Audio

The Authoritative Magazine About High Fidelity

SEPTEMBER 1981 • $1.50 • Ⓕ 06030

SCENES REPORTS ON SUMMER CES

CASSETTE UPDATE: FOCUS ON SHELL MECHANICS

WE TEST THE LATEST TAPES

LASERS & SPEAKER TESTING

CONCLUSION: THD ANALYZER

27100 06030


NO OTHER CASSETTE
HUMAN FEA
Index Scan:
Plays first five seconds of each piece of music on tape to make cassettes as easy to preview as records.
Auto Reverse:
Plays both sides of tape without interruption so you don't have to jump up to flip the cassette.
Real Time Counter:
Digital display tells you how much time is left on tape in minutes and seconds without need for a calculator watch.
PIONEER
Quartz-PLL DIRECT DRIVE
RIBBON SENDUST HEAD
STEREO CASSETTE TAPE DECK
TREBLE
BASS
PIONEER
NON SWITCHING AMP
STEREO AMPLIFIER A-9
nochie, N.J. 07074.

Pioneer has transformed the cassette deck into a component that gives you a new dimension of control over it and the quality of the sound it records and plays. We've done it through a concept we call High Fidelity for Humans.

Electronic and mechanical engineering innovations make Pioneer's new CT-9R a pleasure to listen to.

To start with, Pioneer's engineers have developed a new material for the record and play heads on the CT-9R Cassette Deck. It's called RIBBON SENDUST and it's made with laminations 4 to 5 times thinner than conventional Sendust heads. This virtually eliminates eddy currents that interfere with high frequency response. It also provides a significant improvement in signal-to-noise ratio with extended high frequency response; plus a 3- to 5-dB increase in undistorted headroom at high frequencies. With metal tape the frequency response is an extra-wide 20 Hertz to 22k Hertz. The CT-9R's tape transport system is an incredibly precise dual capstan system with three direct drive motors. The result is an infinitesimal wow and flutter of 0.03%.

More importantly these features allowed our engineers to equip our CT-9R Cassette Deck with a super intelligence: a microprocessor that automatically adjusts bias, level and equalization to maximize the performance of the tape you're using. And this same microprocessor technology makes it possible for the Pioneer CT-9R to offer you an exclusive combination of human engineering features.

Human engineering makes Pioneer's CT-9R a pleasure to live with.

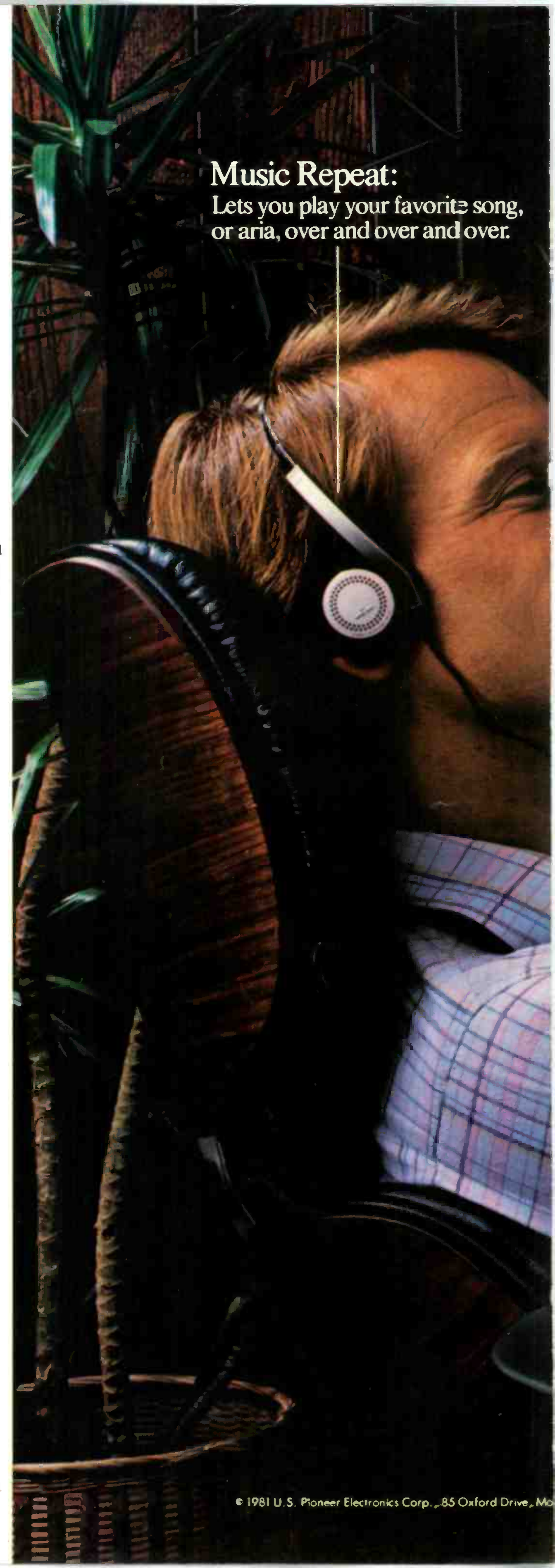
Anyone who records on tape knows how frustrating it is to run out of tape before running out of music. That's why the CT-9R has a Real Time Counter with a digital display to show you how much recording time is left on your tape. Press a button and the same display turns into a Digital Tape Counter. There's also a Blank Search feature that speeds through a partly recorded tape to find the unrecorded section and even leaves a five-second margin between the last song and what you intend to record. To find your favorite song, on a recorded tape, touch Index Scan and the CT-9R will play the first five seconds of each piece of music on the tape. To repeat a song, simply press Music Repeat and listen. The Pioneer CT-9R will even play both sides of a cassette automatically. And the Music Search control automatically plays the beginning of the next song on the tape. There's even an optional remote control.

Now if you think all this sounds too good to be true, visit your nearby Pioneer dealer. You can see and hear the CT-9R for yourself, as well as an entire line of new Pioneer cassette decks. And then if you're wondering why we don't give you less features for the money like others seem to do, it's because we consider that inhuman.

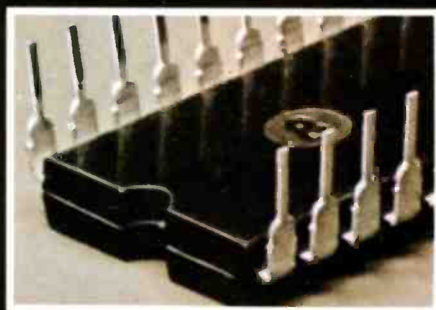
PIONEER

We bring it back alive.

Enter No. 29 on Reader Service Card



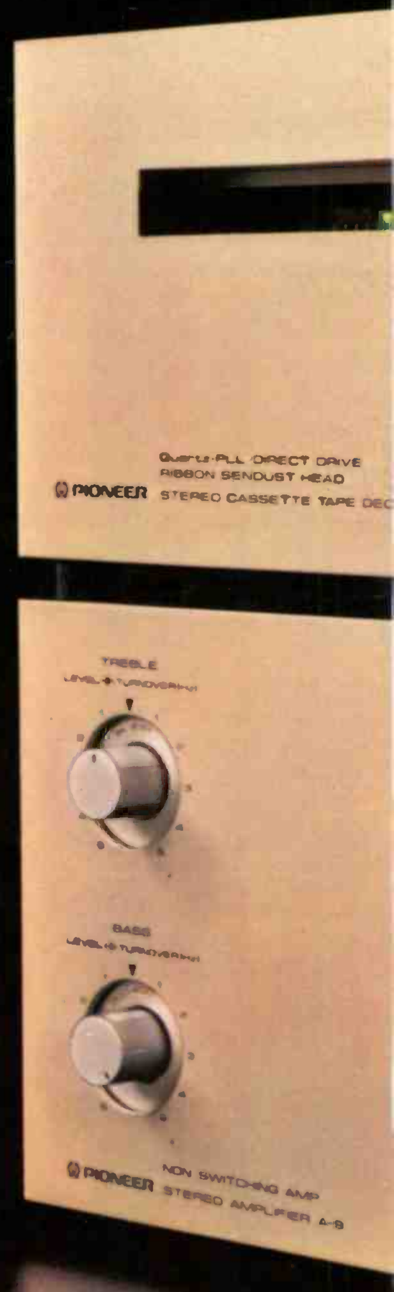
NO OTHER CASSETT
TECHNOLOGICAL FE



Ribbon Sendust Heads:
Pioneer's exclusive tape head material provides superb signal-to-noise ratio.

Advanced Microprocessor:
Automatically determines precise bias, Dolby calibration level and record equalization for each tape.

Three DD Motor Tape Transport:
Three direct drive motors provide exceptional record and play accuracy.



DECK HAS ALL THESE
TURES AT ANY PRICE.

Audio

SEPTEMBER 1981 VOL. 65, No. 9

FEATURE ARTICLES

EQUIPMENT PROFILES

RECORD REVIEWS

AUDIO IN GENERAL

ABOUT THE COVER: How well do the new cassettes perform? See Howard Roberson's articles, which begin on pages 18 and 31. Cover photograph by Susanne Buckler, retouching by Seymour Green, and special thanks for the light-footed elephant to Ringling Bros. and Barnum & Bailey Circus.

Audio Publishing, Editorial and Advertising Production Offices, 1515 Broadway, New York, N.Y. 10036

Subscription Inquiries, (800) 525-9511, in Colorado (303) 447-9330

The best for both worlds

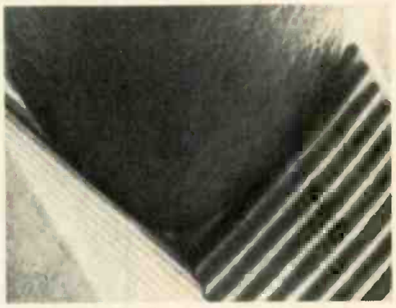
The culmination of 30 years of Audio Engineering leadership – the new Stereohedron®

XSV/5000

One of the most dramatic developments of cartridge performance was the introduction of the Pickering XSV/3000. It offered the con-

sumer a first generation of cartridges, combining both high tracking ability and superb frequency response. It utilized a new concept in stylus design —Stereohedron, coupled with an exotic samarium cobalt moving magnet.

Now Pickering offers a top-of-the-line Stereohedron cartridge, the XSV/5000, combining features of both the XSV/3000 and the XSV/4000. It allows a frequency response out to 50,000 Hz.



The Exclusive Stereohedron Tip

The new XSV samarium cobalt magnet accounts for an extremely high output with the smallest effective tip mass. The Stereohedron tip design is the result of long research in extended frequency response for tracing of high frequency modulations. The patented Dustamatic® brush and stylus work hand in hand with the rest of the cartridge assembly to reproduce with superb fidelity all frequencies contained in today's recordings.

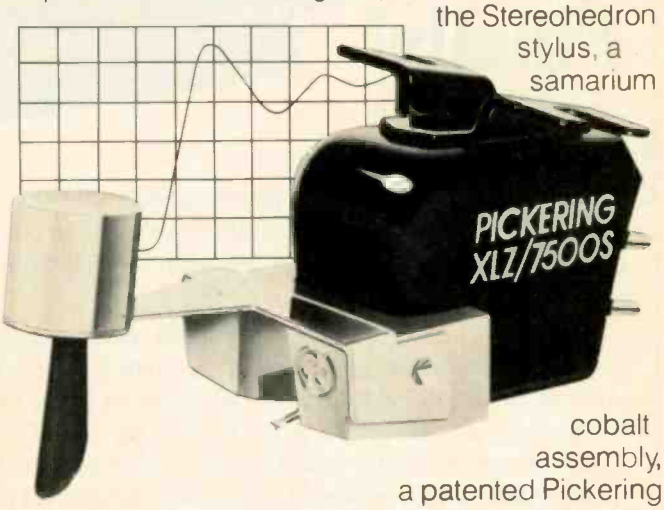
Pickering is proud to offer the XSV/5000 as the best effort yet in over 30 years of cartridge development.

A fresh new breakthrough in cartridge development designed specifically as an answer for the low impedance moving coil cartridge –

XLZ/7500S

The advantages of the XLZ/7500S are that it offers characteristics exceeding even the best of moving coil cartridges. Features such as an openness of sound and extremely fast risetime, less than 10μ seconds, to provide a new crispness in sound reproduction. At the same time, the XLZ/7500S provides these features without any of the disadvantages of ringing, undesirable spurious harmonics which are often characterizations of moving coil pickups.

The above advantages provide a new sound experience while utilizing the proven advantages of the Stereohedron stylus, a samarium



cobalt assembly, a patented Pickering Dustamatic brush, with replaceable stylus, along with low dynamic tip mass with very high compliance for superb tracking.

So, for those who prefer the sound characteristics attributed to moving coil cartridges, but insist on the reliability, stability and convenience of moving magnet design, Pickering presents its XLZ/7500S.

THE SOURCE OF PERFECTION

PICKERING

"for those who can hear the difference"

For further information on the XSV/5000 and the XLZ/7500S write to Pickering Inc., Sunnyside Blvd., Plainview, N.Y. 11803.

from Pickering

Enter No. 30 on Reader Service Card

Audio

Editor
Eugene Pitts III

Assistant Editor
Kay Blumenthal

Editorial Assistant
Deirdre Frank

Art Director
Cathy Cacchione

Production Manager
Mark E. Abraham

Associate Editors:
Edward Tatnall Canby, Bert Whyte

Senior Editors:
Richard C. Heyser, B. V. Pisha
Howard A. Roberson

Features Editor:
Gary Stock

Contributing Editors/Artist:
Tom Bingham, Herman Burstein, Ted Costa, John Diliberto, Leonard Feldman, Joseph Giovanelli, Edward M. Long, C. G. McProud, Jon Sank, Walter I. Seigal, Donald Spoto, Michael Tearson, George W. Tillett, Jon & Sally Tiven

Publisher
Jay L. Butler

AUDIO (ISSN0004-752X) is published monthly by CBS Publications, The Consumer Publishing Division of CBS Inc., 1515 Broadway, New York, N.Y. 10036.
Robert J. Krefting, President
George H. Allen, Senior Vice President/Magazines
Francis P. Pandolli, Vice President and Group Publisher
Michael Brennan, Vice President and Gen. Manager
Leon Rosenfield, Circulation Marketing Director
William Ganz, Advertising Marketing Director
John J. Miller, Group Business Manager
Karen L. Rosen, Production Director

ADVERTISING SALES
Audio, 1515 Broadway, New York, N.Y. 10036
Jay L. Butler, Publisher
Telephone (212) 975-7247
Stephen W. Witthoft, Eastern Adv. Mgr.
Telephone (212) 975-7654

West Coast Sales Office:
Audio, 3807 Wilshire Blvd., Suite 1201
Los Angeles, Calif. 90010
Jay Martin, Western Adv. Mgr.
Telephone (213) 487-5880

Classified Advertising:
Audio, 1515 Broadway, New York, N.Y. 10036
Laura J. LoVecchio, Classified Adv. Mgr.
Telephone (212) 975-7530

England: The Paul Singer-Lawrence Media Group, 54 Burton Court, London SW 3 SY4, England.
Telephone, 01-730-3592

Dewey Decimal Number 621.381 or 778.5

Editorial Contributions are welcomed but should be accompanied by return postage. Submissions will be handled with reasonable care, but the publisher assumes no responsibility for safety or return of manuscripts, photographs, or artwork.

Printed in U.S.A. at Columbus, Ohio. Second Class postage paid at New York, N.Y. 10001 and additional mailing offices.

U.S. Subscription Rates: 1 year $13.94, 2 years $22.94, 3 years $29.94.

Other Countries: Add $6.00 per year.

Back Issues, when available, $5.00 postpaid.

Audio Publishing, Editorial and Advertising Production offices, 1515 Broadway, New York, N.Y. 10036.
Audio Subscription Offices, P.O. Box 5318, 1255 Portland Place, Boulder, Colo. 80322.

Postmaster: Send Form 3579 to P.O. Box 5316, 1255 Portland Place, Boulder, Colo. 80322.

The Onkyo TA-W80.
It will dazzle you, delight you, drive and deliver you.

The Onkyo TA-W80 Studio Deck is the most exciting stereo cassette deck available today. It integrates two cassette tape decks into a single component, with all the controls to operate them individually, simultaneously, or in sequence.

The Onkyo TA-W80 not only provides incredibly pure and exciting record/playback quality . . . it gives you a capability that even two stand-alone tape decks cannot provide.

You can now edit with improved precision . . . make quality high speed dubs in half the normal time without setting levels . . . playback two tapes simultaneously . . . or set them for uninterrupted automatic sequential play. You can even mix your own recordings . . . mixing a mic input with an external source . . . or a mic signal with the program from cassette #1.

Little wonder that The Onkyo TA-W80 was selected as "one of the year's most innovative products" in the Consumer Electronics Design Exhibition.

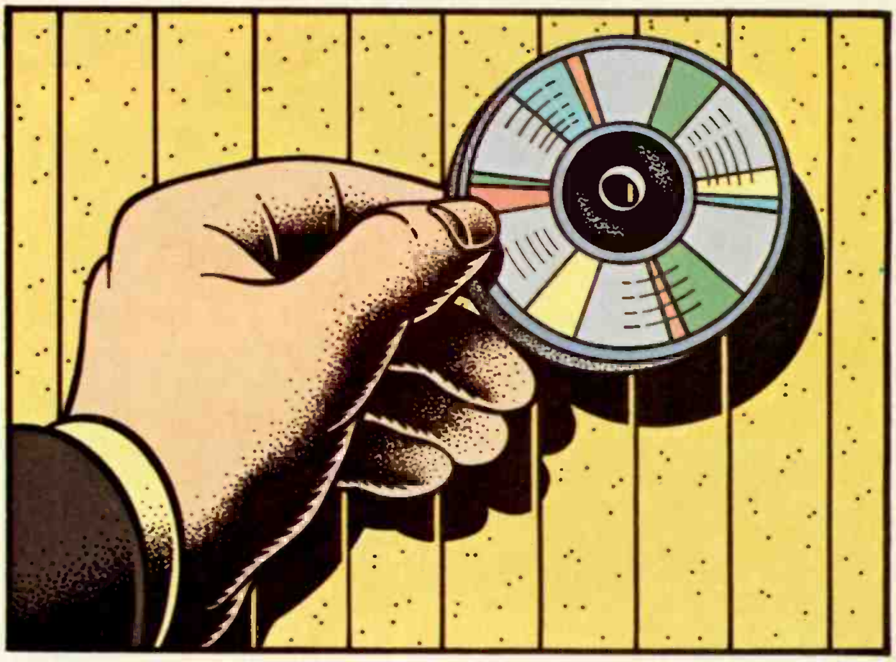
Enter No. 27 on Reader Service Card

Onkyo USA Corporation, 42-07 20th Ave., Long Island City, N.Y. 11105. (212) 728-4639.

ONKYO

BEHIND THE SCENES

BERT WHYTE



Video is the new glamour item of the consumer electronics industry, and this was very positively demonstrated at the 1981 Summer Consumer Electronics Show in Chicago, May 31 through June 3, at McCormick Place. Video products were everywhere, in myriad manifestations, but in spite of the spotlight on video, there were plenty of new audio products on view at McCormick Place and in satellite hotels. The only audio product which might be termed a "technological breakthrough" was the Sony/Philips Compact Digital Audio Disc. Sony, Philips and licensee Marantz were actually demonstrating prototype models which, needless to say, was a foretaste of the future and caused considerable excitement. The Compact Disc is 4.7 inches in diameter, is made of metallized plastic encapsulated with a plastic transparent protective scuff coating, and is thus impervious to dust, dirt, fingerprints, and scratches. The disc rotates in a counter-clockwise direction, with the speed varying from 500 rpm on the inside of the disc (the disc is played inside out) to 200 rpm on the outside to maintain a constant linear velocity. The CD system uses pulse code modulation, with 16-bit linear encoding and a sampling rate of 44.33 kHz. A solid-state laser scans the information pits and flats at a rate of 4.3 million bits per second. Theoretically, the disc can be recorded on both sides, but at present there is only 60 minutes stereo program on one side. An interesting point is that 30 minutes of four-channel playback is possible, and, with a stated channel separation of 90 dB, the signals would be very discrete indeed! The actual information density on a side of the CD is far greater than is needed for 60 minutes of music. Therefore, special-purpose encoding can be employed to provide playback of individual selections in any sequence, to repeat selections, or even to display selection titles, playing time and lyrics of songs via a luminescent or LED device or TV monitor screen. The usual digital specifications . . . 90-dB S/N and dynamic range, 20 Hz to 20 kHz frequency response, unmeasurable wow and flutter, etc. . . . apply to this Sony/Philips CD audio disc. While the Digital Audio Disc committee of the EIAJ did not specifically name the Sony/Philips CD system as their unequivocal choice for a "standard," it certainly is the front-runner and has already been adopted by such companies as Bang and Olufsen, CBS/Sony, Crown, Dual, Matsushita, Nakamichi, Nippon Columbia, Onkyo, Polygram, Sony, Studer/Revox, and Kenwood. Polygram, the huge record conglomerate, is said to be setting up a plant to manufacture the Compact Discs, and CBS/Sony is expecting to have ready a catalog of 100 CD recordings to coincide with the introduction of the CD system in Japan in the fall of 1982, with the U.S. introduction shortly thereafter. Projected price of the Sony/Philips CD player is expected to be between $400.00 and $600.00, with the discs between $9.00 and $12.00. From all this, one must conclude that by January 1983 the digital audio disc will be a reality, which, needless to say, will have a profound effect on many aspects of our industry. As I am sure you are aware, there have been numerous manufacturing problems with the laser-read videodiscs which have resulted in very high return rates. Since the Sony/Philips system has virtually identical playback procedures, the quality control on the CD discs will have to be very stringent to keep the reject rate below one percent and ensure a viable system.

Another peek into the future of consumer electronics was provided at this SCES by the giant Matsushita Co. of Japan. Every few years, Matsushita holds a technology fair in Japan. This year they decided to schedule it in conjunction with the 1981 SCES in Chicago. The massive Matsushita exhibit entitled "Matsushita Technology Today" occupied all 12,000 sq. ft. of the huge Chicago Room at McCormick Place. This was in addition to the usual Panasonic, Technics, and Quasar exhibits on the main floor of McCormick Place. The special exhibit was divided into sections, each representing a particular manufacturing activity of the company. There were sections on health care electronics, featuring such advances as a bone-conduction hearing aid, and a Braille duplication system. Some absolutely fascinating new video technologies will be covered in my "*VideoScenes*" column. The business electronics section had such items as mobile facsimile systems and a Panacopy automatic color-slide processor. In the appliance electronics area, how about a microwave oven that "talks" to you, acknowledging instructions! Component electronics featured microcomputer and memory devices, ICs and LSIs, sensors and opto-electronic devices. There were sections on sensory control, test instruments and production electronics, including an arc-welding robot. The audio item that attracted a great

Illustration: Leo Pando

Imagination has just become reality.

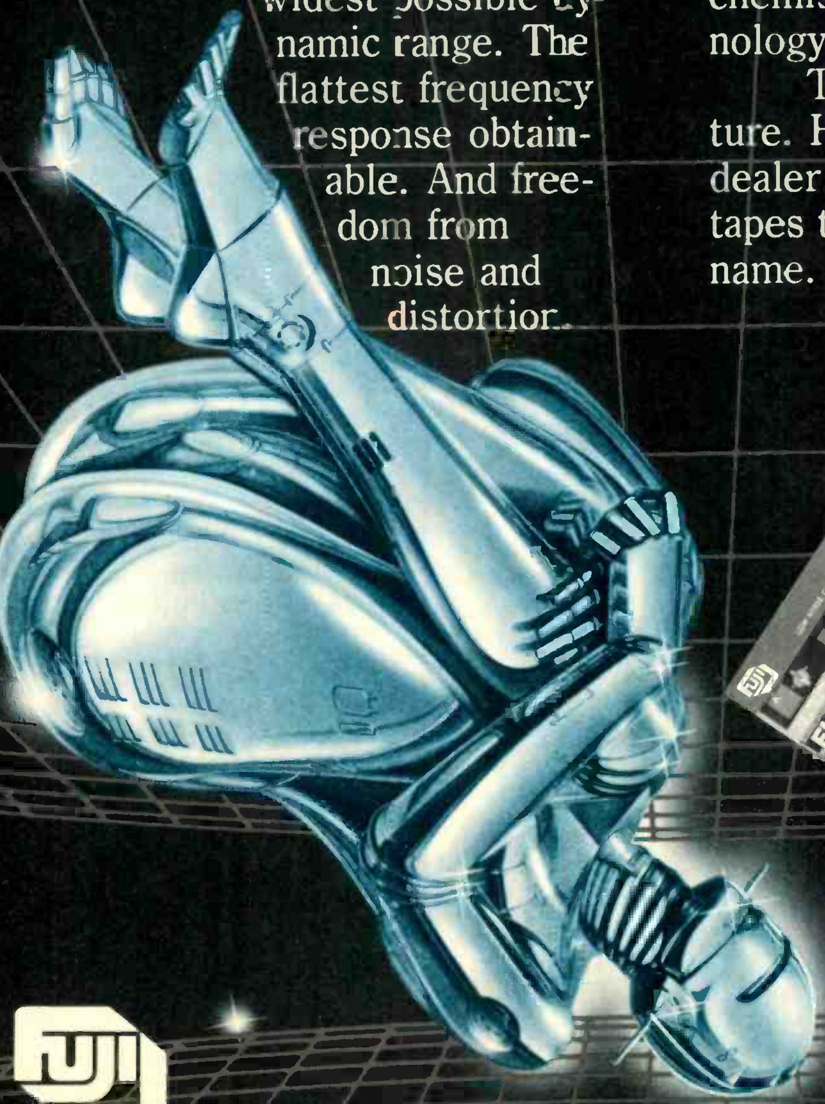
Finally. The elusive goal, attained.

Audiocassettes of such remarkable accuracy and clarity that differences between original and recording virtually vanish.

This is the sound of the future. Tapes with the widest possible dynamic range. The flattest frequency response obtainable. And freedom from noise and distortion.

New Fuji tapes: Born of microscopic particles made smaller, more uniformly than ever before. Permanently mated to polymer film so precise, its surface is mirror smooth. The product of intensive research that unites physics, chemistry, computer technology and psychoacoustics.

The sound of the future. Hear it at your audio dealer today. In four superb tapes that share a single name.



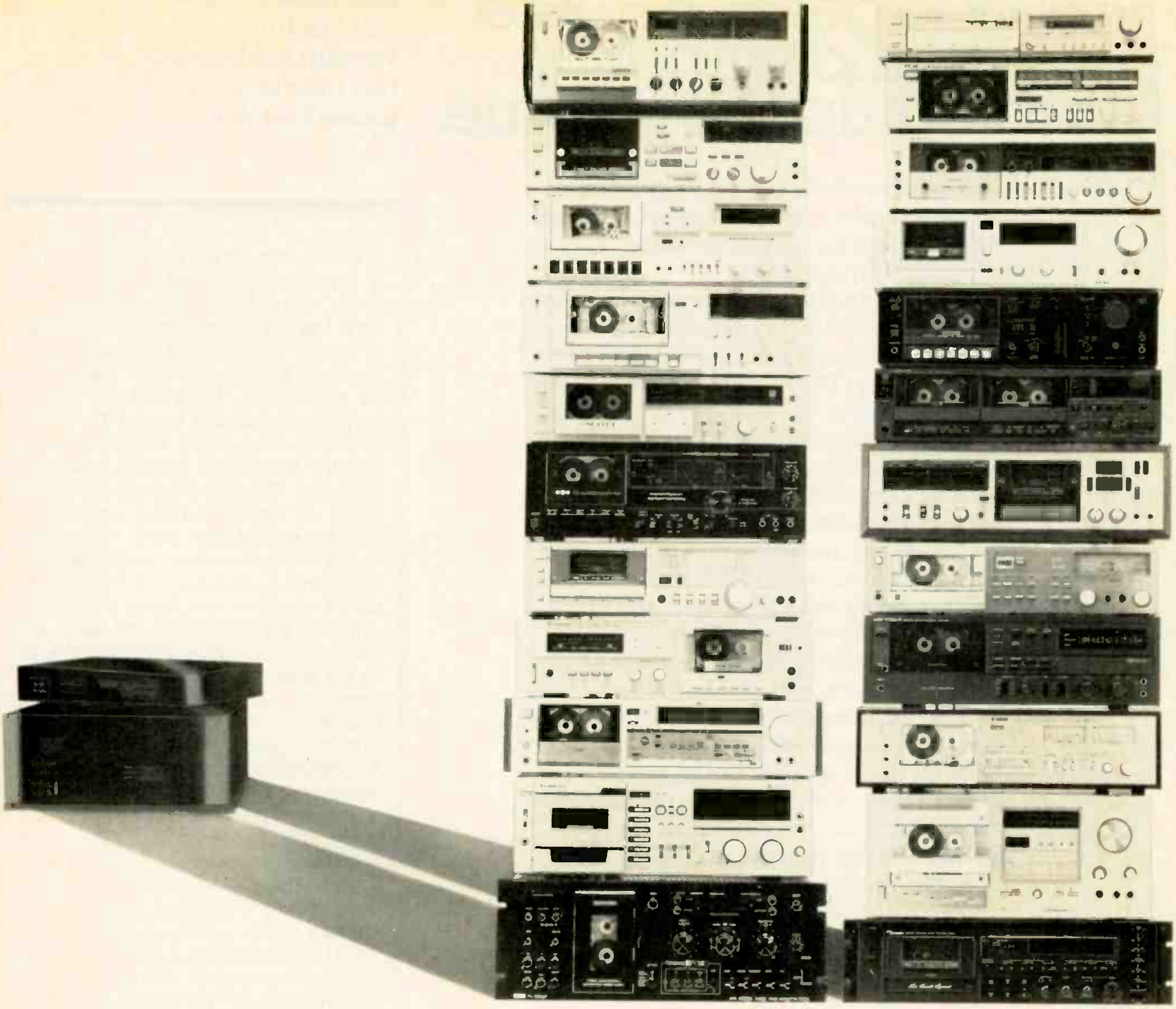
FUJI
CASSETTES
Imagination has just become reality.

Interesting new products at the Summer CES included the Sony/Philips Compact Disc and turntables from Sumiko/SOTA and Dennon.

deal of attention was the SV-P100 digital-audio cassette recorder which was described in April and June 1981 issues of *Audio*. While it might be said that some of the exotic products in the Matsushita exhibit are some years away, there were none that should be described as pure blue sky. The exhibit was certainly a revelatory experience and a tribute to Matsushita's dedication to high technology.

As you might expect, with laser digital-audio discs being demonstrated at the SCES, the doomsayers were out in full cry, proclaiming that the days of the LP record and all analog record-playing equipment were numbered. This is, of course, sheer nonsense. Even if the digital audio disc does not encounter any technical or production difficulties whatsoever, it will be years before any reasonably comprehensive catalog of software exists. The analog LP record will be around for a long time, and there was plenty of new phonograph equipment offered at the SCES to underscore this point. Among audiophiles, the Linn-Sondek turntable has built up an enviable reputation for its "neutrality" and for not imparting any colorations to recordings during playback. Over the years, there have been a number of turntables, whose designer's goal was to knock the Linn from its expensive perch.

One particularly interesting design project with this goal is a joint effort between Sumiko, the importer of Grace and Supex cartridges, and SOTA Industries, both of Berkeley, California. Dave Fletcher, the canny head of Sumiko, is a physicist, and he teamed up with engineer Rodney Herman of SOTA, to design a turntable which they claim is based on Newtonian principles. Although there is one basic design on the turntable, there are two different models. The Gem will be sold through Sumiko and it differs from SOTA's Sapphire in being equipped with either the Grace 707 Mk II tonearm or the Grace 747 Tonearm. The SOTA turntable is sold without a tonearm. Both turntables employ an 18-pound subassembly made of a special zinc alloy, with added lead and synthetic damping. A special four-point suspension is used with a resonance frequency of 2.55 Hz. This is combined with a 12.5-pound cast-zinc alloy base with compound damping. Some 40 percent of the weight is concentrated near



23 deck makers bias with TDK metal. That doesn't leave many for the competition.

When it comes to the critical bias adjustment, the vast majority of manufacturers won't use anything but TDK Metal Alloy cassettes. TDK metal excels in two different cases. The MA-R has the Reference Standard Mechanism, with a unique metal unibody frame. MA uses the Laboratory Standard Mechanism, designed to deliver the smoothest possible flow of music.

Both MA-R and MA incorporate TDK's remarkable tape formulation, FINAVINX, a metal particle with extremely high coercivity and remanence for high frequency response and low distortion. TDK metal has the widest frequency range and highest MOL of all cassettes rated in an independent test.

It's not easy to get 23 quality deck makers to reach the same conclusion. If you use TDK metal, you'll be in good company.

TDK.
The machine for your machine

Enter No. 39 on Reader Service Card

Lux's new PD-375 still has the vacuum hold-down, this time in a manual version.

the rim of the platter to provide a flywheel effect. Under the platter spindle is an inverted sapphire disc bearing, said to be accurate to one wavelength of light. The bearing is at the table's center of gravity. The sapphire disc rides on a hardened chrome-steel ball, claimed to be accurate to 1/10,000,000 of an inch. Most turntables have shafts which extend from the platter. In the SOTA design the thrust shaft remains fixed and immobile. Rotation occurs only at the center of gravity and any unbalanced forces are effectively nulled. In the Gem model, the built-in arms are factory balanced and mass-loaded to compensate for the weight of the sub-assembly and platter. In the Sapphire model, there are variable mass-loading options to adjust for the specific weight of the tonearm selected. In both models, with this approach, total mass of the entire turntable system remains constant, and this offers a combination of static balance and dynamic stability. In the SOTA model, a special belt drives the outer rim of the platter from a brushless d.c. servo motor with 33⅓-rpm and 45-rpm speeds electronically switchable. In the Gem model, the belt drive is the same but employs a different motor with push-button selection of the two playback speeds. Rumble for these turntables is claimed to be –60 db unweighted at a reference of 10 cm/S at 1000 Hz. The price of the Gem is $725 with the Grace 707 Mk II arm and $800.00 with the Grace 747 arm. The SOTA version of the table is $650.00.

A new Denon turntable offers an entirely different "brute force" approach to its design. The platter weighs 35 pounds, there is a 150-pound turntable chassis and base, mounted on massive springs, and the drive is direct via a huge cogless quartz-lock motor. A special arm is provided with the system. Price of this backbreaker is $5000.00.

Lux created quite a stir with its vacuum hold-down turntable at the 1980 SCES. Now they have introduced the Model PD-375 turntable, which, in contrast to the previous model, is a direct-drive unit with a built-in arm. The all-important vacuum hold-down feature is there, but this time the vacuum is established with a manual pump instead of the automatic electric system on the earlier turntable. The good news is that you can now enjoy the disc-flattening and vinyl resonance damping of the vacuum hold-

You might find a bigger loudspeaker at the same price.

You won't buy a better one.

Sadly, some people still think one loudspeaker is much the same as another.

To those of you suffering the consequences of this misapprehension, we have a message—there is a difference!

A difference once appreciated, never forgotten.

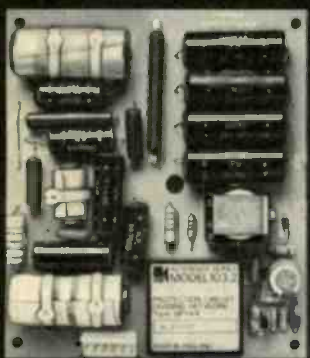
A difference appreciated by Stereo Review, whose noted testing authority, Julian Hirsch, said "... its sound is unusually smooth, balanced, and utterly easy and unstrained. You can pick almost any favorable adjective and it would apply equally to the sound of this loudspeaker." (Stereo Review July, 1981)

The KEF Model 103.2 is a new addition to the renowned Reference Series. It may not look strikingly different, but inside the compact 19 litre cabinet it is a different story: drive units, filter networks and the unique KEF electronic overload protection circuit (S-STOP) represent the latest advances in loudspeaker technology.

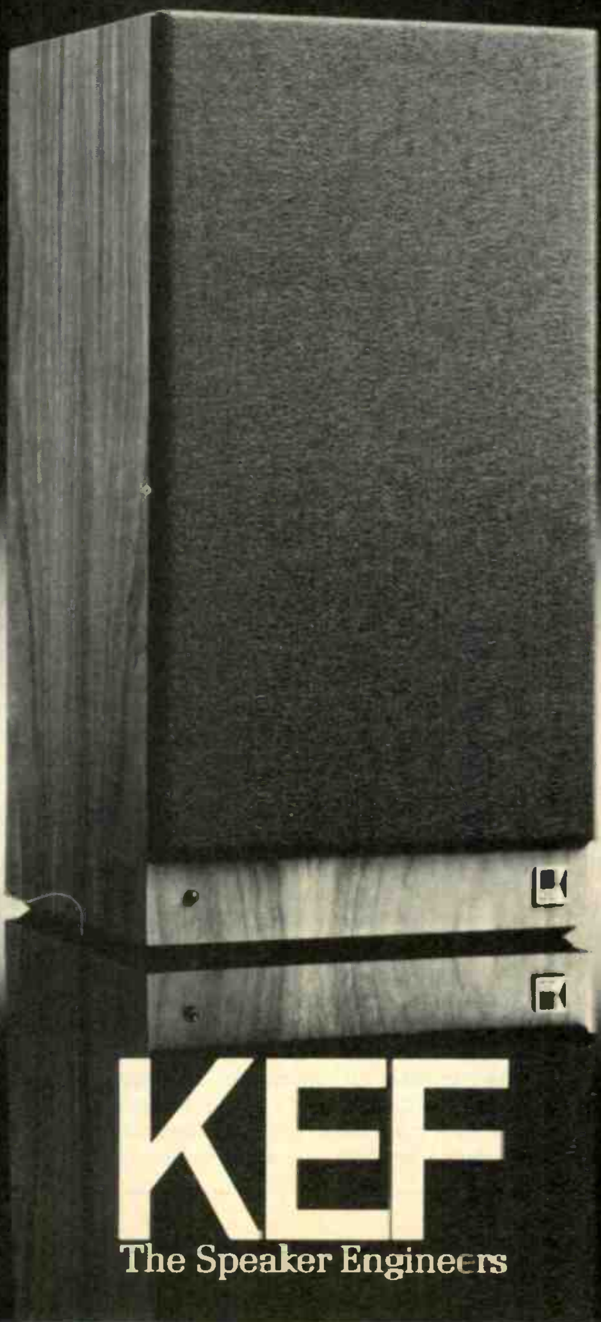
The result is a system which achieves broad frequency response with optimum efficiency, unsurpassed realism and clarity of reproduction.

Stereo Review summed it up . . . "If one were to consider only its size and appearance, it might be hard to justify the price of the KEF 103.2. However, judged (as it ought to be) *by its sound*, it appears to be a *very* good buy."

Contact your KEF dealer for a thorough demonstration. For his name and address, write:
KEF Electronics, Ltd.
c/o Intratec
P.O. Box 17414
Dulles Int'l Airport
Washington, D.C. 20041.
In Canada: Smyth Sound Equipment Ltd., Quebec.



S-STOP circuit



KEF
The Speaker Engineers

Enter No. 21 on Reader Service Card

down for $599.95 instead of the whopping $2995.00 of the original model.

