle and overhang will vary with this type of tonearm. Since the inner null radius on many adjustable pivot arms is 2.375 inches, tracking error may be reduced at that point but it may not be optimum. The second null radius usually ends up in a location that will prevent optimum tracking distortion characteristics over the entire record.

Offset Angle

The offset angle of the tonearm, as seen in Fig. 1, is taken from an imaginary line drawn from the pivot center through the stylus tip and a line parallel to the cartridge body through the stylus tip. Basically, this angle is a result of design specification and not a measurement after the fact of assembly. If the effective length, the overhang, and one of the two null radii are known, the offset angle can be easily determined by the solution of that triangle. All the factors fit together like a jigsaw puzzle — a wrong dimension simply will not fit. For example, given an effective length of 229 mm, an overhang of 15 mm, and a null radius of 60.325 mm, calculate the offset angle of this tonearm.

Offset angle =

$$90\text{-arc cos}\left(\frac{229^2+60.325^2-(229-15)^2}{2\times229\times60.325}\right)\cong 21.85 \text{ degrees.}$$

The manufacturers of the tonearms listed in Table 1 supplied the effective length, overhang, offset angle, and null radii for their tonearms. The submitted data was checked to ascertain that the data were consistent. However, some of the data supplied did not fit the specifications. In one instance, the null radii were recalculated according to the submitted data and were found to be different from those given in the manufacturer's specifications.

A common mistake among many audio dealers, advertising copywriters, and audiophiles is to attribute the geometry of an arm to its shape. A tonearm shape is probably more the result of industrial or artistic design than geometric considerations. There really is no superior shape for tonearm geome-

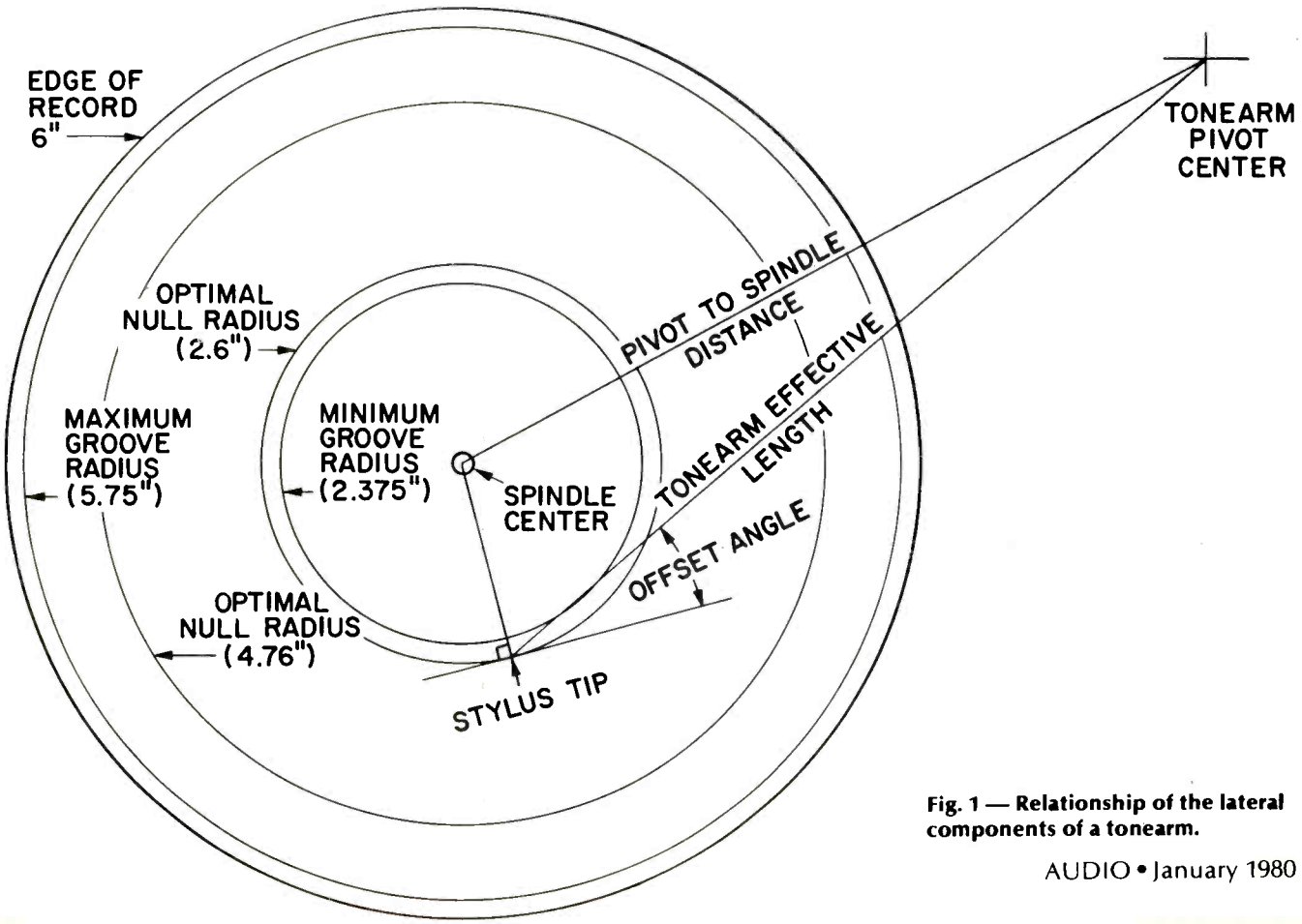

Fig. 1 — Relationship of the lateral components of a tonearm.

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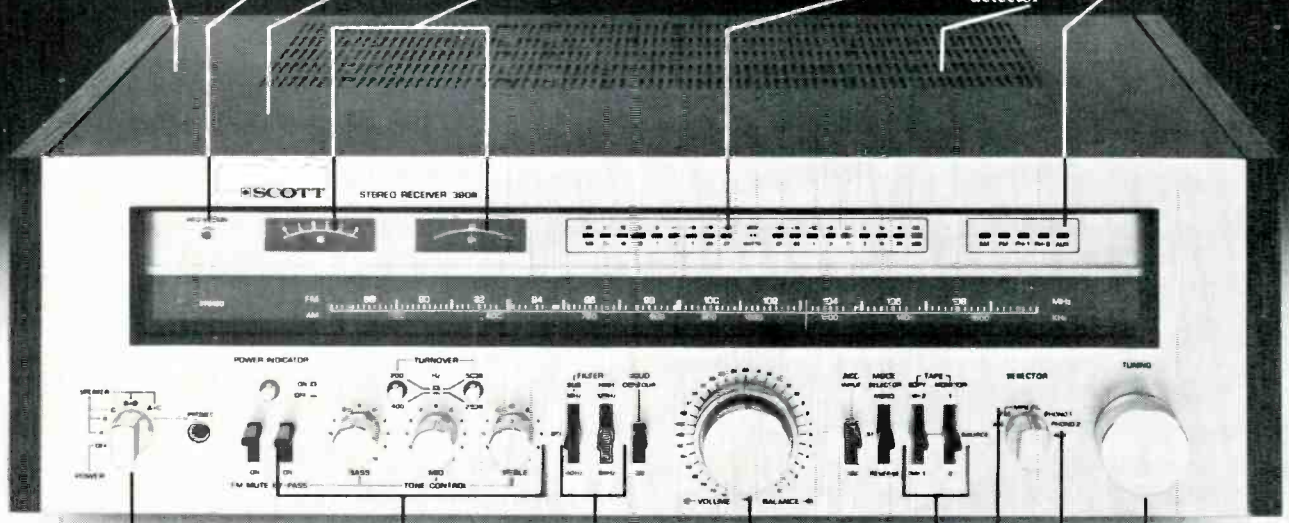

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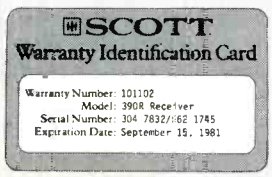

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try since resonance, stiffness, mass, lateral balance, and aesthetics will determine the final shape. With these factors in mind, many of the tonearms in Table I can be optimized with little change in the production process. It would be false to assume that a correction in lateral geometry would have all tonearms looking alike because a change to optimum geometry would be visually imperceptible and the general appearance would remain intact.

Optimum lateral geometry is important, but other parameters and considerations, such as mass of the arm, moment of inertia, resonance characteristics, cartridge compatibility or universality, tube stiffness, vertical tracking angle, bearings, etc., all contribute to the final sound of the arm-cartridge-turntable system. If factors such as those cited above are not properly executed, the contribution of optimum geometry will be lost. The improvement of sound resulting from optimum geometry is subtle but detectable, if it is not overshadowed by other design errors. Even if optimum design is not entirely practical, it is to be hoped the tonearm manufacturers will make absolutely certain that the instructions for setting up their tonearm are detailed and correct according to its design parameters.

Bearings

Correct lateral alignment of vertical bearings is important for maintenance of designed geometry and cartridge azimuth. If records were perfectly flat, the angle of the bearings affecting the vertical axis would not be critical. However, that is not the case, and with vertical tracking angle (VTA) adjustments on some tonearms, the headshell will not remain parallel to the record surface as the arm moves up and down in the vertical axis since the plane of the cartridge body changes with respect to the record surface. If the angle of the vertical bearings is perpendicular to the line through the offset angle, there will be only one angular change, that of the VTA. If, however, the bearings are not perpendicular to that line, the plane generated becomes a compound angle problem — the cartridge plane twists in two angles (azimuth changes). Bear in mind that when setting up the arm, the instructions usually state that a mirror be used to check the front of the cartridge relative to the record surface. As the arm traverses warps or is raised and lowered in the pivots for VTA, the parallel plane is lost in proportion to the difference in angle from perpendicularity from the plane of the cartridge. Visualizing this isn't easy, but if the arm could be rotated up in the vertical plane until it was straight up, the arm whose bearings were in alignment with the offset angle would have the front of the cartridge still parallel to the record surface, whereas the arm not so designed would have the right front edge of the cartridge higher than the left front edge. The problem becomes very complex with unipivots where, with fixed bearing arms, the solution is simple. The resolution of the vectors to bring about the same effect in the unipivot arms is complicated because of counterweight placement. Generally, if the vertical bearings are in alignment with the offset angle, the problems with warp and VTA are made less severe because a simple angle is generated, rather than a compound angle that is typical with many arms currently available. In addition, the height of these bearings is equally important for minimization of warp wow.

Table I seems to be divided on the issue of vertical bearing angle. There should be no disagreement on the preservation of cartridge azimuth. At the moment we are not aware of any literature concerned with the problems of azimuth alignment.

Tonearm Setup Errors

Murphy's Law dictates that practical problems will arise both for the professional setting up audiophile quality equipment and the user trudging through the tonearm manufacturers' sometimes confusing and inaccurate setup instructions. Typical problems that may arise in the course of an installation follow.

1. The cartridge has been pushed all the way forward and the proper overhang still cannot be achieved.
2. The overhang is correct according to the instructions, but the mounting hole was drilled in the wrong place.
3. With a movable pivot arm, there appears to be too little forward adjustment travel and the stylus will not reach the template null and "zero" simultaneously.

Explanation of Table I

The 22 tonearms listed are representative of the majority of arms currently available. Only three arms listed have their geometry optimized, using Bauer's criteria for inner and outer maximum groove radii, when set up according to the manufacturer's instructions. A number of the arms have been optimized using Baerwald's equations, but used inner and outer radii other than those proposed by Bauer.

The first five columns of figures represent manufacturer's tonearm dimensions as supplied. Most of the data were supplied by the manufacturers, and some were calculated. Note that the closer the null radii are to 66.04 mm and 120.9 mm, the closer the arm will be to optimum when set up correctly. The next two columns contain data from Table V for comparison to what the listed arms would be ideally for their effective lengths. The next three columns are the actual absolute weighted errors in degrees per centimeter at the inner groove (60.325 mm), between the nulls, and the maximum radius (146.05 mm). Note that the weighted error between the nulls was calculated using an iterative procedure on a computer. The next column contains the maximum optimum weighted error for an arm of the given effective length. This error will be approximately the same at the innermost, between the nulls, and maximum grooves. For example, for an arm that has a very low error at the innermost groove, weighted tracking error will be compromised over the rest of the record. The next column for reference is the maximally encountered angular tracking error. Generally the maximum error will occur at the outermost groove. The next column is the maximum angular error for an optimum arm of the same length. On occasion this figure will be slightly larger than the actual arm as designed (it was designed for angular error, not weighted error). The next column denotes the method of pivot location — if the arm is fixed, a round hole would be drilled; if adjustable, a slot to allow the overhang to be adjusted. The last column denotes whether the tonearm's vertical bearings were aligned so that they were perpendicular to the offset angle line (yes or no). Since these figures represent "as set up" dimensions, choice of arm should not be based on geometry per se, inasmuch as alignment devices such as the JML and DB protractors and the Dennesen Soundtracktor give the installer a convenient way of aligning the arm-cartridge system to optimum values.

• The SAEC WE-308 SX arm design is based upon research done by the Sansui Electric Co. The AES preprint 1390 (D-5) derived the optimum pivot position from a kinematic point of view, with the mass of the arm, the location of the center of gravity, and the moment of inertia around the system's center of gravity. Resonance was the engineering problem being solved. For this particular arm, it is not advised to optimize the geometry, or the resonance of the system will change to such an extent that the arm will not track properly.

Table I

Manufacturer's Name	Effective Length (mm)	Offset Angle (deg)	Overhang (mm)	Null R_1 (mm)	Null R_2 (mm)	Optimal Offset Angle (deg)	Optimal Overhang (mm)	Weighted Error @ 60.325 mm (deg/cm)	Weighted Error @ Bet Null (deg/cm)	Weighted Error @ 146.05 mm (deg/cm)	Optimal Error @ Max Rad (deg/cm)	Actual Angular Error, deg (max)	Optimal Angular Error, deg. 146.05 mm	Pivot Mount Type (Fix/Adj)	Vertical Bearing Aligned (Yes/No)
Audio Technica AT1009	240.000	21.500	15.000	60.356	115.565	22.914	17.241	0.001	0.140	0.158	0.123	2.314	1.799	Fix	Yes
Audio Technica AT1010	240.000	21.500	15.000	60.356	115.565	22.914	17.241	0.001	0.140	0.158	0.123	2.314	1.799	Fix	Yes
Breuer Dynamic 5A	228.000	25.500	20.000	67.912	128.401	24.195	18.225	0.199	0.142	0.091	0.130	1.322	1.914	Fix	Yes
Decca-London International	232.000	27.000	16.000	42.672	167.980	23.752	17.885	0.711	0.661	0.146	0.128	5.597	1.874	Fix	No
Denon DA 305	244.000	20.500	14.000	59.647	111.254	22.518	16.937	0.012	0.122	0.178	0.120	2.603	1.764	Fix	No
Dynavector DV 505	241.000	21.500	15.000	60.102	116.551	22.814	17.164	0.004	0.145	0.153	0.123	2.236	1.790	Fix	Yes
Fidelity Research FR-12	230.000	23.442	17.068	63.000	120.000	23.971	18.053	0.059	0.143	0.141	0.130	2.027	1.894	Fix	No
Fidelity Research FR-64s	245.000	21.930	15.948	63.000	120.000	22.421	16.863	0.055	0.135	0.129	0.120	1.880	1.756	Fix	No
Grace G-707 Mk II	237.000	24.000	15.000	47.332	145.461	23.221	17.477	0.399	0.423	0.003	0.125	3.506	1.827	Fix	No
Hadcock Super Unilift Mk III	228.900	23.000	16.050	59.287	119.590	24.094	18.148	0.023	0.168	0.148	0.130	2.155	1.905	Adj	No
Infinity Black Widow GF	237.000	21.017	14.359	60.000	110.000	23.221	17.477	0.006	0.119	0.190	0.125	2.778	1.827	Adj	No
JML Co. TA-3A	229.000	24.102	18.156	65.970	121.050	24.083	18.139	0.129	0.130	0.130	0.130	1.904	1.904	Fix	Yes
Lustre GST-801	240.000	22.500	15.000	53.630	130.058	22.914	17.241	0.165	0.256	0.090	0.123	2.136	1.799	Adj	Yes
Magnepan Arm	241.300	22.800	17.145	65.877	121.138	22.784	17.141	0.120	0.123	0.121	0.122	1.773	1.788	Fix	Yes
Mayware Formula 4 MK III	229.000	23.667	17.342	63.500	120.352	24.083	18.139	0.077	0.144	0.137	0.130	2.000	1.904	Fix	No
J A Michell Engr. Ltd. Fluid Arm	232.000	23.750	17.880	65.980	120.894	23.752	17.885	0.127	0.127	0.128	0.128	1.874	1.874	Fix	No
Keith Monks M9BA Mk 3	228.600	23.000	16.184	60.325	118.317	24.128	18.173	0.000	0.160	0.153	0.130	2.235	1.908	Adj	No
SAEC WE-308 SX	240.000	11.974	5.000	39.584	60.000	22.914	17.241	0.014	***	0.533	0.123	7.790	1.799	Fix	Yes
Series 20 PA1000	237.000	21.683	15.000	59.588	115.544	23.221	17.477	0.014	0.147	0.162	0.125	2.370	1.827	Fix	No
Shure SME 3009 Series III	231.190	22.600	15.856	60.325	117.366	23.840	17.952	0.000	0.149	0.156	0.129	2.279	1.882	Adj	Yes
Technics EPA-100	250.000	21.000	15.000	62.174	117.010	21.949	16.502	0.035	0.126	0.141	0.117	2.062	1.714	Fix	Yes
Ultracraft AC-300 Mk II	237.000	22.000	15.000	57.203	120.360	23.221	17.477	0.067	0.188	0.141	0.125	2.052	1.827	Fix	No

TABLE II — Optimum parameters for two different tonearms.

	Arm 1	Arm 2
Effective Length	200 mm	300 mm
Offset Angle	27.854°	18.149°
Overhang	21.055 mm	13.606 mm

Null Radii (for both arms) — Inner = 66.04 mm; Outer = 120.9 mm.

Occurences such as these will frustrate even the most patient audiophile and technician. Both will throw up their hands in defeat and assume the fault was theirs in that they left out an important step. Although one should be as accurate as possible with the setup, many times the instructions accompanying the tonearm are insufficient, in error, or poorly translated. The consumer is seldom aware of the geometric interaction of the lateral tonearm components; errors of a degree here or a millimeter there go unnoticed or are considered insignificant, while actually such errors have considerably altered the geometry of the tonearm.

As a reference, it is important to consider the null radii. The positions of the radii actually represent the design of the arm being installed more than any other parameter. If after careful setup, the arm does not "zero" on its designed null radii, an error may have occurred either in setup or possibly on the drawing board. For the following discussion the relative changes of the nulls will be considered with respect to common errors in setup.

1. What effect does a "small" error in offset angle have on null radii, and does arm length make a difference?

Referring to Table II, suppose the correct geometry of both arms is altered by adding a 0.4° error to the offset angle, leaving all the other parameters the same except, of course, the null radii. The offset angles are changed to 28.254° (27.854° +0.4°) and 18.549° (18.149° +0.4°). It is easy to make a 0.4° error; most people do it inadvertently. The results in Table III show that with only 0.4° error, the small arm misses the nulls by -2.707 mm and +5.159 mm, while the large arm increases to -4.17 mm and +8.14 mm. Note that the longer the arm, the more critical it is to get the offset angle exactly right. Errors over two degrees may put the null radii somewhere off the record — hardly optimum.

2. What happens when small errors in overhang occur?

Using the same optimum tonearms as in Table II, an error of +1 mm will be induced in the overhang. This kind of problem can occur if the arm is mounted in the wrong position but the manufacturer's instructions were to align the overhang of the stylus with reference to the headshell. Since no cross checks are supplied, it is assumed that the job was done correctly. Incidentally, almost no manufacturers supply the consumer with geometric cross-reference checks for the arm setup, especially for those arms with particularly confusing instructions. Referring to Table IV, with +7.539 mm and -7.551 mm translational error in the position of the null radii for the small arm and +13.955 mm and -13.961 mm in the large arm, small errors in overhang become crucial. Actually, if the manufacturer supplied an overhang template to check the overhang over the spindle, the problem would be minimized to a large extent. Overhang changes very slowly compared to changes in offset angle and arm length. The length of overhang is more important than the absolute accuracy of the mount. Also, the longer the arm, the more critical the overhang dimension.