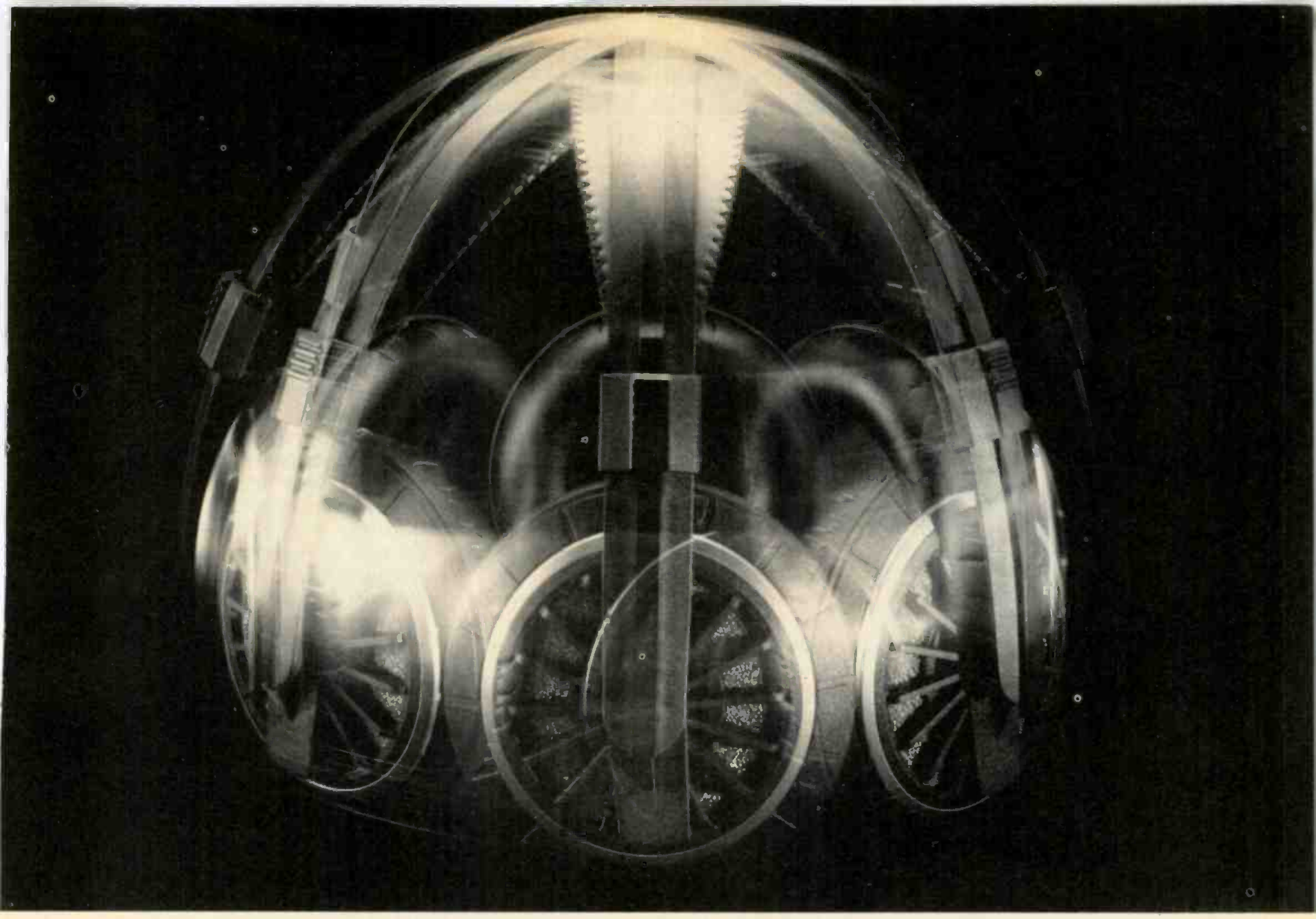
For many years the highly regarded British-made SME tonearms were distributed in this country by Shure Bros. I ran across Alastair Robertson-Aikman, the ever-debonair director of SME at the Show, and he informed me that after a very successful collaboration with Ortofon on a cartridge/arm interface, he had appointed Ortofon U.S.A. as sole distributor of SME products in this country. Those who are interested in 16-inch tonearms will be glad to know that SME has introduced an updated version of its classic arm design in that length.

Speaking of tonearms, no SCES would be complete without the introduction of some really exotic design. This year's winner is probably the Souther Equamass linear-tracking tonearm. The designer, Lou Souther, has produced a unique arm which is molded from epoxy resin and incorporates millions of tiny 0.0002-inch diameter hollow-glass spheres (with a specific gravity of 0.8) and a special aluminum tube 3/32-inch diameter. The total weight of the arm is 1.25 grams! Obviously, this is less than the tracking force of many cartridges. Then, on the back of the arm, Souther positions a counterweight, equal to the weight of the cartridge, at a distance from the horizontal pivot bearings slightly less than the arm's effective length. This enables him to set the exact tracking force for a particular cartridge. The arm is driven laterally across the record by the record groove itself, and ultra-low friction bearings are used. When this arm encounters a record warp and the stylus assembly starts its upward motion, it is met with a total mass just over twice that of the cartridge; for example, this could be 4 grams cartridge, 4 grams counterweight, and arm mass 1.25 grams for a total mass of 9.25 grams. Souther claims there is never enough up force generated to compress the cantilever assembly, and on the down side of the warp, the arm mass is so low that little or no inertia effect is produced. The stylus tracks the grooves perfectly, with no significant changes in tracking force, Souther claims. If you strike the turntable laterally from the side, the shock can cause the counterweight to oscillate left and right as much as a quarter of an inch, yet the stylus will not leave the groove! This super tracking ability is said to provide a much cleaner, more open and highly detailed sound than can be heard from conventional arms. This intriguing arm will be priced at $500.00.

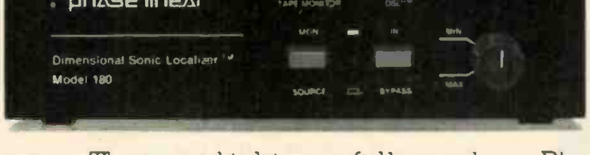
Dennesen was showing an unusual head amplifier for moving-coil cartridges called the Cetus, which is said to operate as a true differential-input transconductance amplifier, treating the moving-coil cartridge as a current source rather than a voltage source. It is said to be derived from a sensing amplifier in a computer's analog-memory system. The Cetus uses a matched pair of high-current thermally coupled transistors in its circuit. The unit is a.c. powered from a remote supply. There is a variable 2- to 120-ohms impedance-matching control, which also varies gain from 26 to 35 dB depending on the impedance. Frequency response is said to be 7 Hz to 250 kHz ±0.01 dB. Input overload is rated at one volt and output is 10 volts. S/N ratio is listed as 85 dB and rise time is a very fast 500 nanoseconds at 2 volts output. No price available.

Moving over to records to really give all this fancy phono gear a tough workout and a super sound source, Mobile Fidelity has introduced their UHQR (Ultra High Quality Record) series, which was developed in conjunction with JVC. It is a "spin-off" from JVC's work in videodisc technology. The UHQR records weigh in at approximately 200 grams, which is a helluva thick record. Points of superiority include channel separation 10 dB better than standard Mobile Fidelity records which use JVC CD-4 super vinyl. Intermodulation distortion is reduced to the theoretical limits of vinyl. Vinyl resonance has been removed from the audible range. S/N ratio is 10 dB better than standard Mobile Fidelity records. Groove depth on the UHQR can be 3 mils or more. Pressing cycle on UHQR is 2½ to 3 minutes compared to 50 seconds for standard Mobile Fidelity pressings. Only one press in the world is set up for UHQR product and Mobile Fidelity has exclusive rights to its use. The first three releases in the UHQR series will be Pink Floyd's *Dark Side of the Moon*, Supertramp's *Crime of the Century* and Earl Klugh's *Finger Paintings*. Only 5,000 pressings will be issued of each limited-edition title. If you really dig this music and you want these super pressings, they will set you back a rather breathtaking $40.00 each! Mobile Fidelity has stated they will not be sending out any review copies of these records. I can't tell you what these particular numbers will sound like, but I already have two UHQR discs with other program material, one a Mozart piano sonata simply stunning in its realism. There just isn't any surface noise, the frequency response goes way out, distortion is the lowest I have ever heard from a record, and volume level and dynamic range are overwhelming. An outstanding achievement, and if the oncoming digital discs mean the end of the analog LP, to paraphrase old Winnie . . . "this is their finest hour."

Many more audio products from the 1981 SCES next month.



HEAR 3-D WITH DSL.



For the first time, your headphones can fill the room with sound instead of just your head.

With the new DSL™ (dimensional sonic localizer to its creators at Phase Linear), you can hear a whole new dimension in sound.

With headphones, the DSL makes music seem to surround you. Front. Sides. And behind.

You'll hear a remarkable difference with your speakers, too. The sound is bigger, fuller and has more depth.

Your friends will probably ask if you've recently upgraded your system.

And while the DSL technology is straight out of the ozone, the price is agreeably down to earth at under $150.

Sound incredible? Wait until you hear it. See your local Phase Linear dealer for a demonstration. Or get in touch with the people at Phase Linear: 20121 48th Avenue West, Lynnwood, WA 98036, phone (206) 774-3571. Then hook the DSL into your system.

And listen to the difference.

Phase Linear®

The Professional Connection

Enter No. 28 on Reader Service Card

TAPE GUIDE

HERMAN BURSTEIN

Brush Strokes

Q. I am generally pleased with my cassette deck, except for one characteristic. Record warp so minor as to be unnoticed when playing a disc is "amplified" during the recording process to the extent that distortion makes the tape unplayable. I have tried various kinds of tape with no success. In order to get a good tape recording of a disc, the disc must be in nearly mint condition. How can I solve the problem? — John Holtzhauer, Dumfries, Va.

A. Your problem is not an uncommon one. It seems characteristic of some cassette decks that they are rather easily overloaded by a low-frequency signal of high magnitude. One possible solution that is quick and cheap is to attach a record brush to the cartridge shell. This *might* damp the warp signal, but of course you would have to increase the tracking force to compensate for the resistance of the brush. A similar but more expensive solution is to buy a phono cartridge with a built-in brush, such as the Shure V15 Type IV, which has a recognized ability to deal with record warp. Still another and possibly better solution is to interpose a subsonic filter between the tape output jack of your system and the tape deck. An example is the Ace Model 4000.

Poly-Saturation

Q. Is the danger of saturation one of saturating the magnetic material of the record head itself by boosting the highs with the equalization circuit? — D. Ohde, Weaverville, Cal.

A. In speaking of the danger of saturation in tape recording, the reference is usually to the magnetic coating of the tape. The problem arises chiefly in the treble range. Treble frequencies receive a good deal of boost in recording, particularly at the slower speeds, in order to overcome several kinds of losses. Up to a point, the amount of signal recorded on the tape is proportional to the amount of signal presented by the record head. But beyond this point, the tape tends to saturate so that the amount of signal recorded on the tape does not increase; in fact, the recorded signal level may even decrease.

A head of poor construction and/or poor materials may also saturate, although this is more likely at the low frequencies. On occasion, saturation may occur in the electronics owing to poor design. In sum, saturation can occur on the tape, in the heads, or in the electronics; most often it is on the tape.

Which Switch?

Q. I use CrO_2 tapes and notice that music sounds better when I set the tape selector switch of my deck to the "standard" position. I would like to know why. Also, is it harmful to the deck if I have the selector switch on "standard" when using CrO_2 tapes? — Scott Eldridge, Crailsheim, Germany

A. In the "chrome" position, the deck supplies more bass boost in playback than in the "standard" position. Accordingly, treble frequencies are depressed more (relative to, say, 1 kHz) in the "chrome" position. In the "standard" position, treble is depressed less, and the sound is brighter — which you apparently find pleasing. No harm is done.

A Definite Zero

Q. How do you define 0 VU recording level? — Jerry Pulice, Staten Island, N.Y.

A. The definition depends on whether you are using a peak reading device, such as a fluorescent bar or peak reading meter, or whether you are using an average reading device such as a true VU meter.

In the case of the VU meter, 0 VU corresponds approximately to the recording level which produces about 1 percent harmonic distortion on the tape at a frequency in the range of 333 to 1,000 Hz. Depending on the tape used, distortion may be slightly above or below the 1-percent figure.

In the case of a peak reading device, 0 VU corresponds to approximately 3 percent harmonic distortion, which is generally considered the maximum compatible with high quality results.

The difference between 1 and 3 percent distortion corresponds to about 6 to 8 dB difference in recording level. An average reading device, such as the VU meter, needs at least this much margin to compensate for the tendency of the meter to lag behind transients.

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

HOWARD ROBERSON

THE NEW CASSETTES: PERFORMANCE UPDATE

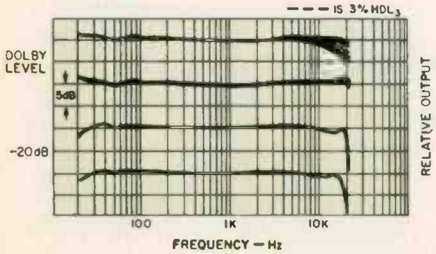
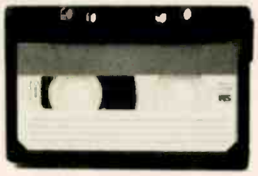


Fig. 1 — High-frequency losses with repeated plays vs. tape type and deck used. Top, Maxell UD-XL I-S on Nakamichi 582; second, Maxell UD-XL II-S on 582; third, Maxell UD-XL I-S on Aiwa AD-3600, bottom, Maxell UD-XL II-S on AD-3600.



This annual cassette tape survey covers 29 different formulations, 14 Type I (ferric/normal), nine Type II (chrome-type/high bias), two Type III (ferrichrome type), and four Type IV (metal particle). There are both new entries and up-dated versions of well-established products. Of particular interest were tapes from manufacturers new to the industry, such as Loran (from Loranger Manufacturing) and Osawa. The Audiophile's Choice and Direct-to-Tape Recording have products with the tape material itself made by others. Each of the manufacturers was requested to supply three each of both C-90 and C-60 lengths. Three samples allows checking the consistency of the product, and the second length gives an indication of possible performance shifts with a change in length by the user. Some of the manufacturers did not supply all the samples requested for one reason or another, but tests were conducted on whatever was supplied. Table I lists, to whatever extent supplied, the manufacturer's specifications and prices.

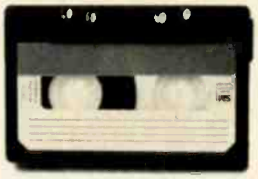
We had pretty well standardized our test scheme from past years' experience, but some recent events caused us to add some checks not run before. For one thing, it had been rather difficult to get consistent flutter data, so tests were run this year on a number of samples with three different-model tape decks. There had been some question raised as to the validity of making cassette tape tests on a particular deck which is not typical, such as the Nakamichi 582 which is the one used for such tests. A number of crosschecks were made on responses and maximum record levels with three other, "more-typical" decks to assess some possible discrepancies. Although the other-deck testing was not at all complete in comparison with the 582 tests, there was confirmation of all results in a relative sense for each of the cases investigated.

As in the past, responses were made with a swept-sinusoid source from 20 Hz to 20 kHz. To ensure that each of the responses shown was a true playback response, they were made by recording the sweep, rewinding the tape, and then plotting the response on playback. With a three-head deck, it is very easy to make such plots simultaneously while recording. Unfortunately, this method can give spurious results since there may be inter-head leakage or effects from bias leakage, or perhaps insufficient allowance for the time-delay effects among the record, playback, and plotter relationships. The UREI 200 plotting system used locks to the *frequency* of the playback signal, it is not dependent on *time* synchronization.

The swept responses were made at both Dolby level (200 nWb/m at 400 Hz) and 20 dB below that. In addition, an investigation was made of the possible losses at high frequency with repeated playings. I had planned to run some tests, primarily comparing CrO_2 and Fe Co formulations, based upon comments made by various people feeling that the CrO_2 tapes "kept their sound better." The interest in this particular facet was heightened considerably by letters to *Audio* from a reader, Edward F. McLain, Jr. Mr. McLain had observed high-frequency losses with repeated playbacks with one of his recorders, and he had conducted a fairly extensive series of tests to pinpoint the cause. It seemed a bit surprising that he was having this problem with a Type I tape; immediately, such a thing seemed more likely with an out-of-date cobalt-doped formulation. Mr. McLain very nicely provided copies of his own plots, and there was no doubt about the losses with repeated replays. A check among three decks on hand showed that there were similar losses with the Nakamichi 582 and the Aiwa AD-M700 decks, but no such losses with the Aiwa AD-3600. Figure 1 shows part of this comparison. Fifteen replays were made with each tape/recorder combination. Just the first, second, fifth, tenth, and fifteenth were plotted for UD-XL I-S and the 582 deck. All other traces are the results of 15 consecutive overlaid plots. The repeatability with the AIWA AD-3600 with either tape is quite evident. The AD-M700 deck was used to get the data on all tapes under test as

TABLE I — MANUFACTURER'S SPECIFICATIONS

BRAND OR MANUFACTURER	TAPE DESIGNATION	TAPE TYPE	COER Oer	RET Gau	SQU RAT	SENS dB	BIAS dB	PRICE C-90
Ampex	ELN	I						$3.29
Ampex	EDR	I						4.29
AudioMagnetics	Tracs	I				0.0		2.19
AudioMagnetics	High Performance	I				+1.5		4.49
Audiophile's Choice	20 to 20	I						3.25
BASF	Performance	I	325	1500	0.87	+1.0	+1.0	
BASF	Professional I	I	280	1600	0.85	+2.0	+0.5	
Direct	Agfa Super	I						3.50
Fuji	FL	I	370	1200	0.86	0.0	0.0	3.95
Fuji	FX-I	I	350	1500	0.88	+2.0	0.0	5.35
Loran	Normal	I	350	1500				7.65
Maxell	UDXLI-S	I	375	1700	0.89	+1.0	+0.3	6.99
Memorex	MRX-1	I				+0.8		
Realistic	Supertape Gold	I	335	1500				3.99
AudioMagnetics	High Performance II	II				+1.5		4.65
BASF	Professional II	II	370	1500	0.85	+3.0	+2.5	
Direct	Type II	II						4.50
Fuji	FX-II	II	600	1500	0.87	+2.0	0.0	5.55
Loran	High Bias	II	450	1400				7.95
Maxell	UDXLII-S	II	670	1700	0.89	0.0	+0.3	6.99
Memorex	HBII	II				+1.2		
Osawa	CR	II	530	1500	0.85	+1.5	+0.8	6.99
BASF	Professional III	III	250	1600	0.89	0.0	+1.5	
Osawa	FC	III	350	1400	0.80	0.0	+2.3	6.99
JVC	ME	IV	1080	3200	0.71	+2.0	+4.5	
JVC	ME-P	IV	1080	3500	0.73	+3.0	+4.5	
Memorex	Metal IV	IV				+2.0		
Osawa	MX	IV	1050	3500	0.80	+2.0	+4.4	



it could be set for automatic cycling of one playback after another. The output level of the 15-kHz playback was recorded on a strip chart for easy comparison among tapes and more accurate data reduction. There does appear to be some element here of pressure and/or tape tension, perhaps related to the magnetostriction and Curie-temperature properties of the formulation. We do not have a definite explanation for the reader on how this effect occurs. What we do report later is the 15-kHz loss for 10 replays on a *particular* deck. You may never experience this problem, but you will know that it is a possibility, and that it appears to be most likely with a Type I tape. Perhaps the tape and deck manufacturers will solve the problem and educate us all at the same time.

The maximum record levels were those where a 3% DL (distortion limit) was reached with harmonic distortion checks form 100 Hz to 2 kHz and twin-tone IM tests from 5 to 10 kHz. The signal-to-noise ratio was referenced to the 400-Hz DL, and IEC A weighting was used. Modulation noise checks used a 1-kHz tone at reference level, with the tone notched out and 500/1500 Hz bandpass filtering on playback. Data was taken on the sensitivity and bias of each tape, but the correlation to the manufacturers data sheets (were supplied) was not high. The bias figures obtained are reported as a guide — within a particular tape type — for possible high-frequency response shifts from changing a tape without readjusting bias. Remember that going to a higher bias tape will get boosted high frequencies, and going to a lower-bias tape will result in a loss of high frequencies, unless the original bias is changed to match the new tape. Skew was measured with pink noise and a 1/3-octave RTA and observing the effect on the high-frequency levels with turning the cassette over, after record-head alignment for the first side. A 3-kHz tone was used not only for the flutter checks, but for tests of output-level stability and dropouts.

Test Results

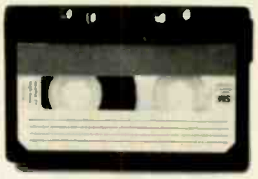
The great majority of the numerical data from the tests are listed in Table II. Take note of the fact that the tapes are listed alphabetically in type number categories. There are also frequency response plots for each formulation for both C-90 and C-60 lengths, if both were supplied. Also included on each of

TABLE II — TEST RESULTS

			RESPONSE AT -3 dB (kHz)		MAXIMUM RECORD LEVEL dB re 400-Hz Dolby Level						15-kHz 10-Play	S/N	MOD	
BRAND	DESIGNATION	Type	0 dB	-20 dB	HDL_3 = 3%				TT IM=3%		LEVEL†	RATIO	NOISE	BIAS
			Level	Level	100	400	1k	2k	5k	10k	dB	dBA	dB	dB
Ampex	ELN	I	9.6	22.2	+4.7	+5.5	+5.8	+5.0	+1.0	-7.9	-2.2	56.3	-47.7	-1.0
Ampex	EDR	I	9.7	21.5	+3.1	+3.4	+3.7	+1.9	-1.0	-8.4	-2.7	53.3	-49.2	-0.1
AudioMagnetics	Tracs	I	9.9	22.5	+1.5	+2.3	+3.1	+2.5	-1.3	-9.5	-1.6	53.3	-48.0	-0.7
AudioMagnetics	High Performance	I	10.9	25.6	+3.9	+4.8	+5.2	+4.2	-1.2	-8.7	-2.5	55.4	-45.8	-0.1
Audiophile's Choice	20 to 20	I	11.0	25.1	+4.2	+5.5	+6.8	+5.6	-0.2	-7.2	-1.4	56.0	-47.5	+0.1
BASF	Performance	I	9.6	26.3	+0.8	+1.5	+1.8	+1.6	-2.0	-8.5	-1.0	52.2	-44.3	-1.2
BASF	Professional I	I	11.7	25.0	+5.0	+6.0	+6.9	+6.0	+0.6	-7.1	0.0	55.2	-47.0	+1.3
Direct	Agfa Super	I	10.8	25.5	+4.0	+5.6	+7.8	+7.6	-0.4	-8.0	-2.2	54.3	-49.4	-0.2
Fuji	FL	I	10.1	24.2	+0.9	+2.3	+4.2	+3.1	-1.2	-8.5	-1.6	53.0	-47.4	-0.5
Fuji	FX-I	I	11.3	26.0	+4.1	+5.3	+6.4	+4.9	-0.1	-7.3	-1.4	57.2	-47.8	+0.4
Loran	Normal/Ferric	I	11.0	25.5	+3.7	+5.1	+6.8	+6.6	-0.6	-8.4	-1.2	55.5	-44.2	-0.6
Maxell	UDXLI-S	I	11.7	26.4	+7.1	+8.7	+10.0	+9.9	+0.9	-6.0	-4.5	58.2	-52.3	+1.0
Memorex	MRX-1	I	11.2	24.6	+6.7	+7.9	+8.2	+6.8	-0.3	-6.8	-3.5	58.6	-49.4	+1.0
Realistic	Supertape Gold	I	10.8	24.6	+5.4	+6.5	+7.3	+4.1	-0.8	-8.4	-1.4	55.9	-48.6	+0.1
AudioMagnetics	High Performance II	II	9.8	24.7	+1.4	+2.7	+3.4	+2.1	-3.5	-8.0	0.0	56.5	-50.4	+0.3
BASF	Professional II	II	9.8	24.0	+4.5	+5.7	+6.2	+3.4	-4.0	-8.5	0.0	62.0	-50.7	+1.3
Direct	Type II	II	9.2	23.0	+4.3	+5.5	+5.1	+2.2	-4.8	-9.4	-0.2	59.4	-49.7	+0.8
Fuji	FX-II	II	9.9	24.3	+1.2	+2.5	+3.2	+2.0	-5.5	-9.5	-0.2	56.0	-51.0	+1.3
Loran	High Bias/Chrome	II	7.5	26.2	+2.9	+4.9	+2.1	-0.1	-7.4	-10.2	0.0	59.8	-45.5	+1.5
Maxell	UDXLII-S	II	10.8	24.2	+4.1	+5.4	+6.0	+4.3	-3.0	-8.4	-0.1	58.0	-49.6	+1.5
Memorex	HBII	II	11.1	24.7	+3.6	+5.4	+6.7	+4.4	-3.4	-8.4	0.0	58.3	-51.2	+1.9
Osawa	CR	II	10.0	25.2	+1.9	+3.4	+4.8	+1.8	-5.5	-9.7	0.0	56.1	-51.3	+0.5
Realistic	Supertape Chrome	II	9.1	23.5	+4.0	+5.0	+4.8	+1.9	-5.4	-9.7	-0.6	59.4	-47.8	+0.8
BASF	Professional III	III	5.0	26.4	+5.3	+7.3	+4.3	+0.4	-6.7	-10.5	-1.0	62.0	-45.2	+2.6
Osawa	FC	III	6.8	24.8	+2.0	+3.8	+4.8	+1.7	-5.8	-10.8	0.0	57.6	-51.4	+1.9
JVC	ME	IV	13.2	24.2	+7.9	+9.3	+9.9	+7.2	+1.0	-4.2	0.0	60.4	-47.0	+4.3
JVC	ME-P	IV	14.0	25.1	+7.3	+8.8	+9.7	+8.0	+1.3	-3.5	-0.2	59.2	-49.0	+3.4
Memorex	Metal IV	IV	14.9	25.1	+9.4	+11.3	+13.0	+8.7	+2.4	-3.3	0.0	62.1	-50.3	+4.6
Osawa	MX	IV	14.1	25.9	+8.3	+10.0	+10.7	+6.5	-0.3	-5.0	0.0	61.2	-51.9	+6.1

†See text.

C A S S E T T E S



these figures is the 3% DL (distortion limit — harmonic or twin-tone IM) from the MRLs for the C-90 (for the C-60 only if no C-90 was supplied). These maximum record levels (in dB in Table II) are referenced to the 400-Hz record level for 200 nWb/m in playback. The actual output levels will be different to the extent there are response variations from flat and compression because of the high levels. Below there are additional comments on each general type and on each specific formulation.

Type I

The general impression of these tapes was that there had been a general improvement in the quality of what was available. This was particularly noticeable in better output-level stability and lower skew. The losses at 15 kHz with repeated plays (on the test deck) were pretty much restricted to this type, although there was quite a range of losses from one tape to the next. A number of cassettes had excellent performance in all respects.

Ampex ELN: The frequency responses of this new formulation were quite smooth and extended, and could have been made more so with a slight decrease in bias. It had average performance for the group (a good one) in other areas. There was slight skewing on some samples, and it varied with time. The output-level stability was good, and the occasional dropouts just approached the audibility threshold. Flutter and the 15-kHz play loss were average, for all of the cassettes tested.

Ampex EDR: The performance of this formulation was very close to that of ELN, and slightly less bias would have extended the EDR's responses as well. The MRLs were a little on the low side for current cassettes. Flutter was slightly less than average, but the 15-kHz play loss was above average. Output level stability was excellent, one of the best measured. There were *no* dropouts during the test period, and the maximum perturbation was only 0.5 dB.

AudioMagnetics Tracs: This tape was not quite average in performance for the group, but its low price could make it appealing for a number of uses. Flutter was average, and the 15-kHz play loss was less than average. There was very little skewing in any of the samples, including the C-60s. The output level stayed fairly constant (within 0.4 dB), and the few dropouts never approached the audibility threshold.

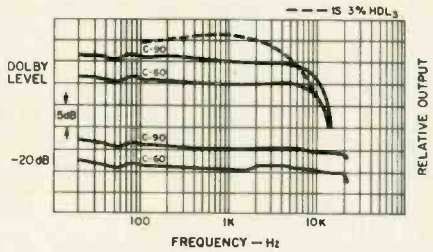
AudioMagnetics High Performance: The performance was good in most respects, with nice responses and good MRLs. There was very slight skewing on some of the samples, not enough to be detrimental. Bais needs for the C-60s were slightly less than for the C-90s, generally true for most of the tapes tested, a minor effect at the highest frequencies. Flutter was just slightly above average, and the 15-kHz play loss was above average. There was an occasional 0.3-dB wander in the 3-kHz output level, quite minor. There were few dropouts of very small amplitude.

Audiophile's Choice: This brand is new to the test program, and the results indicate quite a good product for its fairly low mail-order price. The 15-kHz play loss was less than average (for Type I tapes), but flutter was higher than most. The MRLs and S/N ratio were good, and the output-level stability was within 0.3 dB peak-to-peak. Infrequent dropouts were just to the audibility threshold.

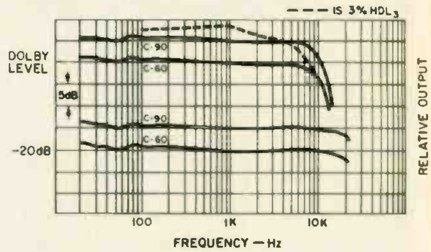
BASF Performance: The responses were good with this formulation, but the MRLs were among the lowest for the Type Is, and noise was rather high. Skew was very small among all of the samples, including the C-60s. The output level remained steady; there were a fair number of dropouts, but they were of limited depth. Flutter was average. The 15-kHz play loss was less than average.

BASF Professional I: This is one of the better Type I cassettes with good responses and high MRLs. The output level stability was fairly smooth, although there were some dropouts approaching the audibility threshold. There was just a

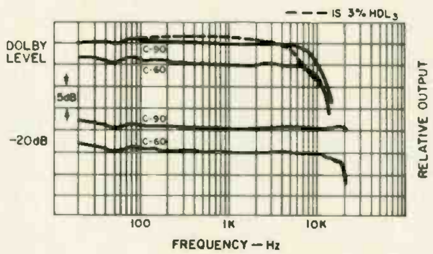
TYPE I



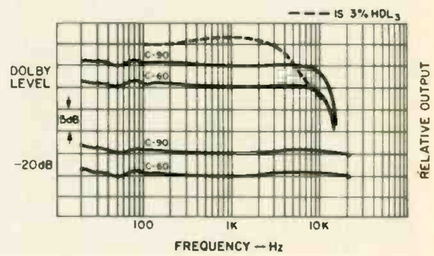
Ampex ELN



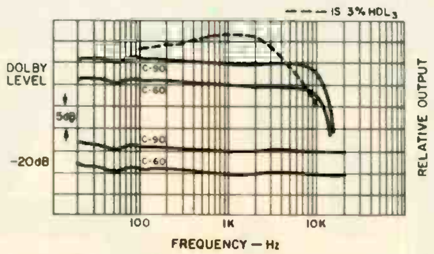
Ampex EDR



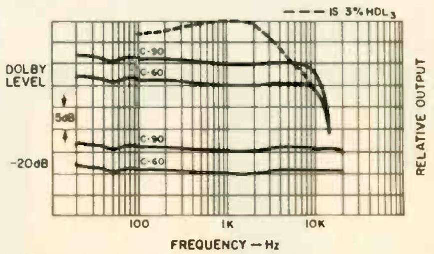
BASF Performance



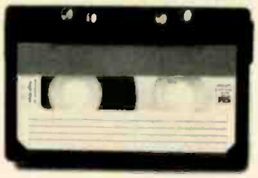
BASF Professional I



Loran Normal



Maxell UD-XL I-S



little skew with some of the C-90 samples, even less with the C-60s. Flutter was average. There was *no* 15-kHz replay loss, a possible advantage to owners of high-tension (?) decks.

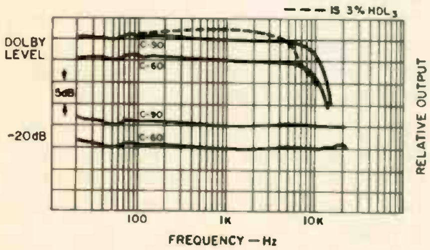
Direct Agfa Super: In general, this relatively low-priced mail-order offering delivered above-average performance. Responses and MRLs were really quite good. On the other hand, there was noticeable skew at times, actually affecting the response plots. There was some wandering in the output level, but it usually kept within 0.5 dB overall. Dropouts were infrequent and of low amplitude. The 15-kHz play loss was above average, but flutter was very slightly lower than most.

Fuji FL: The responses were quite good, but the MRLs were lower than the average for Type I. There was some skew with the C-90s, substantially none with the C-60s. Flutter and the 15-kHz play loss were both a bit less than average. The output level was stable within 0.3 dB, and there were few dropouts, none of any significance.

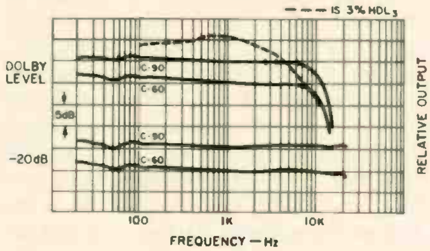
Fuji FX-I: One of the better Type I tapes with excellent responses, good MRLs, and a high S/N ratio. Skew was very low on all samples. C-60 bias was very close to C-90 bias (most showed more difference). The output level was very stable and smooth, and there were no dropouts. Flutter and the 15-kHz play loss were both somewhat lower than average.

Loran Ferric/Normal: The products from Loranger Manufacturing are of interest not just because they are newcomers to the industry. Their cassettes are the most expensive in their respective type categories, which has to raise more than a few eyebrows. *Everyone* claims a quality product, of course, but Loranger literature is quite emphatic on this point. Their most salient feature for many will be their use of Lexan for the shell, with claims of greatly superior thermal stability. The tape itself showed good responses and MRLs, but the modulation noise was the highest of all tapes tested. There was some skew, more so with the C-60s. There appeared to be a shifting of bias needs with time, but this might have been confused by skew problems. The output level was stable, and all dropouts were less than half way to the audibility threshold. Flutter was about average. The 15-kHz play loss was less than average.

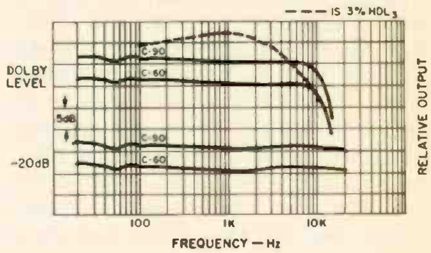
Maxell UDXLI-S: Once again, one of the UD series sets the standard for others to follow. Smooth, wide responses, very high MRLs, the lowest modulation noise of all tapes tested and next to the best



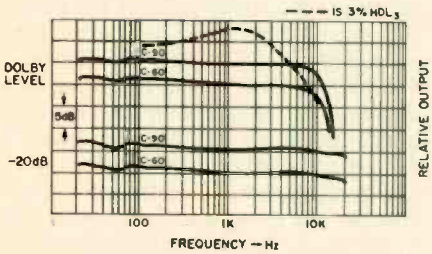
AudioMagnetics Tracs



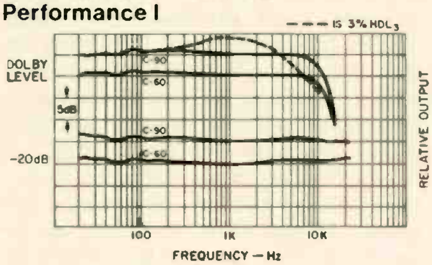
AudioMagnetics High Performance I



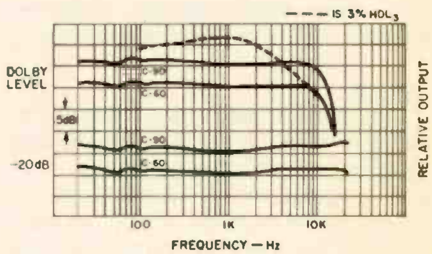
Audiophile's Choice 20 to 20



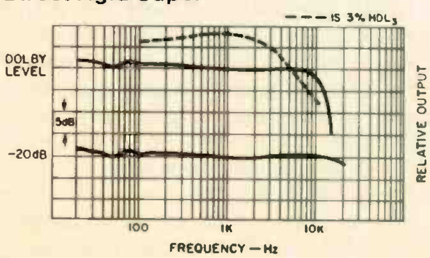
Direct Agfa Super



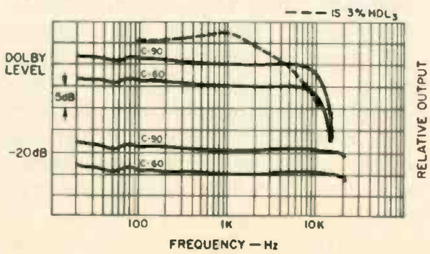
Fuji FL



Fuji FX-I



Memorex MRX-1



Realistic Supertape Gold

S/N ratio. In addition, there was no skew observed in any of the total six samples. The output level stability was excellent, and there weren't really dropouts, just infrequent perturbations to −0.8 dB *maximum*. The flutter was less than average. On the other hand, the 15-kHz play loss was the greatest of all of the tapes tested, and it appeared that additional plays would have brought additional loss.

Memorex MRX-1: The tests were conducted on C-60s only, as the manufacturer did not supply C-90s. The responses were wide, the MRLs were very high, and the S/N ratio was the highest for Type I tapes — in other words, one of the best of the tapes tested. There was very little skew in any of the samples. The output level stability was quite good. Although there were observable dropouts quite frequently, none of them reached the audibility threshold. Flutter was slightly less than average. The 15-kHz loss with repeated plays was much higher than most.

Realistic Supertape Gold: The test results of wide responses and high MRLs puts this Radio Shack product into the category of one of the better Type I tapes, with a price that is certain to increase its appeal. There was less than average loss in the 15-kHz replay tests, but there was noticeable skew, which can result in high-frequency losses. Flutter was average. There was some variation in the output level, but it was always less than 0.5 dB overall. There were many small-amplitude dropouts, but none observed of any significance.

Type II

As the Type I tapes have continued to improve, there has become less and less difference between their overall performance and that of the Type II tapes. Of course, there are good and bad in each category, but there are some criteria we can consider in making any comparisons. First of all, an examination of the results table and the Type I and II response plots will reveal that from the standpoint of responses and MRLs, the Type Is are just as good, or even better than the Type IIs with the test deck used. Note specifically that the Type II MRLs are lower than the Type I's until 10 kHz. Some of the Type II S/N ratios are better, but Maxell UD-XL I-S and Memorex MRX-1 are better than many Type IIs, including their own corresponding products. (The 70-μS EQ, however, gets lower noise in the high-frequency region.) It is at least interesting to note that the falloff in the DL (or MRL) curve is similar in slope and level at 10 kHz for all Type I, II, and III tapes. Type IV tapes have similar DL-curve slopes, but the 10-kHz point is higher. We are not certain of the significance of the many possible contributing factors, such as equalization, properties of the pigments, head design, etc. We can see that if this curve is accepted by the tape user as a practical limit because of distortion, the Type IIs would offer limited advantage over the Type Is, which offer higher distortion limits at lower frequencies. The exception, of course, is the lower tape noise with 70-μS EQ. It should be noted that a number of tests were run using other decks than the test Nakamichi 582, and the Type I and II MRL results were generally the same.

BASF and others have not joined the ferri-cobalt bandwagon and emphasize that they believe that CrO_2 is the superior material. In the Type II plots that accompany this section, the tapes using CrO_2, *except* BASF Professional II, can be characterized as having considerable loss in level with increasing frequency, particularly at Dolby level. There may be less total difference between highs and lows at −20 dB, but the final rise at the highest frequencies causes of a saddle-like response. There did appear to be some rise in the low end with the 582 for all tapes, but it was less than a dB at 100 Hz most of the time. Tests were run with four other recorders, and the responses were almost exactly the same. Perhaps there are decks which will deliver flat responses with these tapes, but none of the five decks tried would do so. Good Dolby system performance requires flat responses, so there may be problems in the use of a tape with a response saddle (or mound).

AudioMagnetics High Performance II: Fairly good responses and moderate MRLs give the tape a fairly good Type II rating. There was very low skew among all of the samples. There was no 15-kHz play loss, but flutter was higher than most. The general output-level stability was good, but there were many dropouts up to the audibility threshold. The sample passed all of the functional tests.

BASF Professional II: This true chrome tape had among the highest MRLs, and the S/N ratio was the highest for the Type IIs. The responses were excellent in notable contrast to the other CrO_2 tapes. Overall, this is one of the best Type II tapes. There was no skew among all of the samples, except for one short period during test. The output-level stability was excellent, and any of the dropouts were very limited in amplitude. There was no 15-kHz play loss. Flutter was below average.

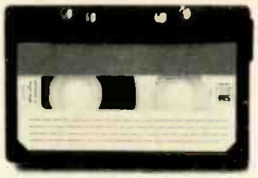
Direct Type II: This mail-order tape compared most favorably with others, showing good responses and MRLs, low modulation noise and a high S/N ratio, as well. There was considerable skewing with both lengths, but there was very little 15-kHz play loss. Flutter was slightly above average. The output level was constant on the average, but there were some rapid fluctuations up to about a dB p-p. There were many dropouts, but only occasional ones approached the audibility threshold. There were no Type II sensing holes, which prevents use on some machines.

Fuji FX-II: The responses were good, and the modulation noise was low, but the MRLs and the S/N ratio were moderate. There was very little skew or loss in 15-kHz playback. The output level was very steady, and there were only a few fluctuations of limited amplitude that might have been called dropouts. Flutter was average.

Loran High Bias/Chrome: This is the other Lexan-shell cassette introduced by Loranger, and it also includes the handy built-in, rotatable erase-prevention tabs — easily set for "safe" or "record." The manufacturer states that there is a double layer, ferric oxide for "low-end boost" and CrO_2 for "high-end boost." As the plots show, the middle, unfortunately, gets left out, and there is a noticeable loss in highs at Dolby level. The S/N ratio is high, but so is the modulation noise. There was substantially no 15-kHz play loss, but there was a little effect on the highs by occasional skewing. Flutter was average. There were minor wanderings of the output level, probably undetectable. There were many dropouts, occasionally up to the detection threshold, very rarely over.

Maxell UD-XL II-S: This is one of the best Type II tapes with wide, flat responses, high MRLs and S/N ratio and low modulation noise. There was no skew ob-

C A S S E T T E S



served in any of the samples of both lengths, and the measured 15-kHz play loss was close to zero, 0.1 dB. There was a little roughness in the output, but the average level was stable. There were quite a few dropouts, although none approached the audibility threshold. The flutter was slightly better than average. The cassette passed all of the functional tests.

Memorex HBII: This new formulation immediately showed itself to be one of the best of the type IIs, smooth and wide responses, high MRLs and S/N ratio, and very low modulation noise. Skewing was slight, and there was no 15-kHz play loss. Flutter was very slightly above average. The output had a 0.4 dB bump every three seconds, and the dropouts were fairly frequent although none were deep enough to be detectable. There were no Type II sensing holes.

Osawa Cr: The manufacturer states that the tape is a dual-layer *cobalt-doped* ferric. Cobalt-doped tapes in the past have not been that good, but this formulation performed quite well in all respects, including zero loss with 15-kHz playback. There was close to zero skew among all of the samples. The output level was very stable, and there were substantially no dropouts. Flutter was average.

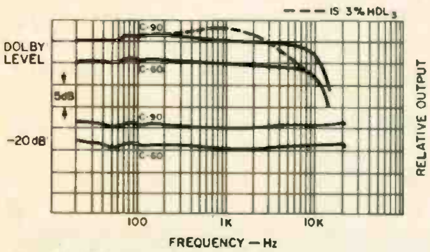
Realistic Supertape Chrome: For the most part, this tape would be classified as one of the better Type IIs. MRLs were quite good, and the S/N ratio was quite impressive. Skew, however, was erratic at times, and rapid variations in level in the 15-kHz play tests required some guessing at levels. Flutter was very slightly below average. The output level was stable on the average, but the fast analyzer scan to check for dropouts showed many rapid variations up to 2 dB. Fortunately, only rare ones got to the 3-dB detection threshold.

Type III

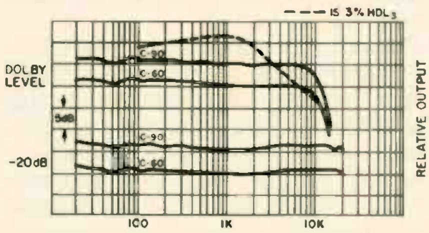
There are very few Type III cassettes being manufactured, and a number of decks do not have provisions to use them. In general, they have shown various performance limitations in the past, poor high-frequency headroom, a saddle-like response at lower levels, and poor amplitude stability. Lately BASF has been promoting their Professional III for car use, and they could work reasonably well for that.

BASF Professional III: Good MRLs at low frequencies, but more limited at high frequencies and high levels, causing a considerable slope in the response at Dolby level. The results shown were checked on other recorders, and they showed as much or more discrepancy between the

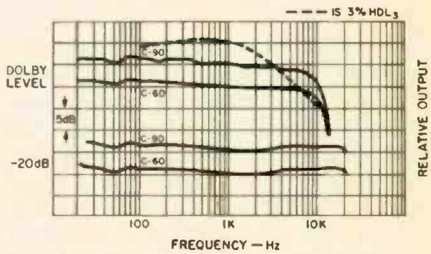
TYPE II



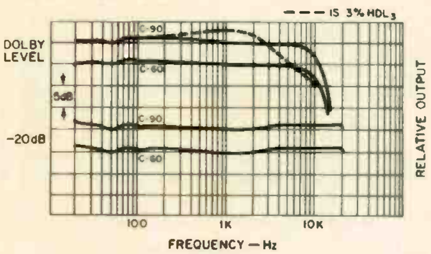
AudioMagnetics High Performance II



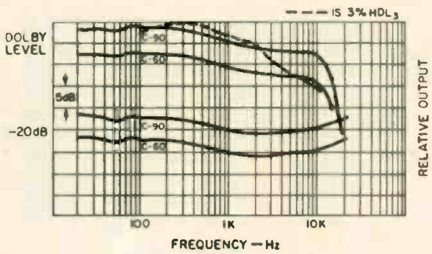
BASF Professional II



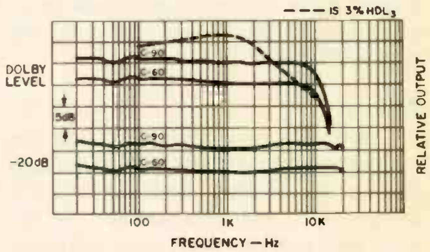
Direct Type II



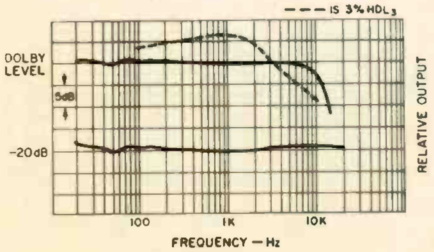
Fuji FX-II



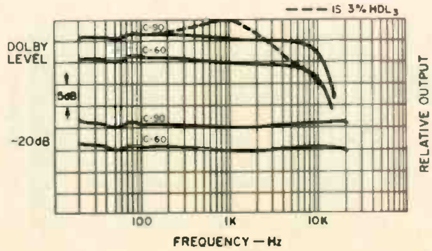
Loran High Bias



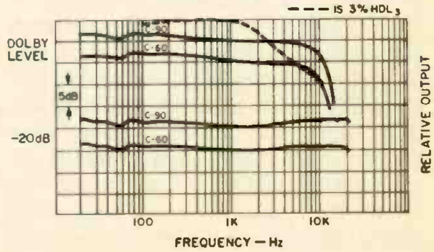
Maxell UD-XL II-S



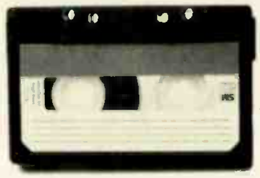
Memorex HBII



Ōsawa CR

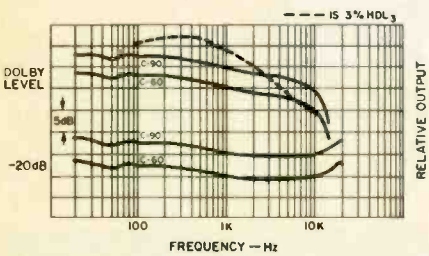


Realistic Supertape Chrome



200-Hz and 2-kHz levels. The S/N ratio was high, but so was the modulation noise. There was very low skew, and there was relatively little 15-kHz play loss. Flutter was below average (better). The output level was constant over a period of time, but there were many rapid variations revealed in a fast analyzer scan up to a dB, with occasional dropouts up to the detection threshold.

TYPE III



BASF Professional III

Osawa FC: This is another dual-layer formulation from this manufacturer, and it showed less of the response deviations of the typical FeCr. There still was limited high-frequency headroom, however. There was very little skew in any of the samples, and there was no 15-kHz play loss. Flutter was average. The output level showed some cycling, but it was limited to a total of only 0.3 dB. There were quite a few small-amplitude dropouts, none of them even close to the detection threshold.

Type IV

Each year other manufacturers join the metal tape suppliers, JVC, Memorex and Osawa this year. Because only one sample each was received for the two JVC and the one Memorex forumulations, the results must be considered as tentative. It is impossible, of course, in these cases to make any statements concerning consistency. Along with other types, metal tapes have been getting better in the areas of amplitude stability, skew, and dropouts. Some readers had written about certain problems in consistency, including loss of pigment on guides, rollers, etc. Perhaps there was some sort of tape/deck interaction in one reported case of shedding. My own checks of the same tape with 25 plays per cassette showed absolutely no deposits. Each reader, however, should draw his own conclusions from what happens with his own tape/deck combination.

JVC ME and ME-P: The responses for these two excellent tapes are shown in the same figure, and slight adjustments in bias could have made them look just the same. Small differences appear in the table of results, but with just one sample each, there was no proof of which was the better — they both were excellent in every way with the exception of some output level wandering (within a dB) and dropouts up to the audibility threshold.

Memorex Metal IV: This metal-particle entry from a long-time manufacturer of tapes showed smooth, wide responses, very high MRLs and S/N ratio, and low modulation noise. There was substantially no skew in the one sample, and there was no 15-kHz play loss. Flutter was average. The output level stability was good, and there were no significant dropouts.

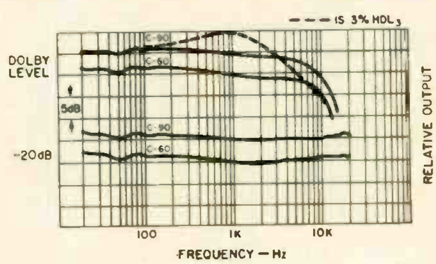
Osawa MX; This formulation gave another demonstration of the wide responses, very high MRLs, and high S/N ratio that go with metal tape, along with low modulation noise. There was no skew observed in any of the samples, and there was no 15-kHz play loss. Flutter was average. The output level stability was excellent with variations limited to 0.3 dB. With the analyzer in fast scan—looking for dropouts—the output level was just as smooth most of the time, with just infrequent and sporadic dropouts almost to the detection threshold.

Summary

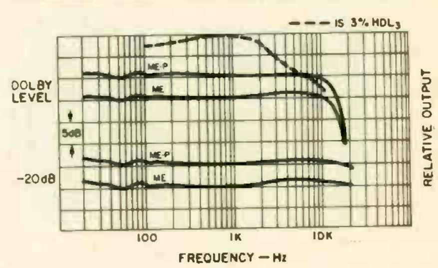
The general quality of cassette tapes is improving, and a number of those tested this year evidence that fact. Improvements in decks, of course, have been part and parcel of the increasing fidelity possible in the cassette format. Type I tapes offer excellent performance, although this year's tests indicate the possibility that some formulations might have high frequency losses with repeated plays on *some* decks.

For Type II in general, ferricobalt tapes gave better frequency responses than did CrO_2 on all of the decks tried, but BASF Professional II was a definite exception. There may be decks which are better matched to the non-BASF CrO_2 tapes, however. Type III formulations are still appearing, but the responses remain mediocre at high *and* low levels. Each new Type IV (metal) tape that is introduced provides another example of a noticeable raising of the DL/MRL curve in the high-frequency region, compared to other types.

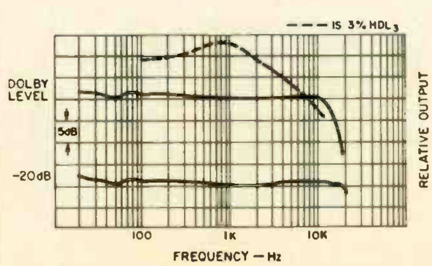
TYPE IV



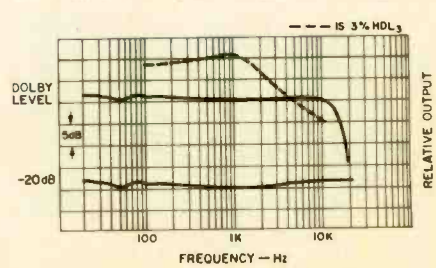
Osawa FC



JVC ME and ME-P, ME-P 3% DL



Memorex Metal IV



Osawa MX

IT DOESN'T COST ANY MORE TO OWN A BANG & OLUFSEN CARTRIDGE.

One of the most prestigious names in audio offers a remarkably affordable way to improve your stereo system. Bang & Olufsen MMC cartridges.

Their audibly superior innovations will now fit virtually all of today's better tonearms.

MMC, Separation and Imaging.

What is MMC? It's the patented Moving Micro Cross* armature found in all five Bang & Olufsen cartridges.

This MMC keeps each channel on its own axis so you'll hear exceptionally accurate stereo separation, depth and realistic stereo imaging.

The manner in which these cartridges pinpoint the placement of individual instruments is uncanny. One audition will convince you.

Longer record life.

It's a result of our extremely low Effective Tip Mass (ETM). How we achieve it is an engineering story in itself. But the low ETM of our stylus assemblies means much longer record life and better tracking even on "hopelessly" warped records.

A cantilever made of a solid, single crystal of sapphire.

You'll find it on the remarkable MMC-20CL. Why sapphire? Because it has very low mass yet is 21% more rigid than beryllium and 500% more rigid than aluminum commonly used in other cartridges.

Model MMC 20 CL
with Universal Adapter.

This rigidity virtually elminates any distortion-causing vibration within the cantilever. Every subtle movement of the stylus tip is translated into transparent, uncolored sound and musical detail.

Audition them for yourself.

Hear for yourself why the critics respect our MMC cartridges. Bring in your favorite records to a select audio dealer and learn how for the price of a fine cartridge... you can own a Bang & Olufsen.

For more information, write to:

Bang & Olufsen

Bang & Olufsen of America, Inc.
515 Busse Road
Elk Grove Village, Illinois 60007

*Moving Micro Cross is a registered trademark of Bang & Olufsen.

Enter No. 6 on Reader Service Card

HOWARD ROBERSON

FOCUS ON SHELL MECHANICS

Fig. 1 — TDK's new Metal Alloy audio cassette comes housed in a Reference Standard mechanism/shell. (Photo, courtesy TDK.)

At least once a year, *Audio* tests a number of the latest cassette tape formulations. The effort is concentrated on electrical performance, such things as frequency responses and maximum record levels. It has been a regular practice to check flutter and skew effects, but we have not taken a detailed look at the mechanical inter-relationships that are involved. This article delves into such questions as: Is there such a thing as a low-flutter cassette? Does it make a difference which deck is used? Do all tapes skew? What should I look for in a cassette if I want good mechanical performance? Are some cassettes more reliable than others?

Even with just a cursory examination in the course of buying tapes, you may have noticed that there is a great deal of difference in the way that the various manufacturers package the product. This can be more important than it might at first seem. To minimize the possibility of getting harmful dust on the tape itself, the package should be sealed in some sort of plastic wrap. The little tab seal used by a few manufacturers will assure you perhaps that the tape has not been used by someone else, but the openings in the typical cassette box can allow a lot of dust to enter. After opening the package (a pull tab is a worthwhile convenience), follow good practice in keeping the cassette in the box when not actually being played. Do not store any tapes in dusty environments. If you must do so, try some of your own plastic protection, or stick to cassettes with better quality

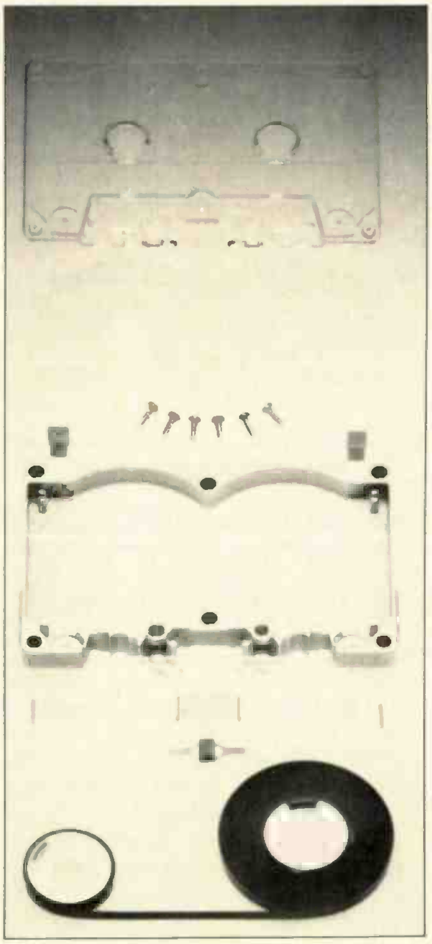


Fig. 2 — Disassembled Reference Standard mechanism. (Photo, courtesy TDK.)

boxes with tighter closures. The new Memorex boxes provide better sealing from dust than the older standard-design ones do.

If you have purchased a number of different tape formulations, you will have learned that manufacturers do not agree on what makes the best label. We're not going to dig deeply into this question, but there are a few things to keep in mind. First of all, is there enough space to write in the necessary identification? Some labels are so small, you might need to use some sort of code or abbreviations. What can you write on the label with? Best of all are those which will accept almost anything, but some require a ball-point pen, making changes very difficult. Some cassettes have extra press-on labels, which is a definite help. Take a look at the outside card while you're at it: Some are good, and some have failings similar to those discussed for labels. Now that we've talked about the wrappings and labels, it's time to take a closer look at the cassette shell itself.

Figure 1 shows the assembled TDK MA-R cassette, the most sophisticated design currently available. It is also relatively expensive, of course, so it is not surprising that most other assemblies are less impressive. The great majority of the premium cassettes sold have plastic half shells which are held together with screws. There are just a few that are sonic welded together, and their manufacturers feel that sonic welding can do just as good a job as screws. It is true that screws must be torqued correctly to hold firmly, but not so tight as to introduce unwanted stresses. It is also true that most of the really cheap cassettes are sonic welded, and that the cassette shells which are most nicely finished are all held together with screws. It is possible, of course, for a manufacturer to use more than one quality of shell and mechanism in its product line. TDK actually uses four, the Reference Standard Mechanism for MA-R tapes, the Laboratory Standard Mechanism for MA and SA-X tapes, the Super Precision Mechanism for SA, OD and AD tapes, and the Precision Mechanism for D tapes. We can't say that this is just the way to do it, but there is a great deal of sense in using a higher quality mechanical assembly to go with higher quality formulations.

To aid in the discussion of design requirements for the assembly, let's examine Fig. 2 which shows a disassembled Reference Standard Mechanism. In the center is the die-cast metal frame which must, and does, provide rigidity and stability, accurate outside dimensions and good finish, good support and accurate location for other components to be mounted in the frame, and parallel sides for mounting the cover plates. The cover plates must be flat with some rigidity and accurately dimensioned. The assembly of these two components has to provide the basic inside space for tape storage and guidance. There are two static-free slip sheets for low-friction restraint of tape wander during play or wind. Now, a cassette shell that is made out of plastic should meet the same basic criteria, accurate dimensions, rigidity, stability, etc. Carefully examine the cassettes you are using for surface smoothness, traces of plastic flash, resistance to bending or twisting, etc. Don't try to find their stress limit, but you may be able to weed out some questionable tapes.

When the tape pack is set into the shell, it is threaded over guide pins at each end and then over guide rollers, passing in front of additional guide pins, the tape pressure pad, and the mu-metal magnetic shield. For good mechanical performance, there are criteria that the tape pack itself must meet. The width must be constant, the slitting must not cause any deformation of the edges, the cutting must be a perfectly straight line, with no skew introduced, and the leader must meet the same criteria. As a fast check of the cassettes you have, look at the surface of the tape at the edge of the cassette. It should be perfectly flat and smooth. Any cupping or rippling might cause a range of tape problems, dropouts, changing levels, high flutter, and its getting wrapped around the capstan. It comes down to this: To get the most out of the tape, it must remain in intimate contact with the heads — easy if its own surface is flat (except as shaped to the head), impossible if its own surface looks like a badly misaligned tire.

The tape must be fastened to the hubs, and yet the hubs must not introduce any bumps as the tape winds on. The hubs must also be accurately round and concentric with the hub-drive opening. All the stationary guide posts must be perpendicular to the shell-frame reference plane. Their surfaces must be long-wearing and must not damage the tape in any fashion. The guide-roller surfaces must be smooth (TDK states "seamless"), concentric with the bearing pin (stainless steel preferred) and with flanges that guide and control tape wander without causing any edge damage. The magnetic shield should be accurately positioned behind the pressure pad. There are different approaches to the design of the pad and its support. Do check to see that the pad surface is flat to the tape and not misplaced crosswise. It is impossible to check out the internal construction of a typical plastic-shell cassette, unless you take it apart. Perhaps if all that is not worthwhile, you would want to check what the manufacturer claims he has done to make his cassette a good one mechanically. If the

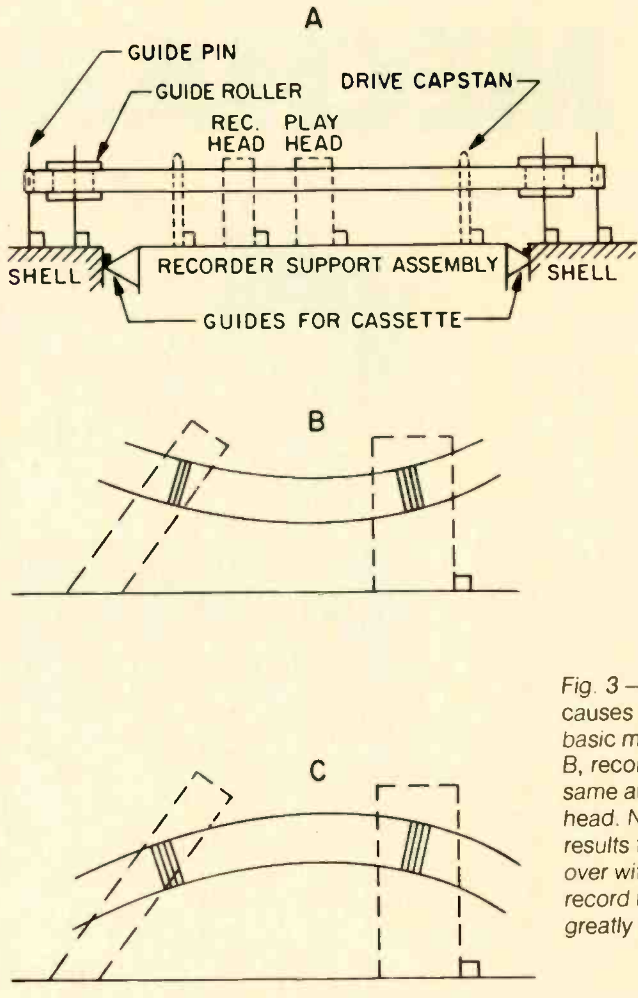


Fig. 3 — How tape skewing causes alignment errors. A, basic mechanical interface. B, record head adjusted for same angle with tape as play head. Note skewing tape. C, results from turning cassette over without readjusting the record head. The effects are greatly exaggerated for clarity.

1939...FIRST DIRECT-DRIVE TURNTABLE.
1951...FIRST MOVING-COIL CARTRIDGE.
1972...FIRST DIGITAL (PCM) RECORDING.

It has become common practice in the audio industry for a manufacturer to produce a "flagship" for the line. Sadly, however, the everyday products derived from this flagship often are similar in little more than appearance.

The "flagship" marketing approach may make a company grow, but good marketing doesn't make good sound. Denon wants to grow, too, but we will never abandon our quest for uncompromised product excellence. The two fine new products pictured on this page should serve as audible proof.

For Denon, the only way to get bigger is to keep getting better.

1981...THE DENON ADVANCED ENGINEERING SERIES: PRA-2000 NON-NFB REAL-TIME EQ PREAMPLIFIER POA-3000 180W/CH. CLASS-A POWER AMPLIFIER

In the audio industry's electronics race, manufacturers are constantly equipping their new models with new features and new technologies—as if, by wishful thinking, these would automatically yield superior sound quality.

At Denon, technology serves sound, not sales. The Non-Feedback Real-Time Equalizer and Direct DC Servo circuitry of the PRA-2000 reduces TIM distortion to 0.003% and IM distortion to 0.002%. The Real-Bias Class-A operation of the POA-3000 for the first time combines the acoustic benefits of Class-A (elimination of crossover and switching distortion) with high power and high efficiency. The POA-3000 delivers 180 watts per channel (20Hz to 20kHz at less than 0.003% THD) without the bulk and heat generation normally associated with Class-A.

Above all, the sound quality of these new Denon separates has instantly placed them at the top of their classes in the opinions of music lovers and "over-" and "underground" reviewers alike.

The Denon PRA-2000 Preamplifier and POA-3000 Power Amplifier. Two uncompromised new musical instruments from the company where innovation is a tradition.

DENON

Imagine what we'll do next.

Enter No. 14 on Reader Service Card

Denon America, Inc.
27 Law Drive, Fairfield, N.J. 07006

edge of the cassette mates poorly and is not straight and smooth across, you should be suspicious of any claims for internal excellence. The key words are smooth, flat, perpendicular, parallel, round, concentric, rigid, stable and accurate.

With a few artistic liberties, Fig. 3 shows some of the cassette/recorder alignment relationships and how tape skew affects head alignment. In "A" the guide pins and rollers are shown to be exactly perpendicular to a rigid shell. The molded-in guide pins near the center of the cassette must also meet this criterion. The drive capstans and the record and play heads are shown as perfectly perpendicular to the recorder support assembly, which supports and positions the cassette shell exactly. This is our ideal of course, and if the tape ran perfectly straight, maybe it could really happen. First of all, recognize that if the cassette is not positioned accurately relative to the recorder components, some of the accuracy in the cassette itself is defeated. In other words, when you insert a cassette, make certain that it seats firmly into position. If there seems to be a favored position for best performance, use that all of the time.

Now let's take a look at how tape skewing affects head alignment and record/playback performance. In "B" of Fig. 3, the play head is shown to be perpendicular to the support plate with the tape curving across it. The curvature of the tape and the resultant angles are greatly exaggerated to facilitate demonstrating what happens. The lines on the tape, are radial lines of the curve and perpendicular to the edges. If we adjust the record head to get it in best alignment with the play head, we get the result shown in "B." Next we flip over this cassette ("C") to see how things would work out, *without* readjusting the record head. For the play head, the radial lines are just put at the same angle on the other side of vertical. With the record head, however, the angular error is twice what it was before any adjustment.

These simple figures tell us a number of things about what is desirable and what to expect. Most desirable are cassettes which have *no* skew and which will seat accurately in the recorder. With such tapes, alignment with both heads will remain correct, including when the cassette is turned over. Maybe this

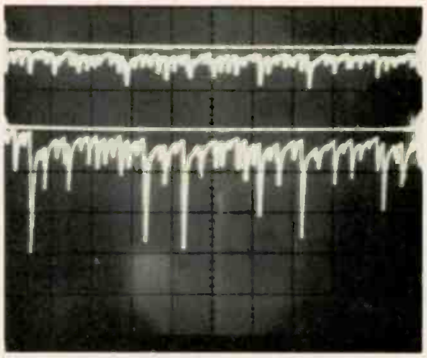


Fig. 4 — Record/playback flutter with Akai GX-F90 deck. Top, TDK MA-R cassette; bottom, BASF Studio I cassette. (Scales: Vert., 0.05%/div.; hor., 1 S/div.)

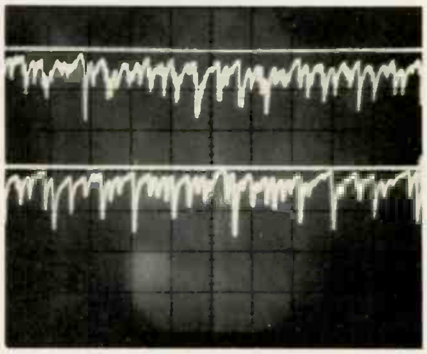


Fig. 5 — Record/playback flutter with Technics RS-9900/US deck. Top, TDK MA-R cassette; bottom, ferric cassette. (Scales: Vert., 0.05%/div.; hor., 1 S/div.)

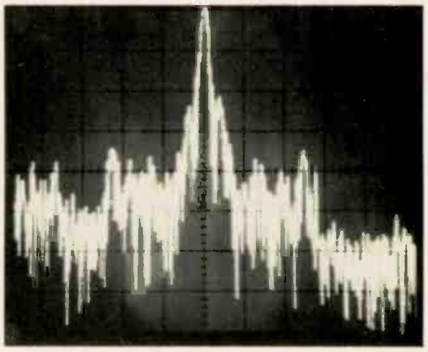


Fig. 6 — Flutter spectrum with Akai GX-F90 deck and TDK MA-R cassette. Scales: Analyzer bandwith, 1Hz; 'scope, vert., 10 Hz/div., hor., 10 dB/div.)

sounds unlikely, but, in fact, we have been able to report on a number of tapes that consistently do not have detrimental skewing from sample to sample and from side to side, including both C-60s and C-90s. Obviously, the problem of poor responses from skewing is more severe with separated record and playback heads. Note, however, that skewing can cause some loss in response even in combination record/playback heads. This is particularly true if you are going to play a tape on another deck than the one used for recording.

We know that smooth tape motion is essential for low flutter and that rough mechanical motion would result in high flutter, but how much does it have to do with the deck? The first part of the investigation utilized an Akai GX-F90 which had shown low flutter, the Nakamichi 582 which had average flutter, and the older-design Technics RS-9900/US. Figure 4 has plots of the record/playback flutter with the Akai deck using a TDK MA-R (top) and a medium-price ferric (bottom). The straight lines are the reference zeros, the vertical scale is 0.05% wtd. pk. per division, and increasing flutter is in the negative direction. The 'scope traces show a number of peaks not indicated on the meter, but there is no doubt about the much lower flutter with the MA-R (0.03% meter) compared to the ferric (0.08% meter). When we tried the same cassettes in the Technics RS-9900/US (Fig. 5), the flutter with the MA-R was higher, the flutter with the ferric was lower, and they were pretty much the same with this deck.

We went back to the Akai deck and plotted (Fig. 6) the MA-R flutter spectrum for 50 Hz each side of our test tone with a 1-Hz analyzer bandwidth. There are sidebands at ±4 Hz, 23 dB down, and at ±24 Hz, 35 dB down. Figure 7 shows the results with the same deck and another ferric cassette, which had shown twice as much flutter on the meter as the MA-R. Note that the sidebands at ±25 Hz are up to -21 dB, and that there is a lot of energy at a higher level at other points. Similar checks with the Nakamichi 582 showed spectra with reduced discrete sideband levels but with considerable "random" energy close to the test-tone carrier. The meter reading of 0.09% wtd. pk. was indicative of the total level of these many flutter components, even though the energy was not concentrated in a couple discrete frequencies.

Subsequent to taking the above data, two Aiwa decks were obtained which had low flutter with many cassettes. A search was made to find cassettes that had mediocre to poor flutter performance. The results from some of these tests are shown in Fig. 8. Please note that the vertical scale is 0.1% per division, as compared to 0.05% per division in the earlier figures. As before, the straight-line traces are the reference zeros, and increasing flutter is downward. The two topmost sets were run with the Nakamichi 582. The so-called mediocre cassette showed no values greater than 0.08% wtd. pk., and an excellent 0.05% was typical. The poor cassette was really that with relatively frequent readings to almost 0.2%, and a few close to 0.3%!

The next two sets were made with the recently introduced Aiwa AD-3600. Preliminary tests had shown very low flutter with many cassettes. The first run with the "mediocre" sample showed most readings below 0.06%, with around 0.04% or less very common. These are certainly excellent figures, but on to the challenge of the cassette that had performed so poorly just before in the other deck. These results (next to the bottom of Fig. 8) were quite unexpected, but the plotted figures were really quite typical — few peaks over 0.06%, with most meter indications less than 0.04% wtd. pk.! This low-flutter result left space for a run with the same cassette in the Aiwa AD-M700 deck, which had also shown well-controlled flutter. There is a noticeable increase, compared to the AD-3600 deck, but the 0.08% maximums are still quite acceptable and much lower than the Nakamichi 582 results. In case there is any question, let it be stated here that exactly the same section of tape was used for each recorder and rechecks were made of all the results.

In general, if you need very low flutter, you must have a good performing deck as well as a good cassette. A cassette cannot force a deck to have low flutter, but many decks are definitely sensitive to the characteristics of the cassette. The Aiwa decks used in the tests reported above were the best seen to date in giving low flutter, regardless of the cassette used. Under a number of condi-

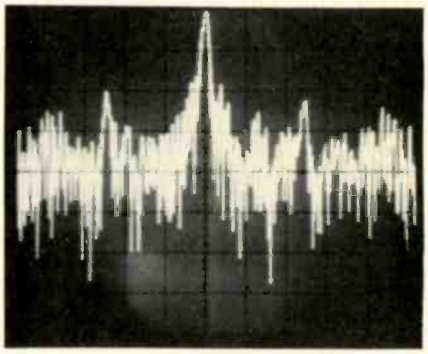


Fig. 7 — Flutter spectrum with Akai GX-F90 deck and a ferric cassette different from the one used to generate the bottom curve in Fig. 5. (Scales: As in Fig. 6.)

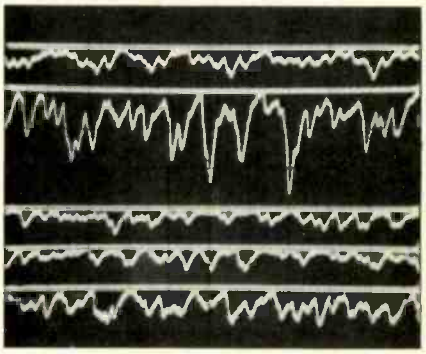


Fig. 8 — Flutter vs. tape and deck. Top, mediocre cassette with Nakamichi 582; 2nd, poor cassette with 582; 3rd, mediocre cassette with Aiwa AD-3600; 4th, poor cassette with AD-3600, and bottom, poor cassette with Aiwa AD-M700. (Scales: vert., 0.1% wtd. pk./div., hor., 1 S/div.)

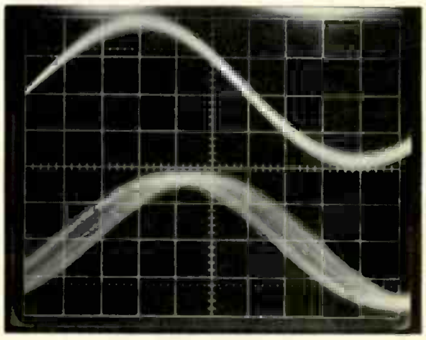


Fig. 9 — Record/playback 10-kHz phase error and jitter between channels. (Scale: Hor., 30 deg./div.)

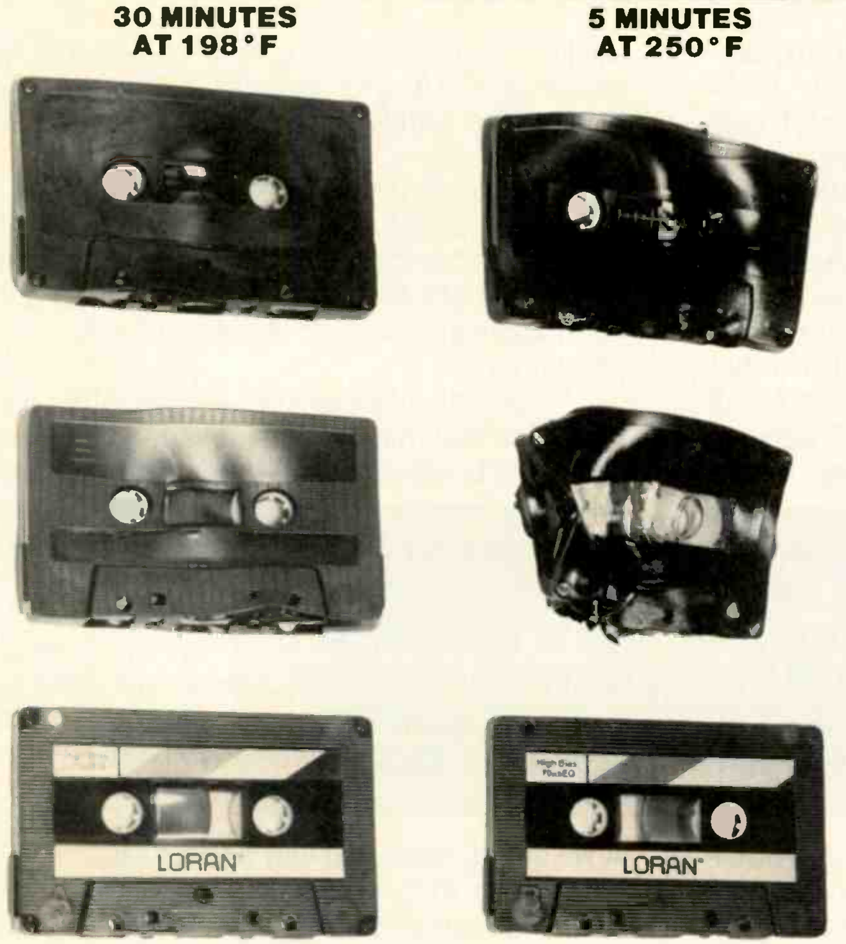


Fig. 10 — The two Loran cassettes shown here were exposed to high temperatures in environmental test chambers along with four leading cassette tapes, labels removed. (Photo, courtesy Loranger.)

tions TDK MA-R appeared to be the lowest flutter cassette. Some of the other good-performing tapes were Ampex EDR, GMI and GMII, BASF Professional II and III, Fuji FX-I, Maxell UD-XL I-S and UD-XL II-S, Memorex MRX-1, Osawa Cr, Realistic Supertape Chrome, Sony SHF, and TDK MA and SA-X. These conclusions must be considered tentative because of the limited, relatively short-time testing and because of the proven influence of the deck.

The last of the tape/recorder interface effects to be discussed is record/playback phase jitter. If the tape motion were perfect across the head, without waving or vibrating, there would be no shifting in time between channel A compared to channel B. Figure 9 shows the output of both channels of a recorder with a 10-kHz test tone, and with the scope locked to "A" (top). The relative phase jitter of "B" causes the trace to move back and forth on the screen, as shown in this timed exposure. The sweep speed was adjusted for 30 degrees per division, and we can see that the total jitter is about 40 degrees, which is fairly good for a cassette deck. A misalignment of about 40 degrees was purposely left in, evidenced by the displacement of the average position of the "B" trace. This angular discrepancy of the 10-kHz tone indicates an 11-µS time difference. Actual jitter and alignment errors can be much greater than that shown. The conclusion drawn after a series of tests with a selection of cassettes and a number of decks was this: Phase jitter is primarily determined by the deck, but the cassette has some influence on the exact results. The deck with the smallest distance between the record and playbcak gaps is most likely to have the least jitter. Recognize that such jitter will exist in any subsequent playback. It is also a fact that jitter and skewing can cause fairly high *level* losses at the higher frequencies when a tape is played back on another recorder, especially when there are head alignment errors.

At the time of this writing, Loranger has just introduced a line of cassettes which have shells made out of Lexan. Among other things, the manufacturer claims that these shells are much more stable with elevated temperatures, such as might be found in car tape players. Figure 10 does show very noticeable damage to the non-Lexan shells, so I subjected C-60 spares to oven temperatures of 120° to 160° for one hour, a temperature period that might well be found on a car dash. I found that the cassettes most sensitive to heat distorted very quickly. Only one-third survived to the end, though some shells were a bit distorted. The Loran Lexan shell showed the least effect, and it should be noted that the Maxell shells showed very little warp. This certainly is a valid area for investigation, and I will try to gather more information for possible publication later on.

Winding

In past years, there were a fair percentage of cassettes that would not survive very many fast winds, and occasional ones that would not even play through one time without jamming. These types of failures are now much less frequent, and there are fewer cases of various types of sounds, squeaking, moaning, chattering, etc. There are still tapes, however, that are very noisy on one deck and most quiet on another. *In general,* it appeared that the cassettes with the smoothest winds (quietest) had the lower flutter and the least likelihood of jamming. There were a number of exceptions, and only very lengthly testing would prove whether there is much of a correlation. Good guidance to the tape pack with slip sheets did reduce over-the-pack failures. Finally — and once again — the total cassette system performance depends upon the mechanical and electrical characteristics of both the tape *and the deck.* ▲

INTRODUCING THE MOST ADVANCED AND REVOLUTIONARY AUDIO CASSETTE IN THE WORLD.

Loran™ proudly introduces an extraordinary breakthrough in audio cassette technology: a cassette shell that is virtually indestructible, with tape of such superior performance that the combination redefines the limits of cassette sound reproduction.

Loran has the only cassette shell in the world made from LEXAN® resin, the incredibly tough space-age material used for bulletproof vests and bank teller windows. Unlike other cassette shells, Loran stands up to extremes of heat and cold. It will not warp at 250 degrees Fahrenheit or shatter at 60 degrees below zero, and its dimensions won't change significantly even when exposed to these extremes repeatedly. You can leave Loran on an exposed car dashboard all day and still be sure of trouble free performance. Molded parts of LEXAN® resin also display astonishing resistance to impact—it has 16 times the impact strength of typical cassette materials, and 4 times the strength of cast aluminum or zinc. For the many tape enthusiasts who have "lost" prized recordings because of temperature extremes in parked cars, or because of accidental falls, this feature alone makes Loran uniquely valuable.

NEITHER THE HEAT OF THE DESERT, NOR THE COLD OF ALASKA, NOR THE OVEN TEMPERATURES OF A CLOSED CAR IN THE SUN, NOR FALLING ON THE FLOOR, OR GETTING SAT ON, OR BEING BAKED IN A BEACHBAG... CAN STOP LORAN™ FROM DELIVERING INCREDIBLY CLEAR, ACCURATE AND BEAUTIFUL SOUND.

But there is more to Loran cassette technology. Unique Safety Tabs™ (patent pending) provide the only wholly integrated reversible erasure prevention system available today. A ½ turn of the Safety Tab™ makes it virtually impossible to erase a recording. However, unlike all other cassettes, you can restore its erase and record capability by simply turning the Safety Tab™ back to its original position.

Another unique feature is the hub lock (patent pending). It offers the highest resistance to leader-tape pull-out in the tape field. And tape-path friction is reduced by Loran's conductive polymer slip sheets and natural fur pressure pad.

Loran's unique formulations offer performance that matches the advanced technology of the Loran shell and tape guide systems. Our Chrome equivalent high bias tape is coated with separate layers of two different oxides. It offers extremely low residual noise levels (−56 dB, A weighted, relative 0 VU) and an MOL of +6 dB relative to 0 VU for 3 percent distortion. This tape provides magnificent low-end response, in addition to the high-end response normally found in other Chrome equivalent formulations.

Loran's Metal, Ferric Oxide and Ferrichrome tapes also deliver improved and outstanding performance levels over the entire spectrum of characteristics associated with these formulations.