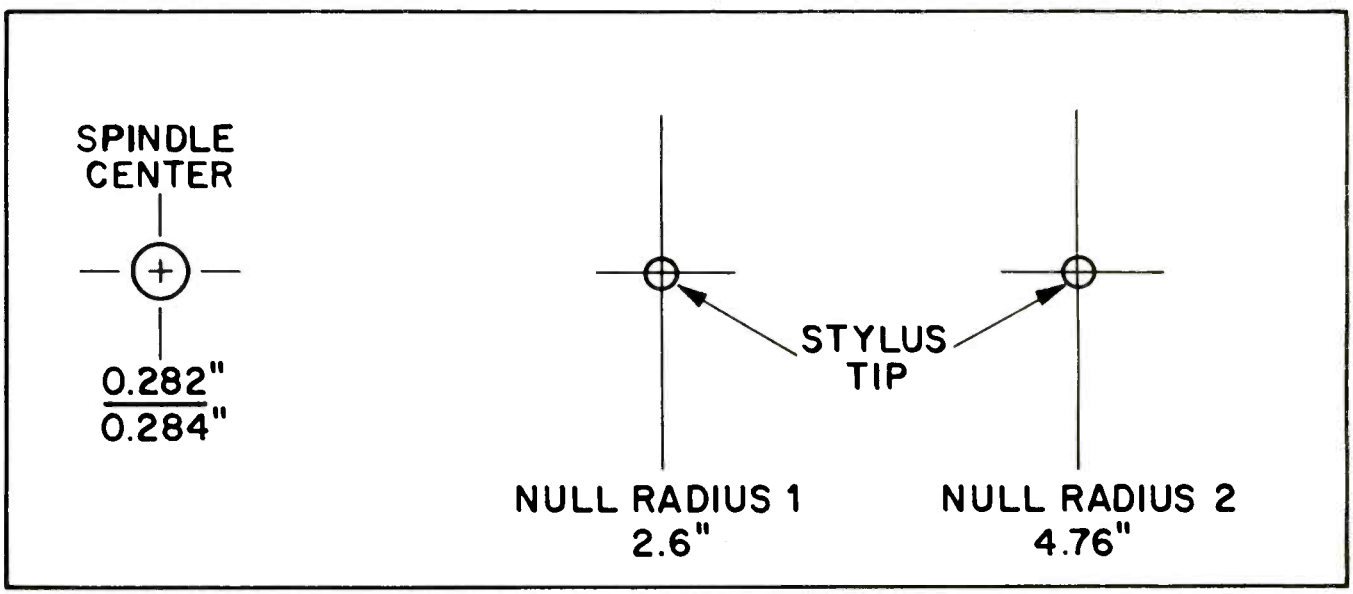
Table III — Change in null radii when 0.4 degree is added to the optimum offset angle of Table II tonearms.

	Arm 1	Arm 2
Effective Length	200 mm	300 mm
Offset Angle	28.254°	18.549°
Null Radius 1	63.293 mm	61.830 mm
Null Radius 2	126.059 mm	129.040 mm

Table IV — Change in null radii when 1 mm is added to the optimum overhang of Table II tonearms.

	Arm 1	Arm 2
Effective Length	200 mm	300 mm
Overhang	22.055 mm	14.606 mm
Null Radius 1	73.539 mm	79.955 mm
Null Radius 2	113.349 mm	106.939 mm

Fig. 2 — Dual null radius protractor.



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3. A movable pivot arm is mounted on a turntable with a predrilled mounting slot. In the course of moving the pivot towards the null template, forward travel stops in the arm before the arm reaches the zero position on the template.

This is unfortunately a more common problem than might be realized. A few of the more popularly priced direct-drive turntables have convenient precut mounting boards. At this point, aesthetics got into the way of performance. Many movable pivot tonearms are relatively short, e.g., 9 in. (229 mm), and platters on the turntables are oversize, up to 13 in. diameter (330.2 mm). In order to preserve aesthetics and prevent a "cluttered look," the mount is located a comfortable distance from the platter, and the slot center may be located at least 0.5 in. (12.7 mm) from where it should be. The result is that the arm probably ends up with its null radii off the record surface (a 3-mm error will accomplish this). The actual results are the same as for example 2, where the offset angle and effective length are "frozen" — the overhang gets the short end (no pun intended).

From the above it can be readily seen that even using care, errors that appear small can create large problems. Most setup procedures supplied by the tonearm manufacturers are inadequate given the tools supplied for the installation — a paper template, whose accuracy is questionable, and many times a confusing set of instructions. The manufacturers should consider providing a cross-reference check template to validate the designed null radii. In tonearms that have a continuously variable VTA adjustment, the lateral error might be so far off that a change in VTA might never be heard.

TABLE V — Optimum values for tonearms (200-250 mm) and angular error.

Effective Arm Length		Optimum Overhang		Optimum Offset Angle	Actual Angular Error, deg. Inner	Between	Outer
mm	inch	mm	inch	deg	60.325 mm	Nulls	146.05 mm
200.0	7.874	21.055	0.829	27.854	0.927	-1.328	2.258
201.0	7.913	20.938	0.824	27.704	0.921	-1.319	2.244
202.0	7.953	20.822	0.820	27.555	0.915	-1.311	2.229
203.0	7.992	20.708	0.815	27.408	0.909	-1.303	2.215
204.0	8.031	20.595	0.811	27.262	0.904	-1.295	2.201
205.0	8.071	20.483	0.806	27.118	0.898	-1.287	2.187
206.0	8.110	20.373	0.802	26.976	0.892	-1.279	2.173
207.0	8.150	20.264	0.798	26.835	0.887	-1.272	2.160
208.0	8.189	20.156	0.794	26.696	0.882	-1.264	2.147
209.0	8.228	20.049	0.789	26.558	0.876	-1.256	2.133
210.0	8.268	19.944	0.785	26.422	0.871	-1.249	2.121
211.0	8.307	19.839	0.781	26.287	0.866	-1.242	2.108
212.0	8.346	19.736	0.777	26.153	0.861	-1.235	2.095
213.0	8.386	19.634	0.773	26.021	0.856	-1.227	2.083
214.0	8.425	19.533	0.769	25.891	0.851	-1.220	2.071
215.0	8.465	19.433	0.765	25.762	0.846	-1.214	2.058
216.0	8.504	19.334	0.761	25.634	0.841	-1.207	2.047
217.0	8.543	19.237	0.757	25.507	0.836	-1.200	2.035
218.0	8.583	19.140	0.754	25.382	0.831	-1.193	2.023
219.0	8.622	19.044	0.750	25.258	0.827	-1.187	2.012
220.0	8.661	18.949	0.746	25.135	0.822	-1.180	2.000
221.0	8.701	18.856	0.742	25.013	0.817	-1.174	1.989
222.0	8.740	18.763	0.739	24.893	0.813	-1.167	1.978
223.0	8.780	18.671	0.735	24.774	0.809	-1.161	1.967
224.0	8.819	18.580	0.731	24.656	0.804	-1.155	1.956
225.0	8.858	18.490	0.728	24.539	0.800	-1.149	1.946
226.0	8.898	18.401	0.724	24.423	0.795	-1.143	1.935
227.0	8.937	18.313	0.721	24.309	0.791	-1.137	1.925
228.0	8.976	18.225	0.718	24.195	0.787	-1.131	1.914
229.0	9.016	18.139	0.714	24.083	0.783	-1.125	1.904
230.0	9.055	18.053	0.711	23.971	0.779	-1.119	1.894
231.0	9.094	17.969	0.707	23.861	0.775	-1.113	1.884
232.0	9.134	17.885	0.704	23.752	0.771	-1.107	1.874
233.0	9.173	17.801	0.701	23.644	0.767	-1.102	1.864
234.0	9.213	17.719	0.698	23.537	0.763	-1.096	1.855
235.0	9.252	17.638	0.694	23.431	0.759	-1.091	1.845
236.0	9.291	17.557	0.691	23.325	0.755	-1.085	1.836
237.0	9.331	17.477	0.688	23.221	0.751	-1.080	1.827
238.0	9.370	17.398	0.685	23.118	0.748	-1.075	1.817
239.0	9.409	17.319	0.682	23.016	0.744	-1.069	1.808
240.0	9.449	17.241	0.679	22.914	0.740	-1.064	1.799
241.0	9.488	17.164	0.676	22.814	0.737	-1.059	1.790
242.0	9.528	17.088	0.673	22.714	0.733	-1.054	1.782
243.0	9.567	17.012	0.670	22.616	0.729	-1.049	1.773
244.0	9.606	16.937	0.667	22.518	0.726	-1.044	1.764
245.0	9.646	16.863	0.664	22.421	0.722	-1.039	1.756
246.0	9.685	16.790	0.661	22.325	0.719	-1.034	1.747
247.0	9.724	16.717	0.658	22.230	0.715	-1.029	1.739
248.0	9.764	16.644	0.655	22.135	0.712	-1.024	1.731
249.0	9.803	16.573	0.652	22.042	0.709	-1.020	1.722
250.0	9.843	16.502	0.650	21.949	0.705	-1.015	1.714

This table gives optimal values for arms tracking within 60.325 mm and 146.05 mm (2.375 in. and 5.75 in.) inner and outer grooves. The last three columns represent the actual angular error for the inner groove, between the null radii, and the outer groove. This table can be used for determining the mounting position for drilling the tonearm mounting board.

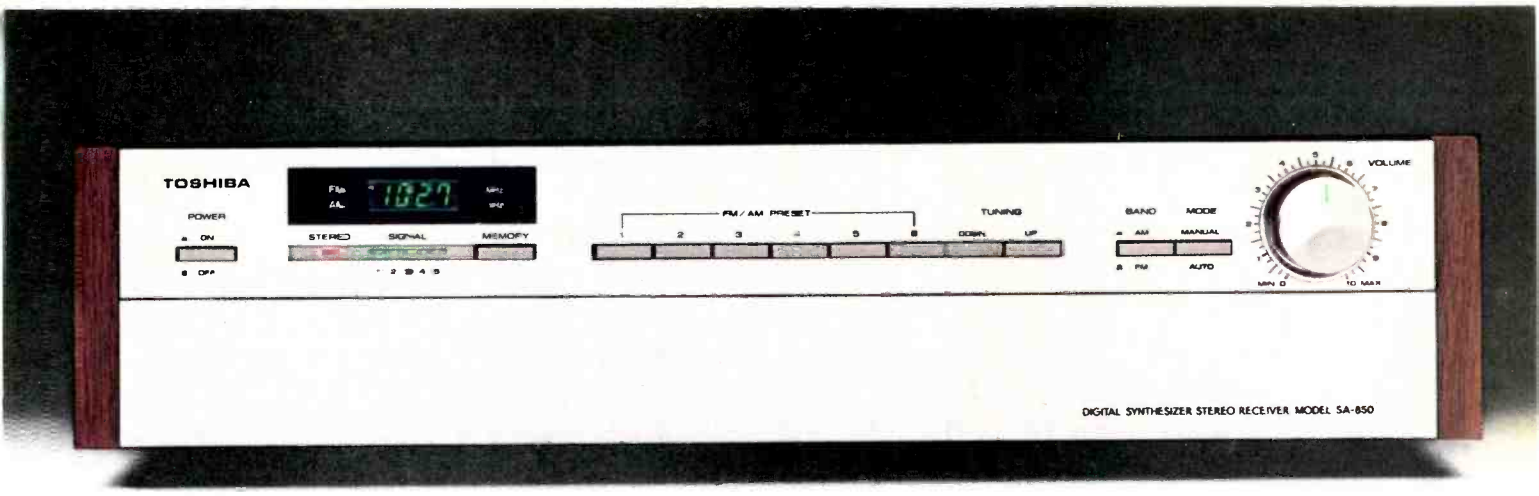
Optimizing Tonearm Geometry

If the tonearm is not optimized, do not be overly concerned, since the result is not wholly fatal. It is feasible to optimize the lateral geometry of the arm if it is already mounted, but only if the arm is reasonably close in its overhang so that the optimization procedure will not compromise the integrity of the arm-cartridge system. For example, on some adjustable pivot arms where the headshell has no mounting slots, the cartridge cannot be twisted in the shell to achieve a line-up with an optimum null radius template if both mounting screws are in place. (At least one dealer we know of connected a cartridge with only one screw in such an arm so as to achieve optimal geometry, but ended up negating all of the good characteristics the arm had — a pyrrhic victory at best.) Another instance occurs in the arms that have correct vertical bearing alignment with the cartridge. Here, one has to decide on a compromise — on most arms designed with correctly aligned bearings, a change in azimuth is less critical than maintaining optimum lateral geometry. Assuming the tonearm's mounting hole is within a few millimeters of optimum and the headshell has slots to allow the cartridge to be twisted and moved, the arm can be optimized by using a null radius template. On other arms, where the mounting hole is out of range, it is up to the user to decide whether the trouble warrants redrilling a new mounting board or leaving the arm as is.

Here it is necessary to discuss the tools that will be required for the optimum tonearm-cartridge setup. Recently, three manufacturers have introduced alignment devices to accomplish an optimum tonearm-cartridge setup — JML Company, DB Systems, and Dennesen Electrostatics.

The JML Universal Tonearm Alignment Protractor is basically a coated-cardboard template with null radii optimized for a record surface within the radii of 2.375 and 5.75 inches. The template and instructions are available for $3.00. It is much better than attempting to construct one as is shown in Fig. 2. The instructions, though adequate, could have been more detailed. The JML Company assumes that the consumer will drill the mounting hole and requires the tonearm effective length to be measured with a cartridge already mounted. This is a difficult procedure, but the instructions say that only approximation is necessary. It is much safer to use the manufacturer's specification for effective length and calculate the optimum overhang and tonearm mounting center from equation 3 once the offset angle is calculated from equation 2. Table V presents the optimum overhang and offset angle for varying effective arm lengths. Note that the mounting center is the effective length minus the overhang. Small inaccuracies are taken care of using the null radius system. Geometrically speaking, if the cartridge nulls at both radii of the JML template, the overhang and offset angle will automatically be correct. If the tonearm has already been mounted and its measured dimensions are not too far off, the nulling system can be used. The procedure can be frustrating, but patience will get accurate results. One point which may not be immediately obvious: The protractor (template) must be rotated to a different position for zero alignment error at each null radius.

A more elaborate version of the JML protractor is the DB Systems DBT-10 Phono Alignment Protractor. This unit is made of mylar and uses the same nulling system as the JML.



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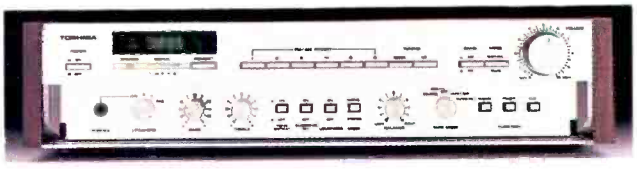

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	Key	Output
Step 1	2.375	2.375
Step 2	+	2.38
Step 3	5.75	5.75
Step 4	Divide	8.13
Step 5	2	2.00
Step 6	=	4.06
Step 7	Square	16.50
Step 8	Divide	16.50
Step 9	2.375	2.375
Step 10	Divide	6.95
Step 11	5.75	5.75
Step 12	+	1.21
Step 13	1	1.00
Step 14	x	2.21
Step 15	9	9.00
Step 16	=	19.88
Step 17	Store Memory	19.88
Step 18	2.375	2.375
Step 19	+	2.38
Step 20	5.75	5.75
Step 21	Divide	8.13
Step 22	Recall Memory	19.88
Step 23	=	0.41
Step 24	Arc Sine	24.13 degrees offset angle

Table VI — Calculator steps for calculation of optimum offset angle.

A good set of instructions comes with the $19.95 unit, which also allows the user to measure tracking angle error.

There is only one rotated position of the protractor that will be correct for any one arm of given effective length. If this position could be fixed, nulling would only have to take place at one radius and could be performed in one step. The Dennesen Geometric Soundtracktor has recently been introduced to perform this function. Available in two models — a plastic version for $35.00 and a metal version for $100.00— the user can, in a single step, align overhang, offset angle, and both null radii, provided the tonearm has an obviously marked pivot center. We have used this tool for the past few months and recommend it without reservation. The instructions are simple, with the actual procedure not taking more than a few minutes. The Soundtracktor will quickly indicate if the tonearm is optimally set up and will make realignment of the cartridge an easy job. The Dennesen Soundtracktor is accompanied by a vertical tracking angle (VTA) reference gauge, which looks like a tonearm rest post and a bubble level for the tonearm. Although the unit does not determine VTA, it does establish the reference number for each record in a collection, where the sound is most focused. Once the VTA is established for a record, it is a simple matter to set the tonearm to the correct VTA number, established earlier. The above-mentioned alignment tools are available from JML Co., 39,000 Highway 128, Cloverdale, Calif. 95425; DB Systems, P.O. Box 187, Jaffrey Center, N. H. 03454, and Dennesen, P.O. Box 51, Beverly, Mass. 01915.

Table VII—Calculator steps for calculation of mounting center and stylus overhang.

	Key	Output
Step 1	90	90.00
Step 2	—	90.00
Step 3	24.13	24.13
Step 4	=	65.87
Step 5	Cosine	0.41
Step 6	x	0.41
Step 7	2.6	2.60
Step 8	x	1.06
Step 9	9	9.00
Step 10	x	9.57
Step 11	2	2.00
Step 12	=	19.13
Step 13	Store Memory	19.13
Step 14	9	9.00
Step 15	Square	81.00
Step 16	+	81.00
Step 17	2.6	2.60
Step 18	Square	6.76
Step 19	—	87.76
Step 20	Recall Memory	19.13
Step 21	=	68.63
Step 22	Square Root	8.28 in. spindle center to tonearm pivot
Step 23	9	9
Step 24	—	9.00
Step 25	8.28	8.28
Step 26	=	0.72 Stylus tip overhang

Calculator Hints

With the advent of inexpensive yet sophisticated scientific calculators, solution of the equations presented in this paper becomes a practical consideration for interested audiophiles as well as engineers. Those who have programmable scientific calculators such as the Hewlett-Packard 67/97 can find quick repetitive answers easily, thus this section is not really aimed at them because the capability of programming already qualifies them to work with algebraic equations.

It is assumed that for practical purposes, the calculator has trigonometric and standard algebraic functions, one memory, and no algebraic hierarchy except single argument functions such as square root. For example, the very inexpensive Texas Instruments TI-30 would be a good choice. Users with more sophisticated equipment can modify the procedure. The calculator mode, for simplicity, will be fixed at two decimal places.

Equations 2 and 4 are of the most interest since they calculate offset angle and overhang.

Example 1: Solve the following equation for offset angle:

$$\text{Arc sin}\left[\frac{2.375+5.75}{9\times\left[\frac{\left(\frac{2.375+5.75}{2}\right)^2}{2.375\times5.75}+1\right]}\right]$$

Refer to Table 6 for the step-by-step procedure.

Example 2: Solve the following equation for mounting center:

$$\sqrt{9^2+2.6^2-2\times9\times2.6\times\cos(90-24.13)}$$

Refer to Table 7 for the step-by-step procedure.

The procedures are general and may not be directly applicable to all calculators. Since the output column gives the intermediate results, one can modify the routines for his own calculator.