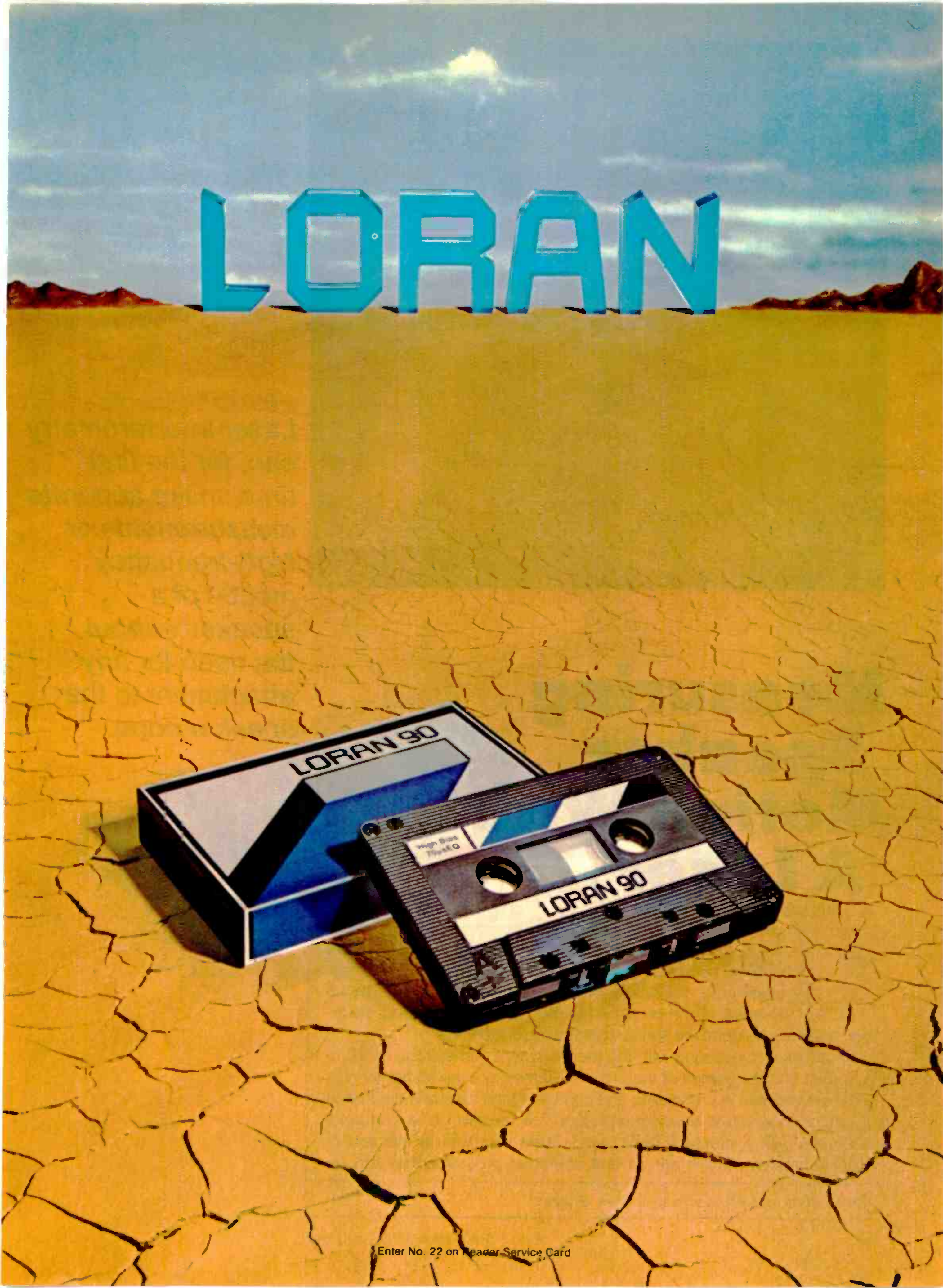
Loran...the most advanced cassette in the world with unique innovations in shell construction, tape guidance mechanisms and state-of-the-art tape formulations. Destined to become a leader. We invite you to share in the excitement. Listen to Loran™

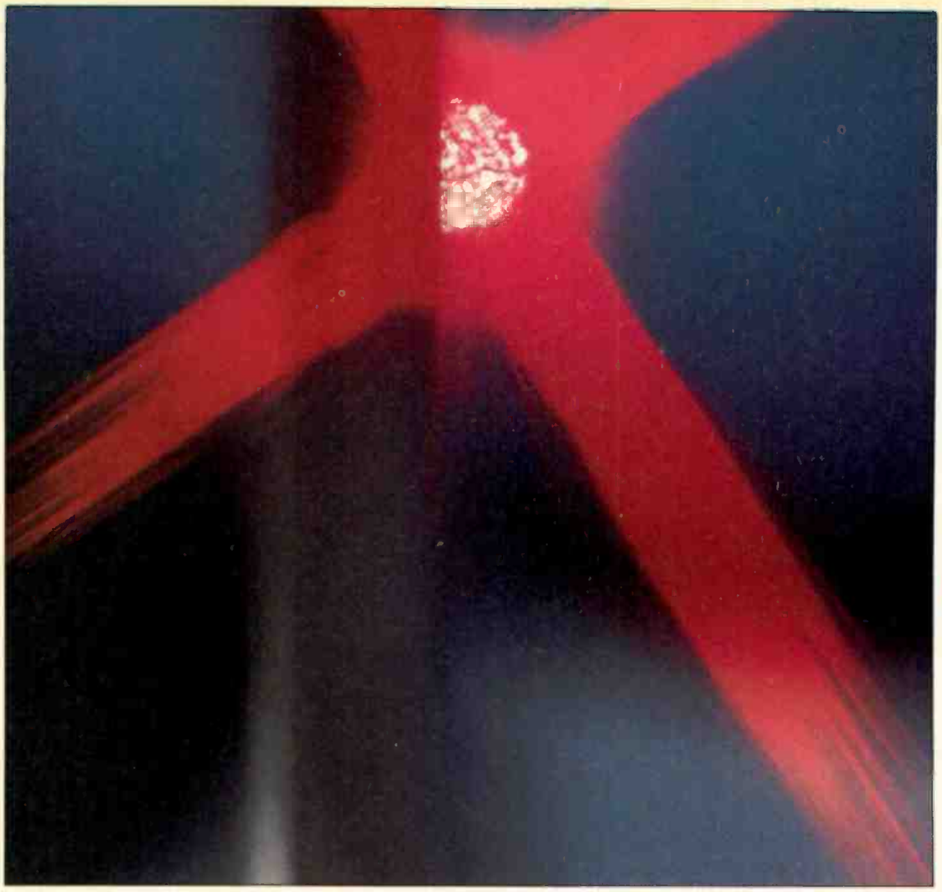
LORAN™
The Great American Sound

Loran™ Audio Cassettes have been selected by the Consumer Electronics Show Design and Engineering Exhibition as "one of the most innovative consumer electronics products of 1981."

Loran™ is manufactured exclusively by Loranger Entertainment.

Lexan® is a registered trademark of the General Electric Company.


LORAN
LORAN 90
LORAN 90



Laser interferometry can, for the first time, make accurate measurements of high-frequency motion of a speaker without the need for any attachment to the speaker cone.

Measuring Speaker Motion With A Laser PART TWO

G. J. ADAMS*

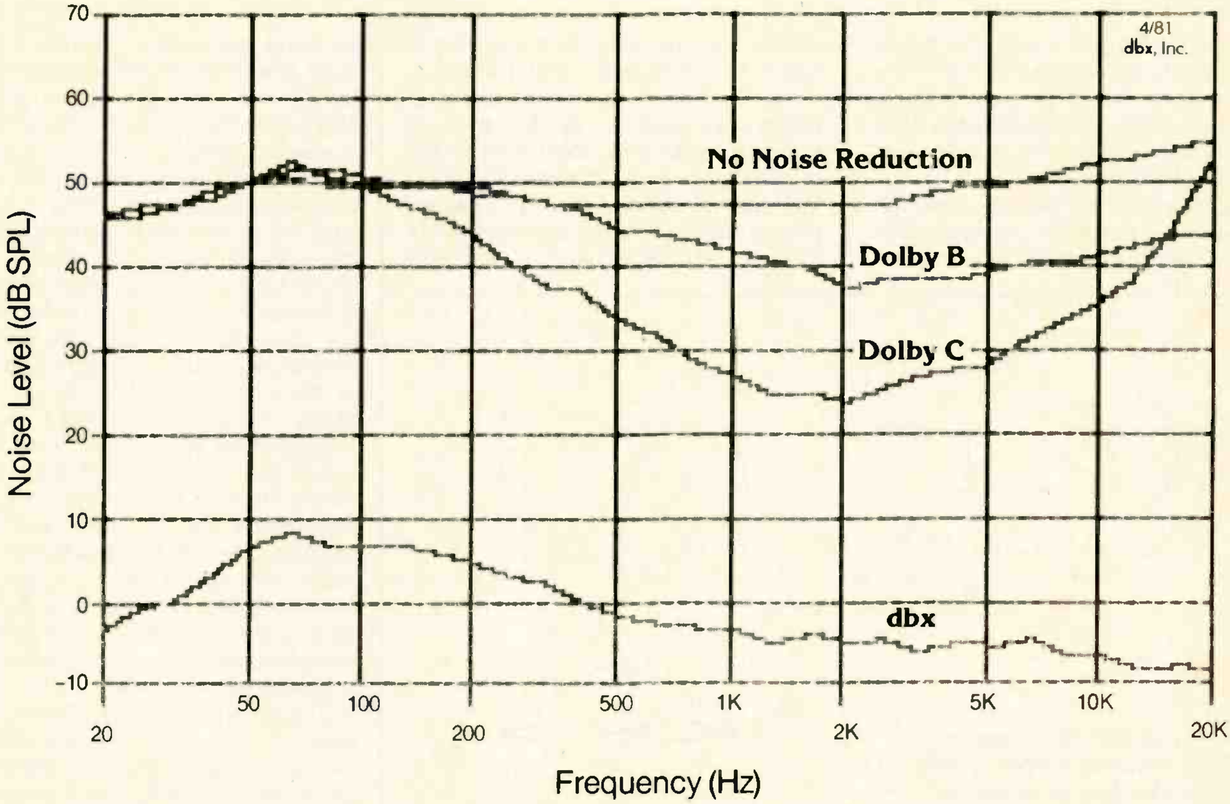
Having described the laser inferometry testing system for making accurate high-frequency loudspeaker cone measurements, I will now proceed to the computer's role in analysis of the breakup patterns, measurements of distortion and calculation of the sound-pressure response.

In addition to assisting with the measurement and storage of vibration data and the control of the point of illumination, the computer also serves a vital role in processing and combining the data and displaying it in a form which is easily interpreted. The flexibility of a computer equipped with a graphics facility lends itself very well to this sort of display problem. There are several computer programs that can be

*B&W Loudspeakers, Worthing, Sussex, England

Photo: © Gary Gladstone/The Image Bank

dbx has been silent too long.



Noise from biased Chromium Dioxide cassette tape, comparing Dolby and dbx noise reduction systems. One third octave analysis. Tape noise level referenced to 200 nWb/m = 110dB SPL.

For years Dolby* has been trying to reduce tape noise.

First came Dolby B. Then Dolby HX. Now there's Dolby C.

At dbx, we think it's time to set the record straight. You see, we've never tried to reduce tape noise. We've never had to.

Because from the beginning, dbx has done what Dolby keeps trying to do: *eliminate* tape noise.

Just compare Dolby's latest attempt with dbx.

Where Dolby C reaches a maximum noise reduction of 20 dB, dbx reaches 50 dB. In a CCIR-weighted noise measurement analysis, Dolby C manages only 18 dB, while dbx achieves 55 dB.

What do these numbers actually mean?

Simply this. When you push the Dolby C button, tape noise decreases. When you push the dbx button, tape noise disappears. (You can perform this test yourself using any blank cassette tape.)

The dbx system reduces tape noise so effectively, that it's beneath the noise floor of even the quietest living rooms. Unlike Dolby C, dbx is effective in more than just the mid-range. It operates across the entire frequency spectrum. There's no low-frequency noise. No high-frequency noise. No noise, period.

No wonder Technics, Onkyo, Yamaha, TEAC and others have designed their newest generation of tape decks with dbx.

There's more to this story, too. With the dbx tape noise reduction system, you're also equipped to play the widely acclaimed dbx Discs, the world's only Full Dynamic Range Records — and the first discs that eliminate record surface noise.

In addition, when digital playback technology finally arrives, dbx is the only system that will faithfully reproduce that sound on tape. You'll even be able to hear the sound of digital in your car, because we've developed a dbx decoding system for car stereo.

So before you rush out to buy a tape deck with Dolby C, we have a suggestion.

Listen to the new tape decks with dbx. Or hear what a dbx Model 222 or 224 can do for your existing system.

At dbx, we've been silent too long.

The fact is, Dolby just reduces noise.

dbx eliminates it.

dbx

dbx, Incorporated, 71 Chapel Street, Newton, Mass. 02195 U.S.A.
Tel. (617) 964-3210. Telex 92-2522. Distributed throughout Canada by BSR (Canada) Ltd., Rexdale, Ontario.

written to display part or all of the data in a number of different aspects or formats. The particular display program which is executed, and hence the display format that is chosen, will depend on the type of vibrational mode of interest.

Conventional loudspeaker cones exhibit two main types of vibrational mode [17] The first type can be thought of as arising from travelling waves running in both circumferential directions, as shown in Fig. 8 (a). These travelling waves may result in the formation of standing waves with nodal lines in the radial direction as illustrated in Fig. 8 (b). This type of standing-wave or breakup pattern has no rotational symmetry about the cone axis and is therefore described as being asymmetric. Distortion of the cone away from its static circular shape, as shown in Fig. 8 (b), causes very little change in the cone circumference for any given radius. The stiffness opposing the bending waves travelling in the circumferential directions is thus mainly influenced by the force required to bend the material and is only slightly influenced by the force required to compress or stretch it. Asymmetric modes generally occur at low frequencies such that the distance between adjacent segments of the cone which are moving in antiphase is small compared to the wavelength of sound in air. Thus, in essence, the air in front of the cone is merely displaced from one cone segment to the next and back again etc., resulting in very little contribution by the mode to the total sound output. The main component of the latter arises from an axial motion which is superposed on that of the alternate segments moving in opposite directions [15].

The second type of vibrational mode proves to have a much greater effect on the sound output than does the asymmetric mode. Travelling waves running in the radial direction from the cone center outwards are partly reflected at the outer suspension back towards the center, as shown in Fig. 9 (a). These travelling waves may result in the formation of standing waves with concentric nodal circles centered on the cone axis, as

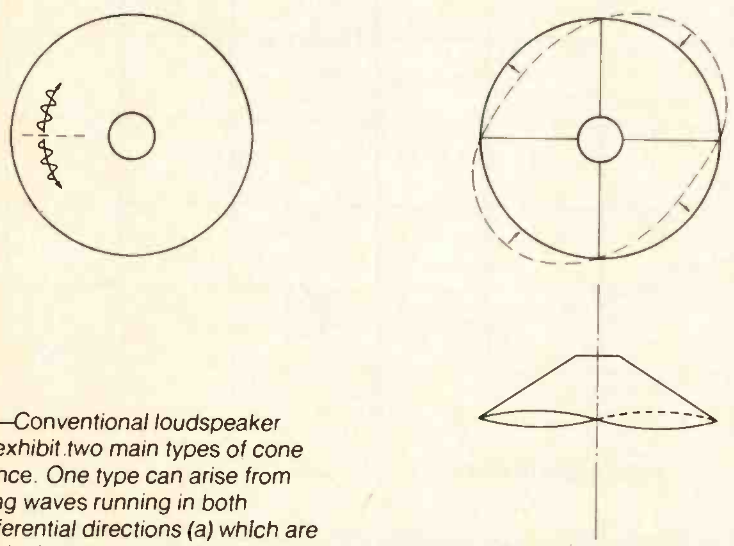


Fig. 8—Conventional loudspeaker cones exhibit two main types of cone resonance. One type can arise from travelling waves running in both circumferential directions (a) which are excited by inhomogeneities in the cone material or by uneven tension in the suspensions due to misalignment. These travelling waves may result in the formation of standing waves with a number of nodal diameters. The example shown (b) has two nodal diameters.

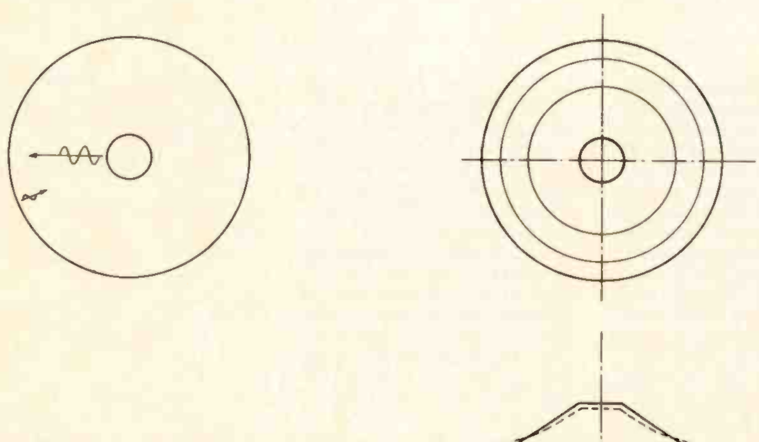


Fig. 9—The second type of cone resonance can arise from travelling waves running in a radial direction (a) which are excited by the motion of the voice coil. These may result in the formation of standing waves with nodal circles. The example shown (b) has two nodal circles.

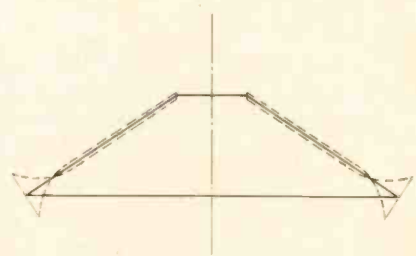


Fig. 10—Because the coupling between bending and stretching notions on the cone is least at the outer edge of the cone, bending waves travelling in the radial direction first appear at the outer edge only. As the frequency of the driving signal is increased the inner boundary of the bending waves moves towards the cone center until eventually the whole of the cone surface is covered in bending waves.

shown in Fig. 9 (b). This type of standing-wave pattern is symmetric about the cone axis and is thus described as being axi-symmetric. Distortion of the cone away from its static shape, as shown in Fig. 9 (b), results in a change in the circumference of the cone at a given radius. The stiffness opposing bending waves travelling in the radial direction is thus, in addition to being influenced by the force required to bend the material, considerably influenced by the forces required to compress or stretch the material. The latter are generally much greater than the forces required for bending, and, as a result, the *total* bending stiffness opposing the propogation of bending waves in the radial direction is much greater than that opposing bending waves travelling in the circumferential directions. The coupling between bending and stretching motions in a cone is the reason why the forming of a flat circular piece of paper into a cone shape makes it more rigid. A mathematical analysis of the mechanical behavior of a cone [27] shows that this coupling leads to a phenomenon which is not observed on a flat diaphragm: Bending waves can only propogate in the radial direction above a certain frequency f_{tb} given by

$$f_{tb} = \sqrt{\frac{E}{\rho}} \bullet \frac{\cos \alpha}{2\pi R_b} \qquad (1)$$

where E is the Young's modulus of the cone material, α is its density, ρ is the semi-apex angle of the cone and R_b is its outer radius. The Young's modulus is a measure of the stiffness of the material, e.g., the Young's moduli for paper and aluminium are approximately 2 and 70 GNm^{-2}respectively. From Equation (1) the values of $f_{tb}$for a paper and an aluminium cone of 16 cm diameter having semi-apex angles of 60° are approximately 1.8 kHz and 5 kHz respectively. These figures indicate the frequencies at which axi-symmetric cone breakup commences.

The degree of coupling between bending and stretching motions at any point on the cone can be shown to be inversely proportional to the radius at which the point lies, i.e., the coupling is greatest near the center of the cone and is least at the outer edge. The result of this variation along the cone radius is that as the frequency of the driving signal is increased above f_{tb}, bending waves first appear at the outer edge of the cone only, while the remainder of the cone still vibrates approximately uniformly, as shown in Fig. 10. As the frequency is further increased, the dividing circle between the cone part which is exhibiting bending and the cone part which is moving approximately uniformly, reduces in radius until eventually, at some frequency f_{ta}, the whole of the cone surface is exhibiting bending.

The sound output of the cone above f_{tb} is largely determined by the motion of the inner region of the cone which is moving approximately uniformly. The outer cone region which is exhibiting bending waves contributes only a little to the sound output because the distance between adjacent (annular) parts moving in antiphase is small compared to the wavelength of sound in air. The outer region thus "short circuits itself." The motion of the inner region is approximately uniform, i.e., the whole of the region moves in phase, but in general its amplitude increases with increasing distance from the voice coil [28]. As the frequency is increased above f_{tb}, the radius of the inner region decreases and therefore the area of the cone which is effective in radiating sound decreases. Thus, one might expect the sound output to decrease with increasing frequency above f_{tb}. However, because the outer cone region is in resonance, the inner region behaves approximately as if it were decoupled from the outer region. The effective cone mass as "seen" by the driving voice coil thus decreases by the same proportion as does the effective radiating area. For a constant driving force from the voice coil, the amplitude of vibration of the inner region increases as a result of the decrease in effective mass such that the sound output remains at approximately the same level

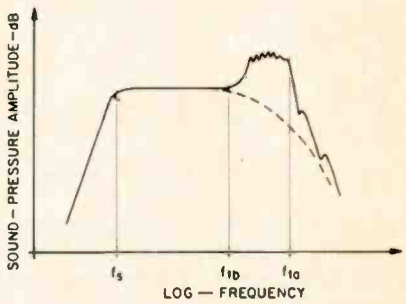


Fig. 11—The typical form of the axial sound-pressure amplitude/frequency response of a straight-sided loudspeaker cone mounted in an infinite baffle. The dashed curve shows the response of the same cone which would be obtained if it were perfectly rigid.

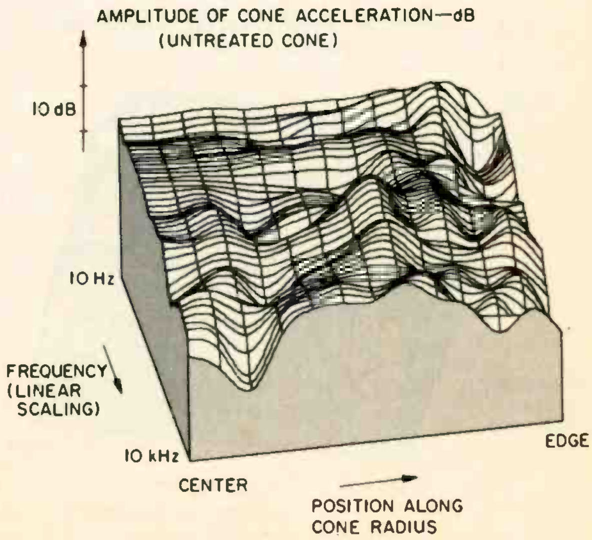


Fig. 12—This "3-dimensional" type of graph generated by the computer shows the variation of the amplitude of the measured cone acceleration along one radius of a loudspeaker cone as a function of frequency.

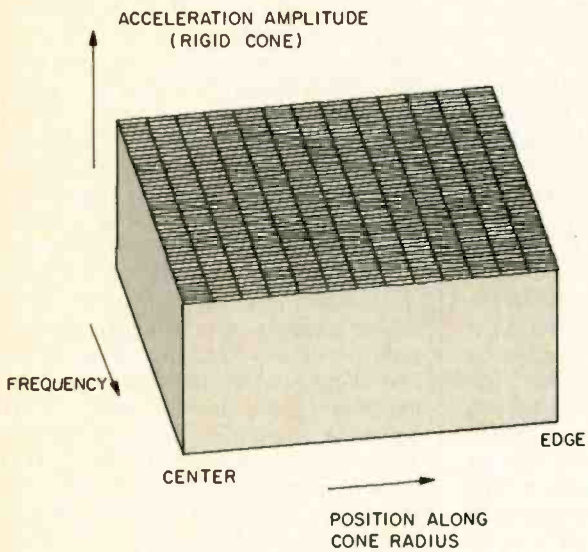


Fig. 13—A perfectly rigid loudspeaker cone has the same amplitude of acceleration at all points on the surface when driven by a constant-amplitude sinusoidal force for frequencies above the fundamental resonance of the system. The 3-dimensional display thus appears as a flat block for a perfectly rigid diaphragm.

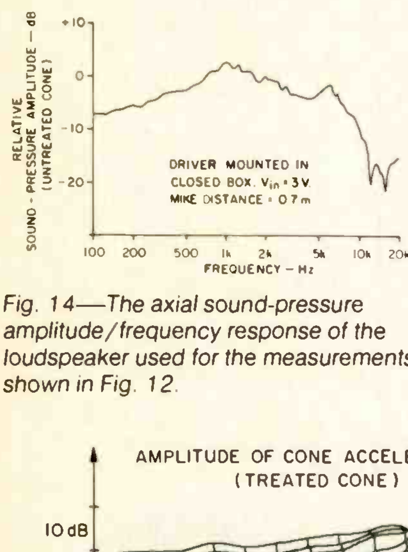


Fig. 14—The axial sound-pressure amplitude/frequency response of the loudspeaker used for the measurements shown in Fig. 12.

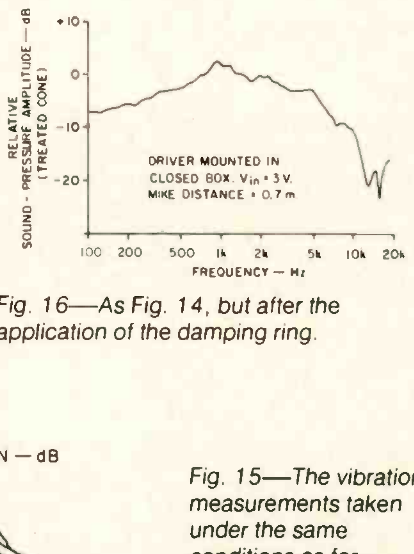


Fig. 16—As Fig. 14, but after the application of the damping ring.

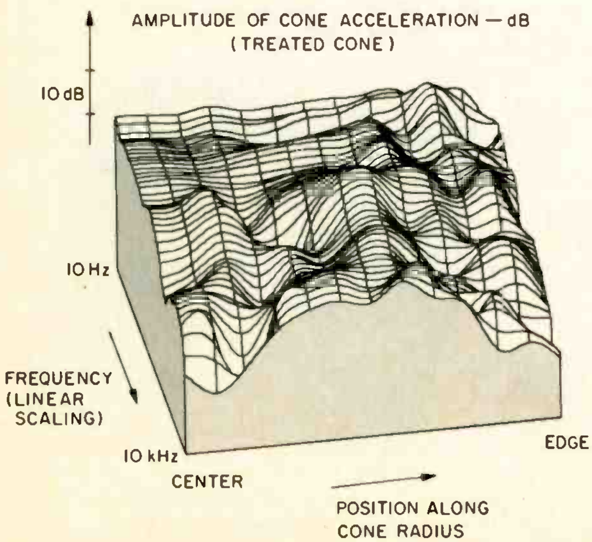


Fig. 15—The vibration measurements taken under the same conditions as for Fig. 12, but following the application of a ring of damping compound to a selected area of the cone.

as below f_{tb}. In practice, the amplitude of vibration of the inner region can often increase with increasing distance from the voice coil resulting in an *increase* in the sound output above f_{tb}. This phenomenon is associated with the "trapping" of energy at the boundary between the inner and outer regions of the cone. See "The Trapping of Acoustical Energy by a Conical Membrane and its Implications for Loudspeaker Cones" by L. J. van der Pauw, *Jour. of the Acoustical Society of America*, vol. 68, pp. 1163-1168, 1980. The sound output eventually falls with increasing frequency because, in addition to the cone becoming completely covered in "non-radiating" bending waves, the excitation of the cone diminishes as a result of the magnitude of the mechanical impedance of the voice coil becoming greater than that of the cone.

Figure 11 shows a typical form of the axial sound-pressure output/frequency response of a cone loudspeaker mounted on a large baffle. Above the fundamental resonance frequency f_s of the loudspeaker driver, the response remains approximately flat until f_{tb} when the output increases due to axi-symmetric cone breakup. Between f_{tb} and f_{ta}, the response is roughly constant with a "fine structure" [17] of resonances caused by the incomplete cancellation of the sound outputs from the parts moving in antiphase on the outer region of the cone. The irregular roll-off of the response at high frequencies is due to resonances in the plane of the cone similar to those which occur in a flat plate. For the sake of interest, Fig. 11 also shows the frequency response (dashed curve) that would be obtained if the cone were perfectly rigid. This demonstrates that cone breakup has the effect of extending the response at high frequencies. Careful choice of the cone geometry and the material parameters of the cone can result in a smooth and useful extension of the frequency response above that of a perfectly rigid cone. The "loudspeaker problem" is often stated as being the elimination of cone breakup; however, a more relevant and useful objective would be the correct control of cone breakup to achieve a smooth frequency response having a wide bandwidth.

The brief discussion given above of the mechanical behavior and sound-output/frequency response of a loudspeak-

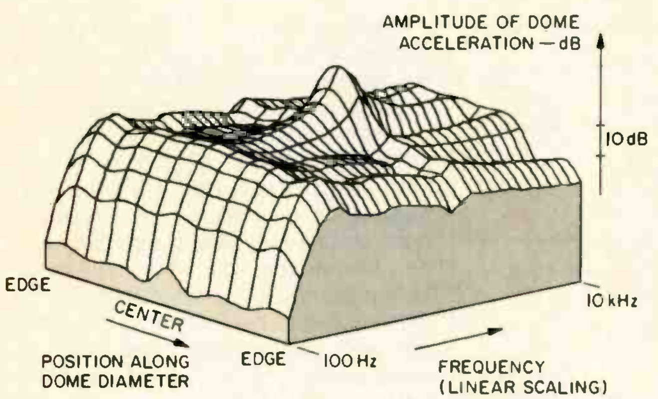


Fig. 17—The 3-dimensional display of the variation of the amplitude of acceleration, as a function of frequency, along a diameter of a hard dome tweeter. The increase in the amplitude of vibration of the center of the dome in the region of 6 kHz is quite remarkable, being about 30 dB.

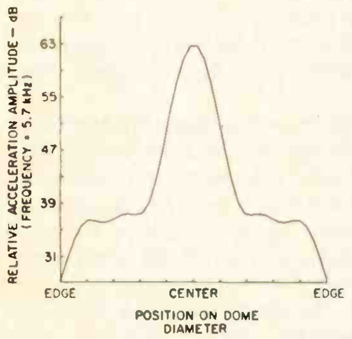


Fig. 18—A vertical cross section of Fig. 17 at 5.7 kHz showing the variation of the vibration amplitude across the dome at resonance.

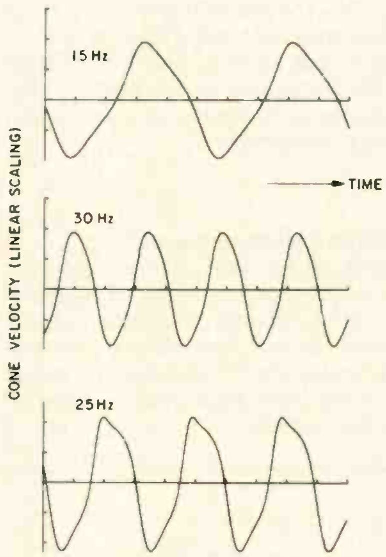


Fig. 19—The velocity waveforms measured at a point on a loudspeaker cone for sine-wave excitation of various frequencies. The distortion of the waveform observed at these low frequencies is due to non-linearities in the moving-coil drive mechanism and in the cone suspension.

er cone is based an interesting the theoretical analysis of a straight-sided cone having an unsupported outer edge [17]. In practice, the outer edge is supported, very often by a suspension made from a different material to that of the cone. In addition, the cone is seldom straight-sided but is usually curved (or flared) to improve "dispersion", and the front end of the voice-coil bobbin is covered by a dust cap. All of these features modify the cone behavior and the sound-output/frequency response. However, the simplified analysis is still very useful because it tells us roughly what sort of mechanical cone behavior we can expect in practice. This information is a helpful guide as to the number and spacing of the points on the cone surface at which the motion should be measured. The theoretical analysis showed that the vibrational modes which have most effect on the sound-pressure/frequency response are symmetrical about the cone axis. Thus, a very useful initial investigation of the cone vibration of some particular loudspeaker driver would be to measure the transfer function between the input voltage to the voice coil and the cone velocity at a number of points spaced along just one radius of the cone. If the cone motion is symmetrical in the frequency range of interest, then these data will be sufficient to enable the cone breakup pattern to be drawn for the whole of the cone at any frequency within this range. Of course, the symmetry or otherwise of the cone motion can only be verified by repeating the measurements along several different radii of the cone (as shown in Fig. 3). This should be the next step after the initial investigation if a more thorough analysis is required.

An example of the data obtained from vibration measurements taken along only one radius is shown in Fig. 12. This is a "3-dimensional" type of graphical representation of the cone motion measured at 13 points evenly spaced along a radius of the cone of a 100-mm diameter mid-range loudspeaker. Points on the dust cap and the outer suspension were included in the measurements because of their often significant contributions to the total sound output. The graph shown in Fig. 12 has effectively three axes and shows the variation of the amplitude of the acceleration at a point on the cone as a function of both the frequency of the driving signal and the position of the point along the radius. The acceleration/frequency responses were obtained form the velocity impulse responses measured at each point as described in the previous installment. The choice of acceleration, rather than velocity amplitude, for the vertical axis of the graph was made because a perfectly rigid cone would have a constant acceleration amplitude at all points on the surface for frequencies above the fundamental resonance of the system. The display for a perfectly rigid diaphragm would thus appear as a flat block as shown in Fig. 13.

The displays shown in Figs. 12 and 13 have been made more easy to visualize by drawing lines through points on the acceleration responses which correspond to the same frequency. By using a spline interpolation curve to join these points, the display acquires a smooth "surface" or "landscape" appearance. If the acceleration/frequency responses are displayed in the same order and with the same relative spacing as the points on the cone to which they correspond, then the display shows the amplitude of acceleration along the radius as a function of frequency.

The measured axial sound-pressure amplitude/frequency response of the loudspeaker used for the measurements shown in Fig. 12 is shown in Fig. 14. The frequency response is smooth with the exception of the resonance around 6 kHz. Examination of the cone vibration measurements in Fig. 12 shows that around this frequency the area of the cone approximately midway between the center and the edge shows a variation in acceleration amplitude which is similar to that of the sound pressure. If mechanical damping can be introduced into this area of the cone without significantly affecting the other material parameters of the cone (notably the density and the Young's modulus), then this resonance should be reduced in amplitude and the sound-pressure/frequency response thereby improved. Figure 15 shows the vibration measurements made on the same driver after the application of a ring of damping compound to the area of the cone in question. The variation of the acceleration amplitude in this area can be seen to have been reduced by this action. The beneficial effect of this "selective damping" of the cone is shown in the sound-pressure/frequency response of the modified driver given in Fig. 16.

Another example of the 3-dimensional type of display is given in Fig. 17 which shows the variation of the acceleration amplitude as a function of frequency along one diameter of a 12-mm diameter hard plastic dome tweeter. The dome of this tweeter shows a remarkable resonance at around 5.7 kHz which is of sufficient amplitude to be seen by the naked eye under normal white light! The resonance is shown by Fig. 17 to be due to a considerable increase (about 30 dB) in the amplitude of the center of the dome around 5.7 kHz. The variation of the vibration amplitude along the diameter can be seen more clearly in Fig. 18 which shows, in effect, a vertical cross-section of the 3-dimensional graph corresponding to a frequency of 5.7 kHz. This type of display is easily obtained from the vibration data stored in the computer and is useful for the detailed analysis of the cone or dome vibration once the frequencies of interest have been identified from the 3-dimensional graph.

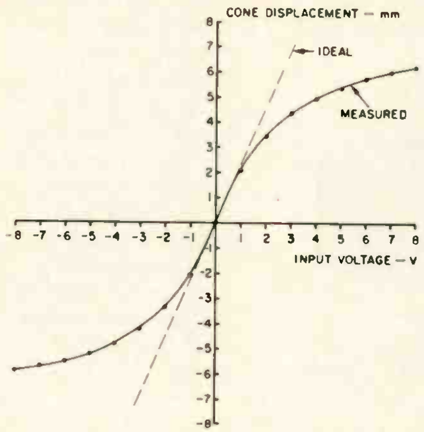


Fig. 20—The static transfer characteristic between the voice-coil input voltage and the cone displacement (for the same driver as used for Fig. 19) measured using the displacement output of the interferometer.

Distortion Measurements

Because the laser interferometer system provides an instantaneous measurement of the vibration at the point of illumination on the cone surface, the system can be used to measure the distortion of the cone vibration at any point on the cone surface.

The loudspeaker can, for example, be excited with a sine-wave voltage, and the velocity waveform at the point of interest observed on an oscilloscope and/or analyzed with a distortion meter or spectrum analyzer. Distortion of the cone motion can arise for a number of reasons. At low frequencies, where the cone motion is greatest, distortion may be introduced by the non-linear stiffnesses of the cone suspensions, by the variation of the force factor Bl of the coil and magnet with cone displacement, and by the variation of the inductance of the voice coil with cone displacement. Figure 19 shows the velocity waveforms measured at a point on the cone of a 16-cm diameter driver. All the waveforms shown were measured at frequencies below that at which cone breakup commences, and thus the distortion is likely to be a result of one, or a combination of, the sources listed above.

The ability of the laser system to measure displacement enables the transfer characteristic between the voice-coil voltage and the cone displacement to be determined. Figure 20 shows the measured characteristic for the same driver as used for the measurements shown in Fig. 19. The departure of the measured characteristic away from the ideal straight-line characteristic is a result of

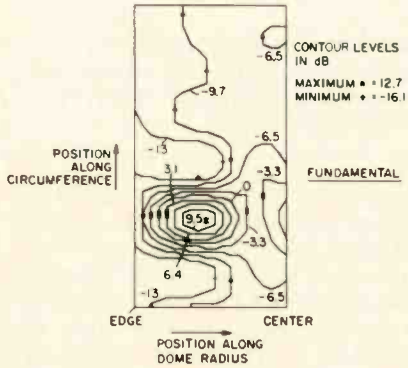


Fig. 22—The fundamental amplitude of the vibration velocity over the surface of the dome measured for a sine-wave input voltage at a frequency of 2.5 kHz. The contour lines are drawn by the computer through points on the surface which have the same amplitude. This "contour map" demonstrates very clearly the asymmetric nature of the dome motion at 2.5 kHz.

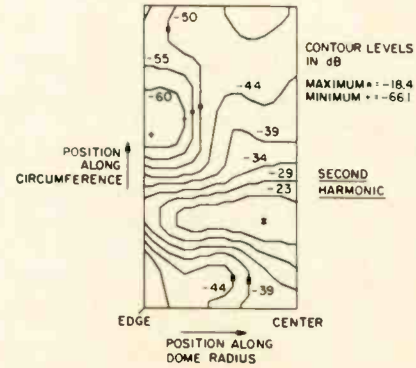


Fig. 23—The amplitude of the 2nd-harmonic distortion of the vibration

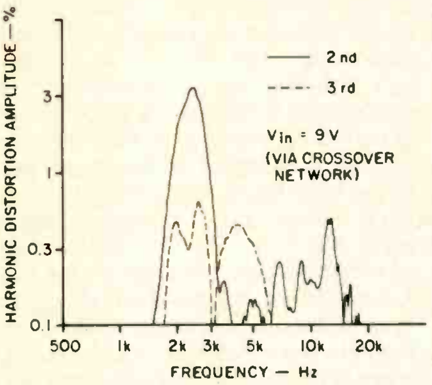
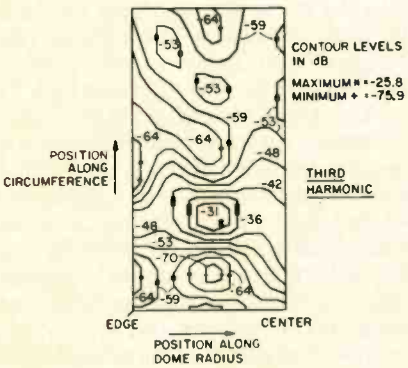


Fig. 21—The measured 2nd- and 3rd-harmonic distortion of the axial sound-pressure output of a 26-mm diameter soft dome tweeter. The high level of distortion observed around 2.5 kHz was unusual for this driver and prompted an investigation of the dome's mechanical behavior.

the variation of the suspension stiffnesses and the Bl factor with displacement.