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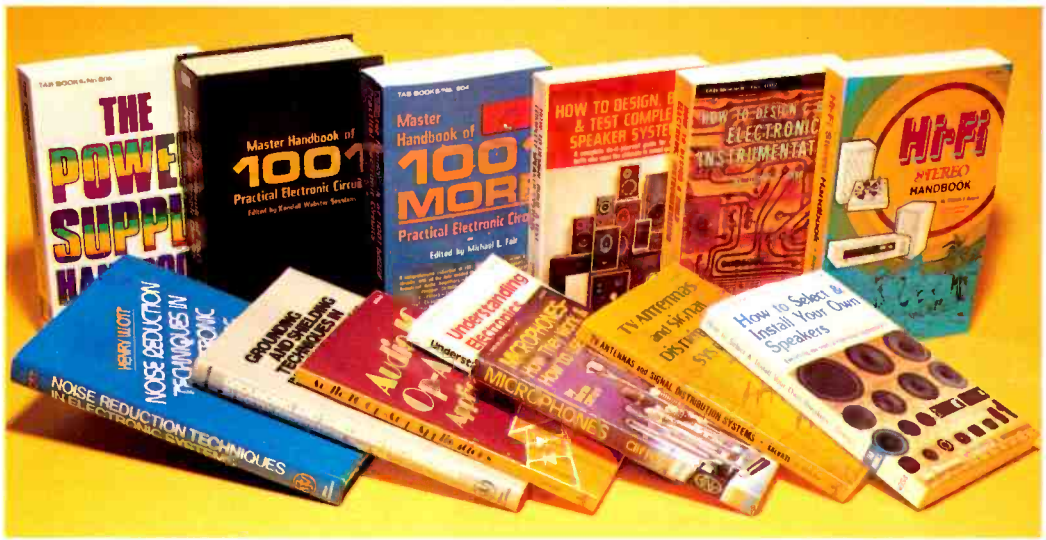

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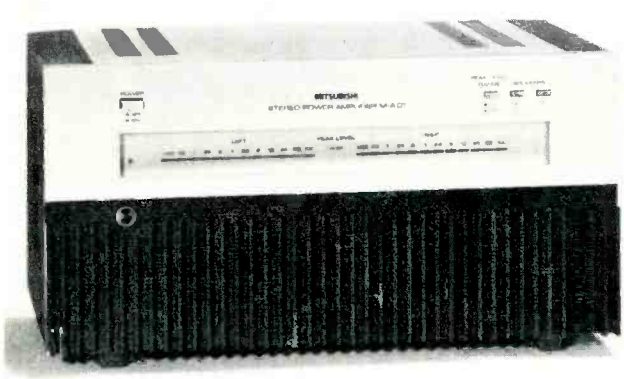
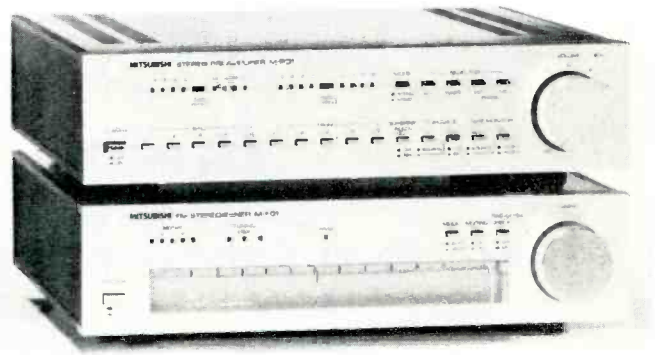
Equipment profiles

Mitsubishi Micros

Model M-FO1 Tuner
Model M-PO1 Preamp
Model M-AO1 Amplifier

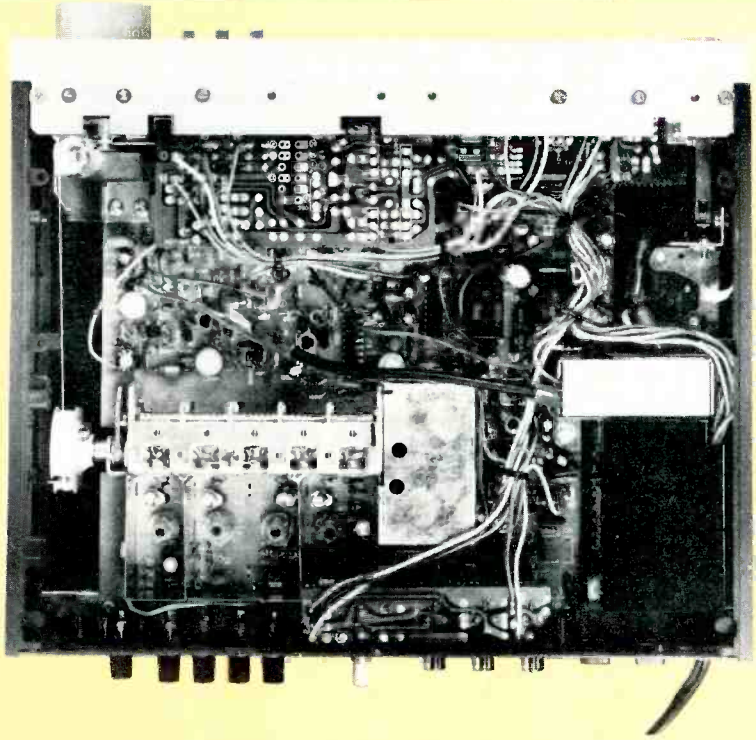


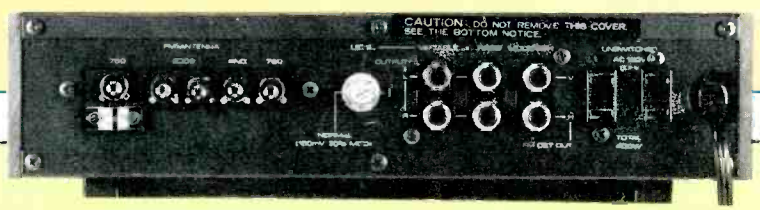


Manufacturer's Specifications

M-FO1 Stereo FM Tuner

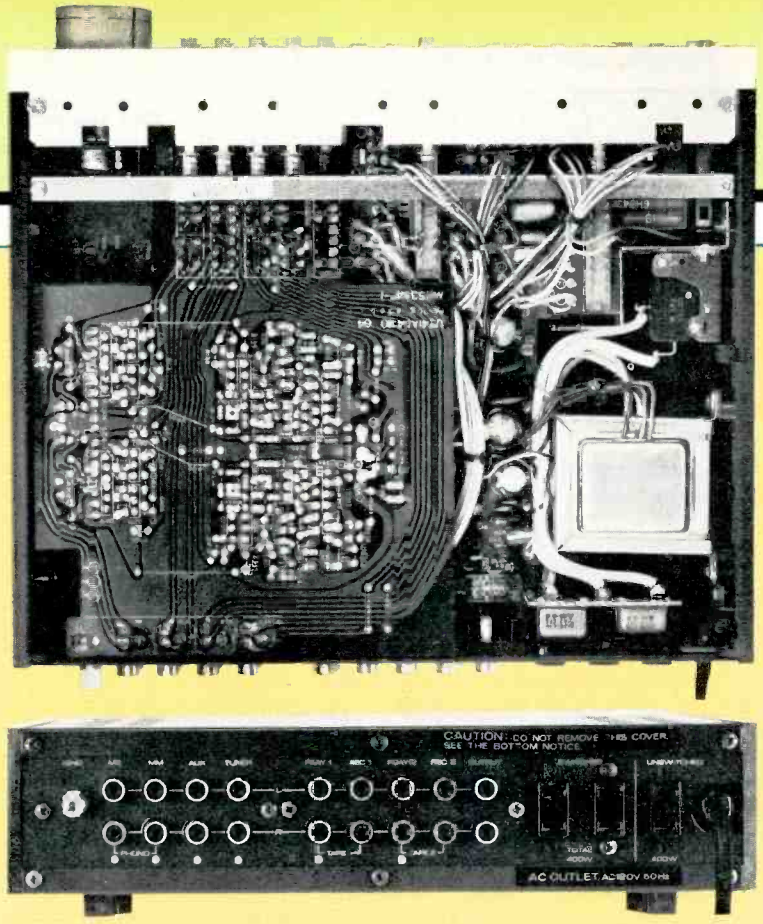
Usable Sensitivity: Mono, 11.2 dBf (2.0 μV); stereo, 22.7 dBf (7.5 μV).
50-dB Quieting: Mono, 19.2 dBf (5.0 μV); stereo, 39.2 dBf (50 μV).
S/N: Mono, 80 dB; stereo, 77 dB.
Frequency Response: 30 Hz to 16 kHz, ±1 dB.
THD: Mono, 0.08 percent; stereo, 0.1 percent; both for 65 dBf, 1 kHz.
Capture Ratio: 1.0 dB.
Selectivity: 70 dB.
I.f., Image and Spurious Rejection: 100 dB.
AM Suppression: 65 dB.
Stereo Separation: 1 kHz, 50 dB; 10 kHz, 40 dB.
Subcarrier Rejection: 70 dB.
SCA Rejection: 80 dB.
Dimensions: 10⅝ in. (27 cm) W x 2¾ in. (7 cm) H x 9¾ in. (24.75 cm) D.
Weight: 7 lbs. (3.18 kg).
Price: $340.00.





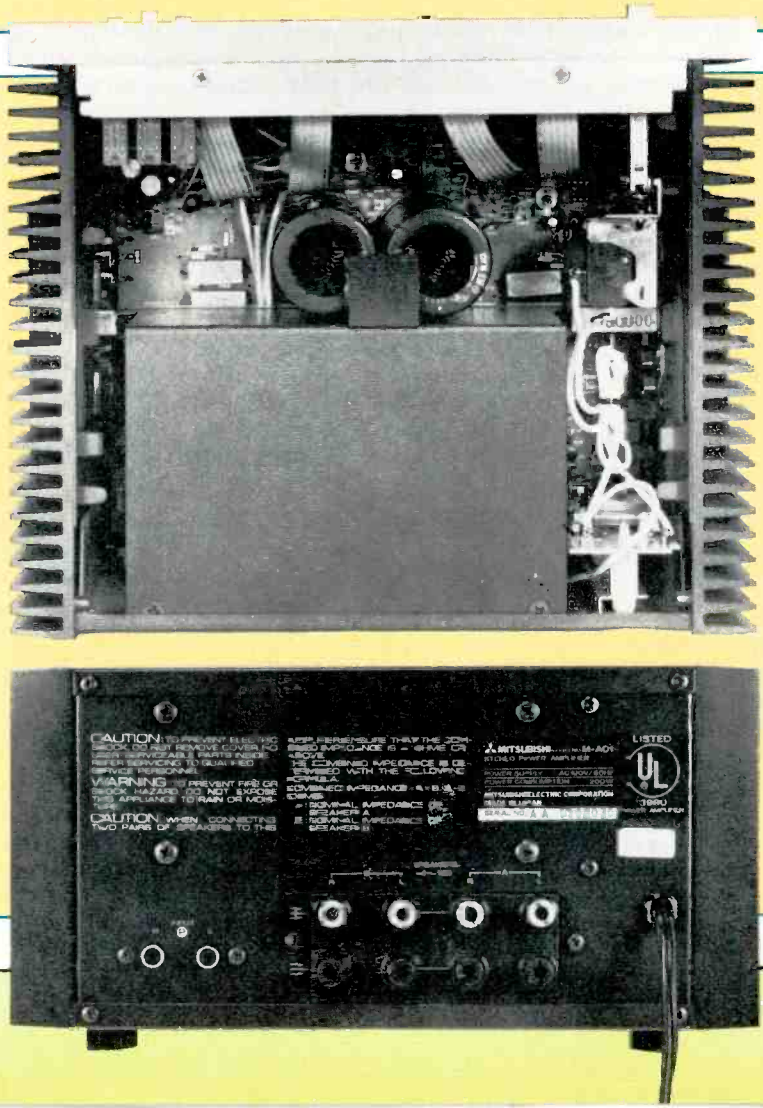
M-PO1 Stereo Preamplifier

Input Sensitivity: MM phono, 2.3 mV; MC phono, 0.1 mV; high level, 150 mV; all for 1 V rated output.
Maximum Output: 18 V.
S/N: MM phono, 84 dB; MC phono, 77 dB; high level, 110 dB; all "A" weighted, referred to rated output.
Phono Overload: MM phono, 290 mV; MC phono, 12 mV.
THD: MM phono, 0.003 percent; MC phono, 0.005 percent; high level, 0.002 percent; all at rated output with master volume control at -20 dB.
Frequency Response: MM or MC phono, RIAA ±0.2 dB, 20 Hz to 20 kHz; high level, 10 Hz to 100 kHz, ±0.5 dB.
Bass Control Range: Up to ±8 dB at 100 Hz.
Treble Control Range: Up to ±8 dB at 10 kHz.
Subsonic Filter: 18 Hz, -6 dB/octave.
Dimensions: 10⅝ in. (27 cm) W x 2¾ in. (7 cm) H x 9¾ in. (24.75 cm) D.
Weight: 7 lbs. (3.18 kg).
Price: $370.00.



M-AO1 Stereo Power Amplifier

Power Output: 70 watts/channel, 8-ohm loads, 15 Hz to 20 kHz, 0.01 percent THD (85 watts/channel, 4 ohms, 0.02 percent THD).
IM Distortion: 0.008 percent.
Frequency Response: D.c. to 200 kHz, -1 dB.
Input Sensitivity: 1 V.
Damping Factor: 100, 20 Hz to 20 kHz.
S/N at Rated Output: 109 dB, unweighted; 123 "A" weighted.
Slew Rate: 30 V/ μS.
Dimensions: 10⅝ in. (27 cm) W x 6-11/16 in. (17 cm) H x 9-9/16 in. (24.25 cm) D.
Weight: 22 lbs. (10 kg).
Price: $500.00.



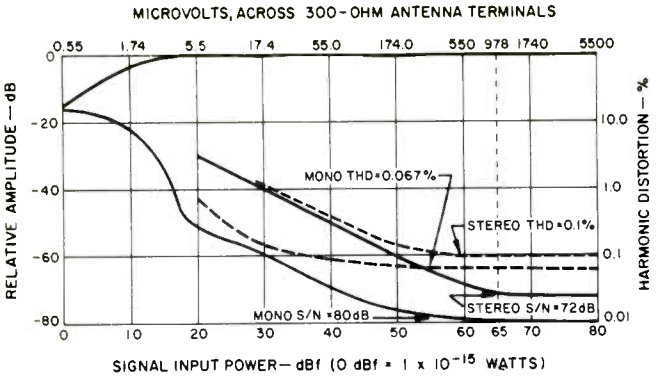
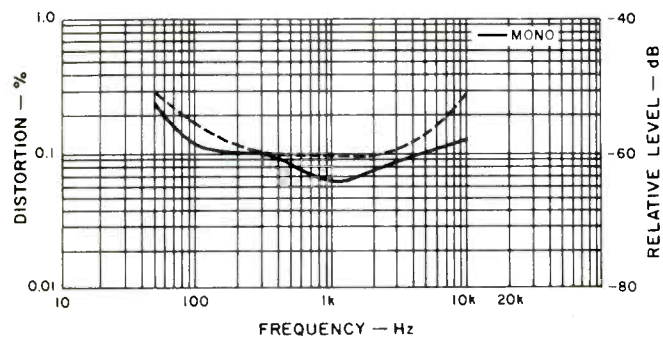


Fig. 1 — Mono and stereo quieting and distortion characteristics, FM section, M-FO1 tuner.

The three Mitsubishi products tested for this report are the first mini- or micro-components to pass through our laboratory, and one thing became clear immediately: They are definitely meant to work with each other, both aesthetically and practically. Accordingly, we are treating this investigation as one overall test report, much as we would in the case of an integrated receiver, which in fact these three units replace.

Before dealing with the individual separate components, which consist of an FM tuner (M-FO1), a preamp-control unit (M-PO1), and a stereo power amplifier (M-AO1), let's consider the matter of space-saving which is said to be one of the major advantages of mini- or micro-components. To begin with, Mitsubishi does suggest not stacking all three components one above the other because of ventilation considerations. Assuming, then, that we stack the tuner and preamp one above the other, their combined height will nicely match the height of the power amplifier which, as Mitsubishi suggests, should be positioned at least two inches to the side of the other pair of units. Following these instructions, we come up with a horizontal and vertical space requirement of about 23¼ by 6-11/16 inches. There are few all-in-one integrated receivers which have front panels that are as large! However, because the depth of the units (9¾ in. maximum) is considerably less than that of most receivers, the signified space-saving comes in shelf depth, so that the trio will fit easily into the depth of a standard bookcase. And, of course, we are dealing with separates, with all their advantages of flexibility, and the fact that you aren't obligated to purchase the tuner, for example, if all you want are record and tape-playing facilities. If you do decide on all three components (and there's no denying that they look just great together and are sure to become conversation pieces), do bear in mind that their *combined* suggested retail price comes to over $1,200.00. With all of this in mind, let's go on to the components themselves.

Fig. 2 — Mono and stereo THD vs. frequency, M-FO1 tuner.



The Tuner

The M-FO1 has an elegantly styled front panel which bears only a single rotary tuning knob at its extreme right. Three small push buttons just to the left select a record-level check tone, FM muting, and mono or auto-stereo. A red LED near panel-center illuminates in the presence of a stereo signal, while further to the left are three LEDs (two red arrows flanking a green square) which together serve as a center-tuning indicator. When you are slightly detuned, one of the arrow LEDs tells you which way to tune to achieve proper tuning. Once that is accomplished, the red arrows extinguish, the green light comes on and, as further insurance that you may now sit back and listen secure in the knowledge that you are at the minimum distortion point, the entire frequency scale changes the color of its illumination from white to a soft green. There are five more LEDs at the left which serve as a signal-strength metering system with the number of LEDs lit indicating the relative strength of the incoming signal. A small power *On/Off* button is located at the lower left of the panel.

The rear panel is equipped with terminals for 75-ohm and 300-ohm antenna transmission lines and a ground terminal. There are also two pairs of output jacks, one providing fixed voltage, the other providing variable output, adjusted by means of an adjacent potentiometer. There are also a pair of multipath output jacks which can be connected to a 'scope for visual multipath indication or may be connected to the AUX inputs of the associated equipment for audible evidence of this effect. Two unswitched a.c. receptacles are also incorporated on the rear panel.

While no circuit diagrams were supplied with these three components, we did remove their top covers in order to determine just how crowded the insides were. In the case of the M-FO1, at least, the internal layout was not overly compressed and access for possible servicing was good. The shielded front end used in the tuner was mounted directly to the main tuner p.c. board, in a manner not unlike that found in more standard-sized components.

FM Performance Measurements

While usable sensitivity in mono fell a bit short of claims (13.2 dBf instead of 11.2 dBf), 50-dB quieting was reached with signal levels of 19.2 dBf (5.0 μV) exactly as claimed. Stereo usable sensitivity was considerably better than specified, with a reading of 18 dBf (3.7 μV), while 50-dB quieting for stereo measured 40 dBf, virtually as claimed, quite usable, but rather poorer than for other tuners in this price category. Signal-to-noise ratio in mono was a very high 80 db, as stated, while in stereo the S/N was a very acceptable 72 dB. All of the various rejection figures quoted by Mitsubishi (image, i.f., and spurious) were met or exceeded, and capture ratio measured 1.0 dB, as claimed. AM suppression was 63 dB as opposed to 65 dB specified. Quieting and THD (at 1 kHz) characteristics of the tuner versus input signal are shown in Fig. 1, while Fig. 2 is a graph of distortion versus frequency in mono and stereo. Distortion at the three test frequencies of 1kHz, 100 Hz, and 6 kHz measured 0.067 percent, 0.13 percent, and 0.13 percent for mono and 0.1 percent, 0.16 percent, and 0.17 percent for stereo, all exceedingly good figures, especially the 6-kHz result in stereo. Frequency response and stereo FM separation are shown in the spectrum analyzer 'scope photo of Fig. 3. A slight dip in response in the region between 3 kHz and 8 kHz seems to be compensated for by the slight rise at the extreme high end resulting from the termination of the 19-kHz notch filter employed so that, overall, response out to 15 kHz was virtually flat (though it was off by about 1.0 dB at the upper midrange). At the three test points of 100 Hz, 1 kHz, and 10 kHz, stereo separation

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It's an ingenious and highly sophisticated system—much like the human nervous system—which controls the deck's functions.

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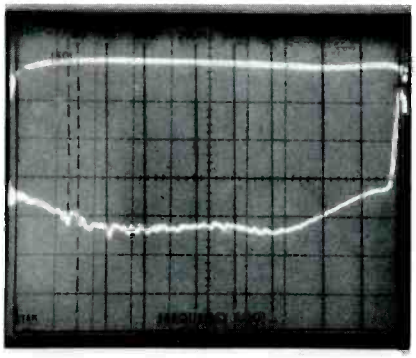

Fig. 3 — Frequency response and stereo separation, M-FO1 tuner.

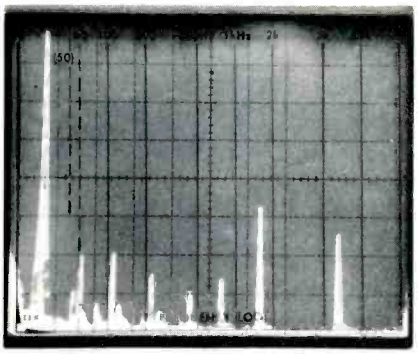

Fig. 4 — Crosstalk components at 5 kHz, stereo mode, M-FO1 tuner.

measured 47 dB, 51 dB, and 33 dB, the latter figure short of the 40 dB claimed.

Figure 4 is a composite spectrum analyzer photo, illustrating the crosstalk component generated when a 5-kHz signal is used to modulate the left channel (tall spike at left), and a second sweep of the analyzer is made with the output of the right channel connected. Sweep is linear (5 kHz per horizontal division) and, in addition to distortion components which are multiples of the 5-kHz modulating signal, we see a rather large 38-kHz spike to the right of mid-screen, as well as one at 48 kHz (38 kHz plus the second harmonic of 5 kHz) further to the right. The sub-carrier product ratio falls short of the -70 dB claimed by the manufacturer, at least in this sample, and the components at 10 kHz and 15 kHz in the unmodulated channel are large enough to suggest that, under certain conditions, this unwanted material would be audible from the speaker that is supposed to be silent when high-frequency information is modulating one channel only. This condition, often described as "poor separation," is in reality a form of spurious crosstalk totally unrelated to the tuner's separation capability.

Since our listening tests were conducted with the three-piece system as a whole, we will go on to describe the other two components and to detail the measurements made before discussing the sound quality of all three.

The Preamplifier

The control layout of the M-PO1 preamplifier/control unit is similar to that of the tuner, in that only a single large rotary knob is found on the front panel, positioned just where the tuning knob is on the tuner. This control, however, is in reality a dual control (with concentric outer and inner knobs) and serves as a master volume control for each channel independently. This obviates the need for a separate balance control. All other control functions are activated by means of small push buttons, many of which have LED indicators mounted above them.

The M-PO1 employs a novel and, in our opinion, desirable tone-control arrangement. Instead of rotary knobs, there are two series of tiny buttons (one group for bass, another for treble). Four buttons in each group select fixed amounts of boost or cut (2 dB, 4 dB, 6 dB, or 8 dB) at 100 Hz or 10 kHz, while the fifth button determines whether that amount shall be boost or cut (+ or -). LEDs above these buttons tell the user what degree of boost or cut has been selected, and there is also another button among each group of LEDs which permits you to bypass the tone controls entirely. When this button is depressed, it becomes illuminated as well.

Function selector buttons are located between the master volume knobs and the tone buttons, and include AUX, tuner, MM phono, and MC phono. There is also a mono/stereo switch in this area of the panel, a subsonic filter button, two tape monitor buttons, and a pair of tape dubbing switches. The power *On/Off* switch is at the lower left of the panel, as in the case of the tuner.

Somehow, the designers managed to incorporate all the needed input and output jacks on the rear panel of the M-PO1, and still had room for three convenience a.c. outlets (two switched, one unswitched) and a turntable ground terminal, which is located adjacent to the phono input jacks. There are no input level controls for any of the preamp inputs (there would hardly be any room for them in any case), but this poses no real problem if a user assembles all three Mitsubishi components, since the tuner is equipped with an output level control which can be set so that equal loudness is obtained when switching from radio to phono.

Preamp Performance Measurements

RIAA equalization for both the MC and the MM phono circuits was so close to perfect from 20 Hz to 20 kHz that we could not even assign a "plus or minus dB" tolerance to this measurement. Suffice it to say that our own inverse RIAA signal generation equipment is accurate to within 0.05 dB, and as we switched from frequency to frequency, the output meter needle just remained stationary. Response via the high level inputs was flat within 1.0 dB from 4 Hz to 47 kHz. The subsonic filter, operative in all program modes, had a -3 dB cutoff point of 17 Hz and a slope of 6 dB per octave. Input sensitivity (based upon the new IHF standards) measured 1.22 mV for the MM inputs (for 0.5 volts out), 0.07 mV for the MC phono inputs, and 75 mV for the high level inputs. S/N for the MM inputs (referred to 5 mV input, 0.5 volts output) measured 76 dB, "A" weighted, while for the MC inputs it measured 66 dB (referred to 0.5 mV in and 0.5 volts out). Phono overload was extremely high, 300 mV via the MM inputs, 12.2 mV via the MC inputs.

Harmonic distortion via all the inputs was virtually unmeasurable, with readings of around 0.0025 percent obtained for the high level inputs and approximately 0.003 percent for the phono inputs at any frequency from 20 Hz to 20 kHz, for a 1.0 volt (rated) output. THD was almost impossible to determine with any degree of accuracy for the MC inputs because it was well below the noise floor, indicating a distortion level of well below 0.01 percent from input to main output.

The very precise action of the bass and treble controls (or, rather, the bass and treble multiple push buttons) is depicted in its entirety in the multiple-sweep spectrum analyzer photo of Fig. 5. The nice thing about this arrangement is its absolutely perfect resettability, though of course, rotary controls having step-detent positions can also be easily reset to preferred amounts of boost or cut.

The Power Amplifier

The Model M-AO1 is, as you might expect, the largest and heaviest of the three components which make up this Mitsubishi system, though it is small and light compared with most standard amplifiers having similar power-output ratings. The upper half of the amp's front panel matches the other components in appearance, with the lower half of the taller com-

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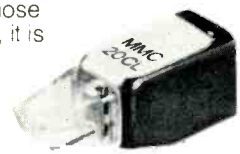
If you've spent a fair amount of time and money on your audio system, it's likely your turntable is ready for the new MMC 20CL cartridge. You do need a tonearm which can track successfully at one gram, one that has its own resonance well damped, and one which features minimal horizontal and vertical friction. Many of today's higher quality units meet these criteria; more likely than not so does the one you own.

THE MMC 20CL, A REFRESHING PERSPECTIVE IN CARTRIDGE DESIGN.

Critical acclaim has identified the MMC 20CL as an exceptional cartridge. It is. It will not only give you more music from your records, but will insure those records last significantly longer. However, it is not one of those 'astounding breakthroughs' that always seem to be hovering around cartridge design and its promotion. No, while the 20CL does incorporate new thinking, new materials, and new manufacturing methods, it should be reasonably viewed just as it is: simply one step closer to the theoretical ideal. When we introduced the first stereo cartridge to Europe over 20 years ago, we knew that someday we would have the 20CL. Our approach to cartridge engineering tells us that 20 years from now we will have something significantly better.



SINGLE CRYSTAL SAPPHIRE, BECAUSE THE CANTILEVER IS CRITICAL.

Unlike aluminum and beryllium, single crystal sapphire transfers the motion of the stylus tip without adding any measurable vibration, and hence distortion, of its own. The absence of this vibration and flexure in the cantilever means the undulations in the record groove are transferred exactly and generate an exceptionally accurate electrical signal. Music is no longer lost between the stylus tip and the armature. Your records open up and music unfolds with new clarity, definition, and spaciousness.

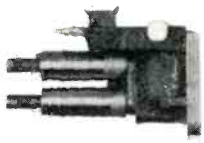
Give your turntable what it deserves. The MMC 20CL with our new universal connector can be mounted directly on most high quality tonearms.

REDUCING EFFECTIVE TIP MASS, BANG & OLUFSEN'S ENGINEERING TRADITION.

As early as 1958, our research demonstrated that effective tip mass (ETM) was the single most determining factor behind record wear and the loss of high frequency sound information. While some manufacturers are now beginning to realize the importance of this specification, only Bang & Olufsen can look back upon a continuous chain of improvements in this critical area. Today, the MMC 20CL with its Contact Line, nude diamond, ultra-rigid sapphire cantilever, and the patented Moving Micro Cross armature features an ETM value of only 0.3mg.

LOW INDUCTANCE, OUTPUT REMAINS CONSTANT REGARDLESS OF LOAD.

As you know, low inductance in a cartridge is related directly to the strength and constancy of the electrical signal fed to your preamplifier input. What you may not know is that the MMC 20CL has an inductance among the lowest of all high quality cartridges available today. This is due to a design which incorporates an exceptionally powerful permanent magnet and coil cores of very low permeability. This design results in very low cartridge induced noise. Subsequently you receive an excellent signal-to-noise ratio without being required to use auxiliary equipment.



INDIVIDUALLY CALIBRATED.

When you manufacture very high quality cartridges, each unit must be tested—not one out of two, or ten, or twenty, but each one. This is why when you purchase the MMC 20CL, you will receive the test results for your individual cartridge. These results include: output voltage, channel balance, channel separation, tracking ability, and a frequency response graph for each channel.

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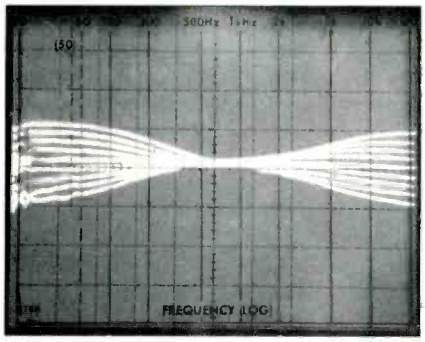
Fig. 5 — Bass and treble control range, M-PO1, preamplifier.



ponent devoted to heat-sink ribs which keep the amplifier running reasonably cool. A power switch at the upper left turns the unit on, and below it is an indicator light to show that power is applied. Two banks of LED power-output indicators are spread across the upper section of the panel and are basically calibrated to read from 0.025 to 100 watts (referred to an 8-ohm load). One of the three remaining push buttons at the upper right changes sensitivity of these displays to read from 0.0025 to 10 watts so that the display remains useful when listening at low to moderate loudness levels. The two remaining buttons are for speaker selection, and while both may be depressed simultaneously, the combined speaker impedance under those circumstances should not be less than 4 ohms. A stereo headphone jack is located just under the upper half of the front panel, nestled in the rib-like heat-sink structure referred to earlier.

The rear panel of the M-AO1 has the usual pair of input jacks and eight color-coded speaker terminals for easy connection of the speaker cable ends. There are no convenience a.c. outlets on the power amp since the user would typically connect its power cord via one of the receptacles on the preamplifier for common turn on or turn off of the entire three-piece system.

Amp Performance Measurements

The amplifier produced 81 watts of power at mid-frequencies into an 8-ohm load before reaching its rated THD of 0.01 percent. While there was ample power reserve at 20 Hz (76 watts per channel for 0.01 percent THD), the amp delivered its exact rated power of 70 watts per channel at 20 kHz for 0.01 percent THD with no margin. The unit's rated power of 70 watts went all the way down to 12 Hz (as compared with the 15-Hz lower power-band limit stated in the specs). At rated output (70 watts), with a 1-kHz test signal, THD measured a mere 0.0025 percent and SMPTE-IM distortion was even lower, with readings of 0.002 percent. CCIF distortion (the 1-kHz "difference" tone produced when two high-frequency signals are fed to the amp simultaneously) measured 0.3 percent at rated output, while IHF IM (the geometric sum of *all* IM components produced during the two-tone test) was nearly as low, with a reading of 0.31 percent. Figure 6 includes graphic plots of THD and IM distortion versus power output for 8-ohm loads (with a 1-kHz test signal), as well as a graph of THD versus power output for 4-ohm loads where rated distortion (0.02 percent) was reached with an output level of 106 watts, well above the 85 watts claimed. Figure 7 shows plots of THD versus frequency for rated output power levels (70 watts for 8-ohm loads, 85 watts for 4-ohm loads). At all but the frequency extremes, THD was so low as to be largely influenced by the residual distortion present in our test signal (under 0.002 percent).

In trying to measure IHF dynamic headroom, we found that the required test signal (a tone burst of 20 cycles worth of 1-kHz signal followed by the same frequency diminished in amplitude by 20 dB) caused the amplifier to shut down as we tried to increase burst level to the observed clipping point. This is the first time that this has happened with any power amplifier we have measured since the dynamic headroom measurement was defined in the new IHF standards. Apparently, the designers of this small amplifier must have been concerned about its size and thermal condition, although we must say that during subsequent listening tests (conducted at levels up to and exceeding the clipping point) we experienced no such shut-down. We cannot, however, report the dynamic headroom figure under the circumstances.

Slew rate, measured visually on our 'scope using a 20-kHz step function, turned out to be exactly 30 volts per microsecond, as claimed. Signal-to-noise ratio, referred to 1-watt output, measured 90 dB ("A" weighted). Translated to rated output (the reference used by Mitsubishi) that would be just over 108 dB. Input sensitivity for rated output was exactly 1.0 volt, as claimed. The high output capability (18 volts) of the M-PO1 preamp, with which this amp is likely to be used, means that there should be no problem whatever in terms of driving compatibility between the two components.

Use and Listening Tests

After completing the measurements on the individual components, we arranged them on a shelf in accordance with the array suggested by Mitsubishi and hooked the amp outputs up to a pair of medium-efficiency, floor-standing, vented-design speaker systems of which we are particularly fond.

We found the tuner section easy to tune accurately and totally free of significant drift even after hours of use. It was reasonably sensitive when hooked up to our outdoor antenna. There was no difficulty with adjacent channel or co-channel interference, even in our relatively crowded signal area. (Our measured selectivity was 73 dB as against a claimed 70 dB; a good choice for a tuner which does not feature selectable narrow/wide i.f. bandwidth.)

Continued on p. 109

Fig. 6—Power output vs. distortion, M-AO1 amplifier.

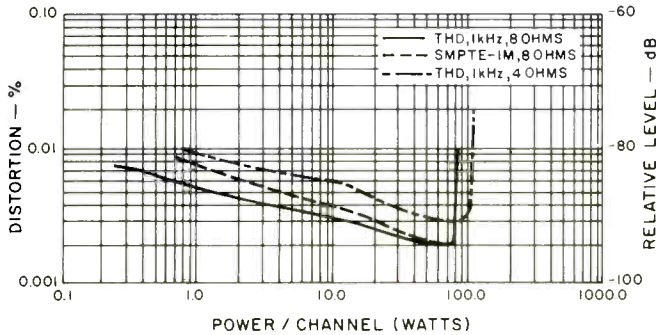
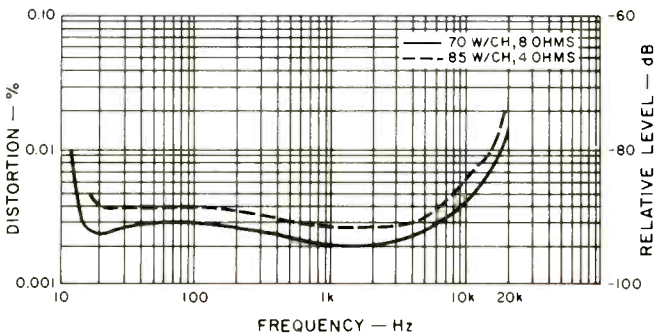
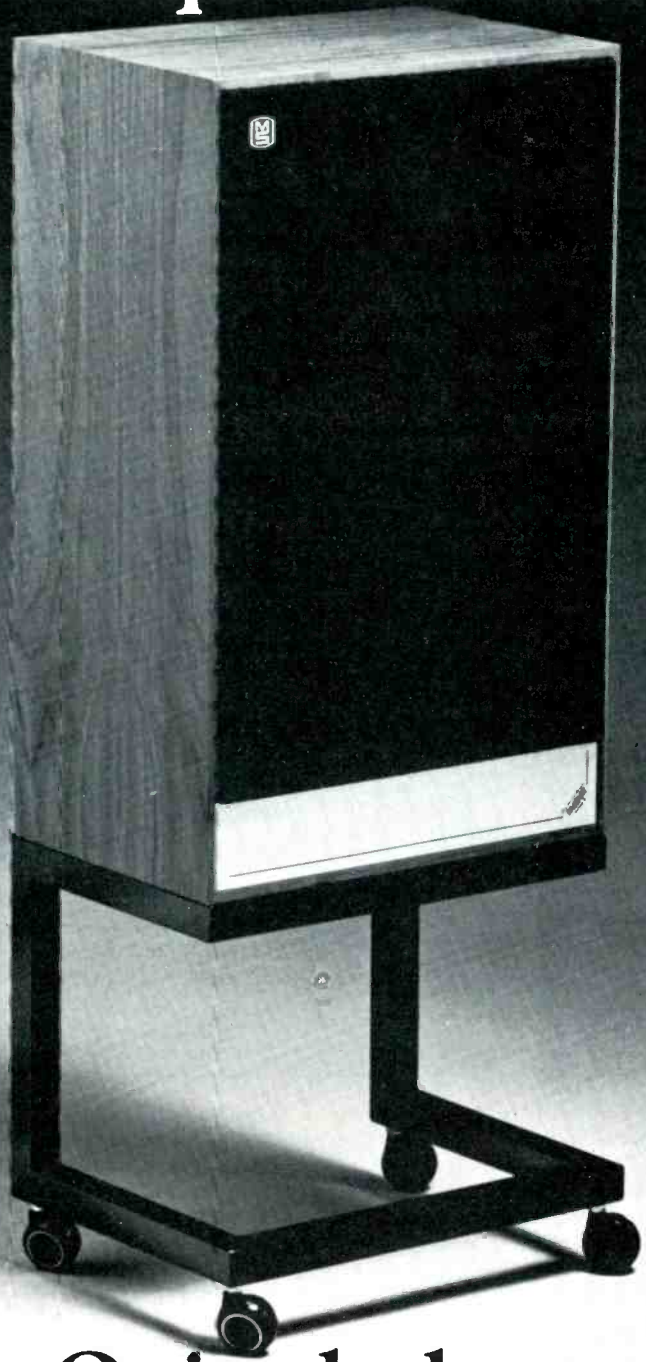


Fig. 7 — Distortion vs. frequency at rated output, M-AO1 amplifier.



Not quite the best known name?



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Pioneer Model PL-630 Automatic Turntable

Manufacturer's Specifications

Type: Two speed.
Motor Type: Quartz-reference, phase-locked loop, Hall effect, d.c. direct drive.
Wow and Flutter: Less than 0.025 percent W rms.
Rumble: -75 dB DIN "B."
Speed Accuracy: ±0.002 percent.
Speed Adjustment Range: ±6 percent.
Tracking Force Range: 0-3 g.
Arm: Static-balance, S-shaped type.
Usable Cartridge Weight: 4 to 12.5 g.
Arm Height Range: ±3 mm.
Dimensions: 18½ in. (46.9 cm) W x 16½ in. (41.9 cm) D x 5¾ in. (14.6 cm) H.
Price: $449.00.

Once upon a time, when there were no automatic features in turntables, we used to put a record on the turntable platter, carefully place the phono cartridge stylus in the groove, and then, at the end of play, lift the arm and return it to its rest — all by hand! Well, of course, we often still play our records like that, but in this computerized age it would be a little archaic to work out a complex equation with reams of paper and a pencil instead of using a calculator. In some areas, obviously, automation is quite necessary. One most crucial area is with the modern high-compliance cartridge, which is quite fragile and can be easily damaged by the ham-handed. Here a cue-lift device is really a "must."

The new Pioneer PL-630 turntable takes automation a lot further: There are push buttons for three different record sizes (when was the last time you saw a 10-in. record?) and for *Repeat* and *Stop* functions, as well as the speed selection. Even the cue lift is actuated by a feather-touch button! No wonder this unit is described as a "fully automatic turntable!" Naturally, it has a quartz-controlled direct-drive motor, but here's a surprise: Instead of a digital readout, speed is displayed on a 2½-in. meter which is calibrated from -6 to +6 percent.

All the controls are located right on the front panel where they are accessible when the dustcover is closed. From left to right they are as follows: Number one is the *On-Off* button and number two is the *Auto-Manual* switch. Then comes a group of four push buttons: Three relate to the record sizes and the fourth is the *Repeat* button. Next to that is a large *Stop* button and a two-position switch for speed selection (yes, it *is* a push button). The aforementioned pitch meter is

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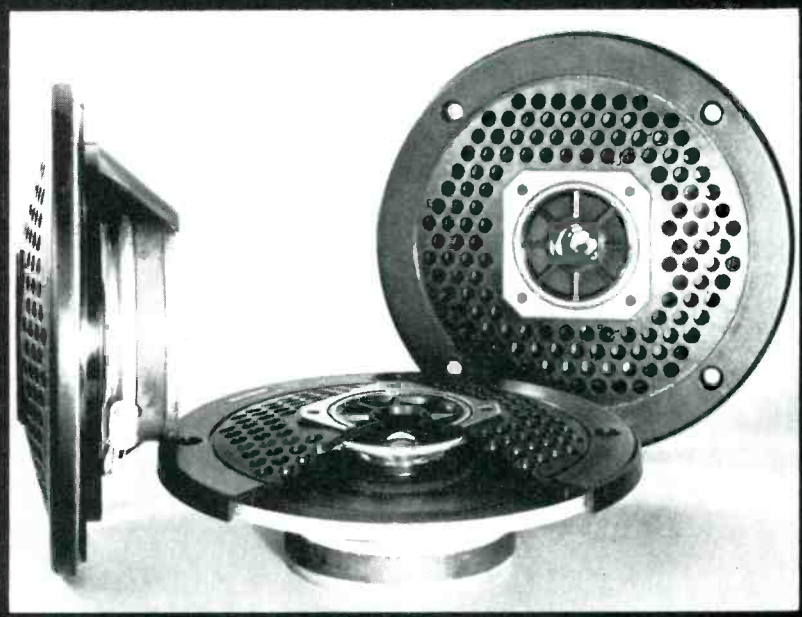

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To get a quality crisp and coherent full range of sound from a superthin speaker Sound Barrier custom designed and engineered the Falcon 20 to be a true coaxial speaker. Utilizing specially developed custom cone paper for both the 4" air suspended woofer and 1⅞" cone tweeter the bridgeless construction of the Falcon 20 generates an unobstructed and unheard of new level of high quality full range performance.

The Falcon 20's 20 watts of power will electrify your ears bolting you into an unbelievable new dimension of full sound from a superthin speaker.

The Gift: Sound Barrier's YF-16 Auto-reverse and YF-17 auto eject stereo cassette players with a built-in 5 band graphic equalizer and 50 watt AMP will amaze you that miniatorization (5⅞"x 2"x6¼") like this launches you into the unknown dimension of minuscule distortion.