At high frequencies, where the cone exhibits vibrational modes, distortion may be introduced by the non-linear bending or stretching of the cone material. Normally this would occur only at high input voltage levels such that the cone material is strained beyond its elastic limit. However, significant distortion of the cone motion can sometimes be observed at quite low input levels if the cone exhibits a vibrational mode of large amplitude. Figure 21 shows the measured 2nd- and 3rd-harmonic distortions of the axial sound-pressure output of a 26-mm diameter soft dome tweeter. The 2nd-harmonic is particularly high in the region of 2.5 kHz which is not typical for this driver. Using the laser, the velocity waveforms at 40 points spread evenly over the dome surface were measured and stored in the computer for a sine-wave rms input voltage of 1V at a frequency of 2.5 kHz. The amplitudes of the fundamental and the 2nd and 3rd harmonics of the velocity waveform at each point were found from the Fourier transform of an integral number of cycles of the waveform. Figures 22, 23, and 24 show the amplitudes of the fundamental and the harmonics as a function of position on the dome surface. A "contour map" type of display has been used here; the contour lines are drawn through points on the dome surface which have the same amplitude. Figure 22 shows very clearly that there is an area of the dome which is vibrating at a much greater amplitude than the rest of the dome. As a result of this greater amplitude, the dome motion is more distorted in this area, as is shown in Figs. 23 and 24. Close examination of the dome surface revealed a slight "dent," about 3 mm wide by 10 mm long, located in the same area as the observed increase in motion. This small imperfection in the dome shape was thus responsible for an asymmetric mode of vibration at 2.5 kHz which was not normally present in this type of driver. Because of the small area of the imperfection, the fundamental sound output at 2.5 kHz was barely affected leaving only the increase in distortion as an indicator of its presence.

Although the last example is not particularly relevant to the general problems of loudspeaker driver design, it illustrates how the laser interferometer can be used to identify those areas of the loudspeaker diaphragm which are the major contributors to the distortion output at any particular frequency. This information can often suggest modifications to the loudspeaker driver which will reduce the distortion.



velocity over the dome surface for an excitation frequency of 2.5 kHz.
Fig. 24—As Fig. 23, but showing the amplitude of the 3rd harmonic.

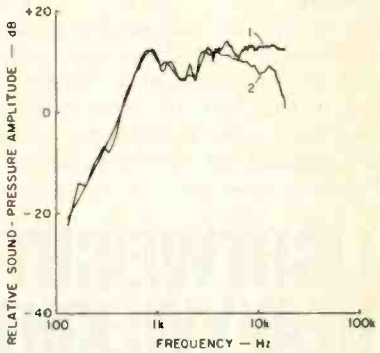


Fig. 25—The sound-pressure/frequency response of a direct-radiator loudspeaker driver mounted in a baffle can be calculated from the velocity impulse responses measured at a number of points spread over the vibrating surface of the driver. Curve (1) shows the measured axial sound-pressure amplitude/frequency response of a 26-mm diameter dome tweeter mounted in a baffle, and curve (2) shows the same response calculated from the velocity impulse responses measured at 33 points.

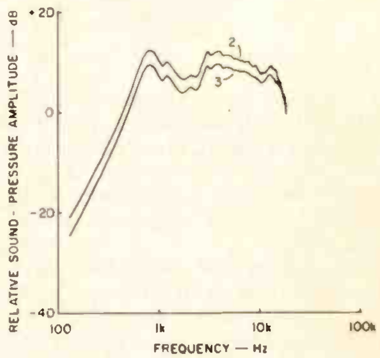
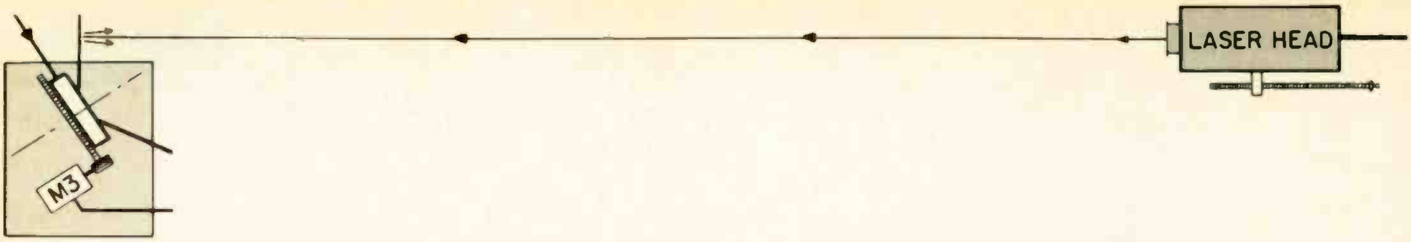


Fig. 26—The contribution which the motion of the dome suspension makes to the axial sound-pressure can be seen by comparing the calculated response shown in Fig. 25 curve (2) to the response calculated using only those impulse responses measured on the main part of the dome, curve (3).



Calculation of Sound-Pressure Response

Knowledge of the amplitude and phase (relative to the sinusoidal driving signal) of the motion at a number of points spread over the surface of the loudspeaker cone enables the sound power output, the directivity diagram, and the axial sound-pressure of the loudspeaker to be calculated corresponding to the amplitude and frequency of the driving signal. If the velocity impulse response is measured at each point (as described earlier), these factors can be calculated as a function of frequency. The calculation process is essentially one of summation; the cone surface is treated as a number of elemental areas which vibrate as tiny rigid pistons such that the total sound-pressure response can be obtained from a sum of the sound-pressure responses of all the individual elements. Each elemental area is assigned an amplitude and phase of vibration which correspond to those measured at a point somewhere within the area. The summation must take into account the areas of the elements and their distances from the point at which the sound pressure is being calculated. The calculation of the sound-pressure/frequency response from measured cone vibration data is discussed in more detail in [29].

Because of the nature of the calculation process, it is a simple matter to determine the contribution which certain areas make towards the total sound power or sound pressure. Thus, for example, the contribution made by the dust cap to the total sound-pressure response could be calculated and compared to the calculated total response. This information might be of considerable interest if, for instance, the motion at points on the dust cap is found to be distorted at some frequencies.

By way of example of the results that can be obtained, Fig. 25 shows the measured and calculated axial sound-pressure/frequency responses of a 26-mm diameter dome tweeter mounted in a baffle. The calculated response was obtained from the velocity impulse responses measured at 33 points spread over the dome and the outer (roll) suspension. At some frequencies the motion of the suspension of this tweeter was found to be more distorted than the motion of the main part of the dome. The contribution which the motion of the suspension made to the total sound-pressure response was thus of considerable interest. Figure 26 shows the calculated total frequency response (from Fig. 25) and the frequency response calculated using only those impulse responses measured on the main part of the dome i.e., the contribution of the suspension is omitted.

Looking Ahead

The laser interferometry measurement system discussed in this article is a considerable advance in the instrumentation available for the analysis and study of loudspeaker cone behavior. In the short time this system has been in use, the B&W research department has learned quite a lot about cone behavior. However, one fact has clearly emerged; there is still a lot more to learn! The behavior of the free-edged, straight-sided cone studied by Frankort [17] is complicated in itself, but real loudspeaker cones exhibit even more complicated behavior due to resonances in the cone suspensions and in the voice-coil bobbin and its dust cap. The theoretical analysis of this more complicated behavior has recently become possible by employing the finite-element technique implemented on high-speed digital computers. Several authors [30, 31, 32] have already used this technique to study the linear behavior of complete loudspeaker diaphragm assemblies. However, there is still much work to be done to explain all the observed phenomena of real loudspeakers. Some workers in the loudspeaker field may argue that the time spent on formulating a theoretical loudspeaker model is wasted because prototypes of the actual loudspeaker can be made so quickly and cheaply that design is best accomplished by experiment. While this is partly true, I believe that the problems of loudspeaker driver design will become better understood by the additional study of an accurate theoretical model, rather than by experimentation only. One approach, which falls between those of pure theory and pure experiment, would be to build up a mathematical model of the loudspeaker driver under investigation by taking measurements of the transfer functions between the voice-coil input voltage and the motion at a number of points on the moving assembly (including the voice-coil bobbin and the cone suspensions, etc.). From this set of transfer functions, it should be possible to compute a model [33, 34] which approximates the real system. Material or geometrical changes to the loudspeaker driver could then be simulated by adjustment of the parameters of the model, and the effect on the loudspeaker perfromance calculated [35].

While we confidently expect the future to hold advances and improvements in laser and computer technology, the future of the loudspeaker driver is less certian. Might we still be paying tribute to Rice and Kellogg in another 50 years time?

REFERENCES

1. C. L. Farrand, "Sound Control Apparatus", U.S. Patent no. 1,847,935; filed April 23, 1921; issued March 1, 1932.
2. "Inventions New and Interesting," *Scientific American*, vol. 125, p. 154; August 27, 1921.
3. C.L. Farrand, "Cone Loud Speakers," *Proc. of the Radio Club of America*, vol. 4, pp. 3-5, October 1926.
4. F.V. Hunt, *Electroacoustics*, John Wiley, New York, 1954.
5. C.W. Rice and E.W. Kellogg, "Notes on the Development of a New Type of Hornless Loud Speaker," *Trans. American Institute of Electrical Engineers*, vol. 44, pp. 461-475, April 1925.
6. E.W. Siemens, "Improvement In Magneto-Electric Apparatus," U.S. Patent no. 149,797; filed January 20, 1874; issued April 14, 1874.
7. C.H. Siemens, "Telephones," British Patent no. 4,685; filed (on behalf of E.W. Siemens) December 10, 1877; complete specification filed April 30, 1878.
8. C. Cuttriss and J. Redding, "Telephone," U.S. Patent no. 242,816; filed November 28, 1877; issued June 14, 1881.
9. O.J. Lodge, "Improvements relating to Telephones, and to Circuit Arrangements and Relays therefor," British Patent no. 9, 712; filed April 27, 1898.
10. S. Hill, "The Kone Loud Speaker," *Electrical Communication*, vol. 6, pp. 24-28, July 1927.
11. M.D. Waller, *Chladni Figures*, G. Bell & Son, 1961.
12. M.S. Corrington, "Transient Testing of Loudspeakers," *Audio Engineering*, pp. 9-13, August 1950.
13. R. Yorke, "An Experimental Approach to the Loudspeaker Problem," Ph.D. Thesis, The University of Southampton, May 1964.
14. J.J. Schurink, "The Twin-Cone Moving-Coil Loudspeaker," *Philips Technical Review*, vol. 16, pp. 241-249, March 1955.
15. N.W. McLachlan, *Loud Speakers*, Clarendon Press, Oxford, 1934.
16. W.O. Rogers, "Stroboscope Aids Dynamic Speaker Design," *Electronics*, p. 30, August 1937.
17. F.J.M. Frankort, "Vibration and Sound Radiation of Loudspeaker Cones," *Philips Research Reports Supplement*, no. 2, 1975.
18. M.S. Corrington and M.C. Kidd, "Amplitude and Phase Measurements on Loudspeaker Cones," *Proc. of the I.R.E.*, vol. 39, pp. 1021-1026, 1951.
19. T. Nimura and K. Kido, "Studies on the Cone Type Loudspeakers (IV)," *The Reports of the Research Institute of Electrical Communication*, Tohoku University, vol. 4, pp. 205-219, March 1953.
20. P. Shajenko, "Holographic Testing of Loudspeakers," *Jour. of the Acoustical Society of America*, vol. 53, pp. 1061-1063, 1973.
21. J. Hladky, "The Application of Holography in the Analysis of Vibration of Loudspeaker Dia-

REFERENCES

phragms," *Jour. of the Audio Eng. Soc.*, vol. 22, pp. 247-250, May 1974.

22. P.A. Fryer, "Holographic Investigation of Speaker Vibrations", paper presented at the 50th Audio Eng. Soc. Convention, London, March 1975.

23. F.J.M. Frankort, "Vibration Patterns and Radiation Behavior of Loudspeaker Cones," *Jour. of the Audio Eng. Soc.*, vol. 26, pp. 609-622, Sept. 1978.

24. L.E. Drain, J.H. Speake and B.C. Moss, "Displacement and Vibration Measurement by Laser Interferometry," SPIE, vol. 136, 1st European Congress on Optics Applied to Metrology, 1977.

25. B.C. Moss, "Laser Interferometry," paper presented at Transducer '79 conference, June 1979.

26. L.E. Drain and B.C. Moss, "The Frequency Shifting of Laser Light by Electro-Optic Techniques," *Opto-Electronics*, vol. 4, pp. 429-439, 1972.

27. E.W. Ross, Jr. and W.T. Matthews, "Frequencies and Mode Shapes for Axisymmetric Vibration of Shells," *Jour. of Applied Mechanics*, vol. 34, pp. 73-80, March 1967.

28. A.J.M. Kaizer, "Theory and Numerical Calculation of the Vibration and Sound Radiation of Cone and Dome Loudspeakers with Non-Rigid Diaphragms," paper presented at the 62nd Audio Eng. Soc. Convention, Brussels, 1979, (preprint no. 1437).

29. G.J. Adams, "Optimisation and Motional Feedback Techniques in Loudspeaker System Design," Ph.D. Thesis, The University of Southampton, December 1979.

30. I. Nomoto and K. Suzuki, "Analysis and Observation of the Vibration Mode of a Loudspeaker by a Computer," paper presented at the 58th Audio Eng. Soc. Convention, New York, Nov. 1977, (preprint no. 1280).

31. T. Ueno, K. Takahashi, K. Ichida, and S. Ishii, "Vibration Analysis of a Cone Loudspeaker by the Finite Element Method," *Nihon Onkyo Gakkaishi*, vol. 34, no. 8, pp. 470-477, 1978.

32. K. Tanada and A. Matsuda, "On the Vibrational Analysis of Dome-Type Loudspeakers by the Finite-Element Method," paper presented at the 60th Audio Eng. Soc. Convention, Los Angeles, May 1978, (preprint no. 1346).

33. A.P. Lincoln, "Modelling of Structural Behaviour From Frequency Response Data," *ISVR Technical Report*, no. 83, University of Southampton, September 1977.

34. H.G.D. Goyder, "Methods and Application of Structural Modelling from Measured Structural Frequency Response Data," *Jour. of Sound and Vibration*, vol. 68, no. 2, pp. 209-230, 1980.

35. A.R. Whittaker and M.M. Sadek, "Optimization of Machine Tool Structures Using Structural Modelling Techniques," paper presented at the conference on Recent Advances in Structural Dynamics held at the ISVR, University of Southampton, July 7-11, 1980.

REFERENCES

phragms," *Jour. of the Audio Eng. Soc.*, vol. 22, pp. 247-250, May 1974.

22. P.A. Fryer, "Holographic Investigation of Speaker Vibrations", paper presented at the 50th Audio Eng. Soc. Convention, London, March 1975.
23. F.J.M. Frankort, "Vibration Patterns and Radiation Behavior of Loudspeaker Cones," *Jour. of the Audio Eng. Soc.*, vol. 26, pp. 609-622, Sept. 1978.
24. L.E. Drain, J.H. Speake and B.C. Moss, "Displacement and Vibration Measurement by Laser Interferometry," SPIE, vol. 136, 1st European Congress on Optics Applied to Metrology, 1977.
25. B.C. Moss, "Laser Interferometry," paper presented at Transducer '79 conference, June 1979.
26. L.E. Drain and B.C. Moss, "The Frequency Shifting of Laser Light by Electro-Optic Techniques," *Opto-Electronics*, vol. 4, pp. 429-439, 1972.
27. E.W. Ross, Jr. and W.T. Matthews, "Frequencies and Mode Shapes for Axisymmetric Vibration of Shells," *Jour. of Applied Mechanics*, vol. 34, pp. 73-80, March 1967.
28. A.J.M. Kaizer, "Theory and Numerical Calculation of the Vibration and Sound Radiation of Cone and Dome Loudspeakers with Non-Rigid Diaphragms," paper presented at the 62nd Audio Eng. Soc. Convention, Brussels, 1979, (preprint no. 1437).
29. G.J. Adams, "Optimisation and Motional Feedback Techniques in Loudspeaker System Design," Ph.D. Thesis, The University of Southampton, December 1979.
30. I. Nomoto and K. Suzuki, "Analysis and Observation of the Vibration Mode of a Loudspeaker by a Computer," paper presented at the 58th Audio Eng. Soc. Convention, New York, Nov. 1977, (preprint no. 1280).
31. T. Ueno, K. Takahashi, K. Ichida, and S. Ishii, "Vibration Analysis of a Cone Loudspeaker by the Finite Element Method," *Nihon Onkyo Gakkaishi*, vol. 34, no. 8, pp. 470-477, 1978.
32. K. Tanada and A. Matsuda, "On the Vibrational Analysis of Dome-Type Loudspeakers by the Finite-Element Method," paper presented at the 60th Audio Eng. Soc. Convention, Los Angeles, May 1978, (preprint no. 1346).
33. A.P. Lincoln, "Modelling of Structural Behaviour From Frequency Response Data," *ISVR Technical Report*, no. 83, University of Southampton, September 1977.
34. H.G.D. Goyder, "Methods and Application of Structural Modelling from Measured Structural Frequency Response Data," *Jour. of Sound and Vibration*, vol. 68, no. 2, pp. 209-230, 1980.
35. A.R. Whittaker and M.M. Sadek, "Optimization of Machine Tool Structures Using Structural Modelling Techniques," paper presented at the conference on Recent Advances in Structural Dynamics held at the ISVR, University of Southampton, July 7-11, 1980.

BUILD A HIGH PERFORMANCE THD ANALYZER

PART THREE

ROBERT R. CORDELL

In Parts I and II the theory and operation of all of the THD analyzer circuits were covered. We will now proceed with construction, adjustment, and troubleshooting. It goes without saying that a thorough understanding of Parts I and II will help immensely in troubleshooting.

Circuit Board Assembly

Assembly of the three printed wiring boards should be quite straightforward if the component placement diagrams are followed carefully. Load all of the IC sockets first (socketing is *strongly* recommended); this will make it easier to identify locations of other components. Note that pin #1 of all ICs faces in the same direction *except* for IC38. Next load the off-board connection terminals ("E" connections denoted by large donut lands on p.c. cards), including those for the power-supply leads. Any suitable terminals may be used here, but Vector Type T-18 terminals are a good choice. The boards come drilled with 0.042-inch holes at these locations for maximum flexibility, but will have to be redrilled to 1/16-inch for the T-18 terminals.

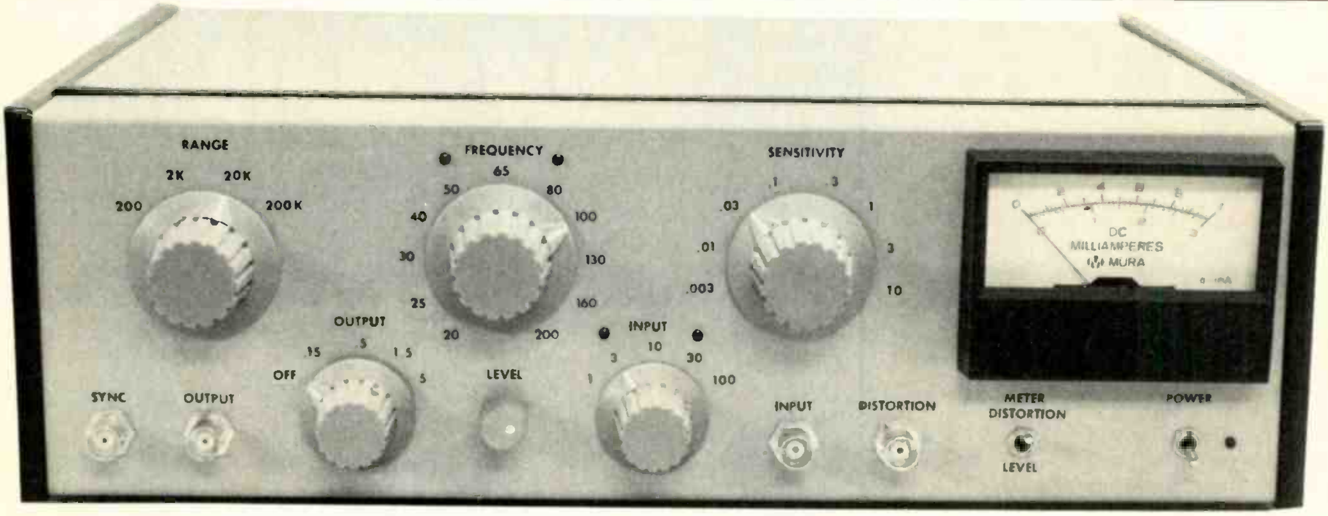
Now load all resistors, diodes, bare jumpers, capacitors, transistors, and insulated jumpers — in that order. Take special care to watch polarity on diodes and polarized capacitors. An elongated pad on the p.c. card denotes the negative terminal of most capacitors and the cathode of all diodes. Also take special care in reading the color code on carbon resistors and the resistance code on precision resistors; many different codes exist for the latter. If you have any doubt, use an ohmmeter. Note that the two diode strings on CP2 (D6-8, 9-11) are each prewired and treated as a single component. Prior to installing FETs Q1, Q5, and Q6, it is a good idea to measure and record their pinch-off voltage (V_p) with the simple circuit of Fig. 24. Knowledge of the pinch-off voltage will permit the best adjustments to be made. Use of 22-gauge, insulated, solid wire is OK for the long insulated jumpers. Note that each of these jumpers connects two points on the board labelled with the same letter of the alphabet.

Complete circuit board assembly by installing all ICs in their sockets, taking care to avoid bent pins, which can sometimes be hard to detect. Again, note that pin #1 of all ICs faces in the same direction *except* for IC38.

Circuit Board Bench Test

Because this is a fairly complex construction project which also involves considerable chassis wiring, it is strongly recommended that most of the electrical testing, troubleshooting and adjustment of the three circuit boards be done one at a time on the bench. This will virtually guarantee success upon final assembly.

Before proceeding further, give each of the boards a *thorough* visual inspection, checking for incorrect polarities or values, cold solder joints, solder bridges



or other shorts, improper IC insertion or placement, missing components or jumpers, etc. This step should not be bypassed.

A ±15V regulated power supply will be required for bench testing. If you don't have one, you may wish to assemble the analyzer's power supply module now and use it.

Signal Source

Prepare CP1 for bench testing by soldering 0.022-µF, ± 10% polyester capacitors from terminal E2 to E3 and from E4 to E5. Connect 3.9-kilohm resistors from E1 to E2 and from E3 to E4. Connect a 2.7-kilohm resistor from E5 to E6. Strap E5 to E9. Connect a 0.1-µF polyester capacitor from E7 to ground. Center the trimmer pot. Connect ± 15V to the power supply terminals (observe polarity!). Connect a scope to E5.

If all is well, you should see 4.5V p-p sinusoid at about 2 kHz on the scope. In any case, it is wise at this point to check all important d.c. voltages. Table 1 provides a listing of all key d.c. voltages as actually measured in the prototype. "BQ3" means the base of Q3, GQ1 means the gate of Q1, -IC1 means the inverting input of IC1, OIC1 means the output of IC1, IC1-6 means pin 6 of IC1, etc. Values indicated by an asterisk may depend on the input signal, adjustment or something similar, and they may not be close to those listed under certain conditions. All values assume a steady-state condition. A voltmeter with a 1 megohm or greater input impedance should be used. Be very careful to avoid shorting adjacent pins on ICs when probing (especially pin 6 on the 318s). When possible, clip to a resistor connected to the desired point instead. When probing certain sensitive points (like the inverting input of an op-amp), it may be necessary to isolate the meter probe with a 10-kilohm resistor to prevent high-frequency oscillations.

A check of the key voltages for CP1 should reveal any problems at this point and aid in finding the cause. It is worth noting that the inverting and non-inverting inputs of an op-amp properly operating with negative feedback should never differ by more than a few millivolts. If a greater difference is observed, there are three possibilities: First, the stage may be over-driven by the input, which may point to trouble further back in the chain. The second is a bad (or unpowered) op-amp. This is generally the case if the polarity of the input differential is not consistent with the output polarity. If this occurs, the output of the op-amp is usually saturated near one power supply rail. If the output is zero, a short from output to ground may be present. The third possibility is a fault in the associated input or feedback circuitry. In this case, the polarity of the input differential will be consistent with the output polarity. In any case, troubleshooting complex circuits involving many possible interactions requires care, thought, and patience. The key lies in separating cause and effect. Often a particular portion of the circuit can be made to look faulty by a problem elsewhere.

If the signal at E5 is large and clipped, and the gate voltage of Q1 is strongly negative, the fault is probably associated with the multiplier circuit (IC3). If the gate voltage is about +0.5V, the problem lies with the a.g.c. control circuit (IC6,7) or the a.g.c. detector (Q2-Q4). In this case a large positive level (greater than +2.5V) at E7 points to the IC6,7 circuitry. A low level (less than 1V) points to the detector circuitry.

If the signal at E5 is zero and the gate voltage of Q1 is strongly negative, the problem lies with the IC6,7 circuitry. If the gate voltage of Q1 is about +0.5V, something is wrong with the oscillator proper (IC1,2,4).

An unstable or varying level indicates a problem with the IC6,7 circuitry involving a.g.c. loop stability. Check R21, R15, R16, R17, C6 and the capacitor connected to E7.

Now check the main output at E11. It should be three times as great as that at E5 if the output amplifier is operating properly.

Replace the resistors from E1 to E2 and E3 to E4 with 39-kilohm resistors. The frequency should drop to about 200 Hz. Observe the full-wave rectifier sawtooth waveform at pin 6 of IC6. Make sure the signal is full-wave and not half-wave; the latter indicates trouble involving IC5, Q3 or Q4. Adjust R24 for perfect symmetry, i.e., so that adjacent peaks are of equal level. Incorrect and correct adjustments of R24 are illustrated by the 'scope photos in Figs. 25 and 26.

Replace the capacitors at C(KM) and

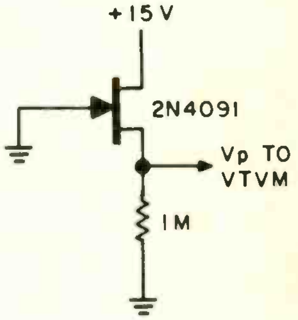


Fig. 24 — Test circuit for measuring J-FET pinch-off voltage.

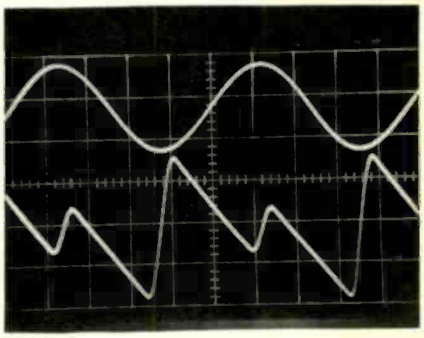


Fig. 25 — Illustration of incorrect adjustment of R24. Bottom trace is from pin 6 of IC6. (Scale: 0.2 V/div.)

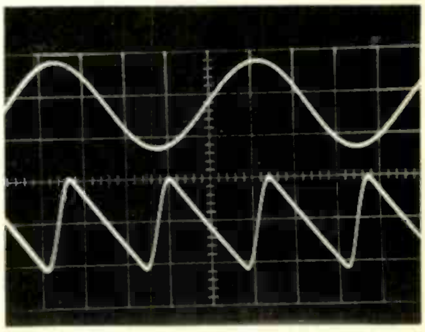


Fig. 26 — Illustration of correct adjustment of R24. Bottom trace is from pin 6 of IC6. (Scale: 0.2 V/div.)

THD
PART THREE

TABLE 1

CP1	CP2-A	CP2-B	CP3-A	CP3-B
OIC1 +2.9	+IC9 -34	E15 -53	OIC25 +2.5	E29 -10
OIC2 +0.8	OIC9 -101	OIC17 -521	IC26-1 -7.6V	OIC31 -14
+IC3 +0.1	+IC10 -12	+IC18 -15.3	IC26-2 -8.2V	E35 -14
OIC3 -4.3	OIC10 +1.2	OIC18 -153	IC26-3 -8.2V	E36 -0.6
OIC4 +1.0	OIC11 +1.2	OIC19 +5.0	IC26-4 -7.6V	E38 +0.1
OIC5 -4.6	+IC12 0.0	IC20-1 -7.52V	IC26-5 -14.0V	E40 +13.6
BQ3 +602	OIC12 +4.3	IC20-2 -8.19V	IC26-6 +5.6V	OIC35 +110
EQ3 +2.2V	OIC13 +0.9	IC20-3 -8.19V	IC26-10 -2.2	OIC36 0.0
E7 +2.2V	OIC14 -5.6	IC20-5 -13.9V	IC26-12 +5.6V	OIC37 +1.7V*
IC6-6 +13	OIC15 -27.5	IC20-12 +8.59V	IC27-5 +1.3V	IC38-3 +3.3V
E8 -2.5V*	E22 -2.1V*	OIC21 +92	IC27-7 0.0*	IC38-6 -3.5V
GQ1 -2.5V*	E23 -1.5V*	IC22-12 +9.3V	OIC28 +7.2	IC38-9 -2.1V*
		E32 +102	IC29-10 -10.4	IC38-13 -12.1V
		AD5 +450	IC29-12 +5.6	IC38-14 +13.3V*
		E31 +48*	IC30-5 +1.4	E47 +12.8V

Table 1 — Key d.c. voltages as measured in completed prototype analyzer operating at 1 kHz with 1V rms input on the 3V input range, reading 0.0005% distortion on the 0.003% sensitivity range. All voltages are in millivolts unless otherwise noted. The asterisk (*) denotes voltages which depend strongly on operating conditions, FET pinch-off voltages, etc. Keep in mind that many voltages may depend significantly on op-amp input offset voltage or bias current, and may even have the opposite sign in some cases.

C(LN) with 0.22 µF, ±10% polyester capacitors. Connect a 1.0-µF polyester capacitor from E7 to ground. The frequency should now be about 20 Hz, the level should be the same as before, and a stable level should be realized within 15 seconds after power is applied.

Input Amplifier And Bandpass Filters (CP2)

Prepare CP2 for bench testing by connecting 0.022-µF, ±10% polyester capacitors from E17 to E18 and E20 to E21. Connect 3.9-kilohm resistors from E16 to E17 and E19 to E20. Ground E14, E15, E22 and E23. Connect ± 15V to the supply terminals, carefully observing polarity.

Check all d.c. voltages for this circuitry (Fig. 12) in Table 1. Pay less attention to those with asterisks. If problems are found, they should be corrected now. Apply 1V rms at 2 kHz to E12 and check for a 3V rms output at E13. Apply the same signal to the bandpass filter input at E15. Observe the signal at E18. It should exhibit a bandpass characteristic centered at about 2 kHz as the input frequency is varied. Set the frequency for maximum output. Adjust R62 for a level of 1.15V rms at E18. Adjust R59 for a center frequency of 2 kHz and retrim R62.

Observe the signal at pin 6 of IC14. It should be approximately 1.0V p-p and in-phase with that at E19. Temporarily remove the short from E22 to ground and connect E22 to -15V. The signal at pin 6 should now be about 1.0V p-p and inverted from that at E19. Repeat this procedure for pin 6 of IC16 with phase checked relative to that of E21 and changing the voltage on E23 from ground to -15V. The results should be about the same. If either of these procedures reveals a problem, one of the multipliers (IC14, Q5 or IC16, Q6) should be suspected. Note that changing the voltage on E22 should slightly affect the center frequency (about ±1.6%), while changing that on E23 should only slightly affect the amplitude at E18 (about ± 3.5%). Check for about 30mV rms at E24.

Product Amplifiers And Auto-Set Level Circuits (CP2)

Connect a 10-kilohm resistor from E27 to E28 and an 82-kilohm resistor from E26 to E28, and check the d.c. voltages for this circuitry (Fig. 13) in Table 1. Voltage measurements at the pins of IC20 and IC22 should be made through a 10-kilohm isolating resistor at the end of the meter probe to prevent oscillations.

With the 1V rms, 2-kHz signal still applied to E15, sweep the frequency and observe the output at E26. A notch should be observed at the center frequency of the bandpass filter. Try to adjust the generator frequency and the setting of R62 for a deep notch (less than 10mV rms). If R62 doesn't have enough range, connect E23 to -15V instead of ground and try again. Now offset the generator frequency to obtain a 100mV rms output at E26. Ground E25 and observe a level of 1.0V rms at E26. Remove the ground at E25. Check pin 6 of IC19 for a level of 100mV rms.

Now check the auto-set level circuitry. A level of about 1.1V rms should appear at the output of the reference VCA (E32), independent of input level over a ±10-dB range. At the nominal 1V rms input level, E31 should be at about 0V d.c., while plus and minus 10-dB input levels should result in approximately minus and plus 3V respectively at E31. Recovery to nominal output from a 20-dB drop in input level should take about 10 seconds. If the level is too large and E31 is strongly negative, the circuitry associated with IC22 and IC23 is probably faulty. If E31 is strongly positive, the circuitry associated with D5 and IC24 should be suspected. If the level is too low, the opposite polarities at E31 will point to the problem areas above.

Check the distortion product output at E29. A level of 100mV rms should be observed, independent of input level variations over a ±10-dB range about 1V rms. This assumes that there is still 100mV rms at pin 6 of IC19 when the input level is 1V rms.

Auto-Tune Circuits (CP3)

Prepare this portion of CP3 (including IC31, Fig. 18) for bench testing by connecting a 10-kilohm resistor from E29 to ground. Center trimmers R135 and R157. Connect ±15V to the supply terminals of CP3 (observing polarity) and check the relevent d.c. voltages in Table 1. Voltage measurements to the pins of IC26 and IC29 should be made through a 10-kilohm isolating resistor. By offsetting R135 or R157, it should be possible to get the respective integrator outputs at E23 and E22 to drift slowly in a positive or negative direction between approximately −12V and +0.3V.

Apply 100mV rms at 2 kHz to E29 and observe the same signal at pin 6 of IC31. Observe a somewhat softly clipped 1.5V p-p version of the signal at pin 6 of IC25. Briefly short E33 to ground and observe a 1V rms level at pin 6 of IC31 and a 2.5V p-p rounded square wave at pin 6 of IC25. Apply 100mV rms at 2 kHz to E21 and observe a softly clipped 0.8V p-p level at pin 6 of IC28. Increase the input level to 1V rms and observe a hard clipped 1.0V p-p signal at pin 6 of IC28.

Further bench testing of CP3 requires the use of CP2. If any problems remain on CP2, correct them now before proceeding. Prepare CP3 by making interconnections E21, E29 and E32 from CP2 to CP3. Remove the existing connections at E22 and E23 on CP2 and make interconnections E22 and E23 from CP3 to CP2. Center R135 and R157. It is assumed that E25 is open and that the attenuator between E26 and E28 is still in place.

With the 1V rms, approximately 2-kHz signal applied at E15 as previously, check pin 6 of IC25 for a 3V p-p rounded square wave. If the level is very

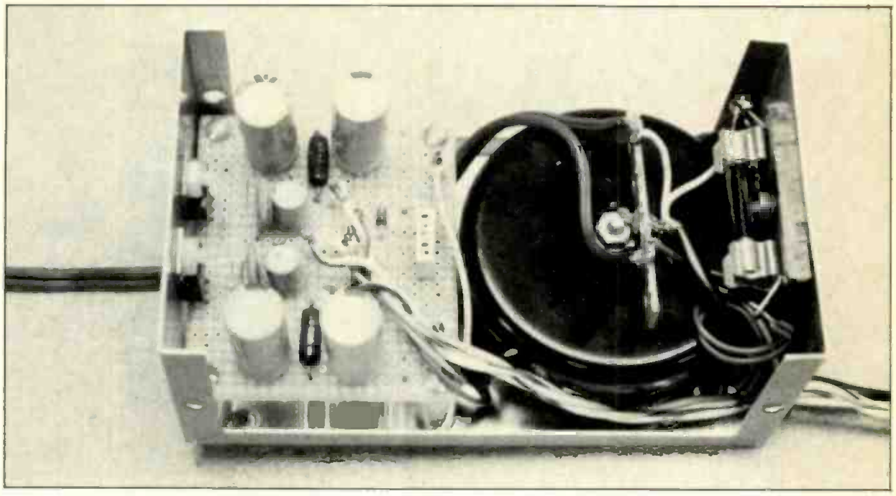


Fig. 27 — Interior of the ±15V power supply module. A torroidal power transformer was utilized in the prototype to minimize hum.

small, the analyzer may have tuned itself. In this case, changing the frequency by about 10% so that it is well out of the tuning range should yield the square wave. Also check for a 1V p-p square wave at pin 6 of IC28.

Adjust the input frequency for a minimal output at E29 and measure the d.c. voltage at E22. Set the input frequency to yield a voltage equal to one-half the pinch-off voltage measured for Q5 (3.5V if you didn't measure it). Now adjust R62 for a d.c. voltage equal to one-half the pinch-off voltage of Q6 at E23. A complete null of the fundamental should now be present at E29, with only distortion and noise visible.

Now place a 100-to-1 attenuator between E29 on CP2 and E29 on CP3; a 100-kilohm series resistor and a 1-kilohm shunt resistor to ground will do. Alternately adjust R135 and R157 for the best possible fundamental null as observed at E29 on CP2. These adjustments should be made slowly, as the time constants in the auto-tune control circuits are long.

Filter, Meter And Status Circuits

Strap E35 to E36 and E40 to E41. Connect a 10-kilohm resistor from E34 to ground. Connect a 1-kilohm shunt resistor from E42 to ground. Center R180 and R192. Apply power and check the relevent voltages in Table 1.

Apply a 300mV rms, 2-kHz signal to E34. Check for 300mV rms levels at pin 6 of ICs 32 and 33. Adjust R180 for about 100mV rms at pin 6 of IC34 and 1V rms at pin 6 of IC35. Drop the input level at E34 to 30mV rms and short E39 to ground. Observe about 100mV rms at pin 6 of IC34 and 1V rms at pin 6 of IC35. Check for 1.4V p-p half-wave rectified signals at the anode of D22 (negative-going) and the cathode of D23 (positive-going). Check for a positive d.c. level of about 1.1V at E42.

Remove the strap from E40 to E41 and place a strap from E24 on CP2 to E41. Apply a 3V rms, 2-kHz signal to E15 on CP2 and check for 1V rms at pin 6 of IC35. Adjust R192 for a +1.1V d.c. level at E42.

Check the status circuits by connecting four LEDs from terminals E43 through E46 to +15V. Remove the strap from E24 to E41 and replace the strap from E40 to E41. Reconnect E29 on CP2 directly to E29 on CP3. Connect a 1V rms 2-kHz signal to E15 on CP2. D26 and D27 should be extinguished, while D24 or D25 should light if the input frequency is tuned above or below the tuning range respectively. They should both be extinguished if a good notch is being observed at E29. Drop the input level to 0.25V rms; D27 should light. Raise the input level to 4V rms; D26 should light.

Bench testing of the circuit boards is

THD
PART THREE

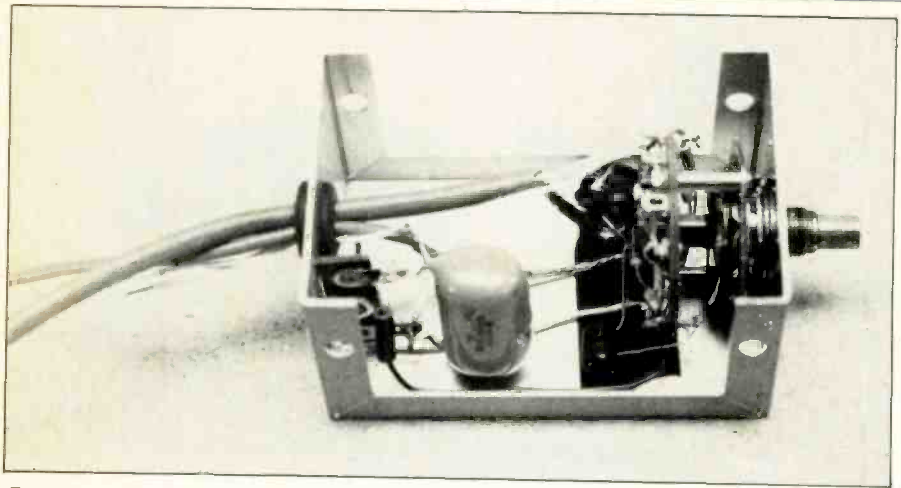


Fig. 28 — Interior view of the input attenuator module.

now complete. If any problems surface after final assembly, they are probably not on the circuit boards.

Chassis Assembly

The first step in chassis assembly is to build the power supply module. It is built inside a 2¼ by 3 by 5¼ inch aluminum utility box. This affords some shielding against 60-Hz hum. Conventional point-to-point wiring is used, employing a perforated board for component mounting. The voltage regulator ICs should be bolted to one wall of the enclosure and insulated with mica washers. Make sure that metal burrs don't cause shorts between the enclosure and the ICs. The power supply module is bolted to the rear of the analyzer enclosure, with the line cord passing through both the power supply and the notched-out analyzer cover. Power leads and switch wiring pass to the interior of the analyzer through a grommet in the power-supply enclosure. A polarized line cord is recommended to guarantee that the power switch is always on the neutral side of the a.c. line so as to minimize hum. The power transformer should be mounted in the module so that it is at the extreme right-rear of the analyzer, far away from CP1 and CP2. A photograph of the power supply is shown in Fig. 27.