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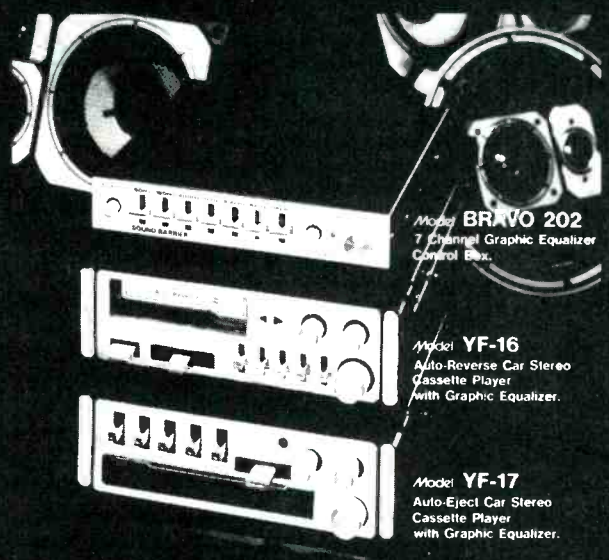

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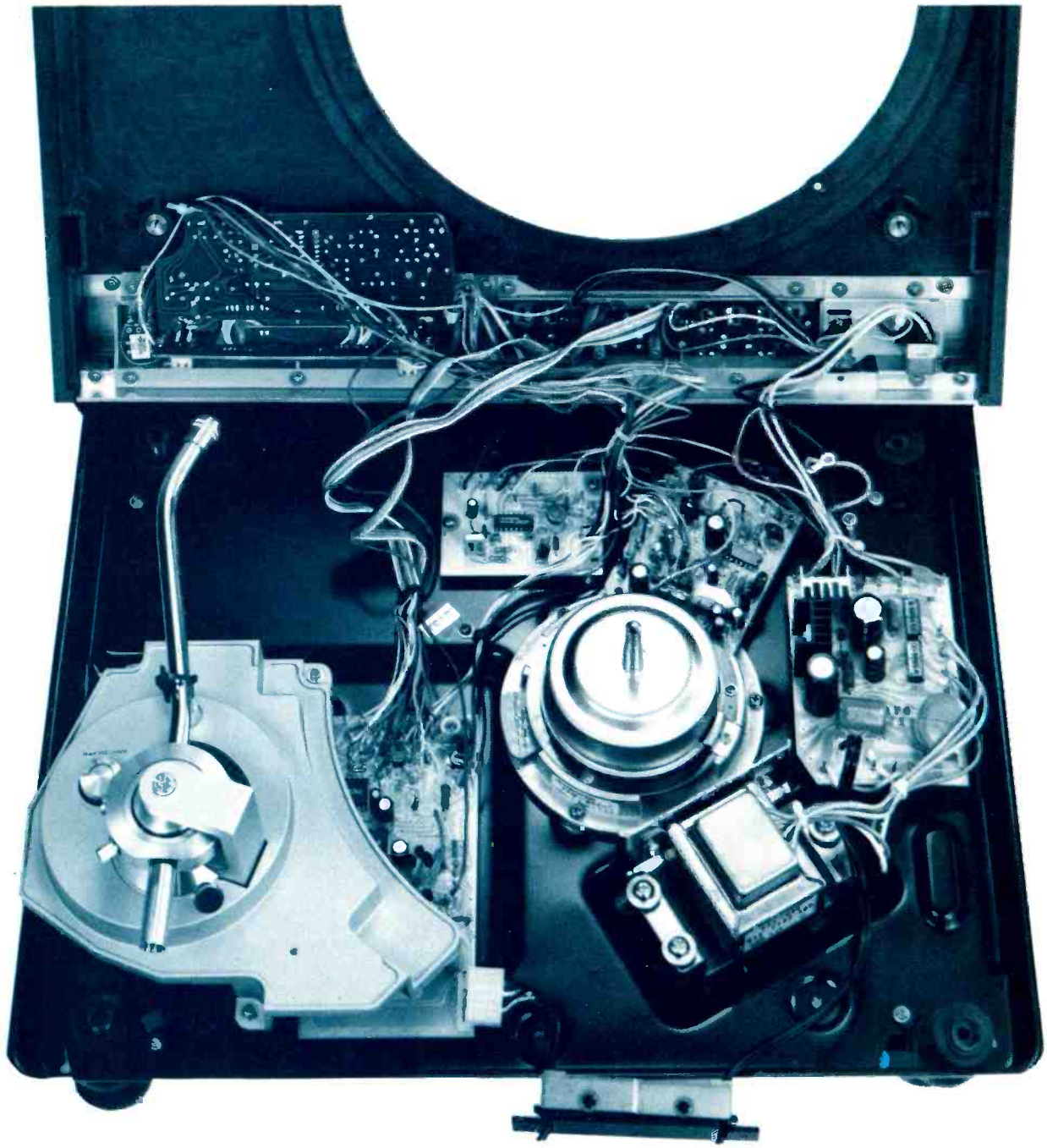

next and, at the extreme right, there is a button to switch off the quartz lock mechanism and a variable speed control. The front panel and motor top plate are of satin-finished aluminum which makes a pleasing contrast to the pair of dark gray end-pieces.

The arm is a conventional S-shaped design made of highly polished aluminum and measuring just over 9½ in. from pivot to stylus. Bearings are spring-mounted gimbal types, and the headshell is made of lightweight magnesium. The arm base rests on a heavy aluminum die-casting which is mounted on the base board, together with the motor, and isolated from the top panel by a spring suspension system. An anti-skating dial is located near the arm base and, like the rear counterweight, it is calibrated from 0 to 2.5 g. The platter is made of die-cast aluminum with a polished bevel edge and weighs about 4 lbs., while the motor itself is a Hall-effect type, servo-controlled by a quartz-locked frequency generator.

Measurements

For test purposes, an Empire EDR.9 phono cartridge was mounted in the headshell, and tracking force was set to 1.5 g with the anti-skating dial turned to a similar figure. The first test was for wow and flutter, and the combined figure measured 0.03 percent, using the DIN 45 507 weighting method. Rumble was a low 63.5 dB (ARLL rating). Arm resonance with the Empire cartridge came out at 8.5 Hz, with a rise of only 2.5 dB. Tracking error was measured using the new db Systems protractor and, as expected, it was within 0.4 degrees per inch. Bearing friction is not quoted in the specifications, but it was completely insignificant in both vertical and horizontal modes. Calibration of the tracking force weight was

Continued on p. 109

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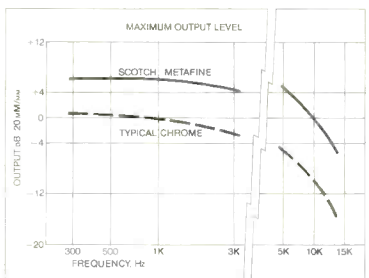

times greater than chrome at low frequencies. Three times greater at high frequencies, a 10dB improvement over today's standard chrome tapes.

When you're dealing with a tape that has this kind of magnetic density and output potential, ordinary decks can't handle it. To record, you need a head that

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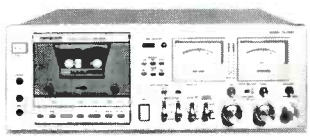

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DB Systems Model DB-6 Stereo Power Amplifier

Manufacturer's Specifications

Power Output: 40 watt continuous per channel, 8-ohm loads, 20 Hz to 20 kHz, with no more than 0.003 percent THD (60 watts, 4 ohms, 0.008 percent THD).

SMPTE IM Distortion: Less than 0.002 percent.

TIM Distortion: Less than 0.04 percent.

Frequency Response: 20 Hz to 40 kHz, +0, -1.0 dB.

Input Sensitivity: 1.0 volt for rated output.

S/N Ratio: -113 dB re: full output, "A" weighted; -96 dB re: 1 watt output, "A" weighted.

Slew Rate: Greater than 15 V/ μS.

Damping Factor: Greater than 400 from 20 Hz to 1 kHz; greater than 40 at 20 kHz.

Output D.c. Offset: Less than 5.0 mV.

Power Requirements: 120 V, 50/60 Hz, 52 watts; no signal applied.

Dimensions: 16 in. (40.65 cm) W x 12.8 in. (32.50 cm) H x 4.9 in. (12.45 cm) D.

Weight: 18 lbs. (8.18 kg).

Price: $495.00.

DB Systems calls their Model DB-6 a "precision amplifier," and it certainly is that. Of course, the level of performance and reproduction of which the DB-6 is capable does not come cheaply, so if you are an audio fan who judges amplifiers on a simple dollars-per-watt basis, you will probably wind up looking elsewhere. On the other hand, if you are using inefficient or even moderately inefficient speakers in a home environment, you will be extremely surprised at how much good sound this amplifier will deliver; further, even if driven into clipping, it recovers beautifully, not degrading sound in such a situation anywhere near as much as substantially higher power-rated amps are likely to do.

The amplifier physically appears quite conventional, with only a toggle *On/Off* switch, a power indicator light, and a pair of clipping indicator LEDs (one for each channel) mounted on the front panel. Heat-sink fins spaced across the rest of the front panel give the unit a rugged and professional look.

In addition to the usual speaker output terminals and input jacks, the rear of the amplifier shows only the line cord and the projecting rear end of the massive power transformer, mounted with its longest dimension in a horizontal plane to keep the height of the amplifier down. Three fuses are located within the chassis, and access to them is gained by removing the four screws which keep the metal cover-wrap in place. One of these is a slow-blow line fuse, while the other two are speaker protection fuses. If either of the speaker fuses blows, the appropriate peak indicator on the front panel remains lit. DB Systems supplies 5-ampere speaker fuses, but recommends substitution of lower values if speakers used with the amplifier have lower recommended fuse values.

Circuit Description

A complete schematic diagram of the signal section of the DB-6 is shown in Fig. 1. C109 and C110 form a high-pass filter which is bootstrapped around the input stage, and D120 through D133 protect the input against damage from overly high input-signal levels. R140 is the only adjustment control in the entire amplifier and is used to set the d.c. offset to within 5 millivolts. Q103 and Q106 form a bootstrapped cascode combination with the input stage. Q107 and Q108 are a current mirror load on the previous stage. Q109 through Q113 are cascode-connected voltage-gain stages. The output is a triple Darlington with three parallel-output power devices for a large safe operating area. The emitter resistors (R119 through R132) are non-inductive carbon-composition types to eliminate possible ringing and phase shift within the amplifier.

Not shown is a safe operating area protection circuit which also senses clipping and clamps internal stages to prevent "latch-up" yet allows fast recovery. The circuit also drives the peak-indicating LEDs and incorporates turn-on, turn-off transient suppression which is accomplished without the use of relays.

The power supply (not shown) is fairly conventional, with ferrite bead and capacitor filtering as well as double electrostatic shields to reduce line-carried r.f. interference. The output of the amplifiers is bypassed with 0.005- and 0.22- μF capacitors to reduce r.f. interference carried in by speaker cables.

Laboratory Measurements

The residual noise and distortion of our signal source prevented us from coming up with any meaningful steady-state

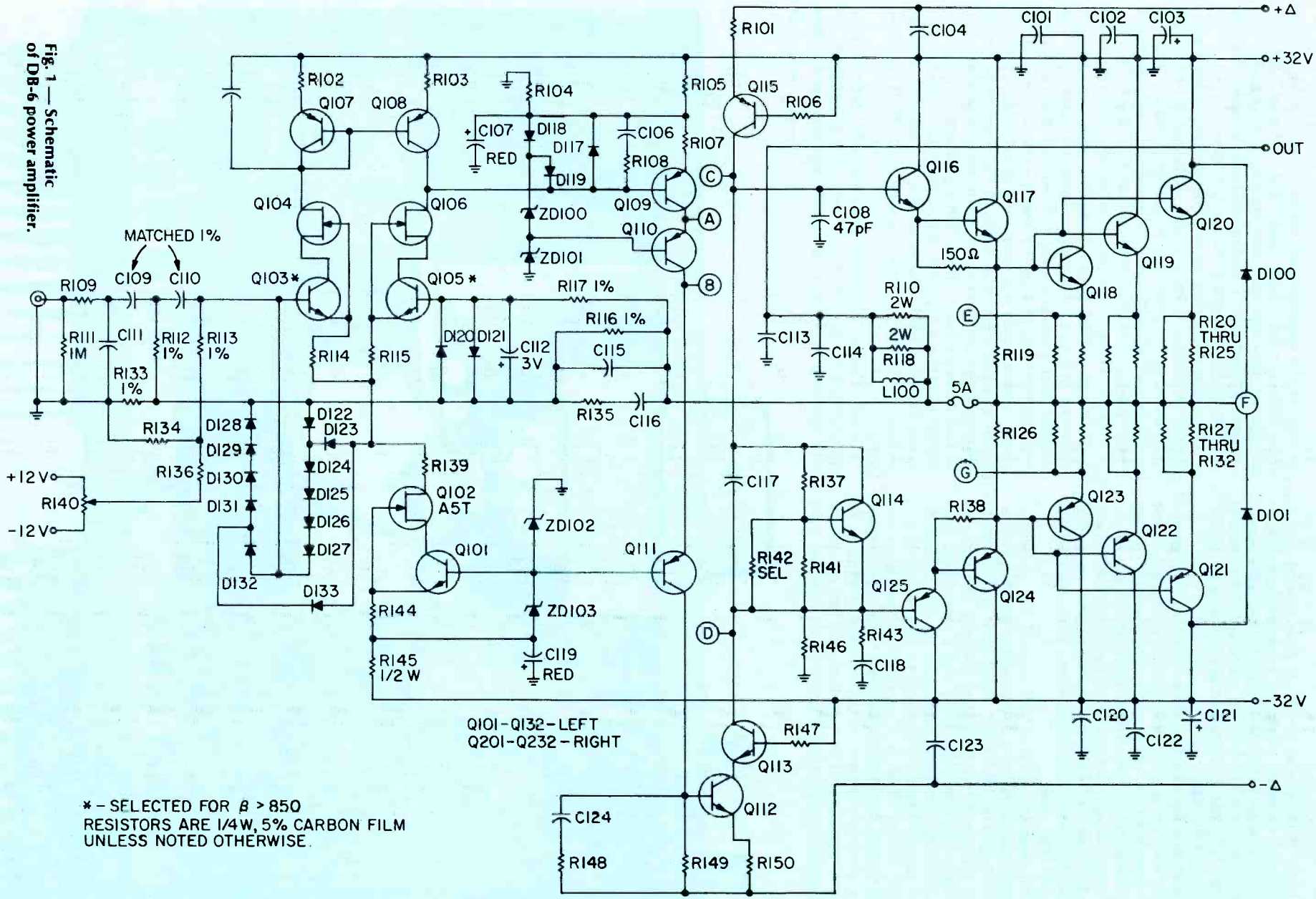

Fig. 1 — Schematic of DB-6 power amplifier.

measurements at low power levels. At rated output (for 8-ohm loads), the amplifier produced a harmonic distortion level of 0.0055 percent, while SMPTE-IM for the same output level measured only 0.0025 percent. At 50 watts per channel output, both THD and IM increased to 0.04 percent, just below the onset of clipping.

We suspect that the slew rate of this amplifier is far greater than the 15 volts per microsecond specified, simply because when we attempted to measure IHF Slew *Factor* (the high ultrasonic frequency at which THD increases to 1.0 percent for rated input voltage), we ran out of frequencies at 100 kHz — a slew factor of 5 (100 kHz divided by 20 kHz, the uppermost audio frequency) and still weren't even approaching the 1 percent THD point.

Frequency response, for a -1.0 dB roll-off, was also better than claimed, extending from 20 Hz (where the built-in subsonic filter begins to take hold) to 50 kHz. For the -3 dB points, we measured 14.5 Hz at the low end (the turnover point of the aforementioned filter) and a surprisingly high 123 kHz at the high-frequency end of the spectrum. The subsonic filter causes infrasonic response to be attenuated by 6 dB at 10 Hz and by 15 dB at 5 Hz. Dynamic headroom was quite high for this amplifier, measuring 2.11 dB. That's equivalent to a short-term power output rating at 8 ohms of 65 watts, which may account for why this amplifier seems able to deliver greater sound levels than would be expected from an amp with its relatively low continuous power rating. Only a few measurements were made with a 4-ohm load, but enough to verify that the same margin of extra power was available (75 watts on a continuous basis as against the 60-watt rating) as in the case of 8-ohm operation.

It should be noted that the amplifier delivered power without any shutdown down to 2-ohm loads and, in the 8-ohm load condition, we were able to parallel a 100 μF capacitor across the load while the amp delivered full rated power at a test frequency of 200 Hz, with no evidence of instability.

As nearly as we could judge, what very slight CCIF IM distortion we could detect using our spectrum analyzer amounted to around 0.04 percent, and the same value was obtained when we measured IHF IM distortion using the two-tone method of IM testing described in previous reports. Figure 2 shows results obtained using 19-kHz and 20-kHz test signals of equal amplitude, while in Fig. 3 we show results obtained when the two test tones are changed to 14 kHz and 15 kHz. (Sweep is linear rather than logarithmic, so frequency notations at the top of the scope face should be ignored. Sweep extended from 0 Hz to 20 kHz, at a rate of 2 kHz per division, horizontally. Vertical sensitivity is 10 dB per division.)

We were unable to measure as high a damping factor as is claimed for this amplifier, simply because our leads from the amp terminals to the test equipment probably contributed

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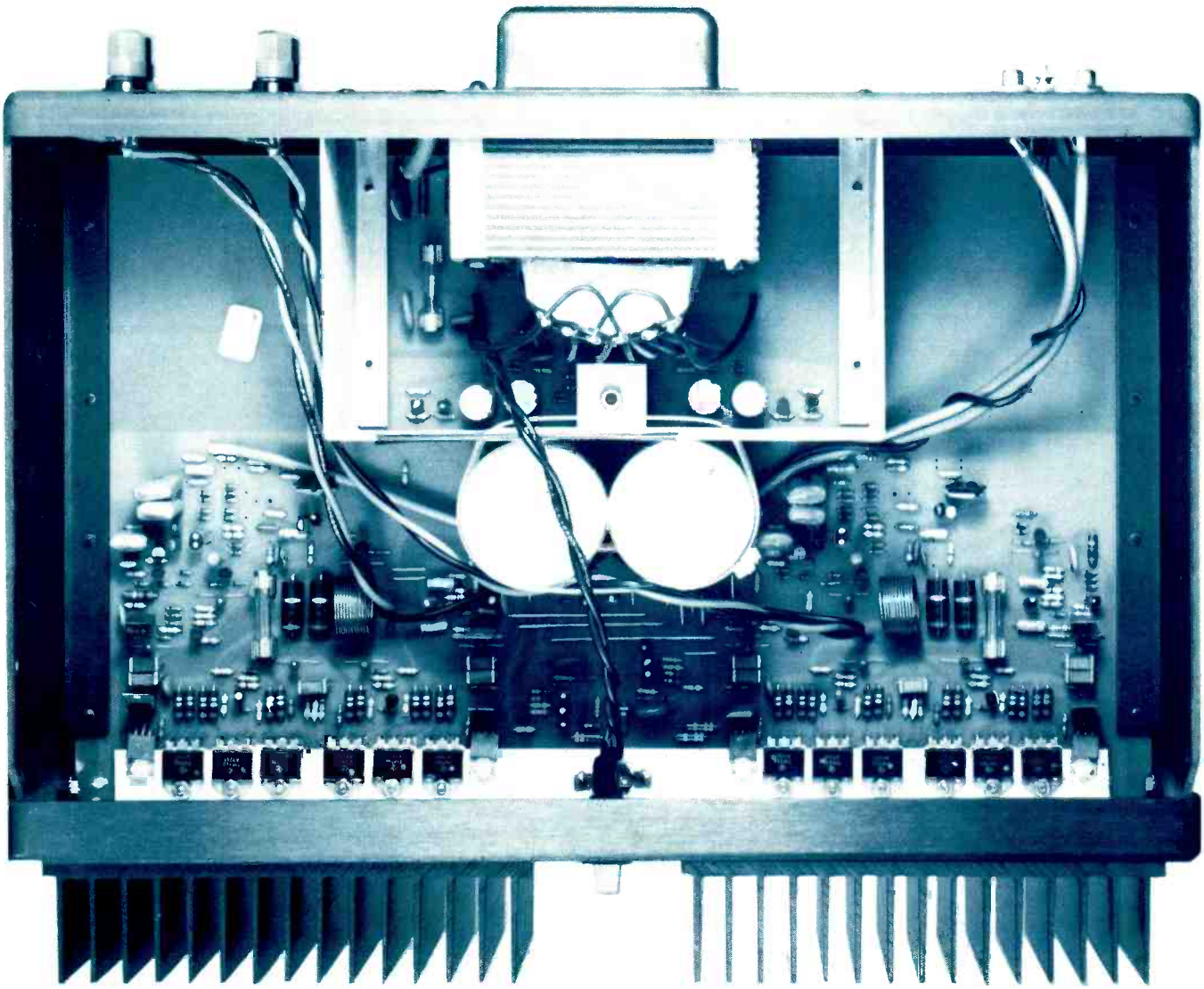

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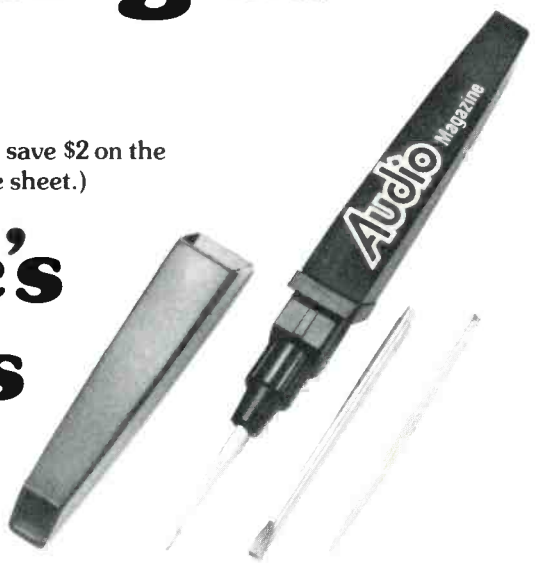

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Sherwood Model S-32CP Stereo FM/AM Tuner

Manufacturer's Specifications

FM Tuner Section

IHF Usable Sensitivity: Mono, 9.84 dBf (1.7 μV).
50-dB Quieting Sensitivity: Mono, 14.17 dBf (2.8 μV); stereo, see note.
S/N at 65 dBf: Mono, 74 dB; stereo, 68 dB.
Capture Ratio: 1.0 dB.
Selectivity: 70 dB.
I.f. Rejection: 60 dB.
Image Rejection: 60 dB.
AM Suppression: 65 dB.
Spurious Rejection: 85 dB.
THD: Mono, 0.1 percent at 100 Hz and 1 kHz, 0.15 percent at 6 kHz; stereo, 0.2 percent at 100 Hz and 1 kHz, 0.25 percent at 6 kHz.
Stereo Separation: 45 dB at 100 Hz, 35 dB at 10 kHz; 1 kHz, see note.
Frequency Response: 20 Hz to 15 kHz, +1.0, -2.0 dB.
Stereo and Muting Threshold: 17.23 dBf (4.0 μV).
Output Voltage: 0 to 1.0 V variable and 600 mV fixed.

AM Tuner Section

IHF Sensitivity: 15 μV.
Selectivity: 25 dB.
Frequency Response: -6 dB at 4 kHz.
Image Rejection: 45 dB.
Spurious Rejection: 40 dB.
Output Voltage: 0 to 300 mV variable, 180 mV fixed; both for 30 percent modulation.