Although the choice of the power transformer is not critical, use of a torroidal design (as shown) will assure low induced hum. The Avel-Lindberg 40/3004 used here is available from Sager Electrical Supply Co., 60 Research Rd., Hingham, Mass., 02043 at a cost of about $24.00. In any case, the input voltage to the regulators under the full analyzer load should not be less than 18V (including ripple dips) nor greater than 35V. If necessary, adjust R211 and R212. The 40/3004 transformer does not have much extra current capacity, so be particularly observant of regulator headroom in this case.

The three circuit boards should be mounted on ⅜-inch threaded 6-32 standoffs and placed as shown in Fig. 4 (Part I, July issue). CP1 is placed so that IC1 is closest to the front panel. CP2 is placed so that IC9 is closest to the front panel. CP3 is placed so that IC38 is closest to the front panel. Make all of the power-supply connections and then the connections between CP2 and CP3. Circuit board power and ground should be distributed on a single-point basis from a terminal strip mounted near the input jack (J3).

Two types of shielded cable were used in this project, low-capacitance microphone cable (34pF/ft.) and high-capacitance miniature cable (124pF/ft.). Unless specified, the miniature cable can be used. Use a shielded cable for the E29 interconnection (shield grounded only at E30).

Now mount and interconnect all of the remaining front panel items except the range and frequency switches (S1 and S3). The resistors residing on the output level, input level, and sensitivity switches (S2, S4 and S5) should be wired onto the switches prior to mounting of the switches.

Level control R30 should be connected to E9 through a shielded cable. The shield should connect to E10 and the CCW end of R30. The output attenuator (S2) should receive its ground directly from the single-point ground. R205 will ultimately be suspended between S2C and S11.

As mentioned earlier, the input attenuator should be mounted in a small, shielded enclosure as shown in Fig. 28. Use shielded cable from the input jack and single-point ground to the attenuator. Four ferrite beads are placed on the lead from C21 to S4 for improved r.f.i. immunity. Connect the output of the attenuator to E15 on CP2 with low-capacitance shielded cable. Note that the shield supplies ground to the secondary single-point ground (E14) on CP2.

Selection of the attenuator frequency-compensation capacitors (shown dotted in Fig. 12) will require experimentation, as the required values and even topology (series vs. shunt connection) will depend on particular parasitics. The best approach is to do the compensation before installing the module, using the actual required length of low-capacitance cable at the output looking into a 100-kilohm low-capacitance load (or a 100-kilohm, 100-to-1 resistive attenuator). Use an audio generator and an audio a.c. voltmeter or oscilloscope to achieve a flat frequency response on all ranges with the module's cover in place.

High-capacitance shielded cable is recommended for connection of the sensitivity switch (S5A) to E28. Note that the attenuator receives its ground from E27 via the shield. The "hot" ends of R90 and R94 on S5A can be connected to a nearby unused switch position.

If you have chosen to implement the simple fixed-product filters of Fig. 19 instead of the tracking filters, wire them now. Use shielded cable for the connections to E29 (on CP2), E34, E35, E36 and E38. The filter ground connection should come via the shield of the cable going to E34, which shield can be connected at E37. The shield of the cable going to E29 should be connected only at E30 on CP2. The 510-pF capacitor in Fig. 19 should be made smaller by the amount of the cable capacitance in parallel with it.

Intermediate Check-Out

At this point, prior to the wiring of the range and frequency switches, a moderately thorough check-out of the analyzer is recommended. This can be done if the temporary tuning capacitors and resistors installed for bench testing have been left on the boards. We assume here that the capacitors in place are 0.022 µF and that the resistors are 3.9 kilohm. The 0.1-µF capacitor from E7 to ground and the 2.7-kilohm resistor from E5 to E6 on CP1 should also be in place. If you have chosen to implement the tracking product filters, strap E29 to E34 and E35 to E36. Connect the source output (J2) to the analyzer input (J3).

The analyzer can now be put through a full set of paces at 2 kHz. Note that you may have to adjust R59 and perhaps R62 to get a null and have reasonable FET control voltages at E22 and E23 (say, -1 to -4V). Also check the oscillator a.g.c. FET gate voltage at E8. Check all functions of the analyzer under a variety of level and sensitivity conditions to determine that everything is working properly. Look for evidence of oscillations.

"Distortion" from a separate signal generator can be injected through a 62-kilohm resistor into the connection between the source and the analyzer. If the source is producing 1V rms and the separate signal generator is delivering 100mV rms to the resistor, a 0.1% "distortion" level will result. Check the calibration of R180 and R192. Check for satisfactory tuning time and instrument residual. If any problems are uncovered, correct them now.

Final Assembly

Assembly of the range and frequency switches may require some ingenuity. S1 consists of nine five-position, two-pole wafers if the tracking product filters are implemented. The resulting length will usually require that S1 be assembled with parts from two or more rotary switches. The shaft can be extended by sawing off the shaft from a second switch and affixing it to the shaft of the switch under construction with a standard shaft coupler. The pair of 4-40 screws which hold the switch together can be extended by joining additional lengths of 4-40 screw to them (obtained from the second switch) with tapped 4-40 standoffs. A close-up of the switches assembled in this way is shown in Fig. 29. Alternately, the Centralab switch components specified in the parts list can be assembled into the required switch.

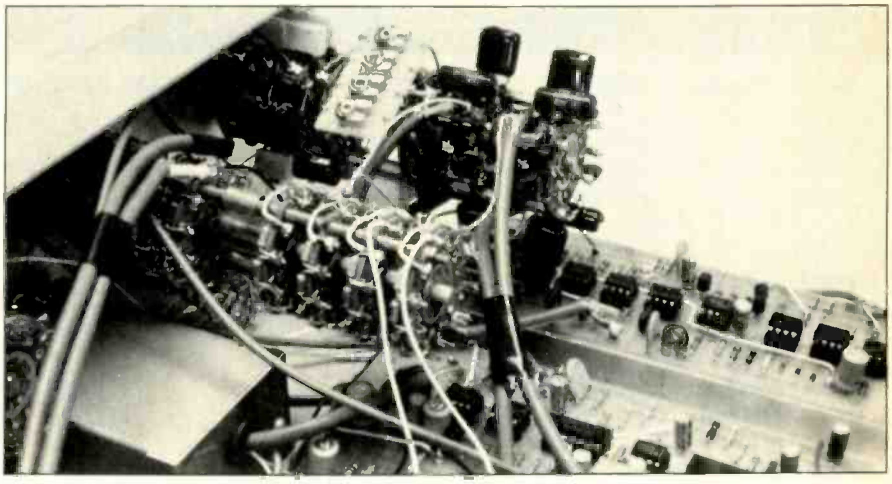


Fig. 29 — Closeup of the specially constructed range and frequency switches.

The capacitors are mounted between adjacent wafers as shown in Table 2. For example, C(KM)-1 mounts between poles K and M at position 1. Poles S1A and S1B are on the wafer closest to the front panel. The capacitor and resistor designations for switch-mounted components assume that the tracking product filters are being implemented and that their components are mounted on the switch sections closest to the front panel. Note that the tuning capacitors for the highest frequency range have a small resistor in series with them. This resistor compensates for a high-frequency phenomenon in active filters known as "Q-enhancement" which results from op-amp high-frequency rolloffs. These resistors can be mounted on the unused position-5 switch terminals. Note that the tuning capacitors are wired so that there is always some capacitance connected even when the switch is between positions, preventing undesirable transients. This is accomplished by wiring the position-4 terminals in parallel with their respective wipers. The use of shorting-type switches would also have accomplished the transient suppression.

The high-pass product filter capacitors [C(BD) and C(DF)] for the 20-kHz range are also used for the 200-kHz range by connecting positions 3 and 4 of the associated switch poles together. This was done because stability of higher frequency active high-pass filters would have been a problem, and the additional filtering is not really necessary on the highest range.

As shown in Fig. 29, the four frequency trimmers (R1 to R4) were mounted on a small piece of perforated board and mounted to poles J and H of S1 with 18-gauge solid bare wire. R206 is mounted on the switch between the two wipers.

After S1 is assembled and loaded with components, mount it and make all possible interconnections to the circuit boards. Each of the four tuning capacitors [C(KM), C(LN), C(OQ) and C(PR)] is connected to the circuit boards by seven inches of low-capacitance shielded cable. The capacitance of the shielded cable is directly in parallel with that of the associated tuning capacitor. Instead of being grounded, the shield interconnects one side of the tuning capacitor to the *output* of the associated integrator. Thus, for example, the shield connects one side of C(KM) to E3. The capacitance of this length of cable has been taken into account in the values of the tuning capacitors for the 200-kHz range, and appropriate alterations should be made to these capacitors if other values of shielded cable capacitance are used. The shields are connected to switch poles K, L, Q, and R.

Frequency switch S3 consists of eight 11-position, single-pole wafers, and

THD
PART THREE

TABLE 2

Range	Position	C (AC)	C (EG)	C (BD, DF)	C (GI)	C (KM, LN)	C (OQ, PR)
200 Hz	1	0.1 μF	0.068 μF	0.22 μF	1.0 μF	0.22 μF*	0.22 μF*
2 kHz	2	0.01 μF	6800 pF	0.022 μF	0.47 μF	0.022 μF*	0.022 μF*
20 kHz	3	1000 pF	680 pF	2200 pF	0.1 μF	2200 pF†	2200 pF†
200 kHz	4	100 pF	47 pF	2200 pF	0.01 μF	200 pF† +68 Ω	200 pF† +180 Ω

Table 2 — Capacitor connections on range switch S1. The asterisk (*) indicates polypropylene, polycarbonate or polyester of at least 100 V working voltage. The dagger (†) indicates polystyrene or silvered mica, again of at least 100 V working voltage. The others are not critical.

TABLE 3

Frequency	Position	Desig.	R (A, B)	R (C)	R (D)	R (E, F, G, H)
20	1	R( ) 1-2	1500	3600	9100	7500
25	2	R( ) 2-3	1000	2400	6800	5620
30	3	R( ) 3-4	1300	3000	7500	6190
40	4	R( ) 4-5	750	1800	4700	3830
50	5	R( ) 5-6	680	1600	4300	3480
65	6	R( ) 6-7	430	1000	2700	2150
80	7	R( ) 7-8	360	910	2400	1960
100	8	R( ) 8-9	330	820	2200	1780
130	9	R( ) 9-10	220	510	1300	1100
160	10	R( ) 10-11	180	470	1200	1000
200	11	R( ) 11-*	750	1800	4700	3830

Table 3 — Resistor connections on the frequency switch S3. The asterisk indicates a tie-point, position 12 if available; otherwise use an insulated terminal. R (E, F, G, H) should be 1%, ¼-watt carbon-film types where each group of four like values should be matched to within 1%. Others are standard 5%, ¼-watt carbon film. All values are shown in ohms.

should be constructed in the same way as S1 above. If possible, it is recommended that switch shields be installed between sections 4 and 5 and between sections 6 and 7. The resistors on S3 are mounted between adjacent positions on a given wafer. The wiring is documented in Table 3. For example, R(A) 1-2 goes on S3A, the wafer closest to the front panel, between positions 1 and 2.

Although precision 1% resistors are preferred for R(E) through R (H), the only requirement is that the four resistors of each position be matched to each other within 1%. Thus, you may save some money or hassle by measuring and matching 5% carbon-film resistors. If you buy 10 of a given value at the same time, there is a very good chance you'll find four with the required match. Try not to get all of the resistors which err on the high side placed on one wafer, and vice versa.

As with the tuning capacitors, S3 is wired so that resistance is present even when the switch is between positions. This is done by wiring the position-1 terminal to the switch wiper. The free end of the lowest valued resistor connected to position 11 can be tied to position 12 if you have a 12-position switch or to a small, insulated terminal on or near the switch if you have an 11-position switch.

With S3 assembled and loaded with components, mount it and make all of the remaining interconnections. Where possible, make the interconnections with positions on S1 that already have a wire running back to the appropriate circuit board terminal.

Connection of the tracking-filter components on S1 and S3 to E29, E34, E35, E36, E37 and E38 can be done with shielded cables as discussed earlier for the fixed filtering option. In this case, however, the connections to E34 and E36 must be made with low-capacitance shielded cable. The value shown for C(EG) for the 200-kHz range assumes about eight inches of this cable. The product filter interconnections between S1 and S3 need not be shielded, but should be dressed as far away as possible (i.e., against the front panel) from the signal leads and components of the oscillator and analyzer sections. There is a very substantial amount of gain between the oscillator/BPF circuits and the product filters. Failure to get adequate isolation here could result in oscillations, particularly on the 200-kHz range. Leads associated with the analyzer section should also be dressed away from those of the oscillator section. Assembly of the analyzer is now complete.

Test And Calibration

The signal source should be checked first. Center trimmers R1 to R4. Apply power, and monitor the main output on a 'scope and a.c. voltmeter. Also monitor the d.c. voltage at E8, the gate bias for Q1. Check operation at all frequencies. Check frequency response flatness and level stabilization time. Check to see that the gate voltage of Q1 does not get within 0.5V of either zero or the measured pinchoff voltage at any frequency. Check the action of the output attenuator and level control. If you have a frequency counter, check all the frequencies; at this point they should be within ±20% of the selected value, and should increase monotonically as the frequency switch is advanced. Check for oscillations as well.

Set the analyzer to 650Hz, and adjust frequency trimmer R2 for a source frequency of exactly 650Hz if you have a frequency counter. Otherwise use a Lissajous pattern with a 650-Hz oscillator as a reference. Connect the signal source to the analyzer input, and apply 1V rms on the 3V input range. Monitor the d.c. levels at E22 (frequency control) and E23 (amplitude control). Adjust R59 and R62 as necessary to get the analyzer to tune and to set these voltages to half the measured pinchoff voltages of the associated FETs.

The remaining frequency trimmers in the oscillator will now be adjusted to bring the oscillator into alignment with the center frequency of the analyzer for the remaining frequency ranges. At 65Hz, adjust R1 so that the d.c. voltage at E22 equals half the recorded pinchoff voltage for Q5. Adjust R3 at 6.5 kHz and R4 at 65 kHz in the same manner. Now check the voltages at E22 and E23 at all frequencies to make sure that neither one gets within 0.5V of either zero or the associated pinchoff voltage. Make compromise adjustments among R1, R3, R4, R59, and R62 as appropriate. A problem with the E22 voltage (frequency control) may mean an incorrect frequency-setting resistor somewhere on S3. Now that the oscillator trimmers are set, it would be useful to recheck the oscillator frequency calibration. Typically it should be within ±10%.

If the amplitude control voltage (E23) changes substantially toward the high end of the frequency range (between 50 kHz and 200 kHz), this could be an indication that the Q-enhancement compensator resistors in series with C(OQ) and C(PR) on the highest range need some adjustment. The value shown in the schematics is a good compromise value, but it does depend somewhat on the individual rolloff characteristics of the op-amps (ICs 10, 11, 12, 13, and 15). If E23 goes too positive (toward zero), these resistors may be too large. If E23 goes too negative, these resistors may be too small.

Another phenomenon to watch for toward the high end of the 200-kHz range is "slewing oscillations." Too much phase lag around an active-filter loop can cause Q-enhancement and, ultimately, oscillation. If the signal being handled by an active filter causes one or more of the op-amps to slew-rate limit, the effect is equivalent to a substantially increased phase lag. This can result in oscillations which drive the amplifiers even deeper into slew-rate limiting. The only way to stop such an oscillation is to tune to a lower frequency or remove power. The normal signal levels in this analyzer cannot touch off such an oscillation, but a sufficiently large transient can. That is why the range and frequency switches are wired so as not to generate transients when they are operated. However, occasionally a power-on transient can trigger such an oscillation in this analyzer if it is powered up when tuned to greater than about 100kHz.

The frequency response of the tracking product filters should be checked at this point by injecting a signal at their input in place of E29. If the level at three times the front-panel setting is taken as 0 dB, then the lower and upper 3-dB-down frequencies should be at 1.4 and 10 times the set frequency, respectively (0.14 and about 8 times on the 200-kHz range).

To calibrate the distortion reading, two signal sources should be used. Apply 1V rms at 1 kHz to the analyzer from the internal signal source. Put S6 in the "Level" position and adjust R192 for a full-scale reading with the input attenuator on the 1V range. Apply 1V rms at 3 kHz from a second audio generator through a 62-kilohm resistor. The analyzer will now see 0.99V at 1 kHz and 10.1mV at 3 kHz, or a "distortion" level of 1.02%. Set the sensitivity switch (S5) to the 1% range and adjust R180 for a meter reading just a hair over full-scale.

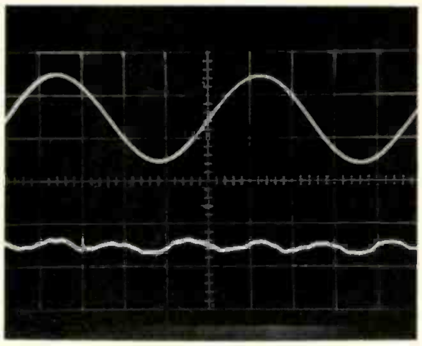


Fig. 30 — Analyzer residual at 20 Hz, 1V rms operating level in the 0.003% sensitivity range. (Scale: 0.2 V/div.)

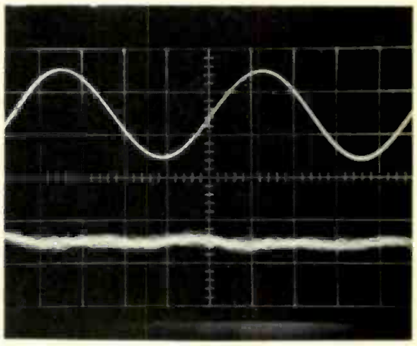


Fig. 31 — Analyzer residual at 1 kHz, 1V rms operating level in the 0.003% sensitivity range. (Scale: 0.2 V/div.)

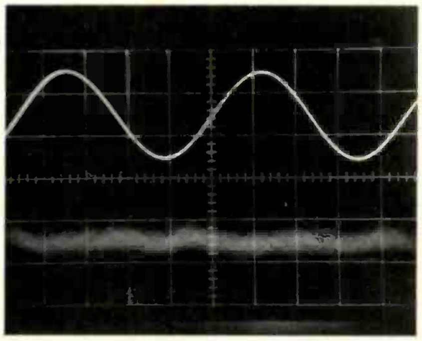


Fig. 32 — Analyzer residual at 20 kHz, 1V rms operating level in the 0.003% sensitivity range. (Scale: 0.2 V/div.)

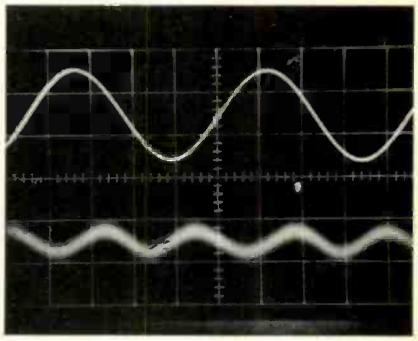


Fig. 33 — Analyzer residual at 200 kHz, 1V rms operating level in the 0.03% sensitivity range. (Scale: 0.2 V/div.)

THD
PART THREE

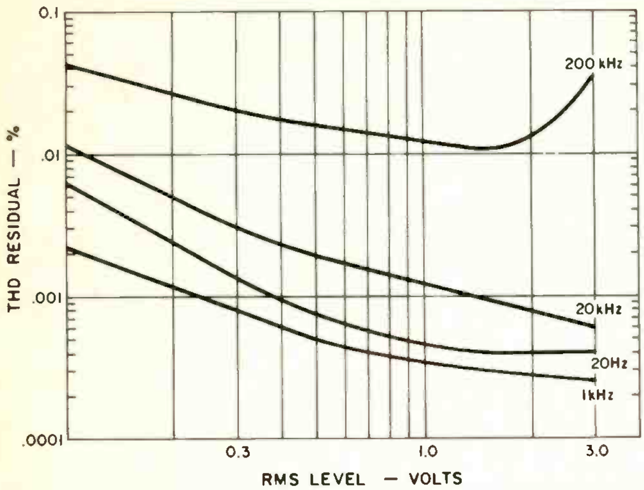


Fig. 34 — Residual vs. level as a function of frequency in the 3V input range.

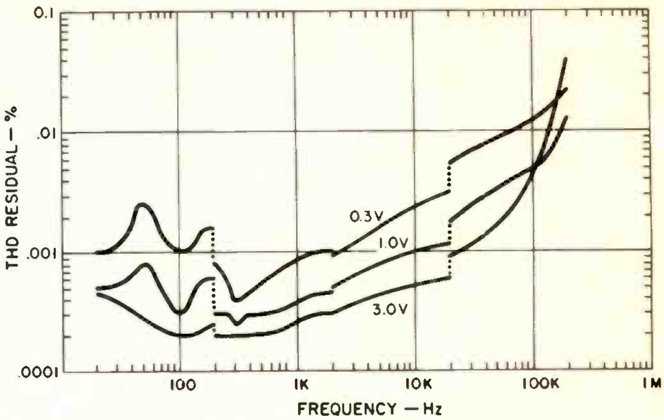


Fig. 35 — Residual vs. frequency as a function of input level in the 3V input range.

To complete testing, measure the analyzer's residual at all frequencies and at various levels by connecting the signal source directly to the analyzer input. It is useful to observe the "Dist. Out" signal on a 'scope at this point.

If the residual seems particularly noisy or jumpy on only one range, don't hesitate to suspect the trimmer pots and the tuning capacitors. This is a sensitive application and even minor deficiencies in these components may cause trouble; I've experienced trouble with both. I strongly recommend the use of high-quality tuning capacitors.

Hum can be particularly insidious in an instrument such as this where full-scale sensitivities on the order of 30 microvolts are encountered. Although the construction details are intended to minimize hum, you may still have to fight it. It will be most noticeable on the 200-Hz range. Remember, hum can be picked up capacitively by a high-impedance circuit (shielding helps here) or it can be magnetically induced into any circuit, including grounds. Hum will probably be reduced when the instrument is fully housed in its enclosure.

Performance

Performance of the prototype is illustrated in Figs. 30 to 35. Scope photos of the analyzer's residual at the nominal 1V internal operating level for 20 Hz, 1 kHz, 20 kHz, and 200 kHz are shown in Figs. 30 to 33.

The total residual (noise and distortion components) is plotted as a function of level for the four frequencies above in Fig. 34. The residual as a function of frequency for 0.3, 1.0 and 3.0V rms internal operating levels is plotted in Fig. 35. Best performance is generally achieved near the high end of its allowable range of operating levels. At operating levels above about 1.5V rms, the residual is below 0.001% across the full audio band.

Parts Availability

A serious attempt was made to design the THD analyzer with readily available parts, and many constructors will have no trouble finding most of the parts at normal outlets. As an aid, however, several dealers of various parts are listed below. Because of the substantial number of parts involved in this project, I recommend obtaining and searching through the catalogs that many of these and other companies make available. Although most of these companies provide broad lines, a few are worth special mention because they have some of the less commonly available parts. The NE5534AN op-amps and the Centralab rotary switches are available from Newark Electronics ($25.00 minimum order). The 2N4091 J-FETs and a suitable power transformer are available from CFR Associates. Precision one-percent resistors are available from International Electronics Unlimited.

Digi-Key Corp.
P.O. Box 677
Thief River Falls, Minn. 56701
800/346-5144

Active Electronic Sales Corp.
P.O. Box 1035
Framingham, Mass. 01701
617/879-0077

CFR Associates, Inc.
Newton, N.H. 03858

Jameco Electronics
1355 Shoreway Rd.
Belmont, Calif. 94002
415/592-8097

Newark Electronics
146 Route 1
Edison, N.J. 08817
201/572-2103
(or contact nearest branch)

International Electronics Unlimited
435 First St., Suite 19
Solvang, Calif. 93463
805/688-2747

PARTS LIST

All resistors are ¼-watt, 5-percent carbon-film unless otherwise specified. Those specified as "1 percent" are ¼-watt metal-film types. Substitution of 5-percent resistors for the 1-percent type will only degrade accuracy of the attenuators.

R1, R2, R3, R4, R59, R62, R192—5 kilohm trimpot (Panasonic K4A53)
R5, R19, R58, R102, R116, R140, R141, R162, R163, R190—6.8 kilohm
R6, R11, R14, R15, R18, R22, R23, R25, R26, R27, R56, R60, R61, R63, R64, R67, R71, R77, R80, R87, R96, R134, R136, R143, R145, R147, R156, R158, R165, R168, R178, R188, R195, R197, R199, R208—10 kilohm
R7, R66—150 kilohm
R8, R72, R74—560 ohm
R9, R73, R75—330 ohm
R10, R68, R76—270 ohm
R12, R69, R78, R137, R204—1.5 kilohm
R13, R70, R79—750 kilohm
R16, R33, R50, R86, R105, R119, R120, R123, R142, R146, R164, R171, R174—100 kilohm
R17, R31, R82, R128, R149, R150, R183, R185, R186, R187—1 kilohm
R20, R35—1.3 kilohm
R21, R41, R42, R43, R53, R103, R117—1 megohm
R24, R135, R157—1 kilohm trimpot (Panasonic K4A13)
R28, R57, R126, R133, R138, R139, R155, R160, R161, R206—22 kilohm
R29—5.6 kilohm
R30—2.5 kilohm potentiometer
R32, R84—2.2 kilohm
R34—2.0 kilohm
R36—1.8 kilohm
R37—820 ohm
R38—620 ohm
R39, R40, R213, R214—220 ohm
R44—68.1 kilohm, 1 percent
R45—42.2 kilohm, 1 percent
R46—90.9 kilohm, 1 percent
R47—11 kilohm, 1 percent
R48—100 kilohm, 1 percent
R49—3.16 kilohm, 1 percent
R51, R176—1 kilohm, 1 percent
R52—2.05 kilohm, 1 percent
R54, R65—82 kilohm
R55, R85—18 kilohm
R81, R196, R198—33 kilohm
R83, R98, R99, R101, R112, R113, R115, R129, R130, R131, R132, R148, R153, R154, R167, R172, R173, R175, R181, R182, R207—100 ohm
R88—1.1 kilohm, 1 percent
R89—10 kilohm, 1 percent
R90—7.5 kilohm, 1 percent
R91—2.15 kilohm, 1 percent
R92—750 ohm, 1 percent
R93—316 ohm, 1 percent
R94—6.2 kilohm
R95—1.1 kilohm
R97, R100, R106, R111, R114, R118—15 kilohm
R104—470 ohm
R107, R108, R109, R110, R125, R151, R152—4.7 kilohm
R121—910 kilohm
R122—22 megohm
R124—12 kilohm
R127, R179, R200, R201, R202, R203—2.7 kilohm
R144, R166—68 ohm
R169—390 ohm
R170—3.3 kilohm
R177—9.09 kilohm, 1 percent
R180—2 kilohm trimpot (Panasonic K4A23)
R184—9.1 kilohm
R189—20 kilohm
R191—270 kilohm
R193—8.2 kilohm
R194—39 kilohm
R205—2.7 megohm
R209, R210—3.3 ohm, 2-watt; remove if using 40/3004 transformer
R211, 212—10 ohm, 2-watt; see text
R(A) through R(H)—See Table 3 and text
C1, C25, C27—15 pF silver mica (Arco DM15-150)
C2, C3, C26, C28—22 pF silver mica (Arco DM15-220)
C4, C5, C23, C41, C43, C45, C46, C47, C49—10 µF, 25-V radial electrolytic (Panasonic ECE-AIEV100S).
C6, C7, C8, C17, C18, C35, C36, C42, C52, C53, C55, C56, C57, C59, C66, C67, C72, C73, C83, C84—100 µF, 16-V radial electrolytic (Panasonic ECE-AICV101S)
C9—1 µF, 100-or 250-V metallized polyester (Panasonic ECQ-E2105KZS)
C10—0.47 µF, 100-V metallized polyester (Plessey Minibox 0.47/100 F box)
C11—0.1 µF, 100-V metallized polyester (Plessey Minibox 0.1/100 C box)
C12, C76—0.01 µF, >100-V metallized polyester (Plessey Minibox 0.01/630 C box)
C13, C14, C15, C16, C29, C30, C31, C32, C33, C34, C60, C61, C62, C63, C64, C65, C81, C82—0.1 µF, 25-V ceramic disc (Panasonic ECK-DIE104ZFZ)
C19, C20, C37, C38, C39, C40, C44, C48, C50, C68, C69, C70, C71, C74—1 µF, 50-V radial electrolytic (Panasonic ECE-AIHV0-10S)
C21 — 2 µF or 2.2 µF, 250-V metalized polyester (Panasonic ECQ-E2225KZS)
C22 — 47 pF silver mica (Arco DM15-470)
C24 — 10 pF silver mica (Arco DM15-100)
C51 — 0.22 µF, 100-V metallized polyester (Plessey Minibox 0.22/100 D box)
C54, C58 — 0.47 µF, 50-V (Radio Shack 272-1071)
C77, C78, C79, C80 — 470 µF, 35-V radial electrolytic (Panasonic ECE-AIVV471S)
C (AC) through C (PR) — See Table 2 and text
D1 through D23 — Switching diode (1N914, 1N4148 or equiv.)
D24 through D28 — Red LED (Opto Electronics XC209R)
D29 through D32 — 1N4002, 1N4003, 1N4004 or equiv.
Q1, Q5, Q6, Q7, Q8, Q9 — 2N4091 J-FET (National)
Q2, Q3, Q4 — 2N3904 or equiv. gen. purpose silicon; NPN
IC1, IC2, IC3, IC4, IC8, IC9, IC10, IC11, IC12, IC13, IC14, IC15, IC16, IC17 — NE5534AN (Signetics, TI)
IC5, IC6, IC7, IC18, IC19, IC23, IC25, IC28, IC31, IC32, IC33, IC34, IC35, IC36 — LM318N (National, TI, etc.)
IC20, IC22, IC26, IC29 — LM1496N (National, Mot., etc.)
IC24 — LF356N (National, Fairchild, etc.)
IC27, IC30 — LM1458N (National, Mot.)
IC37 — UA741CN (Fairchild, National, etc.)
IC38 — LM324N (National, etc.)
IC39 — LM340T-15 or UA7815CT (National, Fairchild)
IC40 — LM320T-15 or UA7915CU (National, Fairchild)
T1 — 32-48 V c.t., 1-amp power transformer (e.g., CFR Associates Tranny 1 or Avel-Lindberg 40/3004)
F1 — 1-A 3AG slow-blow fuse
S1 — 5-position, 9-section, 18-pole rotary switch (Centralab PA302 6-inch index assy., Newark #22F652 plus 9 PA-32 sections, Newark #22F842 or see text). (If using fixed filters, 5-position, 6-section, 12-pole, PA1033, Newark #22F833)
S2 — 5-position, 2-section, 4-pole rotary switch (Centralab PA1013, Newark #22F813)
S3 — 11-position, 8-section, 8-pole rotary switch (Centralab PA302 6-inch index assy., Newark #22F652 plus 8 PA-30 sections, Newark #22F840 or see text). (If using fixed filters, 11-position, 4-section, 4-pole, PA1015, Newark #22F815)
S4 — 5-position, 1-section, 2-pole rotary switch (Centralab PA1003, Newark #22F803)
S5 — 11-position, 4-section, 4-pole rotary switch (Centralab PA1015, Newark #22F815)
S6 — Miniature SPDT switch
S7 — Minature SPST switch
M1 — 1-mA meter movement, preferably with 0-1 and 0-3 scales (MURA PM-702)
Misc. — case; power supply and input attenuator enclosures; line cord; BNC jacks; knobs; shielded cable; PWB terminals; DIP sockets; mounting hardware, etc. A set of three etched, drilled and solder-plated circuit boards (CP1, CP2 and CP3) is available for $35.20 post-paid (in continental U.S.A.) from Circuit-Works, 1118 7th Ave., Neptune, N.J. 07753. New Jersey residents must add 5-percent sales tax. Please allow 3 to 4 weeks for delivery.

1

TECHNICS RS-M95 CASSETTE DECK

Manufacturer's Specifications

Frequency Response: 20 Hz to 17 kHz, 20 Hz to 19 kHz with CrO_2 tape, 20 Hz to 20 kHz with metal tape.

Signal/Noise Ratio: 60 dB, 70 dB with Dolby NR.

Input Sensitivity: Mike, 0.25 mV; line, 60 mV.

Output Level: Line, 650 mV; headphone, 88 mV at 8 ohms.

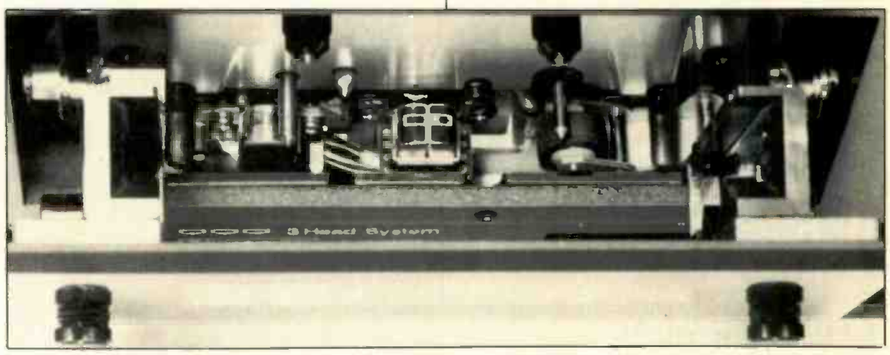
Flutter: 0.03% wtd. rms.

FF & RWD Times: 80 seconds for C-60.

Dimensions: 17¾ in. (450 mm) W x 5⅝ in. (142 mm) H x 13¾ in. (348 mm) D.

Weight: 26.5 lbs. (12 kg).

Price: $1300.00.



The Technics RS-M95 cassette deck has excellent performance and a number of useful convenience features. The unit incorporates quite an array of front-panel controls and switches, but they are laid out and identified well, so there is little likelihood of confusion. The gold printing on the dark-brown background, however, is difficult to read when the room light is dim. When observing the unit in use, my attention was caught by the three-digit fluorescent tape counter, the flashing *Strobo* indicator to its right, and the two-channel, fluorescent-bargraph level meters. The tape counter is different from most other units not only in its display but in its mechanism, which uses a magnet and Hall-effect integrated circuitry to detect motion without actual contact. In addition to the three digits, there is a series of one to four bars, which appears to the right of the numeric display, and the change to the next digit occurs when all of the four are blank. These improve counter resolution and are particularly helpful toward the end of the cassette. (The *Strobo* indicator flashes on/off continuously at about a one-second rate, whatever mode the deck is in, helpful for timing pauses or short sections of music.

The fluorescent level meters cover a wide range, from below "−40" to "+8" dB, white up to zero and orange-brown above, with the Dolby-level reference at "+3." There are a total of 30 segments in each channel with individual thresholds, so the resolution is excellent, with 1-dB steps from "−5" to "+4." Next to the top level on the display (on the right), there are annunciators for *Record* mode, *Peak* meter response, and *Dolby NR*, which last also lights up little double-D symbols at "+3" — very nice. Metering can also be set to have VU ballistics, and there is a peak hold function which works with both meter responses. The Technics deck has two memory functions. *Memory 1* has a reset/clear button which resets the counter to "000" and puts on the "M1" annunciator. The deck will now stop at this point in play or either wind mode. A second push clears the stop function and its indicator. The *Stop/Play* button allows adding a *Play* command to the stop-at-zero instruction, and there is an "MP" added below "M1" when it's selected. *Memory 2* allows setting the stop point, storing the counter number for reference. The set button can also be used to recall that number to the display at any time. The *Clear* button does just that, and there's an "M2" to show if that might be necessary. It is a flexible memory scheme, and it is helpful that stops will be made with either direction of wind.

The transport control is with light-touch bar switches, with useful status lights for *Rec*, *Play*, *Pause* and *Rec Mute*. The deck has more flexibility than most units as it is really possible to make any normal mode changes. For example, for *Rec* and *Pause*, use either one first or both together. You can even make flying start recording from a fast wind mode: Just push *Rec* and *Play*, and there it is. *Rec Mute* is the desirable momentary contact type, and the indicator light emphasizes that muting is taking place. The four tape-select switches are interlocked, and the indicators are a must to show which bias and EQ has been chosen. The indicator of the monitor switch shows red for source and green for tape. The friction between sections of the input level pot seemed slightly high; some knurling on the knobs would facilitate making inter-channel adjustments.

Below the items discussed above are four bias adjust pots with handy center detents and knobs, and pots for meter brightness and output level. The adjustment for meter brightness is an unusual one, and it did allow setting the fluorescent display anywhere from medium to high brightness. Rotary switches select the functions of *Timer* (*Play/Off/Rec*), Dolby NR (*Out/In/In with Filter*), and input (*Mike/Line/400 Hz/400 Hz & 8 kHz*). In the *400-Hz* position, an internal tone is fed to both record channels internally. Then, with monitor in *Source*, the input level control sets a zero level on the meters. Next, in *Tape*, the screwdriver-adjust *Rec Cal* pots are trimmed to get the same zero indication. In the *400-Hz/8-kHz* position, the lower frequency goes to the left channel, the higher frequency to the right channel. The bias adjust pot is trimmed, if necessary, for a matching zero indication. The actual tone levels are 20 dB lower on the tape, and a calibration amplifier provides the gain needed for a zero-dB display. It is a good scheme, and in my opinion such capabilities should be part of any top-end deck. The two mike phone jacks are mounted on the same sub-panel, and the manufacturer provides a clear cover panel which can at least slow down unwanted diddling with the adjustments.

The clear-door cassette carrier moves out and tilts with a push of the color-coded eject button. The power push-button switch and the headphones jack are below. On the top cover are two block schematics, one on the audio portion of the deck and

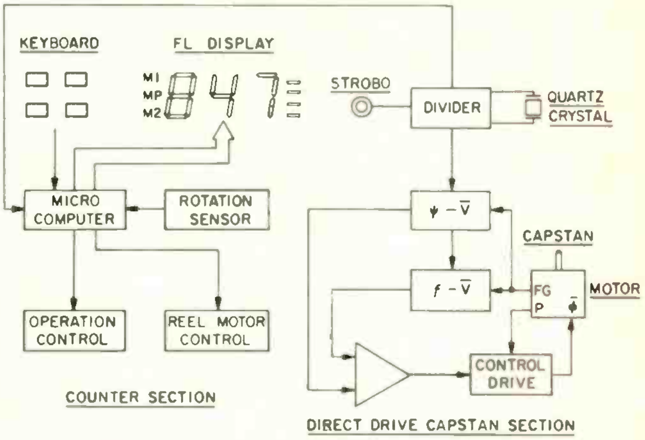


Fig. 1 — Block diagram of counter and capstan-drive sections.

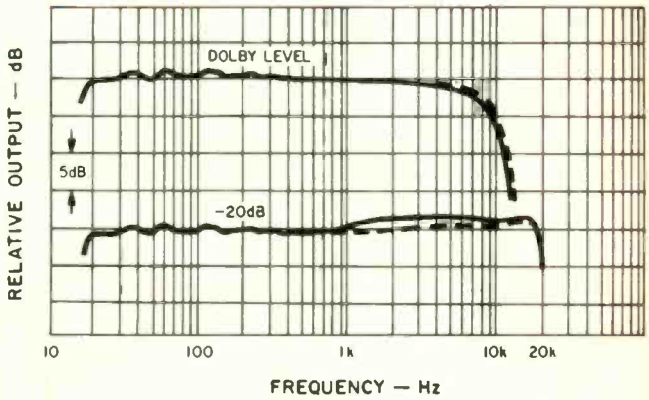


Fig. 2 — Frequency response with and without (dashed line) Dolby NR using Maxell UD-XL I-S tape.

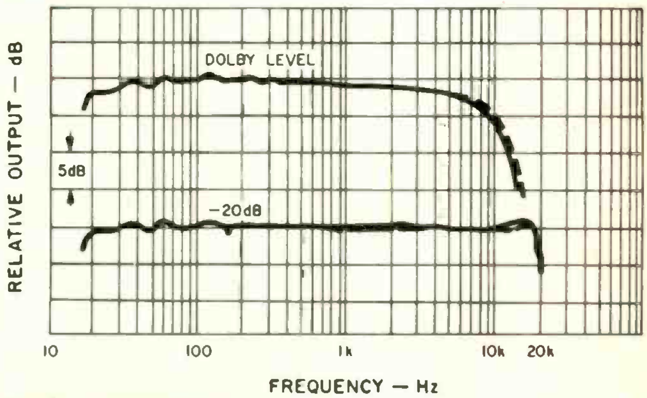


Fig. 3 — Frequency response with and without (dashed line) Dolby NR using Technics XA II tape.

Technics RS-M95 cassette deck offers excellent performance and many very useful convenience controls and features.

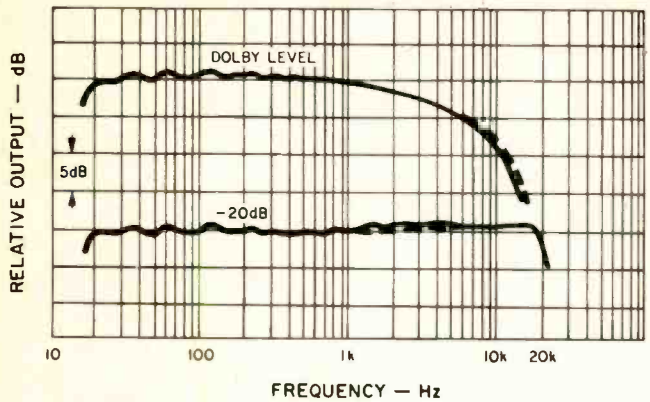


Fig. 4 — Frequency response with and without (dashed line) Dolby NR using Sony Duad tape.