General Specifications

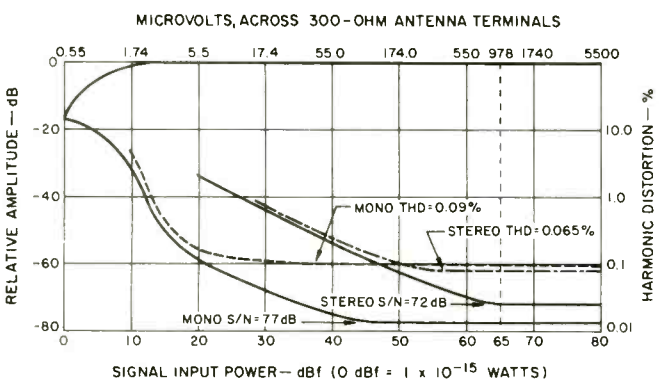
Power Requirements: 120 V, 50/60 Hz, 10 watts.
Dimensions: 17 in. (43.18 cm) W x 5¼ in. (13.35 cm) H x 12¾ in. (32.4 cm) D.
Weight: 14½ lbs. (6.6 kg).
Price: $250.00.

Note: The two specifications called out above are named "Certified Specifications" by Sherwood, and the exact performance of each unit in each area is measured and listed on a "notarized" certificate packed with each unit purchased.

The Sherwood Model S-32CP FM/AM tuner is a low-cost unit with relatively few convenience features or frills, but one that offers exceedingly good fundamental performance for its price. For most FM listeners, it should prove to be a more-than-just-adequate tuner component, especially when you consider the quality level of most of what is currently being broadcast over FM in this country.

The few controls along the lower portion of the front panel of this tuner include a *Power On/Off* lever switch, a rotary *Output Level* control, a program *Selector* switch with settings for mono FM, auto stereo FM, and AM, a large tuning knob coupled to a flywheel dial-pointer arrangement, an MPX "blend" filter lever switch, and an *FM Muting* switch. It is interesting that Sherwood is able to supply *separate* mono/stereo switching and muting switching, while makers of some tuners and receivers costing much more insist upon combining these functions on one switch, thereby limiting the listener to strong-signal stereo reception even if that listener wants to listen to weaker signals in stereo.

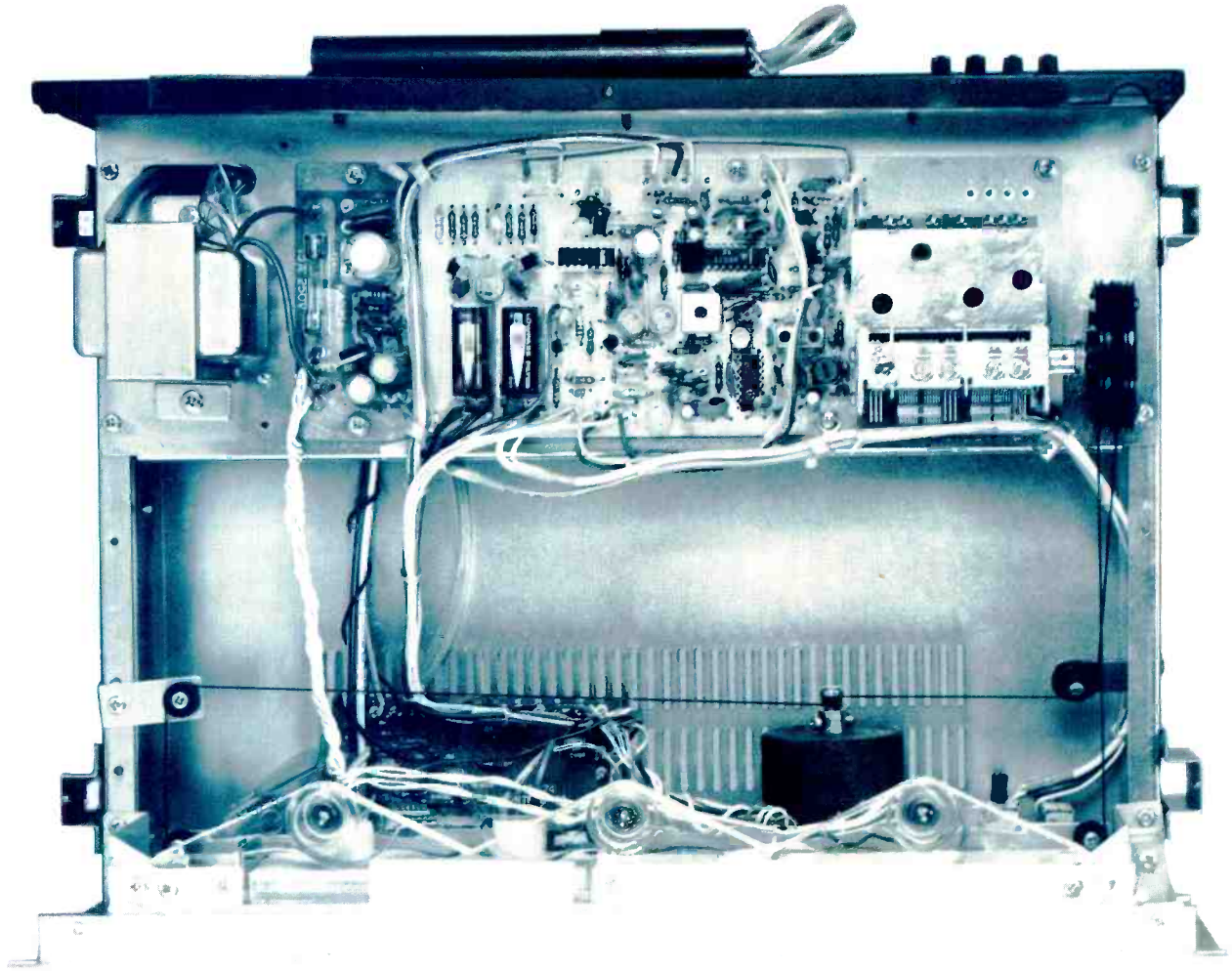
Fig. 1—Mono and stereo quieting and distortion characteristics, FM section, Sherwood S-32CP.



The upper portion of the dial area, at the top of the front panel, contains two meters, one for signal strength indications, the other for center-of-channel tuning on FM. Finding two meters on a tuner in this price category is, in itself, rare, but finding a center-of-channel meter that correlates perfectly with true lowest-distortion tuning across the FM band is even rarer—at any price level. (Such correlation turned out to be excellent in the case of the S-32CP.) To the right of the meters are three indicator lights for stereo FM and AM or FM program indications. Just below are a long, linearly calibrated FM frequency scale with markings at every 200 kHz and a similarly expanded AM frequency scale.

The rear panel of this Sherwood tuner is equipped with two pairs of output jacks—one providing fixed levels, the other controlled by the level control on the front panel. This double output arrangement not only frees up a record-out pair of jacks on any associated preamplifier or integrated amplifier (and with all the new sound processing add-ons available, most of us can use every tape monitor circuit we've got—and more), but permits the user to vary listening levels of AM or FM program sources by means of the front-panel level control without altering recording levels being fed to a connected tape deck.

Screw-type terminals are provided for 75-ohm or 300-ohm FM antenna transmission lines and for an external AM antenna, should one be required. A pivotable AM ferrite-bar antenna is also located on the rear panel. A three-position slide switch is located near the output jacks and has settings for 75-, 50- or 25-microsecond de-emphasis.



FM Performance Measurements

Usable monophonic sensitivity measured 10.3 dBf (1.8 μV), while mono 50-dB quieting was obtained with signal strengths of 14.1 dBf (2.8 μV) as claimed. Stereo sensitivity is one of the specifications which is supplied by Sherwood on a separate "certified performance" sheet, along with stereo separation at 1000 Hz. Unfortunately, there was no such individual sheet in our sample, so we could not verify the "certification." (Editor's Note: The "Certified Performance" sheet was apparently lost in transient; however, results were more than adequate.) In any event, our sample had a measured stereo sensitivity of 17.2 dBf (4.0 μV), governed more by the stereo threshold point than by actual quieting or distortion figures. The 50-dB quieting point was obtained for stereo with input signals of 39 μV (37.0 dBf) as against 34.7 dBf claimed.

Distortion levels were extremely low for a tuner in this price category, measuring a mere 0.09 percent in mono and an even lower 0.065 percent in stereo. Quieting and distortion characteristics as a function of signal strength are shown in the graphs of Fig. 1 (for a 1-kHz modulating signal). Frequency response was down 2.0 dB at 15 kHz, as shown in Fig. 2. Also plotted in the 'scope photo of Fig. 2 are the separation characteristics without the MPX blend circuit (lower trace) and with that circuit activated. We measured 50 dB of separation at 1 kHz, 53 dB at 100 Hz, and 38 dB at 10 kHz without using the blend switch. When the blend switch is used, separation decreases to 16 dB at mid-frequencies and to around 10 dB at 10 kHz. The switch should only be used when listening to stereo FM signals that are otherwise too noisy to enjoy.

Crosstalk components appearing in the unmodulated channel output when a 5-kHz signal is used to modulate the desired channel fully are depicted in the spectrum analyzer photo of Fig. 4. The large signal at the left is the 5-kHz "desired" signal (sweep is linear and at a rate of 5 kHz per division, with vertical sensitivity equal to 10 dB per division), and superimposed upon it is the actual 5-kHz signal detected in the unmodulated channel output. That signal is some 48 dB lower than the desired signal. To the right are distortion components at 10 kHz and 15 kHz, as well as a residual 19-kHz pilot signal component, all of which are approximately 60 or more dB below the reference desired signal level.

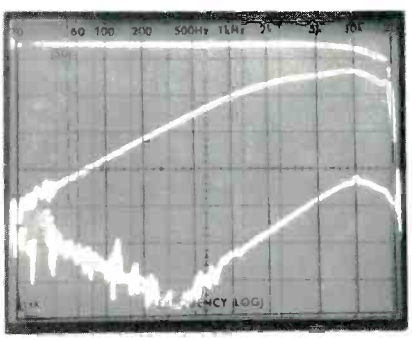


Fig. 2—Frequency response and stereo FM separation.

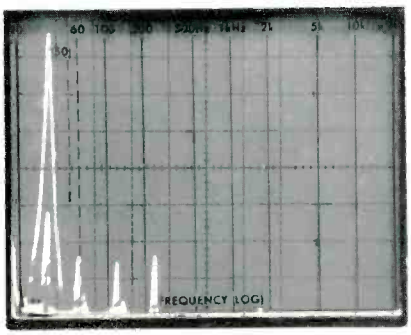
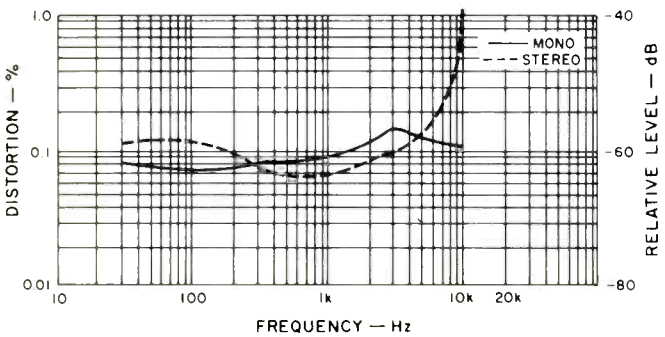


Fig. 3—Crosstalk components for a 5-kHz modulating signal.

Figure 4 is a graph showing distortion versus modulating frequency for both mono and stereo FM reception. THD in mono at the frequency extremes of 100 Hz and 6 kHz measured 0.075 and 0.13 percent, while for stereo, we obtained readings of 0.12 and 0.16 percent. AM suppression measured 63 dB, while capture ratio measured exactly 1.0 dB as claimed. Image, i.f., and spurious rejection were all better than claimed, with readings of 65, 63, and 90 dB respectively. Stereo switching threshold was set at 4.0 μV (17.2 dBf), while muting threshold was set somewhat higher, at 7.0 μV (22.1 dBf).

AM frequency response, depicted in Fig. 5 (here the sweep is logarithmic again, so that frequency notations at the top of the 'scope face do apply), was surprisingly flat within the pass band which extended from around 40 Hz to 4 kHz for the -6 dB end points. While this hardly represents "high fidelity" performance, it is actually somewhat better than what we usually encounter in typical AM tuner circuits for products costing considerably more than this Sherwood tuner.

Fig. 4—Distortion vs. frequency.



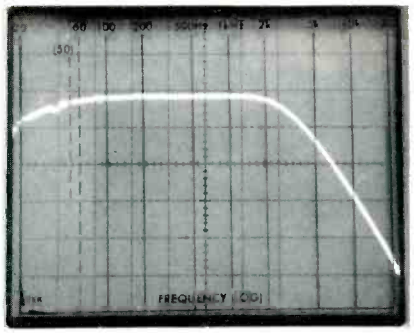


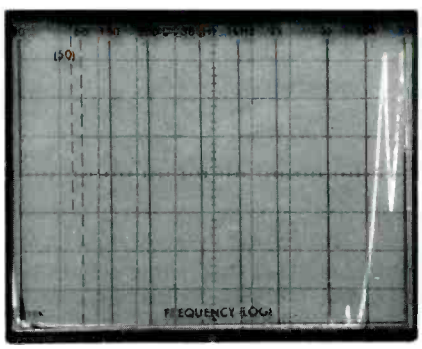
Fig. 5—AM frequency response.

Listening and Use Tests

It is only reasonable that in a tuner of such low cost a few performance areas have to be compromised to some extent. In the case of the S-32CP, such secondary specifications as image, i.f. and spurious rejection are not as high as they are on the most expensive models. However, in most listening situations, such deficiencies seldom cause serious problems. With a good outdoor antenna, properly oriented for best reception and lowest multipath interference, we could not tell any difference between the quality of received mono and stereo FM broadcasts heard on the Sherwood S-32CP and those heard, for comparison purposes, on a tuner costing fully twice as much. With a simple indoor dipole antenna, some differences were noted when the same comparisons were made, with the Sherwood tuner producing a bit more noise on weaker stereo stations. Still, when you consider the fact that a decent outdoor antenna can be had for $25.000 or so (and is not too difficult to install yourself), the money you save on a no-frills tuner such as the S-32CP will represent a very considerable amount. Considering the present state of most FM broadcasting, such apportioning of your hi-fi component budget makes a lot of sense. *Leonard Feldman*

Enter No. 93 on Reader Service Card

Fig. 2 — Twin-tone IM measurement using 19- and 20-kHz signals. (See text for scales.)



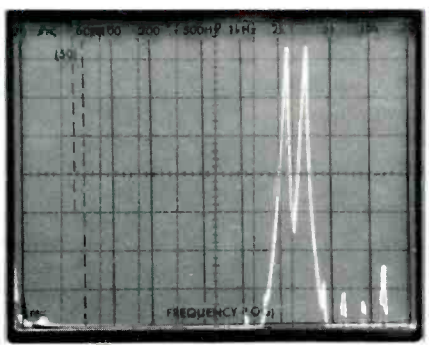


Fig. 3 — Twin-tone IM measurement using 14- and 15-kHz signals. (See text for scales.)

DB Systems *continued from page 104*

more resistance than the entire internal resistance of the amplifier. We wondered, however, whether the 400 figure quoted by DB Systems could possibly be realistic in view of the speaker protection fuses. Then we took another look at the schematic and realized that the speaker protection fuses are not in series with the output signal but are installed in the main negative-feedback loop. Pretty clever, in our view!

Listening and Use Tests

The DB-6 is, first and foremost, an accurate sounding amplifier. Even when deliberately driven into clipping, and severe clipping at that, the sound peaks produced are more reminiscent of what we fondly used to call "tube sound" than they are of most solid-state designs we have auditioned recently. Recovery is, as the makers claim, effortless and almost instantaneous. At ultra-low listening levels there is not even the slightest hint of crossover or notch distortion. In return for this Class A-like sound one has to accept a fair degree of warmth on the heat sinks even when the amplifier is operated in its quiescent mode (with no signal applied) since the people at DB Systems are apparently forward biasing the output stages pretty heavily to avoid any such low-level, higher-order harmonic distortion. Clearly, if high power at low cost is what you are after, you can buy a lot more watts for the price of the DB-6 than are being offered by DB Systems. But if the subtle differences between "brute force" designed amps and amps that offer utterly clean and accurate sound reproduction are what you are after, power output limitations won't stop you from enjoying the sound quality of this finely crafted piece of equipment. Should you feel, as we do, that this is one great sounding amplifier but that you require higher power, you can always turn to DB Systems' strapped, mono version, the DB-6M, which delivers a full 140 watts into 8 ohms at less than 0.008 percent from 20 Hz to 20 kHz or 225 watts into 4 ohms at less than 0.02 percent over the same power band. *Leonard Feldman*

Enter No. 92 on Reader Service Card

Mitsutishi Micros/continued from page 96

The signal-strength LED bank is, in our opinion, superior to the conventional mechanical signal-strength meter arrangement. Frequency calibration was just about perfect from 88 MHz to 108 MHz, and switching from mono to stereo in the auto-FM mode is non-erratic and noise-free. Center-tune lock indications (via that green LED) corresponded well with minimum distortion tuning points both on the test bench and in actual station-monitoring use.

As for the M-PO1 preamp/control unit, we were particularly impressed by the tone control arrangement which, at the touch of a couple of buttons, was able to introduce precise and totally repeatable degrees of tonal adjustment. With these controls set to flat (no buttons depressed), there was no audible difference in sound heard with the controls fully bypassed or in-circuit.

Overall, the MM phono inputs were sufficiently free of hum and noise so that record reproduction was limited only by the surface condition of the records used. Using the moving coil inputs, we were able to detect some audible hum during quiet passages, despite our best efforts to avoid any ground loops or external-field pickup. The accuracy of the RIAA equalization was at once apparent, and on the whole record reproduction was tonally well balanced and free of preamp/equalizer-generated distortions of any kind.

The subsonic filter, though possessing a moderate 6 dB/octave slope, was effective in reducing subsonic rumble effects, as clearly evidenced by an observation of the woofer cones of our reference speaker systems. Audibly, the use of the subsonic filter did wonders for overall clarity and transparency of record reproduction. Since the filter did not in any way degrade musical reproduction (rather, it helped it), Mitsubishi and others might just as well have incorporated the subsonic roll-off as a permanent feature, rather than as a switchable one, in the phono circuit. That might have left room for a high-cut filter which some purchasers of a full-featured preamp do feel is important.

Finally, turning our attention to the M-AO1 amplifier, this unit does deliver an incredible amount of clean power for its small size, and overall system sound quality (which, in the last analysis, is determined as much by this "final" component as by the program signals fed to it) could not be faulted in any way. We did note that under no-load conditions, or with highly reactive loads on the test bench, there is a slight tendency for the amplifier to become unstable. Operated with our reference speakers, however, no such instability resulted during our listening tests, though some electrostatic speakers might present problems to this amplifier. However, we have not verified this, and it does seem an unlikely pairing.

The real question regarding this or any other system composed of micro-components is price versus performance. Clearly, one could assemble a fairly respectable standard-sized receiver having equal power and features for less money. One could, in fact, even put together a pretty good system of standard-sized separates for the same cost. It is equally clear to us that many potential purchasers will find the physical format of these micro-components extremely appealing, and there's no doubt about it, they do look good. Whether these micro-components, or others like them, eventually capture a significant portion of the audio component market remains to be seen. That depends entirely upon the unpredictable tastes of the American consumer, who, in the past, has generally felt that "bigger is better." Of course, the current trend towards smaller cars may well signal an overall reversal of that attitude. And smaller cars, I am told, often are generally more popular than the gas guzzlers these days. Is there an analogy to be drawn here? *Leonard Feldman*

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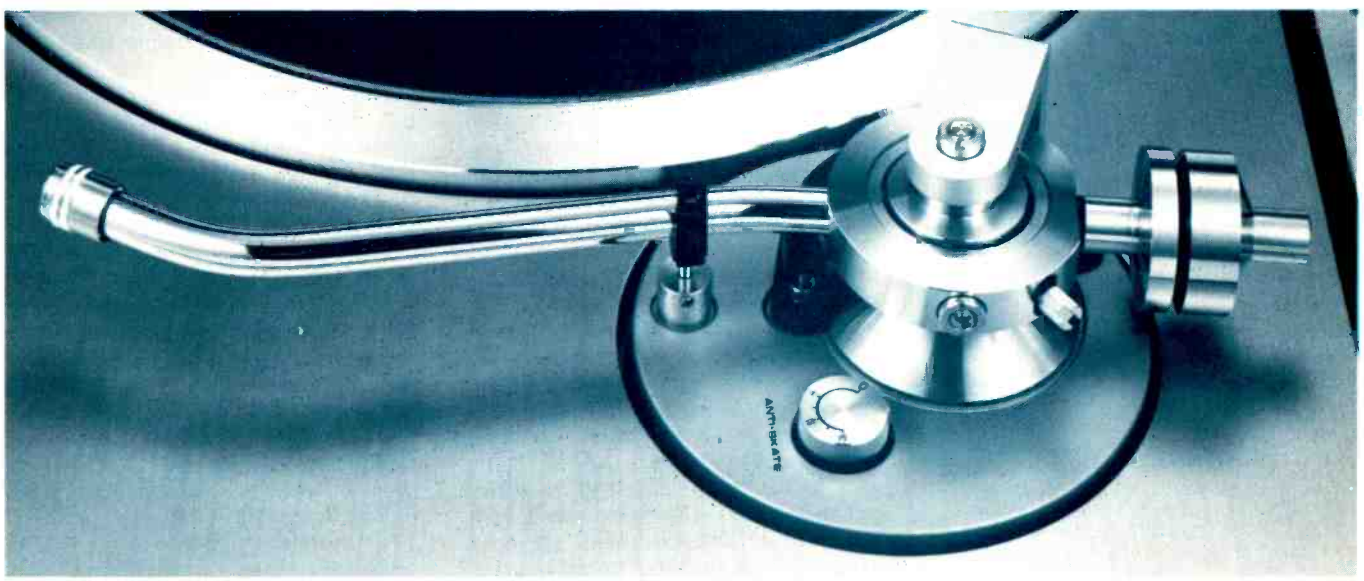


Pioneer/continued from page 100

less than 5 percent low above 1 g. Speed variation was -6.6 to +9.1 percent, which is more than adequate.

Use and Listening Tests

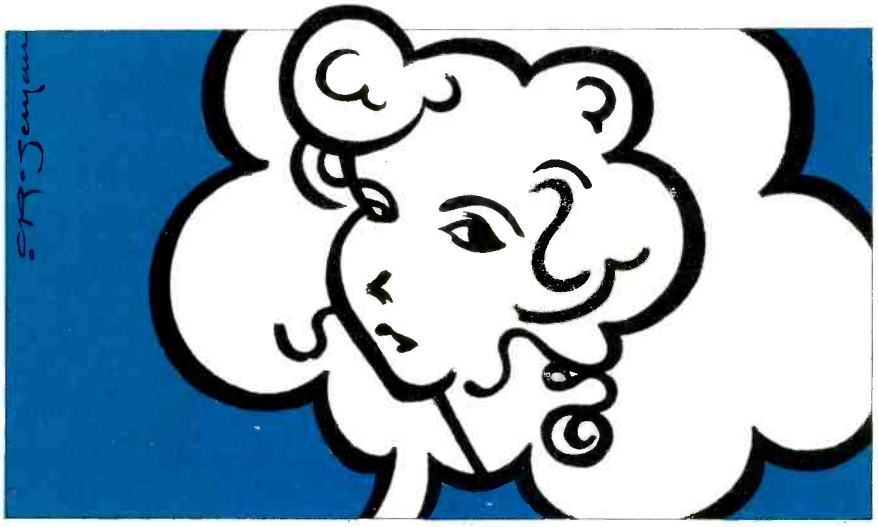
The PL-630 proved to be a real pleasure to use, and those push buttons give a feeling of effortless smoothness with no fuss or bother. The cue lift had an absolute minimum of backlash and appears to be very well damped. The platter reaches full speed in less than one-third of a revolution, and, when the tonearm swings back to its rest, the motor stops almost instantly as a reverse current is applied to it. A small refinement — but it does show that more than ordinary care has been taken in the design. Because of the floating suspension system, the unit is less prone to acoustic feedback than most. Incidentally, closing the dustcover reduces the chances of direct feedback while allowing access to all the controls — including the cue lift.

The Pioneer PL-630 must take its place among the top few really good turntables now available under $600.00. At its price of $449.00, it offers exceptional value. *George W. Tillett*

Enter No. 91 on Reader Service Card

Michael Tearson
Jon Tiven

The column



Eat to the Beat: Blondie
Chrysalis CHE 1225, stereo, $8.98

Funny what a little thing like an international breakaway smash hit will do for a band. If it comes too fast and too sudden, it can lock the band into a permanent adolescense. Like Boston. Less frequently it will give the group fresh poise and confidence to fire their work to a new plateau. Like Blondie.

After the first two singles off **Parallel Lines** flopped, the disco crowd almost by accident discovered *Heart of Glass,* a wonderful song that discoers can take at face value and rockers can take as parody. It rapidly turned into a mega-selling worldwide hit and, more important to the band, finally gave them the big break in America that had previously eluded them.

Anticipating **Eat to the Beat** I became very concerned that the band would wholeheartedly follow the sound of *Heart of Glass* into utter discodom. They didn't. They are still a rock and roll band first and foremost. Yet they have the nerve to tackle various sounds and do them up right. True, there is the nod to the *Heart of Glass* vibe with *Atomic,* but reggae's backbeat surfaces in *Die Young Stay Pretty. Sound-a-Sleep* is a lush ballad *without* strings. *Union City Blue* goes after the Phil Spector wall of sound. Blondie emerges as a mature band with the strength and chops to play whatever they want to achieve their ends.

The star of the band, the focus, is Deborah Harry, as it has been since the band's conception. An important part of their appeal is and has been that the camera adores her. Debbie Harry cannot look bad in a picture without great effort. It is not a question of *if* she will make it in movies, but of *when.* But she is not the whole show. As she stridently states in interviews, Debbie Harry is not Blondie and Blondie is not Debbie Harry. Not by a long shot.

The band grows with each record by quantum leaps. Their playing and performance is ever more assured and supple. Mike Chapman became their producer with **Parallel Lines,** and he is ideal for them. He brings a focus, a clarity, an economy they previously needed badly.

Then there is the matter of material. Well, the songs on **Eat to the Beat** are the best collection Blondie has produced. *Dreaming,* the album's first European hit, is at once a tough rocker built upon a drum beat reminiscent of Buddy Holly's *Peggy Sue* and a dreamy, yearning melody rich with rhyme and terrific lyrics.

Wit from the sardonic to the bizarre dominates their songwriting. *Accidents Never Happen* (in a perfect world) is likely a lefthanded salute/slap to Elvis Costello, an answer, actually more a rebuttal, to his *Accidents Will Happen* (it's only hit and run) from **Armed Forces.** A companion to *Accidents* is the album's other Jimmy Destri song, *Living in the Real World.*

Blondie's time arrived with **Parallel Lines.** It is just that they broke across different lines than long expected which was surprising. Obviously suc-

cess has not fazed them at all, since with **Eat to the Beat** they have hit a real stride. Not just a step or a pace, but a real full stride. *M.T.*

Sound: B+ Performance: A

Mick Taylor
Columbia JC 35076, stereo, $7.98.

Considering that the guy spent six years of his life as a Rolling Stone, Mick Taylor comes off as a pretty unassuming guy on his first solo outing. Encompassing a wide variety of styles and with a fairly high quality of playing throughout, Mick chooses not to rely upon famed guest stars to sell him, but has instead come up with an album that will not disappoint those who enjoyed what he did with The Stones.

They could have called it **The Many Faces of Mick Taylor.** On *Broken Hands* he sticks close to the Chuck Berryisms of late-period Stones (sort of similar to *Hand of Fate* from **Black & Blue,** the first post-Taylor Glimmer Twins outing. *Baby I Want you* and *SW 5* could have been covered by Eric Carmen (or Barry Manilow), *Leather Jacket* is very Phil Rambowesque (perhaps an obscure reference, but the two have jammed upon occasion), and the rest of the album is practically all guitar improvisational tracks. Taylor is a more than able soloist, and here is some of his best work since **Blues from Laurel Canyon,** whether it be the blues mode or jazz-fusion a la Jeff Beck's *Blow By Blow.* Actually, I prefer the cuts on which he sings, as Mick's got a fine voice (I hate to say it, but he sort of resembles a better version of Ronnie Wood). Altogether an LP to be proud of, though it probably won't knock Peaches & Herb off the charts. *J.T.*

Sound: B Performance: A-

Dream Police: Cheap Trick
Epic FE 35773, stereo, $8.98

Cheap Trick's fourth studio album is very interesting, not only because they're a creative bunch of fellas but due to the fact that it was recorded before their chart-topping **Live at Budokan** made them the big stars they are today. As a result, the attitude is still of a group trying desperately to make it, and you best believe that the *next* Cheap Trick album is going to be light years away from this one. But this is Cheap Trick on their knees, appealing to the public to *please* buy their records already, and the result is some fine, although somewhat pedestrian, music.

Oh, there are clinkers — *I Know What I Want* is Tom Petersson's first vocal and he's still pretty shaky, *The House Is Rockin with Domestic Problems* and *Writing on the Wall* seem like your average Cheap Trick tunes with no surprises, and *Gonna Raise Hell* (altough it's amusing) shows exactly how far the group is willing to go to be successful — a *disco* track! What the heck, you can't blame the guys for trying to be "commercial," but it's so obvious in retrospect that it's almost embarrassing.

Enough of the negatives already, there are some lovely tunes here: *Way of the World, I'll be With You Tonight,* and *Voices* the cream of the crop featuring Robin Zander's best John Lennon/Jeff Lynne imitation. Rick Nielsen's guitar playing is admirable but not always inspiring. He's definitely worked up a fine technique and invents some nice riffs, but when it comes to improvising a solo he only manages to deliver something memorable on the slow tunes, which is a shame. However, from time to time he quotes from the books of Jimmy Page (*Think About It*) and The Beatles (*Please Please Me*) just to show he's got enough taste to steal from the right sources.

The sound of **Dream Police** is perhaps the least adventurous thing about it: The mix is mundane, the drums recorded very conservatively, and the whole texture of the sound lacks individuality. It should be very interesting to hear Cheap Trick's next album, the one where they drop all their cares about being popular and just go the aesthetic route. My bet is that you're going to find an album far noisier, much *more* interesting, and far less conventional than **Dream Police.** And it's about time that they were allowed that privilege. *J.T.*

Sound: C+ Performance: B+

Shades of Ian Hunter: The Ballad of Ian Hunter and Mott The Hoople **Columbia C2 36251,** stereo, 2 discs, $9.98.

Forget that it's the bargain of the century, two albums for ten beans — forget that nothing on the album is less than two years old, 'cause this is over 90 minutes of state-of-the-art rock 'n' roll from Ian Hunter. I won't say that everything good he ever did is on these two records, but I can unequivocally state that there's at least three sides of stuff that is absolutely *great* and plenty of tracks that even serious Ian Hunter fans havn't been able to get their hands on. And even though I like his **Schizo** album plenty,

there ain't a track on it that could hold a candle to anything here, and that's no hype, son.

First, you get the hits: The obvious *All the Young Dudes*, a Mick Ralphs tune which mutated into Bad Co.'s *Can't Get Enough* called *One of the Boys*, and various other Mott goodies that I won't dwell on as you should know them by heart. Then the U.K. singles and flip sides (*Saturday Gigs, Foxy Foxy, Where Do You All Come From, R.I.P.*, and *Rose*) and the rather astounding bonus of a live rendition of *Marionette*, a tune from the last Mott album which, in this particular incarnation, easily stands the test of time. Side three is a synopsis of Ian's two American solo albums, of which the first was a gem and the second eminently forgettable aside from the two tracks offered here.

But side four — that's the killer. Because back in 1977 Hunter put together an outfit called The Overnight Angels for one last solo album on CBS. It featured Peter Oxendale (an excellent keyboardist now a solo artist in his own right), Earl Slick (a hard-hitting Ronson clone), and Dennis Elliot (Foreigner's drummer) and was produced by Roy Thomas Baker. This particular record was never rleased in America

for business reasons, but stands as Roy Baker's finest production since **Queen II** — on this he pulled everything out of his bag of tricks to make Hunter's most quirky yet relentless LP ever. Four tracks from this album are found here to delight the listener, as well as a special added attraction: *England Rocks*, a single by the Overnight Angels underproduced by Hunter, but far more interesting than its illegitimate son, *Cleveland Rocks*.

Now, you may have to turn up the volume a little bit higher than usual to groove out to **Shades of Ian Hunter,** as they had to drop the level a tad in order to fit all this great stuff on two albums. Just thank your lucky stars that it's available at all and in one well-conceived package to boot. An excellent gift for both budding punk rockers and old fogies alike, and a list price you can't beat . . who says there is no justice in this world? *J.T.*

Sound: A- Performance: A+

The A's
Arista 4238, stereo, $7.98.

The A's are a charged-up young American group with energy and catchy tunes to beat the band. The opener, *After Last Night*, is a glorious rocker with some dandy smart/stupid lyrics. *Grounded* is another, as is *Teenage Jerk Off. Who's Gonna Save the World?* is in a Roxy Music/Cars space.

It's not all there yet. Some songs are decidedly lightweight, but there is more than enough meat to make **The A's** a very strong debut. The production is nothing special, but it never gets in the way of a good song, and the band's good spirits prevail anyway. Heck, if the *Twist and Shout* strains woven into *Grounded* don't make you smile, you're just not a rock & roller. It's that simple. *M.T.*

Sound: B- Performance: B+

jazz & blues

John Diliberto

Upon Reflection: John Surman
ECM ECM-1-1148, stereo, $8.98

John Surman is the pride of the British jazz community. Though he is one of the few baritone sax virtuosos around, it is as a multi-reed player that he has made his mark. His various horns have been found in collaboration with John McLaughlin, Karl Berger, Mike Westbrook, Terje Rypdal, and Albert Mangelsdorff in efforts that are never less than adventurous. **Upon Reflection** is his second solo outing. Like its predecessor, **Westering Home** (HELP 10), it is an introspective work featuring Surman either solo or multitracking himself. But unlike **Westering Home,** Surman uses synthesizers and a layered overdubbing to make this work texturally interesting and melodically complex.

As a set of tone poems, **Upon Reflection** traverses many moods that have a distinct flavoring of the Renaissance with a few of the songs designed as dances. *Edges of Illusion* is a midnight stomp of trolls and elves in a mist of sequencer patterns, lopping baritone sax bass line, and a plaintive bass clarinet soloing on top. *Prelude and Rustic Dance* accompanies the peasants dancing outside their feudal lord's manor. Not far from the dancers, however, is the ominous dirge of *Beyond a Shadow*. Dark, sustained saxes underpin a tortured lament by Surman on baritone sax while synthesized bells chime eerily from beyond.

Surman has wrought this work with an uncommon care for detail and subtlety. *Caithness to Kerry* is a sweet , happy folksong on which Surman plays unaccompanied soprano sax with notes that bend as they ehco off the hills. From the simplicity of recording a solo sax, he moves to the multilayered *Constellation*. It's a starbound fugue of sequencer counterpoints and slowly evolving bass moans that propel Surman's twisting soprano in a journey of awe and amazement.

Upon Reflection is a quintessential example of the ECM/Manfred Eicher production style. Each instrument is recorded with a clarity and isolation that is unheard of in most recordings. Surman's compositions and Eicher's production fit together in perfectly balanced fashion. John Surman has crafted an album of provoking contemplation.

John Diliberto

Sound: A Performance: A

I Loved You Then . . . : Gayle Moran
Warner Bros. BSK 3339, stereo, $7.98.

One of the peculiarities of the fusion movement has been the affinity of many of its musicians towards different spiritual movements. John McLaughlin comes immediately to mind with his Mahavishnu Orchestra and dedication to Sri Chinmoy. But there are many others, including Charles Lloyd (Transcendental Meditation) and Chick Corea (L. Ron Hubbard and the Church of Scientology). All these musicians have claimed to use music as both a way of inner fulfillment and a communication of spiritual values with their audience. For some, like The Mahavishnu Orchestra, this communication took the form of scorching and breathtaking music that aspired for the heavens. For others, it runs along the lines of placid contentment and fatuous self-satisfaction. Gayle Moran falls into the latter category.

Like Chick Corea, with whom she has been singing and playing keyboards for the last three years, Gayle Moran follows the teachings of L. Ron Hubbard and the Church of Scientology. Her lyrics are rife with allusions to the inner happiness she has derived

from Hubbard, such as "You can play with the outside but the inside is here to stay" from *Outside/Inside*. Moran's mellifluous soprano is wrapped around her childlike keyboard filigree and bathed in a glycerine of strings and vocal choirs. Nostalgia and wistfulness eventually drown through lack of tension and dynamics.

I Loved You Then . . . has all the earmarks of a Chick Corea production. Moran's simple melodies are set in a satin background and surrounded by cute, cliched counterpoints and punctuations from such stalwarts as Stanley Clarke. Victor Feldman, and Corea himself. For those who seek a soft and soothing sound that won't interrupt your self-contemplation, your spiritual muzak is here.

John Diliberto

Sound: B+ Performance: C

Wishes: Kochi
Inner City IC 6021, stereo, $7.98.

Kochi is actually a one-shot deal with Japanese keyboard player Masabumi Kikuchi fronting an American group composed of Miles Davis personnel from the mid-'70s. Steve Grossman and Dave Liebman handle the reeds, with Reggie Lucas on guitar and a rhythm section of Anthony Jackson on bass, Al Foster on drums, and M'tume on congas. The group is finally rounded out by fellow countryman Terumasa Hino on trumpet. Though it is Kikuchi's show, it is Hino who grabs all the light.

The opening track of **Wishes,** Auroral Flare, seems to promise an ambitious East-West fushion. But the result is only a temporary graft. After an intro featuring some primitive Biwa (a stringed instrument) over a keyboard drone and shakuhachi-like flute, the group comes in for a strong rhythmic vamp with everyone noodling around while someone takes a solo up front. This format can work when the leader is a Miles Davis or the group is made up of intuitive geniuses like early Weather Report. But here things frequently founder with no direction. Kikuchi's keyboard style consists of textural shading, punctuation, and filling in cracks — but he never really takes command with anything more than some high-volume organ chords similar to Miles Davis' work on that instrument.

Terumasa Hino does step out, however, and when he solos the rhythm section cooks noticeably harder. In particular, on *Electric Ephemeron* the group nods along until halfway through, when Hino takes a riveting solo full of perilous leaps and plunges. Hino seems to play best when he's with people that have an electric fusion consciousness. And here he's certainly among the finest.

Wishes is another record leased to Inner City from the prolific East Wind company in Japan. Their straight forward production manages to record each instrument cleanly yet maintain that rough edge of spontaneity that is frequently missing from American fushion albums. Recorded back in 1976, Kochi represents the original idea of fusion music: Improvisational music incorporating strong rhythms and electric instruments. Like most improvised music real fusion doesn't always succeed. It doesn't even have that standard level of cliched virtuosity we've come to get from most groups. But when these groups get it together, as Kochi frequently does, you know that collective creativity is what it's all about.

John Diliberto

Sound: B- Performance: B-

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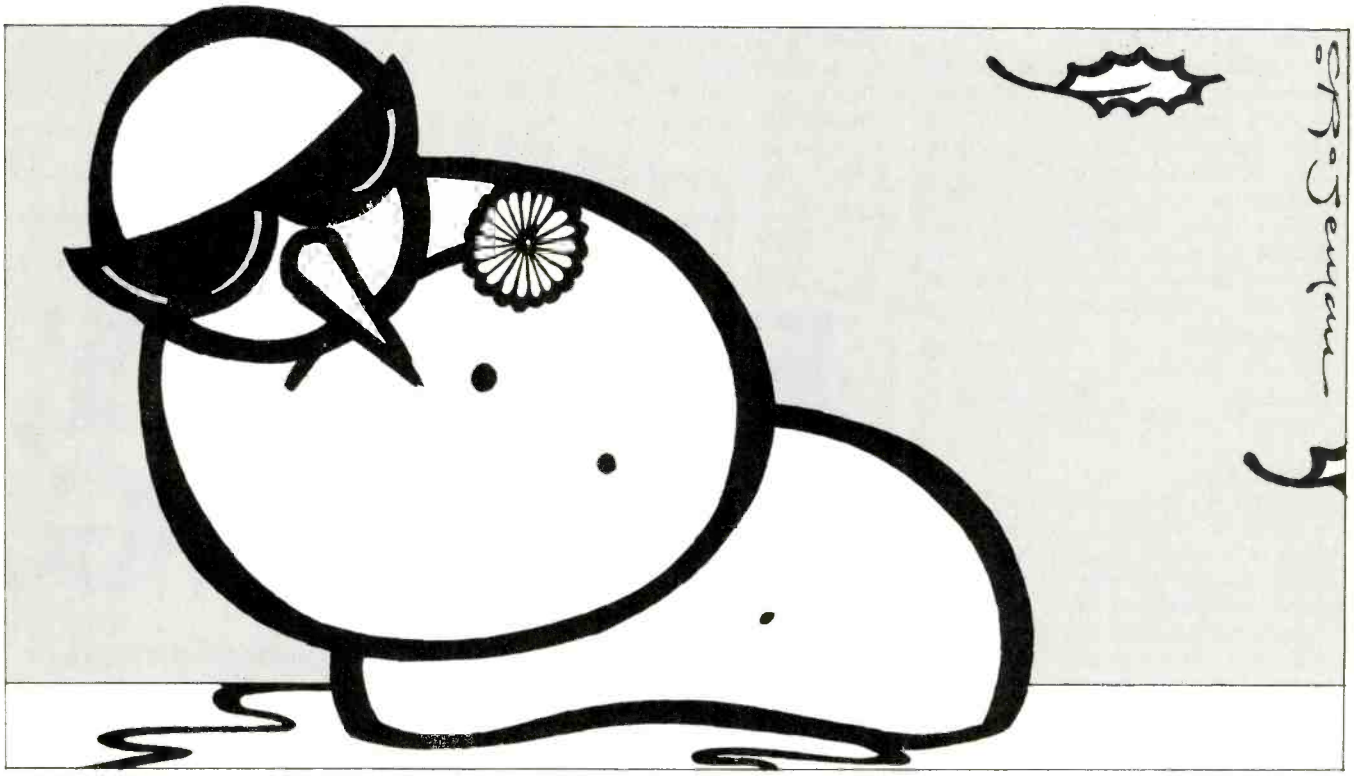


Vivaldi: Four Seasons. Vivaldi Ensemble Tokyo, Hayakawa. **RCA RDCE-501/2,** 2 discs, 45 rpm, stereo, $27.95.