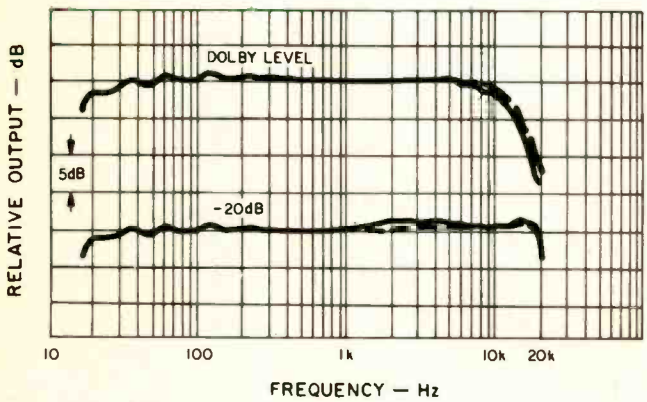


Fig. 5 — Frequency response with and without (dashed line) Dolby NR using Technics MX tape.

another on the counter and direct-drive capstan schemes (more below). On the back panel are the dual in/out phono jacks and a socket for a remote control. The unit is supplied with rugged rack adapters, an important feature to some users. The deck is quite a good size, but the interior was found to be fairly well filled with about a dozen circuit cards. A lot of the interconnections were made with multi-pin cables, but there was some direct wiring. Soldering on the p.c.b.s was excellent. Components were all identified, as were adjustments, with some labels on both sides of the cards. The tape drive appeared to be quite rugged and sophisticated, in particular the reel and the large-diameter direct-drive capstan motors and the two solenoids. There were two fuses in clips, and the large power transformer was mounted at an angle, undoubtedly to minimize hum pickup.

Circuit Description

As noted above, the RS-M95 has a lot of circuitry in it, and there are some interesting elements associated with the counter and the drive system. Figure 1 is a block diagram of the functions of interest, and it can be seen that the output of the quartz crystal and its divider goes three ways. For one thing, it controls the *Strobo* indicator so that it flashes at a very exact rate. Another output from the divider goes to the micro-computer of the counter. The computer also takes inputs from the keyboard for *Memory 1* and *2* in setting stop and start points and from the rotation sensor which establishes how much the tape has moved from any reference point. The fluorescent display, of course, shows what the status is of these inter-related things. The output from the micro-computer also controls stop, wind, and play memory functions and the associated actions called for by the reel motor.

The direct-drive, quartz-controlled capstan system is, in many respects, the offspring of the drive system introduced in the Technics RS-1500/US open-reel recorder. As the direct-drive capstan motor rotates, its frequency generator output is fed to both frequency and phase comparing circuits. Both compare the input against a reference voltage, but the phase comparison is done in conjunction with the output from the crystal divider. In a considerable simplification, we can say that the frequency-dependent closed-loop gets the drive on speed, and the phase-dependent closed-loop provides much tighter control of instantaneous speed, substantially eliminating all perturbations. (Results from speed and flutter tests are given later).

Performance

The playback responses with standard alignment tapes were excellent at low and mid frequencies, but there was a roll-off at the high end of about 4 dB at the highest frequency for both equalizations. There were also variations in level in this region, cycling about 2 dB with a one-second period. It seemed to match the rotation of the pressure roller, but this was not proven. Play level indications were very close to standard, and tape play speed measured exactly correct (within 0.05%). The majority of the record/playback tests were conducted with the four tapes supplied with the deck, Technics XA II, Sony Duad, Technics MX, and Maxell UD-XL I, with the exception that level variations with the XL I prompted its replacement with a sample of XL I-S received directly from Maxell. Pink noise/RTA tests showed that the adjustable bias allowed matching most tapes in the four type categories, with the exception of low-bias tapes, mostly non-high-fidelity formulations. The record/playback responses were made at Dolby level and 20 dB below that, both with and without Dolby NR. The RS-M95 is a three-head deck, but all plots were made by recording, rewinding, and then plotting on the playback. Experience has shown that many three-head units show a better, but inaccurate, frequency response if plotting is done simultaneously with recording — a matter of inter-head leakage.

The results with the preferred procedure are shown in Figs. 1 to 4, and the response limits are listed in Table I. All of the results are quite good with the exception of Sony Duad at Dolby level. Dolby tracking was very good, no doubt aided by the adjustment of bias and record sensitivity using the built-in calibration scheme. Occasionally, there were level changes of about a dB in the higher frequency portion of the sweeps, similar to those noted with the alignment tapes. The record-sensitivity pot had a broad range from −12 to +5 dB with Technics XA II tape. The bias control went from very low bias (with low output)

Record/playback results were quite good, while separation, crosstalk, and erasure performance figures were all well above average.

Table I—Record/playback responses (-3 dB limits).

	With Dolby NR				Without Dolby NR			
	Dolby Lvl		-20 dB		Dolby Lvl		-20 dB	
Tape Type	Hz	kHz	Hz	kHz	Hz	kHz	Hz	kHz
Maxell XL I	18	8.2	18	19.7	18	9.1	18	20.0
Technics XA II	18	6.9	18	19.0	18	7.9	18	19.4
Sony Duad	18	3.6	18	20.4	18	4.0	18	20.6
Technics MX	18	12.0	18	20.3	18	12.9	18	20.4

Table II—Signal/noise ratios with IEC A and CCIR/ARM weightings.

	IEC A Wtd. (dBA)				CCIR/ARM (dB)			
	W/Dolby NR		Without NR		W/Dolby NR		Without NR	
Tape Type	@ DL	HD=3%	@ DL	HD=3%	@ DL	HD=3%	@ DL	HD=3%
Maxell XL I	61.0	64.5	53.3	56.8	59.4	62.9	49.2	52.7
Technics XA II	63.7	66.8	55.5	58.6	62.3	65.4	52.4	55.5
Sony Duad	64.8	68.8	57.0	61.0	64.6	68.6	54.7	58.7
Technics MX	62.8	67.3	54.7	59.2	61.7	66.2	51.8	56.3

through a peak (+2 dB) to a point where the 8-kHz tone was brought back down to –4.5 dB with XA II, a range which would facilitate a match with many tapes. With a 10-kHz test tone, the playback showed just 20-degrees phase difference between channels, much better than most decks, and phase jitter was just 25 degrees, also better than typical decks.

The output polarity of the deck matched the input polarity, whether in source or tape monitor. The response of the multiplex filter was 1 dB down at 15.8 kHz, 3 dB at 16.5 kHz, and 32.0 dB at 19.0 kHz. Bias in the output during recording was very low. The 400-Hz tone (404 Hz actual) had about 3.8% distortion, and the 8-kHz tone (8.66 kHz actual) had about 10% distortion — both adequate for the calibration scheme used. The separation between channels with a 1-kHz test tone was 45 dB. Crosstalk was down 74 dB, and erasure was at least 80 dB. The erasure at 100 Hz with the MX metal tape was 69 dB. All of these figures are excellent.

A 1-kHz tone was recorded from 10 dB below Dolby level with increasing level up to the point where the third harmonic distortion reached 3%. Figure 5 is a plotting of the results obtained with three of the tapes. Other distortion products were quite low in level, particularly with the XA II and MX tapes. Figure 6 shows the level of HDL_3 vs. frequency from 30 Hz to 7 kHz in Dolby mode with MX tape, recorded at 10 dB below Dolby level. The distortion figures are quite good, but lower distortion with XL I-S would have been desirable. The signal-to-noise ratios, with both IEC and CCIR/ARM weightings, were measured for all four tapes. As Table II shows, all of the figures are excellent. The highest values were obtained with Sony Duad, but that tape could only be recommended with this deck where there was relatively little high-frequency energy to be recorded.

The input sensitivities were 0.26 mV for mike and 63 mV for line, very close to spec. Input overloads were at high levels, 48.5 mV for mike and 30.6 V for line. Output clipping appeared at +16.6 dB re: meter zero. The two sections of the input-level pot tracked within a dB from maximum down at least 60 dB, and output level pot tracking was within a dB for 55 dB — excellent

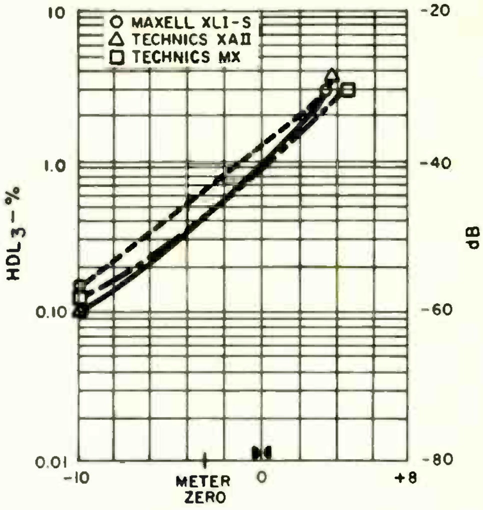


Fig. 6 — Third harmonic distortion vs. level in Dolby mode at 1 kHz using Maxell UD-XL I-S and Technics XA II and MX tapes.

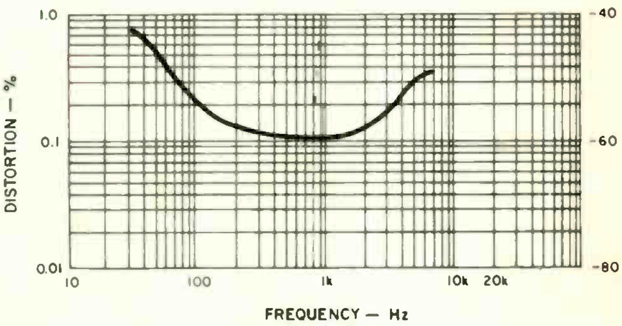


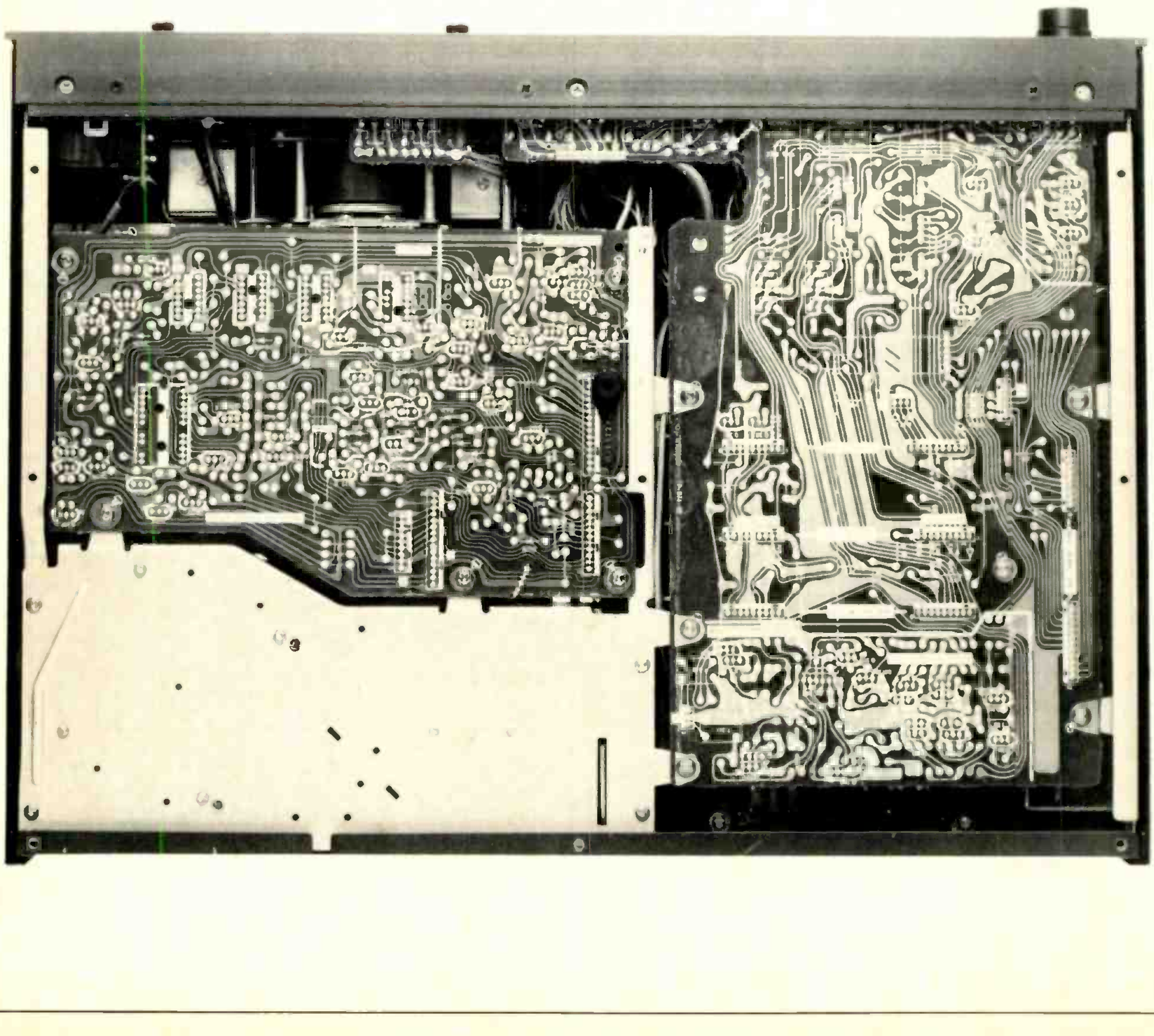
Fig. 7 — Third harmonic distortion vs. frequency in Dolby mode at 10 dB below Dolby level with Technics MX tape.

results. Output levels were 83 mV to an 8-ohm load for headphones and 635 mV for line, dropping to about 470 mV with a 10-kilohm load. The source impedance of about 4 kilohms is rather high if load impedances will be relatively low. Volume level was good with most phones tried, but slightly weak with one set. The frequency response of the level meters was within 3 dB from 17 Hz to 28.1 kHz. In VU mode, the response time was the desired 300 mS. In peak-responding mode, the display ballistics met IEC Standard 268-10 with 3- and 10-mS bursts, including decay time. The meters correctly showed increased peak levels for both positive and negative d.c. shifts of the tone burst. The level indications were high at the low end of the scale, within 2 dB at "–30," and within 0.5 dB for most points above that.

Tape play speed had been shown to be very accurate in earlier tests, and playback of a recorded 3000-Hz tone while changing the line voltage demonstrated that the deck was immune to such effects. The record/play-back flutter was 0.037% wtd. rms and 0.078% on a wtd. peak basis. These figures are excellent, and lower numbers might have been possible if any time had been spent looking for a low-flutter cassette. The wind times were to the specified 80 seconds for a C-60. The time required to make changes in transport mode was always 1 second or less. The tape-time strobe flashed about 56 times per minute.

In-Use and Listening Tests

Good guiding of the cassette aided loading and unloading. Access for maintenance was very good, even better with the clear door plate removed. All switches and controls were completely reliable, and there were no problems with the tapes whatever was done in changing tape motion. I found it worthwhile to remind myself that the tape select switches were mechanically interlocked, going back to *Normal* if another switch wasn't pushed hard enough to latch. All calibrations were most easy to do, and the meters aided in this task. The annunciators for "Dol-



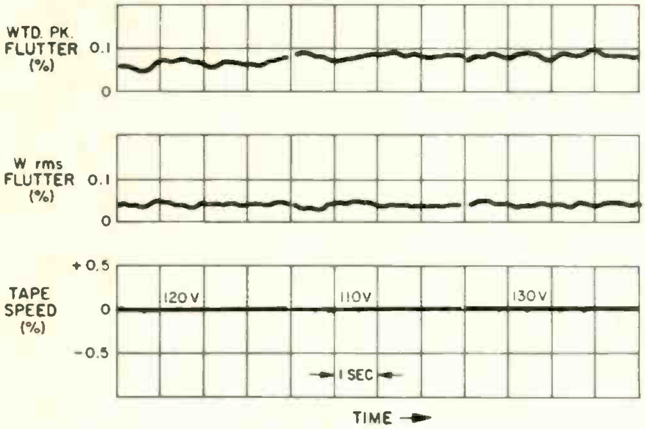


Fig. 8 — Tape play speed vs. time and line voltage, and wtd. rms and wtd. peak flutter, three trials each.

by" and "Peak" were continually helpful, and the orange-brown of the segments above zero seemed a good color choice.

The text of the instruction manual is excellent with additional helpful notes set off in blocks. The illustrations are very good and well tied to the text. A detailed schematic is supplied, and there are the schematic blocks on the top panel. Most of the listening checks used discs for sources, and included Cleo Laine's *Born on a Friday*, Fennell's *Macho Marches* on a Telarc digital, Milhaud's *Suite Francais* with Fennell, the dbx-encoded version of Ravel's *Bolero* with Morton Gould and the London Symphony, and other works.

All of the results were very good in every respect, with only one case of high-frequency, high-level roll-off. There was obviously good Dolby tracking, with minimal sonic shifting when switching NR in and out. All record, pause, and stop noises were very low, actually down into tape noise. On timer start, there was a three-second delay after the application of power before starting play or record, as selected.

The Technics RS-M95 cassette deck offers many useful features and excellent performance, particularly in the area of stable tape movement. It has excellent metering and calibration facilities, greatly aiding the process of setting record levels accurately and matching tapes to the machine. It is most worthy of consideration and compares very favorably with any other deck in its general price category.

Howard Roberson

Enter No. 90 on Reader Service Card

2

WHARFEDALE E-90 LOUDSPEAKER SYSTEM

Manufacturer's Specifications
Nominal Impedance: 8 ohms.
Typical Frequency Response: 43 Hz to 18 kHz, ±3 dB.
Sensitivity: 95 dB SPL for one watt at one meter.
Power Handling: 140 watts.
Size: 44 in. (112.5 cm) H x 15 in. (38.0 cm) W x 15 in. (38.0 cm) D.
Weight: 93 lbs. (42 kg).
Price: $925.00.

The Wharfedale E-90 is a three-way floor-standing loudspeaker system. Two 250-mm (10-in.) moving-coil bass drivers are combined in a 110-liter vented enclosure to produce a maximally flat Butterworth fourth-order bass loading. The bass drivers are crossed over at 200 Hz to two 100-mm (4-in.) moving-coil midrange drivers, which carry the response to 2 kHz. A 25-mm (1-in.) compression-driver, horn-loaded treble speaker continues the response to past 18 kHz.

The enclosure stands 1125 mm (44 in.) high and is 380 mm (15 in.) wide by 380 mm deep and weighs 42 kg (93 lbs.). Wharfedale has provided a securely mounted handle at the top rear of the enclosure for ease of movement about a room.

Electrical connection is made to a recessed socket on the rear of the enclosure. A special six-meter connecting cable with mating connector and DIN plug for amplifier connection is supplied with each speaker.

The E-90 system is supplied as a left speaker and a right speaker pair. Each is clearly marked by a label mounted adjacent to the electrical connection.

A modest degree of midrange and treble equalization is provided by two 5-position rotary switches mounted on the front of the enclosure. These are accessible without removing the protective grille and are marked *Low* and *High* with index positions labelled *0*, *-1*, *-2*, *-3*, and *-4*. The operation of these controls, together with pertinent technical information, is clearly presented on a descriptive label placed on the rear of the enclosure. This, together with the descriptive brochure accompanying each speaker, allows error-free hookup of this system.

Rated at 8 ohms, the E-90 is stated as having a sensitivity of 95 dB SPL at one meter for 1-watt drive. Power handling (per DIN 45-573) is 140 watts, and Wharfedale states that the E-90 is suitable with amplifiers rated from 15 to 200 watts. Frequency response is stated to be ±3 dB from 43 Hz to 18 kHz.

Measurements

The impedance load which the Wharfedale E-90 presents to a power amplifier is shown in Figs. 1 and 2. The magnitude of this impedance, Fig. 1, reaches a minimum value of 5.1 ohms at 42 Hz. The measurement was made through the interconnect wire which Wharfedale supplies with the E-90. The nature of this impedance is such that the E-90 can be safely considered an 8-ohm system from the standpoint of amplifier drive requirements. The complex impedance plot, showing reactance as well as resistance, is shown in Fig. 2. The impedance is rather benign, as far as the reactance load which it presents to an amplifier; however, there is a 25-degree lagging angle, with a magnitude of 10 ohms, at 2.6 kHz. Since this lies in the important music overtone range, some consideration should be given to choosing a high-quality power amplifier to drive the E-90 if one listens at robust sound levels.

The free-field frequency response of the E-90, amplitude and phase, is shown in Figs. 3 and 4. These are measured under anechoic conditions at a one-meter axial position, and use a constant drive voltage corresponding to one average watt across

[redacted]

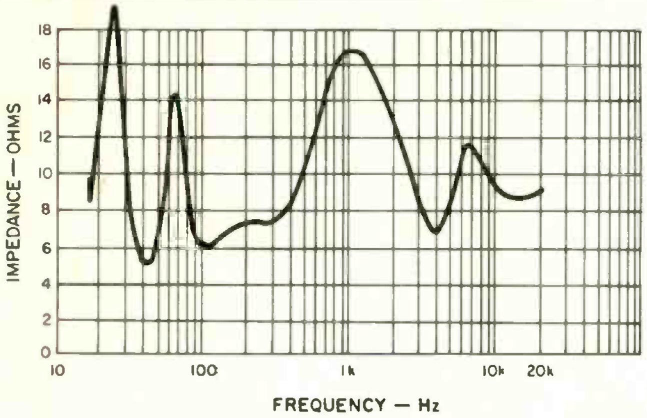


Fig. 1—Magnitude of impedance.

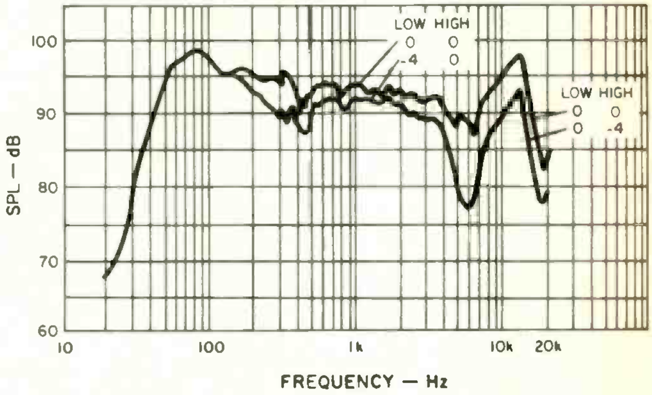


Fig. 3—Anechoic axial response at one meter with constant voltage drive corresponding to one average watt into 8 ohms.

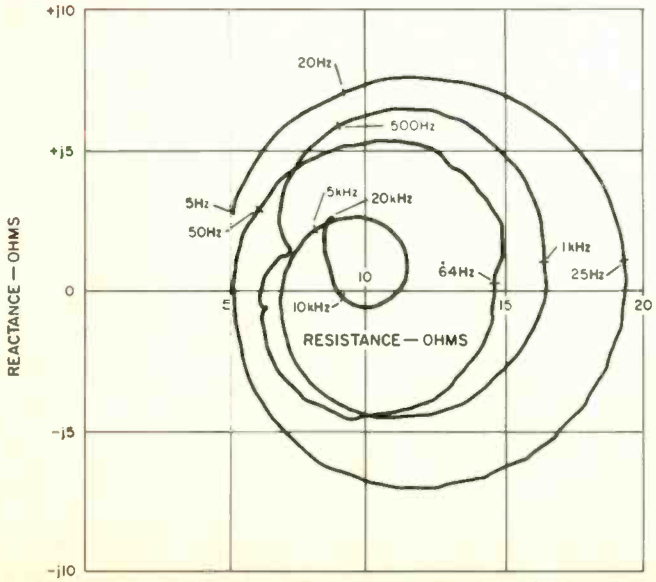
a nominal 8-ohm resistance.

The amplitude response, Fig. 3, is taken for two equalizer settings, midrange at -4 and tweeter at -4. As this measurement shows, the tweeter response does drop 4 dB for this setting, but the midrange is only reduced 2 dB. Actual acoustic crossover occurs at 2 kHz.

Sound pressure level at the equivalent of one-watt drive is very high for the E-90, averaging nearly 93 dB SPL in the midrange and rising to 97 dB at 12 kHz. This is an extremely efficient system and can give brisk sound levels with moderate-sized power amplifiers.

Low-frequency response extends smoothly down to about 45 Hz. The midrange is quite smooth, but the highest frequency performance is relatively disappointing for a system of this general high quality. An acoustic interference dip at 6 kHz is followed by a peak at 12 kHz, and this combination cannot be corrected with the equalizer controls supplied with the E-90.

Fig. 2—Complex terminal impedance.



The phase response, Fig. 4, is corrected for the air-path delay in the 1 to 5 kHz frequency range when the microphone is one meter in front of the enclosure; this delay is 3.2422 milliseconds. Acoustic transitions occur at 1 and 5 kHz. The corrected phase response shows an angle of positive 90 degrees, which identifies the midrange response as being of non-minimum phase type. The lower frequencies and higher frequencies are of minimum phase type.

The three-meter room response is plotted in Fig. 5. The microphone is placed one meter above a carpeted floor and 3 meters from the front of the enclosure. This simulates an average listening position. The frequency spectrum of the first 13 milliseconds of sound which reaches the listening position is shown in this measurement. Two configurations are measured, directly in front of the system, and 30 degrees to the side which simulates a conventional left-channel stereo listening configuration. The measurements are separated 10 dB on this plot for clarity of presentation.

Response at the listener's ear is quite uniform throughout the major part of the audio spectrum. The shallow depression near 5 kHz is due to time-delay interference between the two highest frequency drivers and progressively deteriorates off axis, as shown in this plot. This is also evident in the phase plot of Fig. 4. A more uniform listening response is obtained when listening on-axis to the E-90. This infers that the speakers should be rotated toward the preferred stereo listening position in a room.

Horizontal and vertical polar energy response, which shows the corresponding sound dispersion patterns, is plotted in Figs. 6 and 7. These measurements indicate that the preferred horizontal listening position lies within 20 degrees of the front axis. The vertical position for best listening is slightly above the geometric center of the speaker, which is approximately where the listener's ear would be for this floor-standing system. Both vertical and horizontal patterns are smooth, with no strong hot spots or interference lobes. Since a substantial part of the sound is launched upward, the E-90s should not be placed directly be-

Stereo imaging is quite good, though the illusion of depth is slightly lacking because of some vertical beaming.

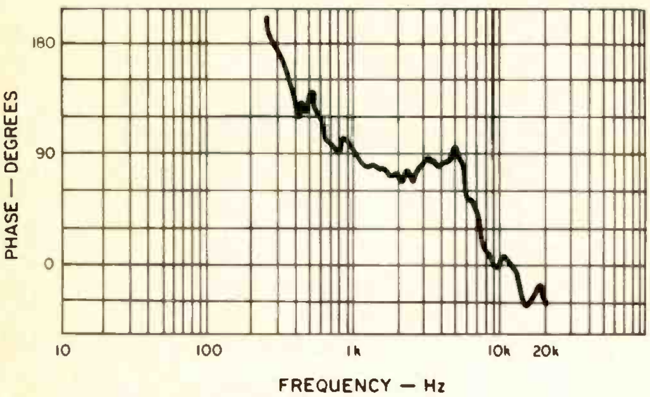


Fig. 4—Axial one-meter phase response correct for upper register air-path delay.

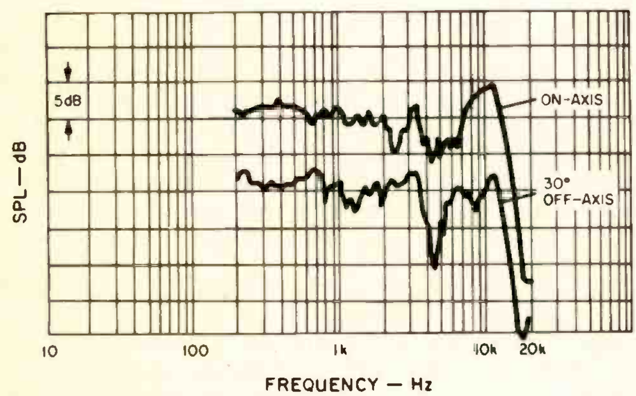


Fig. 5—Three-meter room response.

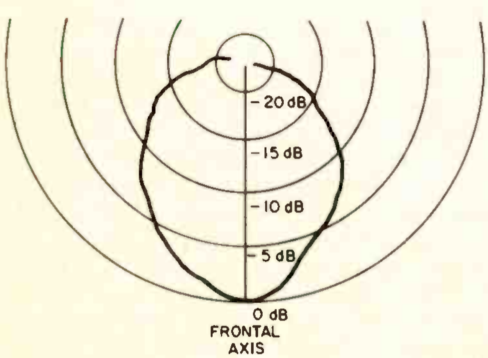


Fig. 6—Horizontal polar energy response.

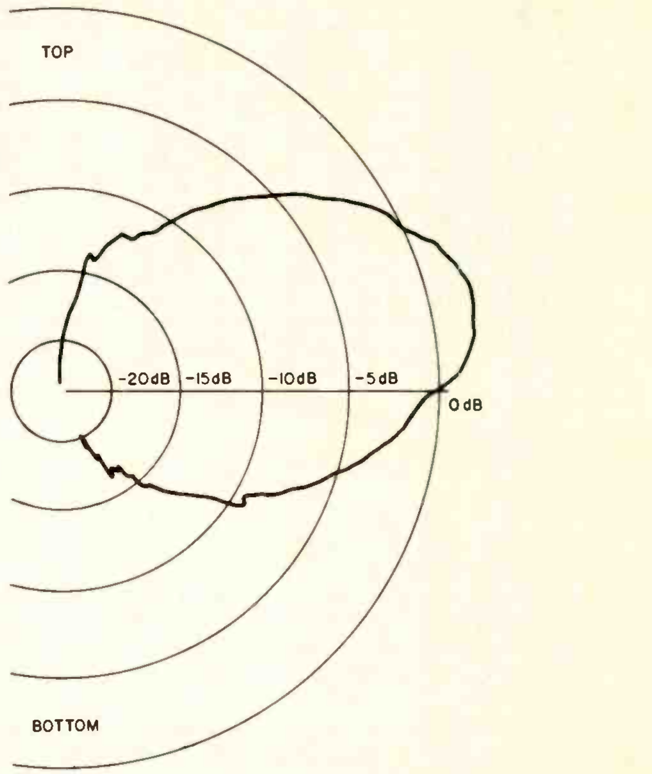


Fig. 7—Vertical polar energy response.

neath shelves or overhanging objects which could scatter sound back toward the preferred listening position.

Harmonic distortion for the tones of E_1, A_2, and A_4 (41.2, 110, and 440 Hz) are plotted as a function of drive power in Fig. 8. The tones of A_2 and A_4 are handled with very little distortion, and the E-90 ranks among the cleanest units we have tested for this property. Low E_1, however, is the Achilles heel. Harmonic distortion rises quickly with increasing drive at 41 Hz, reaching several percent at one average watt. This system should not be driven at high levels with extreme low bass.

Intermodulation distortion for tones of A_4 and E_1, mixed in equal portion, is plotted in Fig. 9 as a function of average power. Two regimes are evident, separated at about the one-watt level. Below one watt, the modulation of A_4 by E_1 (the low frequency modulating the higher frequency) is principally amplitude modulation. Phase modulation begins to dominate above one watt, even though the total IM remains quite low at all drive levels.

Acoustic transfer gain, which is the ratio of SPL to drive voltage, is essentially constant up to 100 average watts. This was measured for tones of 80 Hz, 262 Hz (middle C), and 440 Hz (A_4). This means that substantial intensity swings will not cause timbral change.

The E-90 fares only slightly poorer in the crescendo test. Tones of 262 Hz and 440 Hz are slightly suppressed when broad band noise is superimposed at an average level 20 dB

The Wharfedale E-90s did extremely well on our energy-time test, which indicates an excellent ability to handle transients.

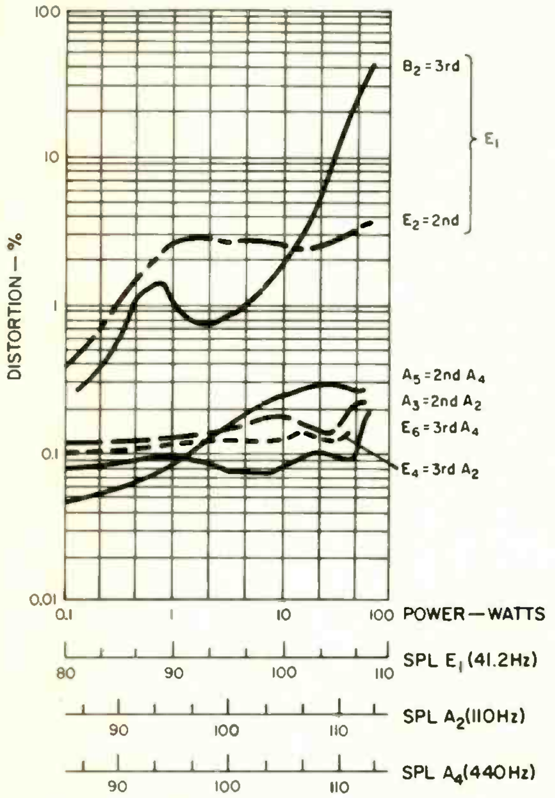


Fig. 8—Harmonic distortion for three tones, E_1 or 41.2 Hz, A_2 or 110 Hz, and A_4 or 440 Hz.

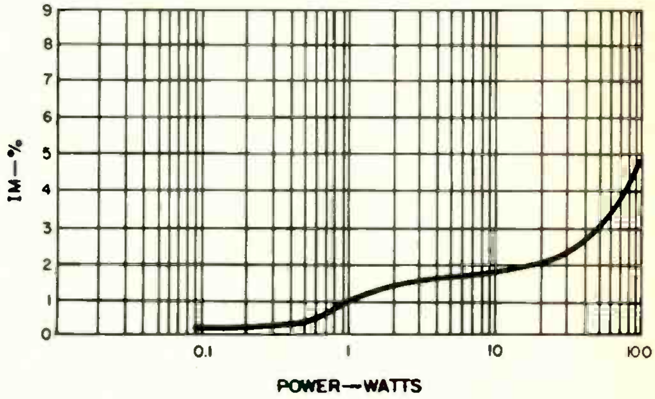


Fig. 9—IM distortion on A_4 (440 Hz) by E_1 (41.2 Hz) when mixed at a one-to-one ratio.

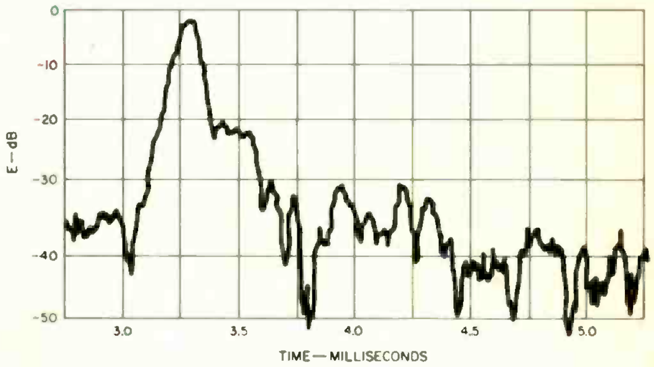


Fig. 10—Energy-time curve.

above that of the single tone. This suppression amounts to only 0.5 dB for the maximum tested noise peak of 400 watts, which implies a slight stereo drifting of inner musical voices during orchestral peaks.

The energy-time measurement for the E-90 is plotted in Fig. 10. This is a plot of the arrival time of energy for an axial microphone position one meter in front of the enclosure. The first peak of energy arrives at 3.24 milliseconds and is principally due to the tweeter, with a minor subsidiary energy spread up to 3.4 milliseconds due to the midrange. The clustering of energy, represented by this measurement, is extremely good and indicates an excellent transient response for the Wharfedale E-90s.

Listening Test

The listening test was made with the speakers flush mounted against a draped wall. This position was reached after considerable experimentation in room placement, and was found to give the most accurate sound to my ears.

The Wharfedale's have good low-low bass, but the sound is slightly dominant in the low- to mid-bass region. This tends to give a slight boominess and hangover to percussive bass.

To my ears, the E-90s are mildly strident in the upper registers, particularly on strings. For this reason, I preferred the E-90 midrange equalizer set at 0 and the tweeter equalizer set at -3. While this does reduce the extreme top end, the sonic accuracy was improved, in my opinion. Piano sounds somewhat brittle, but is spectrally balanced with this control setting.

Lateral dispersion and left-right stereo imaging is quite good. There is, however, some vertical beaming. For this reason, the illusion of depth was somewhat lacking, giving a stereo stage with adequate width but reduced depth. Because of this effect, solo instruments are accurately reproduced, but massed vocals are somewhat indistinct.

The E-90 is highly efficient and produces room-filling sound with modest amplifier power. This efficiency is coupled with an ability to produce high sound level without breakup or audible distress. The E-90 handled the famous Telarc/Holst drum excellently at high sound level, although there was some audible bass hangover.

Sonic accuracy, while not perfect, is quite good and the Wharfedale is a highly listenable system. While it would not be the first choice for a recording studio monitor system, where continuous high sound pressure levels are required, this system can be listened to, and enjoyed, for extended periods of time without fatigue. *Richard C. Heyser*

Something Like a Bird: Charles Mingus
Atlantic SD-8805, stereo, $7.98.

Sound: C — Performance: A

Distressing as it was to hear the news of Charles Mingus' death two years ago, there is solace to be taken in the amount of attention belatedly paid Mingus by the media. The volatile and sensitive man has at last been publicly acknowledged as the most diverse and possibly the most important composer in jazz after Duke Ellington.

Not the least of Mingus' contributions to jazz was the way in which he made Ellington's methods of compositional organization available to groups smaller and of a more modern orientation than Ellington's Orchestra. A good example is the title piece of this posthumous release. At just over 32 minutes, and stretching across one side of the disc to the other, it is superficially no more than a long string of solos introduced by, and interspersed with, a pragmatic blues riff similar to one Charlie Parker might have played. But Mingus has broken the 27-piece orchestra into matching pairs and sets and has also sequenced the solos judiciously. First the tenor saxophonists (Michael Brecker, Ricky Ford and George Coleman) blow one or two choruses apiece before trading 16-, 8-, 4-, and 2-measure barbs. The procedure is repeated in turn by the trumpets (Jack Walrath and Randy Brecker), the baritones (Ronnie Cuber and Pepper Adams), the basses (Eddie Gomez and George Mraz), the pianos (Bob Neloms and Ken Werner), the trombones (Jimmy Knepper and Slide Hampton), and finally the altos (Charles McPherson, Lee Konitz, Akira Ohmori, and Coleman pressed into double service). The result is something like a rough-and-tumble jazz equivalent of Britten's "Young Person's Guide to the Orchestra," except that Mingus bases his lessons, as Ellington did, on the realities of individual voices rather than on the ideal nature of instruments. The soloists vary in approach and in their commitment to the thematic material Mingus has placed before them, but each is inspired to abandon by the presence of his own kind. Mingus' achievement here is that he has legislated the most primal and anarchic jazz behavior — the after-hours cutting contest — into composition with no loss of excitement or spontaneity.

Completing the album is "Farewell, Farwell," a shorter, gentler piece titled after Farwell Taylor, a painter whose death preceded Mingus' by about a year. (Taylor was also the protagonist of the earlier, more ambitious "Far Wells, Mill Valley.") There are lustrous solos here by Konitz, Gomez and guitarist Larry Coryell, and an especially vibrant one by tenorist Ford. Behind them, the orchestra sobs and sighs with the power and dignity of the human voice.

"Farewell" is Mingus' valedictory statement — and his intimation of immortality. Confined to his wheelchair by the time of these January 1978 sessions (which also yielded the earlier, more uneven collection *Me, Myself An Eye*), he delegated arranging and conducting duties to Jack Walrath and Paul Jeffrey and entrusted the bass chores to Gomez and Mraz. Yet it is the hand of Mingus which seems to move these musicians. The music burns, and Mingus' legacy rises from its ashes like a phoenix.

Sound is uneven. Separation is good, but there is an absense of clarity and depth at times. *Francis Davis*

When you're ready to "face" the music we have a tip for reduced distortion

Whether you are seeking to reproduce the full dynamic range in the grooves of today's new superdiscs, or simply to obtain maximum listening pleasure from treasured "oldies" in your record collection, you need a phono cartridge that will deliver optimum trackability with minimum distortion.

Because the phono cartridge is the only point of direct contact between the record and your entire stereo system, its role is critical to faithful sound re-creation. That's why upgrading your phono cartridge is the single most significant (and generally least costly) improvement you can make to your stereo system.