This Japanese series began at 45 rpm, then reconverted to 33 as maybe more practical; now, with each of the four concertos, and four seasons, on one side, 45 turns out to be ideal, assuming your turntable can play it. (I wrestled 10 minutes with belt and pulley in the inner darknesses of my equipment cabinet before I got things going.)

Somehow, these recordings exist in another world, oddly out of step with current developments and yet, even so, at the top in terms of sonic quality. Direct-to-disc, all of them, and not a mention of digital. I.e. modern, but not ultra-modern. And the mike technique, also excellent, is just a wee bit dated, with a lot of different microphones spread around here and there. Even the music is a tiny trace old-fashioned — the Japanese still do their European Baroque with the grandly slowed-down endings that were fashionable in the West 30 years ago. But all this merely sets a kind of atmosphere. The playing is mostly very good, the sound is mostly extremely fine, the 13 players have all the impact of 70 in the big, reverberant hall; the surfaces on the discs are excellent, the cutting level remarkably high (possible at 45, I suppose) — so all is well!

Do not confuse these continuing RCA imports, produced by a Japanese affiliate, with RCA's own American digital operation launched earlier this last year. Both are good but they are unrelated, in personnel and in technique.

Sound: A Recording: A- Surfaces: A-

Mozart: Violin Concertos in D, K. 218; B Flat, K. 209; Adagio in E, K. 261; Rondo in B Flat, K. 269. Henryk Szeryng; New Philharmonia Orchestra, Sir Alexander Gibson. **Philips Festivo 6570 109,** stereo, $6.98.

One of the nicest recordings of early Mozart violin concerti I have ever heard, fresh spontaneous, unaffected, enthusiastic and meticulously accurate as well as beautifully shaped. It seems to take one of Great Britain's respected "Sirs" to do this sort of thing for the great classics — witness the absolutely superb Beethoven Symphonies by Sir Adrian Boult on Vanguard, my choice ablve ALL others for sheer Beethoven enjoyment. Same here! Far too often these little concerti, or concertos if you will, become slick vehicles for ambitious violinists on the make, and on the orchestral side, are treated as not very important. No such high-and-mighty attitude here. Just lovely, easy music. And Henryk Szeryng, he of the unrememberable spelling, plays a wonderfully modest and appropriate fiddle part, beautifully blended into the orchestra. Believe me, you will not do better on this Mozart. Even the recording is lovely — and it's a "low priced" item, presumably a re-issue.

Sound: B+ Recording: A- Surfaces: B+

Tchaikovsky: Manfred Symphony. New Philharmonia Orch., Ashkenazy. **London CS 7075,** stereo, $7.98.

What a big fat sound! I had not heard an "ffrr" of this sort for some time—the continuity from the first days of *ffrr,* long before stereo, is amazing. Still the same rather loud, steely strings, the even spacing of all the instruments at a seemingly identi-

cal distance, the big, fat bass and the shiny treble, the ultra-clear semi-close-up instrumental colors, larger than life .... Also, a very high effective level (if I am right, this is not entirely a matter of dB but, rather, a subjective effect, born of the microphone technique) and along with that, a lovely, quiet surface. Enough said! There are other schools of thought on recording, but this is one very fine way to put down a symphony orchestra.

Manfred is not one of the easiest of Tchaikovsky's works. It is enormously lugubrious, sprawlingly big, an elephant-like partner to the much more concise and intense *Romeo and Juliet*, in that both are picture works, based on a "program." In *Manfred* Tchaikovsky works up the ominous, impending-fate sort of music to its most extreme—and we tend all too easily, now, to lose contact. How long can you be forbiddingly ominous and brooding about terrible things to come? Not long, today! It took the big old masters of conducting, the practitioners of high drama like Willem Mengelberg, Toscanini, even our recent old friend, Stokowski, to maintain any sort of real continuity and emotional shape in a sprawler of this sort.

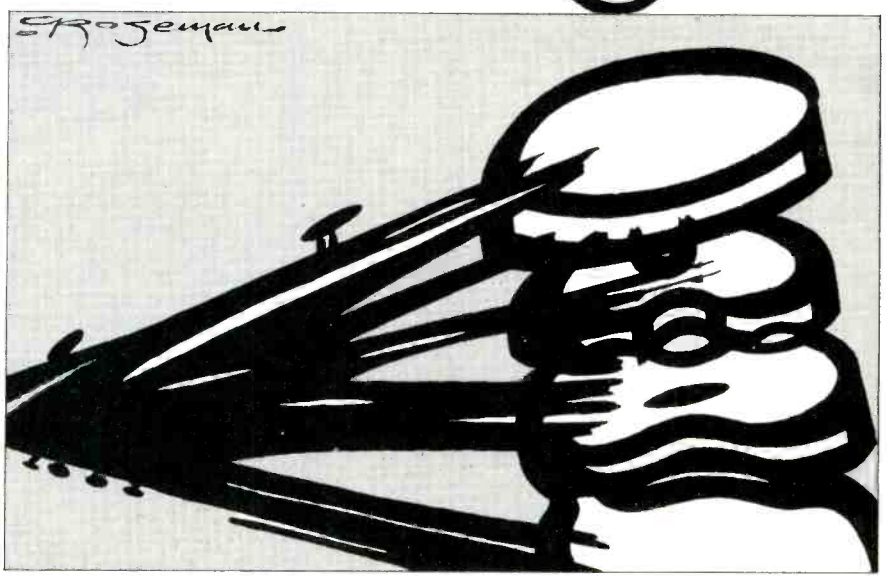
"The Ash Can" (as some have flightily called him) is young and vigorous, and Russian, too—I speak, of course, of Ashkenazy. But there are many moments in this rendition when one senses that the musicians are playing the notes, just as written, and wondering themselves what is going on. They seem to flounder—the opening lugubriousness on side one is a drag. You may blame Tchaikovsky if you wish; nevertheless, I expect that the conductors of a generation ago could have made this music go, along with their own more understanding performers. It was their music, after all, of their day.

But when, inevitably, things begin to get moving, the music comes to life along with the excellent Philharmonia. This is no second-rate orchestra—on side two, when the musical fireworks begin, it really opens up and plays. I'm not suggesting that you begin with side two; T. might turn in his grave at the thought. But hold on awhile, while side one plays its lugubrious way. That will make side two so much the better, especially with such an interesting recorded sound. Brilliant.

Those who know Symphonies No. 4 and 5 will find remarkable remembrances of those works here—not surprising, since *Manfred* comes right between those well-known symphonies.

Sound: A- Recording: A- Surfaces: A-

Folk bag



I'm Old But I'm Awfully Tough: Traditional Music of the Ozark Region Missouri Friends of the Folk Arts 1001, 2 discs, stereo, $10.50.

The Ozark region of southern Missouri and northern Arkansas has not lacked for documentation, but this set of recent field recordings suggests there are many worthwhile performers in the area whom previous collectors overlooked.

Only one of the artists heard here has recorded before. Tip McKinney was lead singer for Pope's Arkansas Mountaineers, who recorded for Victor in 1928. Though his voice is weathered with age, he sings with feeling and a great deal of dignity, especially in the religious songs. Lawrence Baker, who also performs unaccompanied, sings a few traditional nonsense songs, a genre which seems to have survived hardily in the Ozarks. Green Berry Horton's clawhammer banjo-playing features a crisp, ringing melody line which he fills in with a dancing fifth-string drone and distinctively full chords.

The dominant instrument in this set is, as you might expect, the fiddle. Emmanuel Wood, given jumping rhythm guitar and bass support by his sons and daughter, plays rough yet exciting versions of regional fiddle tunes which deserve to be more widely known (*Dixie Blossom* in particular). Troy Lee plays a number of more familiar tunes in a comparatively smoother, more deliberate manner; his *Kentucky Waltz*, though, is so unflattering, it should have been left out. Jake Hockemeyer's contest-fiddling style strikes me as more generally Midwestern than specifically Ozark. Vesta Johnson is a fine fiddler with a sleek, polished style who deserves more than just two short tunes. Frank Reed and Alva Lee Hendren are a supremely coordinated fiddle-banjo duo; Hendren plays banjo in an unusual up-picking style which sounds like frailing in reverse, so to speak.

The most important items here are on side four, which is devoted to the music and cultural traditions of Old Mines, one of the last remaining French communities in Missouri. (The French were the first Europeans to settle in the area.) It's worth noting that the frisky, jabbing, staccato-filled style of Charlie Pashia and Joe Politte differs considerably not only from Ozark fiddling, but also from the more prominent French survivals in North America (i.e., French Canadian and Cajun).

Along with the music, there are spoken reminiscences and anecdotes by the performers. The enclosed booklet includes biographical information, notes on the tunes, and a lengthy essay on the settlement of Missouri. However, this essay, while certainly interesting, is of dubious relevance at times to the music at hand. (Missouri Friends of the Folks Arts, Box 307, New Haven, Mo. 63068) *Tom Bingham*

Sound: B Performance: B- to A

The Bramble & The Rose: Mary McCaslin and Jim Ringer
Philo PH 1055, stereo, $7.98.

Even though Mary McCaslin and Jim Ringer both rank among my personal favorites, I confess I approached their first duet album with misgivings. After all, the history of modern country music is overloaded with solo stars whose vinyl pairings have ranged from inconsequential throwaways to unmitigated disasters. (To cite an obvious example, how many of Loretta Lynn and Conway Twitty's chart-topping duets have had either the authority or validity of their individual hits?) As harmonious as they may be offstage, I doubted whether McCaslin and Ringer could reconcile her neo-traditional Western sensibilities with his laidback country-folk approach.

In a sense, McCaslin and Ringer have sidestepped the issue by playing it safe. Rather than stick their necks out by attempting to merge their styles, they've dipped into those subgenres of country music in which duet and harmony singing have long been established (country-rock, gospel, bluegrass, the brother duos of the '30s, etc.). From these areas, they've chosen songs which could be easily adapted to a comfortable middle-of-the-road country-folk format.

But if the album is relatively safe, it is by no means superficial. The Ringers' selection of material digs below the threshold of instant recognizability to revive such under-exposed gems as The Dillards' *Copperfields,* West Coast singer-songwriter Jon Wilcox's *Stages of My Life,* the traditional *The Bramble and the Rose,* and a Dakota Dave Hull arrangement of *Oh Death.* I can't say the world would have been any poorer without another version of *Geronimo's Cadillac,* but Ringer's relaxed interpretation paradoxically makes more sense than Michael Murphey's justifiably angrier original. Perhaps the most unorthodox choice is Ray Charles' oldie *Hit the Road Jack,* which translates to country unexpectedly well.

The singing throughout is leisurely, reflective, and thoroughly listenable. The instrument backing is as immaculate as you would expect from such seasoned and compatible pros as Jay Ungar, Winnie Winston, Dick Fegy, Ken Bloom, and Billy Mundi.

There may not be many surprises here, but it's certainly not a throwaway, either. Rather, it's a beautiful record which should delight anyone who loves McCaslin and Ringer separately. *Tom Bingham*

Sound: A- Performance: A

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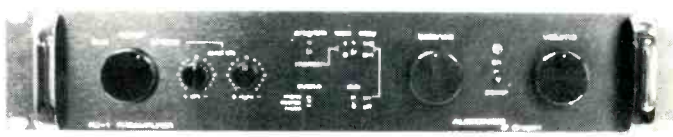

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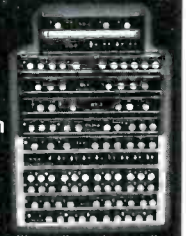

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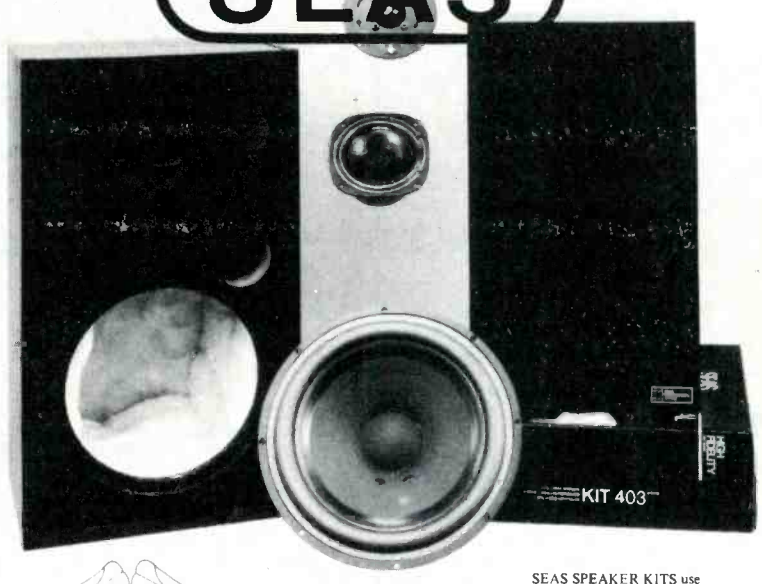

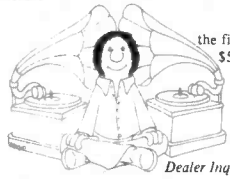

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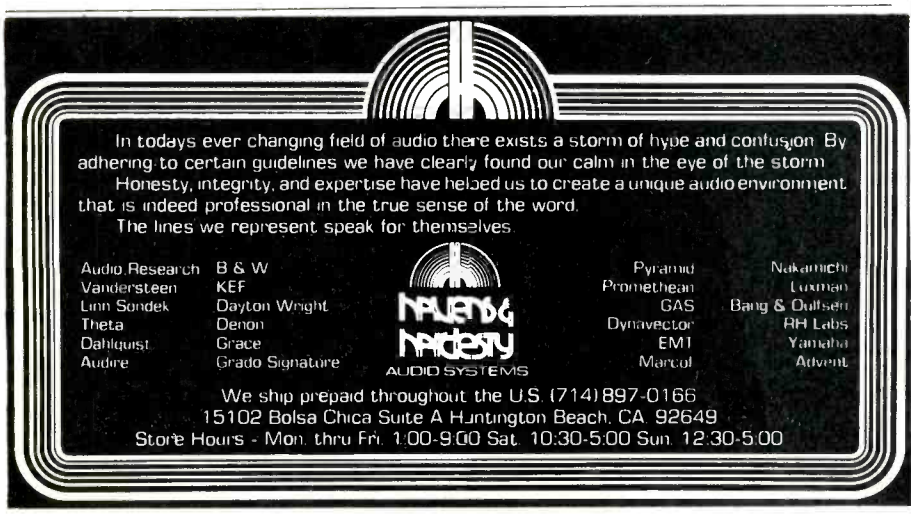

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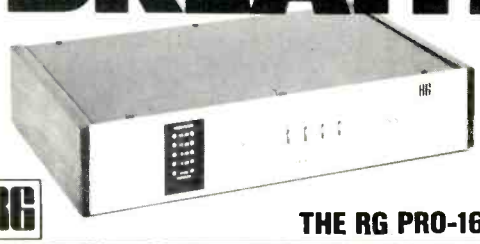

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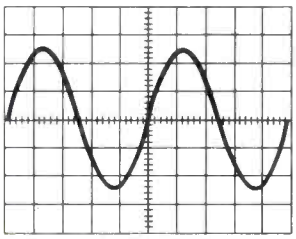
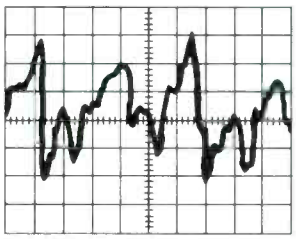
Many amps can deliver pure sound. The Sansui AU-919 delivers pure music.

Today's audio engineering has reached the point where you can select among a number of affordable high-power amplifiers that have virtually no "total harmonic distortion." That's good. But THD measurements only indicate an amplifier's response to a pure, continuously repeating, steady-state test signal (below, left). They don't tell you how the amp responds to the never-repeating, rapidly-changing transient waveforms of real music (below, right). And only an amplifier designed to reproduce the demanding dynamics of music signals can satisfy the critical audiophile. An amp like the Sansui AU-919.



SINE WAVE



DYNAMIC MUSIC SIGNALS

Because low THD without low TIM is like sound without music, the Sansui AU-919 is designed to respond well to both simple sine-wave test signals and also to handle the jagged, pulsive edges required for realistic reproduction of music—without imparting that harsh, metallic quality known as "transient intermodulation distortion" (TIM).

The Sansui AU-919 sounds better than conventional amps because Sansui developed a unique (patent pending) circuit that is capable of achieving both low THD and low TIM simultaneously.

Our DD/DC (Diamond Differential/DC)* circuitry provides the extremely high drive current necessary to use proper amounts of negative feedback to reduce conventionally-measured THD (no more than 0.008%, 5Hz-20,000Hz into 8 ohms at 110 watts, min. RMS) without compromising our extraordinary 200V/μSec slew rate, ensuring vanishingly-low TIM, as well. The power amplifier frequency response extends from zero Hz to 500,000Hz.

Since ultimate tonal quality depends on more than the power amplifier alone, Sansui also uses its DD/DC* circuitry in the phono equalizer section—where current demands are also particularly high—to prevent TIM. ICL (input capacitorless) FET circuits are used throughout the AU-919, and a "jump switch" is provided that will let you run pure DC from the Aux. input to the output.

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*The Diamond Differential/DC, Sansui's (patent pending) totally symetrical double ended circuitry with eight transistors, is named for its Diamond-shaped schematic representation.

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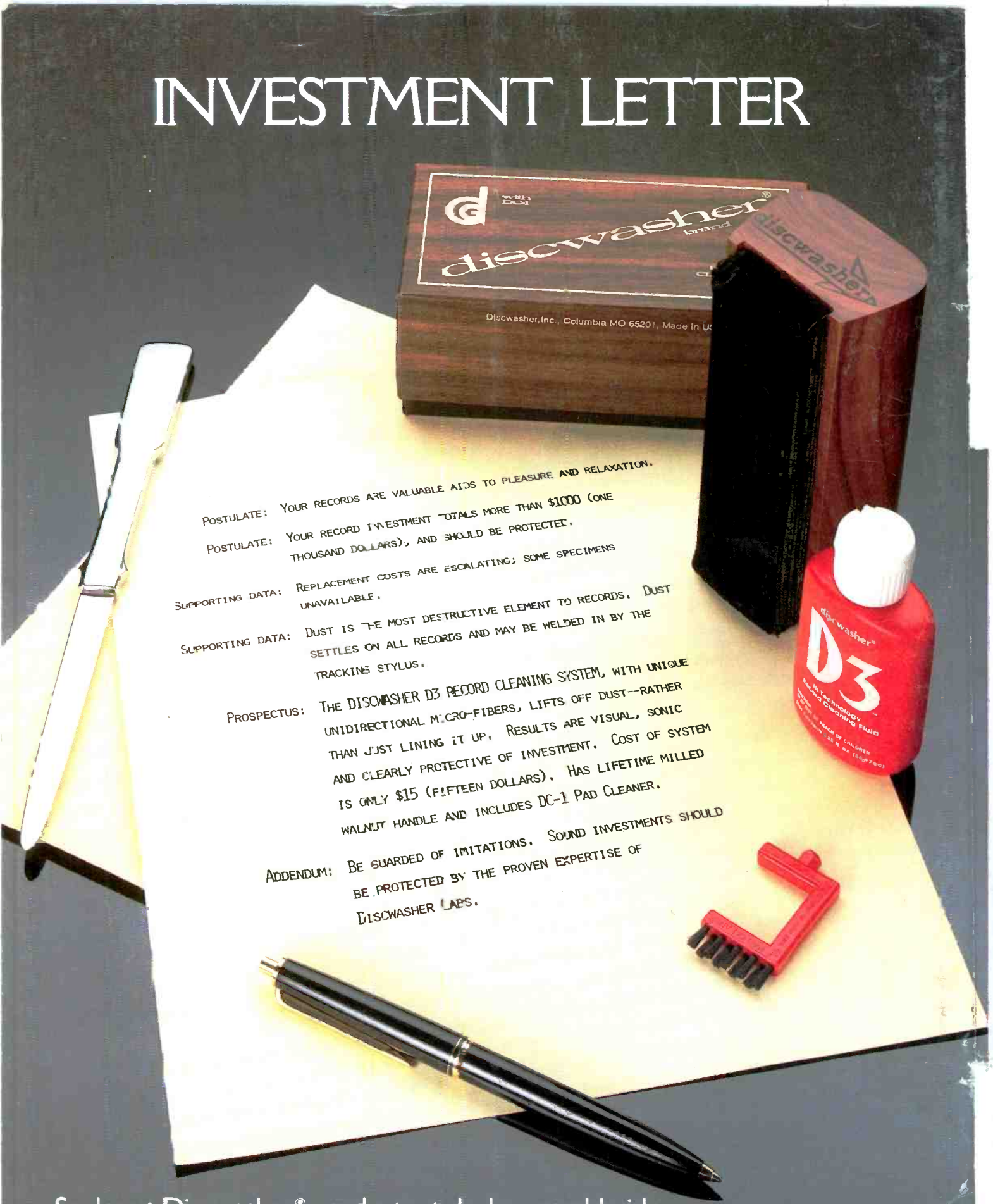

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