To that end Shure now offers the Hyperelliptical Stylus Tip configuration—first introduced on the critically acclaimed V15 Type IV—in a *full line* of cartridges with a broad range of prices.

The Hyperelliptical Stylus Tip has been called the most significant advance in decades in tip geometry. It has a narrower and more uniform elongated contact area that results in significantly reduced intermodulation and harmonic distortion.

Look over the list at left to see which Shure HE cartridge best matches your tracking force requirements.

Shure has been the top-selling cartridge manufacturer for the past 23 years. For full details on this remarkable line of cartridges write for AL667.

The HE Family:
Hyperelliptical-Equipped

Go with the leader—Shure.

SHURE®

Shure Brothers Inc., 222 Hartrey Ave., Evanston, IL 60204
In Canada: A. C. Simmonds & Sons Limited
Manufacturers of high fidelity components, microphones, sound systems and related circuitry.

Enter No. 50 on Reader Service Card

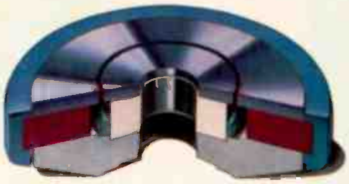
Any loudspeaker system this flat deserves a fair hearing.

If you like the flatness of our L112 frequency response curve (below), you'll be even more impressed by the smooth, natural, uncolored sound that goes with it.

The L112 is a perfect example of JBL's advanced engineering design philosophy at work. Lasers, holography, computers and the human ear interfacing toward one end: The flattest, most accurate sound reproduction in JBL bookshelf history. The kind of pure, uncompromised sound quality that's made JBL the longstanding choice of audio professionals worldwide.

The overall performance quality of the L112 bookshelf system is the result of many precision-engineered components working together to achieve sound so natural there's no sense of a speaker at all—only the music.

Cleaner, more powerful bass. The L112's Symmetrical Field Geometry (SFG) 12" woofer, with its larger 3" edge-wound voice coil and specially coated cone, delivers the bass notes of music with extremely low distortion. Lower than any other bookshelf system we've ever tested. You'll hear crisp, clean, powerful bass all the way down to the lowest notes.

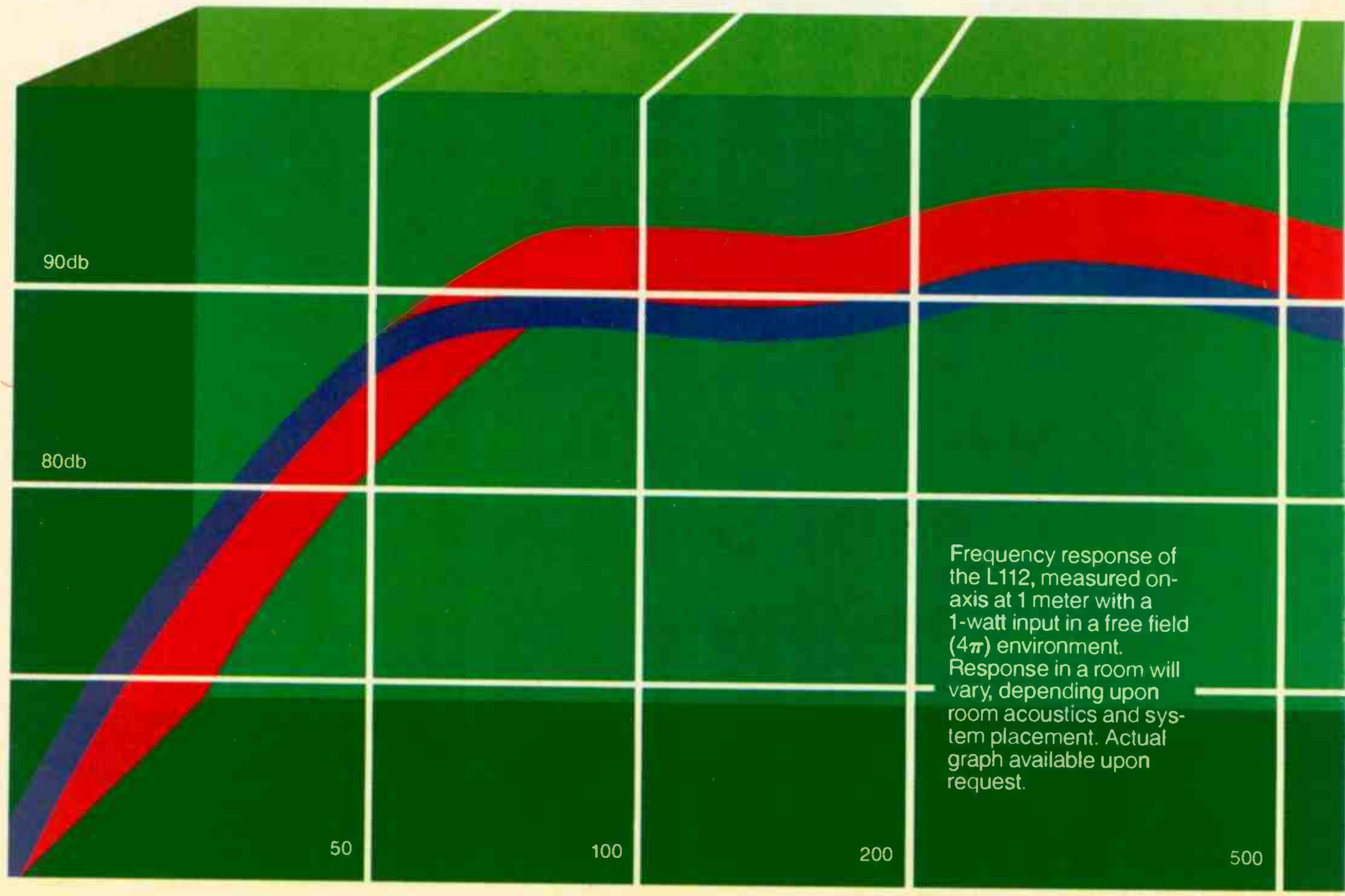


Our SFG innovations—the symmetrical magnetic field at the voice coil gap, and the aluminum Flux Stabilizing Ring—dramatically reduce the second harmonic distortion found in conventional drivers.

More high frequency detail. Specifically designed for the L112 system, our new 1" 044 high frequency dome radiator is formed of a lightweight phenolic material, coated with aluminum by means of a vapor deposition process. The 044 tweeter was developed using the capabilities of our fully equipped laser-optics laboratory.

Laser holography helps our engineers examine tweeter cone movement like an X-ray allows physicians to examine the human body. Diaphragm excursions have been refined for exceptionally smooth response, maximum stereo imaging and high power handling. You'll hear harmonics you've never heard before.

JBL First with the pros.



Frequency response of the L112, measured on-axis at 1 meter with a 1-watt input in a free field (4π) environment. Response in a room will vary, depending upon room acoustics and system placement. Actual graph available upon request.

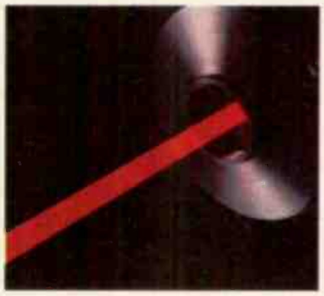
Superior transient response. Our new High Resolution Dividing Network enables the L112 to deliver transients with startling immediacy. The network controls each of the L112's drivers throughout its full operating range. You'll hear sound so coherent it will seem that only one extremely wide-range transducer is responsible.

Traditional JBL craftsmanship. The L112 represents more than engineering excellence. It is also an example of JBL's longtime commitment to fine craftsmanship and unrelenting quality control. Each speaker is crafted in the U.S.A. at our Northridge, California facility, and undergoes more than 50 inspections and tests during manufacture.

Each L112 is veneered in American black walnut, oiled and hand-rubbed to a lustrous fine furniture finish.

In the end, we know that you—and you alone—are the final judge of the products we work so long and so hard to produce.

So, listen to the L112 bookshelf system for yourself.

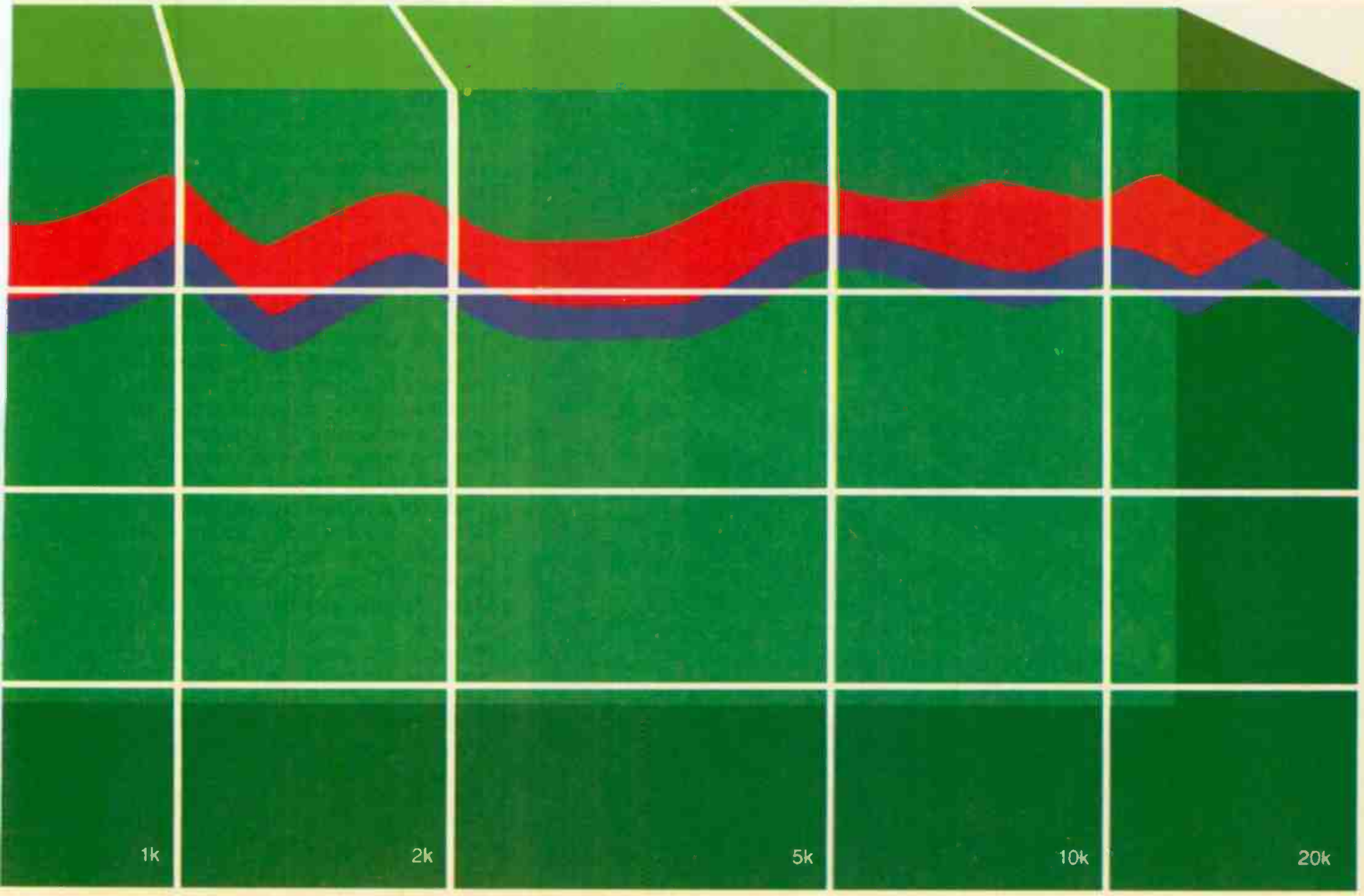


Audition it with the kind of music you like best, with the help of the audio specialists at your nearest authorized JBL dealer.

For the name and address of the JBL dealer nearest you, write: James B. Lansing Sound, Inc., 8500 Balboa Blvd., P.O. Box 2200, Northridge, CA 91329.

Comparison Analysis now available. Recently, we conducted a very enlightening series of performance tests comparing the L112 against several competitive speakers. For a copy of the documented results, as well as reprints of recently published L112 reviews, please write to us at the above address, attention: L112 Comparison Analysis.

JBL/harman international



Enter No. 19 on Reader Service Card

Gravity: Fred Frith
Ralph Records FF 8057-L, stereo, $8.98.

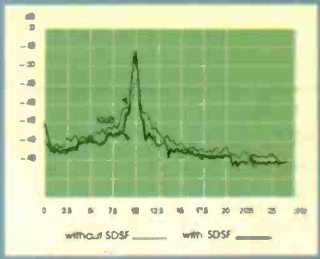
Sound: B Performance: A–

Fred Frith is a musically enigmatic character whose every endeavor has been a challenge and confrontation for his listeners. For most of the last decade he was the consistent force behind the group Henry Cow and its offspring, The Art Bears. They forged a combination of political and social polemics with a fusion of jazz, rock and avant-garde music, multiple fusion music if you will. While Frith's guitar playing was barely traditional with these groups, it was totally anarchic in a solo context. There Firth created his own technique, the most traditional being his prepared guitar, a concept similar to John Cage's prepared piano. The instrument is prepared by sticking paper clips, erasers, screws, etc., into the strings and then playing the instrument. Frith takes this a bit further by altering two guitars, laying them side-by-side on a table, and, with loud amplification, whipping, beating, bending, and drilling them (literally). The music that results is a metal-on-metal fabric of splintered sheets, fractured lines, and a mesmerizing fascination.

This is Frith's second solo outing not including his *Guitar Solos Two* and *Three* which were actually samplers, and his work with Henry Kaiser. *Gravity* is the Fred Frith dance album, dance being the defeat of gravity and the elevation of the spirit. Previously Frith had been imposing, ominous, brilliant, and virtuosic. On *Gravity* he is all of these and clever besides.

Any talk of dance music these days still conjures up images of sleek disco. But Frith's dances are those of world musics, from the Middle East to the thudding beat of mid-'60s soul. He blends them all together in an almost seamless cultural brew that opens incongruously with irreverent laughter and solemn Tibetan bells. Wind sounds and wooden chimes rise up to be met by ritualistic drums and Frith's ethereal violin. As the intensity increases, Frith's fuzzed guitar raises the music to a high tension level then suddenly segues to a lighthearted horse and buggy romp. The album is full of these sudden shifts. The music of a quaint bar mitzvah metamorphoses into a Middle Eastern waltz. On side two, where he's backed by a Washington, D.C.-based fusion group called The Muffins, piercing feedback guitar against a clanging "Twilight Zone" background gradually turns into Martha and The Vandellas' stomping "Dancing in the Streets." With a heated R&B beat, Frith plays the melody on a cool Hawaiian steel (or a reasonable facsimile) while a backwards tape collage roars and squeals through the background as if on a dance floor in a drunken stupor.

MORE MUSIC. LESS NOISE. MORE MACHINE. SANSUI.



Noise is a thief. It robs you of the quality of music you are entitled to hear from a fine cassette deck. On the right is a picture of a type of dynamic distortion known as modulation noise. It makes music sound gritty, whether the sound is loud or soft. What these spectrum analyzer traces show, and your own ears will confirm, is that Sansui's new D-550M cassette deck, with

D-550M

its exclusive (pat. pending) Dyna-Scrape Filter, reduces modulation noise by as much as 10dB! That represents a startling audible difference and a profound reduction in this most pervasive of tape noises. Until now, scrape filters were found only in professional reel to reel tape decks. Now Sansui has ingeniously engineered this valuable technology into a truly affordable cassette deck.

The D-550M is a 3-head machine with full IC logic control. It has a frequency response from 25-21,000Hz (± 3dB, metal tape); user adjustable bias control; 2-motor drive that reduces wow and flutter to a miniscule 0.035% (WRMS); plus state-of-the-art heads and electronics that improves signal to noise ratio to 70dB (with Dolby-B™).

And if it is logical for our top-of-the-line D-550M to have full IC logic, then it is logical for our more modestly priced D-300M to have it as well. In fact, much of Sansui's advanced technology that's in our most costly models is also found across the entire Sansui line. Indeed, our lowest priced cassette deck, the D-95M, like the D-550M, D-350M and D-300M, has metal tape capability.

More music, less noise. More machine. Better value. That's what Sansui cassette decks are all about.

Come see the full line now at your local Sansui dealer.

SANSUI CASSETTE DECKS

D-550M
Metal-Tape Compatible
D-350M
Metal-Tape Compatible
D-300M
Metal-Tape Compatible
D-95M*
Metal-Tape Compatible

*D-95M available in silver only. All other models in silver or black.

D-95M

D-300M

Sansui

SANSUI ELECTRONICS CORP.
Lyndhurst, New Jersey 07071 · Gardena, Ca. 90247
SANSUI ELECTRIC CO., LTD., Tokyo, Japan
In Canada: Electronic Distributors

Enter No. 35 on Reader Service Card

Gravity is a whirlwind flight across a cultural landscape where features run into each other with a rush. Only Frith, your tour guide, is a constant landmark with his palette of guitar styles that still have the distinctive Frith imprimatur.
John Diliberto

Jillian: Warren Vache
Concord CJ-87, stereo, $7.98.
Polished Brass: Warren Vache
Concord CJ-98, stereo, $7.98.

Sound: A   Performance: A

It must be the California sunshine, the high musical standards, and the dedication of Concord Records President Carl Jefferson that produces the full-bodied, free-swinging, unabashedly lyrical jazz heard on these two Warren Vache releases.

Vache, a neo-swing flugelhornist and cornetist whose work displays touches of Bunny Berigan, Bobby Hackett, Roy Eldridge, Clark Terry and Ruby Braff, has developed into a vigorous and exciting musician whose playing bubbles with vitality and confidence. Listen to his jumping, biting work on "It's All Right With Me" on the *Jillian* album or the romping "Ida, Sweet as Apple Cider" on *Polished Brass*.

Highlighting both releases is the beautifully deployed acoustic guitar of Cal Collins — his impeccably conceived solos, lovely chordal support, and delicate duets with Vache are among the delights of the two collections. Drummer Jake Hanna, also heard on both albums, provides a fine propulsive drive and lays down forceful rhythmic patterns which never interfere with the soloists. On *Polished Brass*, Hanna's drums are teamed with Michel Moore's fine walking bass. Pianist Nat Pierce, featured on several *Jillian* tracks, helps to keep things moving at a sprightly pace.

Count Basie's fine altoist Marshall Royal, another mainstream stalwart, contributes energetic, eloquent solos on several *Jillian* cuts. Both Vache's Concord releases offer skillful, virile, melodic music that remains true to the classic jazz tradition.
John Lissner

Family: Hubert Laws
Columbia JC 36396, stereo, $8.98.

Sound: B+   Performance: C

For better or worse, Hubert Laws has been the definitive name in jazz flute in the last 10 years. This reputation has often followed him for reasons other than his pure tone and crystal improvisations. Hubert Laws has always been one to take his music outside the normal parameters of jazz, sometimes legitimizing it by updating classical themes as heard on his many CTI records *(Rites of Spring)* or infusing it with electric funk and disco rhythms with immense commercial success *(The Chicago Theme)*. While both of these formulas figure into Laws' output, he plays just enough improvisational flute to maintain his reputation as a jazz player.

Family isn't much different from his earlier albums except there is more meat amongst the fattening strings. It opens inauspiciously with the musical cliche of the '80s, Ravel's "Bolero," made obnoxious by the movie "10." Laws' arrangement uses relatively subdued strings with a quietly prodding electric backdrop. It takes an interesting turn when Chick Corea steps out for a heavily chordal piano solo that is pleasantly out of character for him. The remainder of the album is dominated by mild ballads and upbeat funk numbers that are a little too limber, rhythmically, to be dismissed as disco. Laws takes his best solo on "Wildfire," doing several turn-arounds over the perky rhythm of Leon "Ndugu" Chancelor on drums and Nathan East on bass.

Even on this straightforward record, Laws insists on cluttering his work with unnecessary strings, and the concept of sweetening dies hard.
John Diliberto

ELECTRO RESEARCH

ASK THE MAN WHO OWNS ONE

EK-I Disc Playback Control Center

ELECTRO RESEARCH CORPORATION
9259 ETON AVE., CHATSWORTH, CA91311, 213/709-1107

Enter No. 15 on Reader Service Card

Denon's Digital Technology

Japan's Denon Company was the first, back in 1972, to produce commercial digital recordings. For the most part, their efforts went unnoticed in this country, due to their lack of cross-licensing ties with any major American record company. In recent years, at least in the U.S., digital recording technology has become almost exclusively associated with blockbuster showpieces, the technique being exploited purely for its sonic values. (On too many occasions, it has been the excuse for charging more for a poorly produced recording.)

Denon has over the years continued to use their digital resources for the bulk of their product — most if it definitely *not* of the blockbuster variety. They have refined their technology during this time, but curiously they have stayed with a 14-bit system while much of the professional industry has gone to 16. This difference means only that the Denon system basically has a dynamic range of 84 dB, while the 16-bit machines have 96 dB. For some years, the Discwasher Company has been importing Denon discs into the States, and during the last year I have been provided with enough review albums from them to allow for an overall assessment of the system.

Meanwhile, the digital versus analog controversy rages on. Digital recordings have been publicly blamed for provoking stress and causing headaches. Lord only knows what accusations may have been made in private. From the point of view of production variables, digital recordings are subject to exactly the same excesses that have plagued the mainstream of classical recording in recent years: Too many microphones, too much gain manipulation, and other aspects of what we may call "over production." In many cases the released discs themselves are cut at excessive levels, resulting in some edginess to the sound. If anything, the digital medium bares these faults all the more!

It is small wonder that some critics have, without a knowledge of cause and effect in recording processes, zeroed in on "digital" as the culprit when they hear a digital recording they don't like. One thing is certain: No one can condemn a digital recording system unless he has actually had the machine in his own hands and had the experience of making blind comparisons of its input *versus* output on a wide variety of program material. One *positively cannot* make such a judgment on the basis of isolated digital discs because the wide range of production variables and the mechanics of disc transfer and playback will easily swamp the characteristics of the digital recording process itself.

The reason for this rather long-winded preamble is to suggest to the reader that if you find even one superb recording made with a digital process, then that record becomes the vindication of that particular recording process. In a larger sense, it becomes the vindication of the charges which have been leveled against digital technology in general.

There's More to Noise Reduction Than Silence.

How noise reduction systems work

In all companding noise reduction systems, noise reduction occurs at the time of playback by means of an expander circuit which constantly adjusts the playback volume. The idea is to turn down the volume on quiet musical passages, thus turning down the noise as well, and to turn the volume back up on loud passages which hopefully mask the noise. The expanding process is preceded when the recording is made by a complementary compression action, whereby the record level is turned up on quiet passages and down on loud ones. The net result on playback should therefore be a restoration of the dynamics of the original program material along with noise reduction (Figure 1).

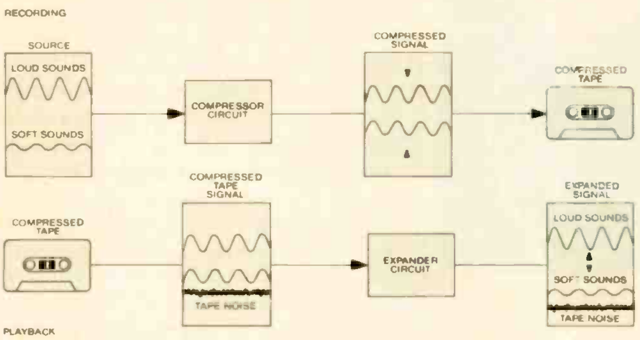


FIGURE 1: NOISE REDUCTION SYSTEM BLOCK DIAGRAM
Companding noise reduction systems operate both at the time a recording is made and at the time of playback, when noise reduction occurs.

The problem of noise modulation

Designing a noise reduction system would be easy if any loud musical signal masked all noise. Unfortunately, that does not happen. A bass drum note, for example, cannot hide tape hiss, no matter how loud the drum is. The sound from the drum is so much lower in frequency than tape hiss that the ear can easily detect both the drum and the hiss simultaneously.

The result with a conventional, wide-band companding noise reduction system is what is called noise modulation. On playback, the expander circuitry turns up the volume on a loud bass drum note. But it also turns up the volume of the tape hiss at the same time. If at that moment there is no music at higher frequencies, the sound of the drum will be accompanied by an audible burst of hiss.

In other words, the bass drum modulates, that is changes, the perceived hiss level. Thus with conventional noise reduction systems, the noise level continually changes with the music — audibly so at least part of the time.

Dolby noise reduction reduces noise modulation

Dolby noise reduction is free of audible noise modulation on virtually any type of program material. Instead of compressing and expanding the entire musical range all at once, Dolby noise reduction operates over a constantly changing, or sliding, band of frequencies (Figure 2). The band extends low enough to provide effective noise reduction on silence. On a bass drum note, the band slides up out of the way of the drum, so that on playback it comes through at full volume, while noise above the drum is almost as effectively suppressed as though the drum weren't there. If the drum is accompanied by higher-frequency instruments, the band slides up further still, to let all the music through at full volume, while noise at frequencies above the music is still effectively suppressed. In other words, the presence of musical signals does not prevent noise reduction from occurring where it is still needed (Figures 3 and 4).

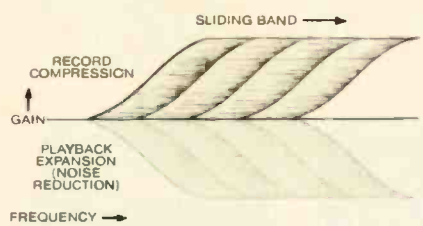


FIGURE 2: THE SLIDING BAND PRINCIPLE
Dolby noise reduction operates over a band of frequencies which slides up out of the way of the music, resulting in noise reduction just where there is no musical signal to hide the noise. Thus the perceived noise level is consistently low at all times.

Dolby B-type and Dolby C-type noise reduction are both sliding-band systems. With the standard B-type system, noise reduction begins at 500 Hz and rises to 10 dB at 4 kHz and above, while with the new C-type system, noise reduction begins at 100 Hz, rising to 20 dB at 1 kHz and above. Neither system introduces noise modulation or other audible side effects on virtually any kind of music.

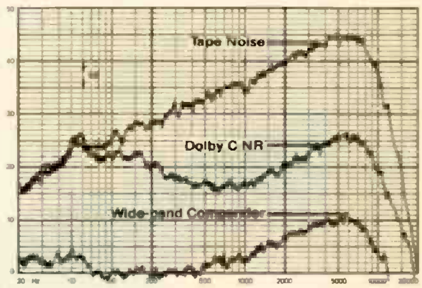


FIGURE 3: NOISE AND NOISE REDUCTION IN THE ABSENCE OF SIGNALS
Noise from biased cassette tape without noise reduction, the effects of Dolby C-type noise reduction, and the effects of a wide-band compander are shown in the *absence* of any signal.* Dolby C's noise reduction effect results in an overall perceived noise level below the ambient noise of many listening rooms, even at high playback levels. In the absence of signals, the conventional wide-band compander provides still more electrical noise reduction (but usually no more audible noise reduction).

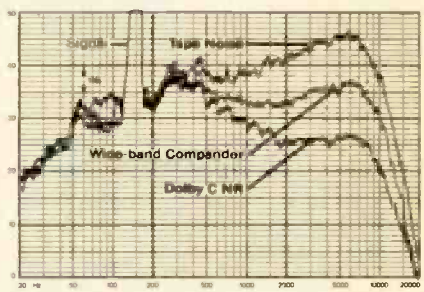


FIGURE 4: NOISE AND NOISE REDUCTION IN THE PRESENCE OF SIGNALS
In the *presence* of a signal (148 Hz, D below middle C on the piano, recorded at Dolby level), in all cases noise in the region of the signal will be masked by it. However, at higher frequencies, especially between 2 kHz and 10 kHz where tape hiss is clearly audible, Dolby noise reduction provides almost as much noise reduction as if the signal weren't there, while the compander allows the noise to increase to a considerably higher level than with Dolby C. (Note: the overall increase in noise in the region of the test signal compared to Figure 3 is a combination of tape modulation noise and distortion by-products.)

*70 µs equalization, measured with a constant-bandwidth wave analyzer, and weighted (CCIR/ARM) to reflect the ear's sensitivity to noise and noise reduction effects.

Dolby

Dolby Laboratories Licensing Corp., 731 Sansome St., San Francisco, CA 94111, Telephone (415) 392-0300. Telex 34409.

Many critics made this positive judgment of the merits of digital recording long ago. For those who haven't yet done this, I suggest that you get your hands on the following two-record set:

Schubert: Symphony No. 9 in C Major (Heinz Rogner conducting the Berlin Radio Symphony Orchestra). **Denon OB-7351-51-ND,** digital, stereo, $15.00.

This two-record set is a collaboration between Denon's Nippon Columbia label (no relation to CBS) and the East German VEB Deutsche Scallplatten Company. The sound is gorgeous in every respect. The ensemble is precisely imagined in both left-right and fore-aft dimensions. Above all, there is a naturalness to the spectral balance, and the strings have a lovely sheen which bespeaks the proper choice of microphones and their placement. The recording venue is a semi-draped church in East Berlin, and the producers have found that happiest of combinations, the correct reverberation time and the correct balance between direct and reverberant sound. The result is warmth coupled with analytical detail. All too often, one attribute has to be sacrificed for the other.

The sprawling work is spread over four sides, with an average of about 14 minutes each. This ensures that the ending diameters are suitably large to avoid inner-groove problems. As we have come to expect of just about all Japanese discs, the pressings are faultless.

The double-fold jacket is in French, English and German, as well as Japanese. Photos of the recording session reveal an overall spaced-apart pair of microphones along with an ensemble of six accent microphones, highlighting the first chair strings and providing a secondary stereo pick-up of the woodwinds and brass. Altogether, this is a handsome production, one which will set the record straight on digital for many audiophiles.

Here follow some capsule reviews of other Denon digitals:

Mozart: Symphonies Nos. 36 and 38, Otmar Suitner conducting the NHK Symphony Orchestra, OX-7156-ND. The Japanese state radio orchestra is given much the same luminous treatment noted in the Schubert, this time in a more intimate acoustical setting.

Vivaldi: The Seasons, Rudolph Baumgartner conducting the Lucerne Festival Strings, OX-7174-ND. Spirited performances along with finely etched sonics.

Janos Starker: Virtuoso Music for Violincello, OX-7171-ND. One of the world's great cellists sumptuously recorded. The Chopin G-minor sonata is the chief work here. *John M. Eargle*

The Delos Series of DMS Digitals

In early 1979, Delos Records, a Los Angeles-based classical label, embarked on an ambitious program. Amelia Haygood, the label's founder, noted that digital recording technology had for the most part been relegated to showcase orchestral recordings with heavy emphasis on sound for its own sake. She reasoned that there would be an audience for high-technology recordings of music-making of a more modest sort, such as chamber groups and solo performers. Haygood also felt that such music could benefit just as positively from advanced recording processes as the heavier orchestral textures that were the mainstay of so many other labels involved in digital recording.

At the present time there are 10 items in the series, with four more due for release in the fall of 1981. Following are capsule reviews of several of the DMS records:

Vivaldi: The Seasons. Gerard Schwarz conducting the Los Angeles Chamber Orchestra, Elmar Olviera, violin. DMS 3007, $17.95.

Gerard Schwarz has worked wonders with the Chamber Orchestra, continuing in the traditions of its founder, Neville Marriner. The playing is precise and has all of the rhythmic drive which this music characteristically needs. At the same time the playing is fluid and yielding when it needs to be. The recording was made in Bridges Hall at Claremont College east of Los Angeles. This recital hall is one of the finest recording venues for modest musical resources anywhere; its wood and plaster interior provides plenty of reverberation, but the reverberation time is short enough that articulation does not suffer.

The lavish production includes a double-fold album complete with thematic analysis of the score, along with facsimiles of Vivaldi's sonnets which accompanied the original scores for the four concertos comprising the music. Only one minor flaw needs to be mentioned. There is some groove echo to be heard in quiet passages or in passages where the solo violin is playing. Some of this is endemic in disc transfer processes themselves, and the nature of the music, as well as the exceedingly quiet surfaces, makes it more apparent than might normally be the case. It is, however, a minor problem which most listeners will not be aware of.

Water Music of the Impressionists. Carol Rosenberger, piano. DMS 3006, $17.95.

Ms. Rosenberger plays a Bosendorfer Imperial Grand in this program of music by Ravel, Debussy, Liszt and Griffes. The recording venue again is Bridges Hall. At the time this recording was made, the instrument was fairly new, and its relatively soft hammers did not provide the attack, or ictus, which is characteristic of an instrument thoroughly broken in. In addition, microphone placement was a bit on the distant side, and the net result is a mellowness and fullness which is perfectly appropriate to the music at hand. The gorgeous sonorities of the Bosendorfer are at times seemingly transformed into a new instrument, almost a cross between a harp and a piano. Rosenberger's playing is stunning, and her performance of Ravel's "Ondine" is the equal of any.

The Bosendorfer Imperial Grand has 97 keys, nine more than usual, for added low-frequency resonance. The extended bottom octave is very tempting to a pianist. There are a number of doublings in the bottom octave which would be musically compatible with the impressionistic repertoire, but Rosenberger uses this facet of the instrument only in one passage, the tolling of giant bells in Debussy's "Engulfed Cathedral." The low C-string with its nominal fundamental of about 16 Hz yields a sound rarely heard either on disc or in the concert hall. The JVC pressings are as quiet as one could wish for.

The Sound of Trumpets. Gerard Schwarz playing music of Altenburg, Biber, Vivaldi, Torelli and Telemann. DMS 3002, $17.95.

This album was among the first in the DMS series and was recorded in the Masonic Temple Auditorium in New York City. Orchestral accompaniments are by the Y Chamber Orchestra of New York, conducted by Schwarz. In three of the works Schwarz is aided by members of the New York Trumpet Ensemble, and the high point of this ensemble playing is undoubtedly the "Sonata for Eight Trumpets" by Biber. The orchestral playing again evinces the conductor's flair for rhythmic drive coupled with a yielding or bending of rhythmic flow as dictated by the music.

Although the disc was transferred at normal levels, beware the problems of inner-groove mistracking. If you hear any breakup whatever on loud passages, I suggest checking out your phono cartridge. With a really first-rate cartridge, the sound will be absolutely flawless.

Ravel and Bartok. String Quartets. The Sequoia String Quartet. DMS 3004, $17.95.

The Sequoians, in residence at the California Institute of Arts, give us a broadly paced and leisurely performance of the Ravel work. The recording venue was the auditorium at Immaculate Heart College in Los Angeles. The lushness of the recorded sound, along with the broad stereo spread, works wonders for the Ravel. The Bartok "Third Quartet," on the other hand, is not as well served. This music ideally calls for a thinner overall texture and precise highlighting of instruments. Again, we are treated to flawless surfaces. *John Eargle*

Die Mannheimer Schule (The Mannheim School). Music of the Early Classical Era. Camerata Bern. **Archive 2723 068,** 3 discs, stereo, $29.96.

Sound: A– Recording: A Surfaces: A–

D-G's Archive Series began way back in the early mono LP days, with sets of buff-colored single records complete with a frightening amount of German scholarship, though the music was excellent. Archive has mellowed since then and even the packaging is now human, as are the annotations in numerous languages and, of course, the music. They do really original things and on a large scale, where so many "early music" labels go in for inexpensive small ensembles.

Every student of music history has heard of the famed "Mannheim School," the dynamic court musical establishment of the fabulous Elector Theodor which, from around 1740 through 1778, turned instrumental music inside out with its innovations. Everybody who was anybody in music, including young Mozart, went to Mannheim to see and to hear the phenomenon.

So now you can catch up on your Mannheim listening. Here is the source for much that we know in Haydn and Mozart and even Beethoven. The first truly modern musical idiom, and it is fascinating to hear, so to speak, in the flesh. Some of the works in this album are taken from manuscript, never heard since their first playings. None of the very few well-known Mannheim works are included and just as well. The others speak the better for themselves.

True, much of it "all sounds alike," like 50 million Chinamen to Western eyes. It was a tight, controlled environment, extremely competitive, advancing rapidly, but everyone was attentive to everyone else, like today's admen borrowing each other's ideas. It was the newness and originality of the whole group of performer-composers that mattered, not the individual differences between artists. Such a fluent, easy, light-hearted kind of expression, such expertise, such virtuosity!

Nice recording, with a familiar, slight seeming edginess to the strings that I have noticed before — nothing to bother about. And superb playing. It's marvelous dinner music. *E.T.C.*

CLASSIFIED ADVERTISING RATES

BUSINESS ADS- 75c per word, minimum charge $6.00 per line for spaced ads specifying five or less words per line. First line set in bold face type at no extra charge. Extra words set in bold face type $1.00 per word. One point ruled box, extra charge $8.75. **Full payment must accompany order.**

NON BUSINESS ADS- 50c per word, minimum charge $4.00 per line for spaced ads specifying five or less words per line. First line set in bold face type at no extra charge. Extra words set in bold face type $1.00 per word. One point ruled box, extra charge $8.75. **Full payment must accompany order.**

FREQUENCY DISCOUNT-3 times, less 10%. 6 times, less 15%. 12 times, less 20%. (line copy ads only)

DEADLINE- 1st of month two months preceding the cover date. If the first of the month falls on a weekend or holiday, the closing date is then the last business day before the holiday or weekend. ADS RECEIVED AFTER THE CLOSING DATE WILL BE HELD FOR NEXT ISSUE UNLESS OTHERWISE STATED.

BLIND ADS-Box numbers may be used at $5.00 extra for handling and postage.

GENERAL INFORMATION Ad copy must be typewritten or printed legibly and received on or before the 1st of the month, two months preceding the cover date. Display advertisers must make a space reservation on or before the closing date, material (Camera Ready Only) may follow by the 10th. The Publisher, in his sole discretion, reserves the right to reject any ad copy he deems inappropriate. All advertisers must supply: Complete name, Company name, Street address (P.O. Box is insufficient), and telephone number before ads can be published. Classified ads are not acknowledged and do not carry Reader Service Card Numbers. Frequency contracts not fulfilled will be short-rated accordingly. Ads submitted for a 3 time frequency or less are unchangeable. Classified ads are payable in advance **BY CHECK OR MONEY ORDER ONLY.** (Sorry, we can not accept credit cards.). Additional information available upon request. Contact: Laura J. Lovecchio, Advertising Coordinator, 1515 Broadway, NYC 10036 . . . Direct Dial (212) 975-7530.

MAIL ORDER AND DISPLAY CLASSIFIED RATE

1 col x 1"	$175
1 col x 2"	$275
1 col x 3"	$375
2 col x 1"	$275
2 col x 2"	$475

Advertiser must supply complete film negative ready for printing for display ads.

AUDIO Magazine
1515 Broadway
New York, N.Y. 10036

Sound Ideas INC
13606 third n.e. seattle washington 98125

MASTER TAPES

The ultimate software available for the finest systems! Our third generation tapes duplicated in real time from the catalogs of Windham Hill, Kaleidoscope, 1750 Arch Records and more featuring artists such as: • David Grisman • William Ackerman • Glenn Yarbrough • San Francisco String Quartet
15 ips, 7½ ips — ½ & ¼ track and Metal Cassettes
Send for our free catalog at Sound Ideas Dept AU2 13606 Third N.E., Seattle, WA 98125

HOW TO ANSWER BOX NUMBER ADS
When replying to an Audio Box Number Ad, please use this address Box No. — c/o Audio, 1515 Broadway, New York, N.Y. 10036

FOR SALE

AAAAAHH, AT LAST — POLYPROPYLENE DRIVERS, Ribbon Tweeters, Xovers, Horns, Plans, Replacements, Ferrofluid Domes, Catalog $1.00. SOUNDBOX, Dpt. A 411 South Carlisle Street, Philadelphia, PA 19146

AAAA QUALITY 1.25 GRAM (ACT. WT.)
S.L.T. TONE ARM
"WORLD'S ONLY" PURELY
MECHANICAL LINEAR ARM
Selected by "Design News" mag as ". . . One of the leading technical ideas in sound technology. . ." The Souther Linear Arm provides vastly superior performance with "Equa-Mass" system and "Absolute-Zero" tracking error. Fits most turntables and cartridges. Now available custom made at $500.00. Full details, specs and color photos, $3.00 refundable.
Southern Engineering Products
429A York Street
Canton, MA 02021

AAA mint condition WIN TURNTABLE $1695. (315) 437-1209.

ABOLISH LIST PRICES ON MID & HIGH-END AUDIO COMPONENTS! Get low prices, great selection and service, plus seasoned advice on a wide range of products. Warranties, of course! Join the thousands we've served in full satisfaction. Use your VISA or M/C or 50% deposit. Write for quotes: AUDIO, LTD., Box 28402, Philadelphia, PA 19149.

WHOLESALE AUDIO VIDEO
The most comprehensive Buyer's Guide available, tells how and where to buy thousands of products of every kind — TV's, Video Recorders, Hi-Fi Stereo Equipment, Tape Decks, Cassettes, LP's, Computer Components, Photographic Cameras and lenses, U.S. Government Surplus and much more! Only $9.95 postpaid. Moneyback Guarantee.
COMMAND PRODUCTIONS • Box 26348-A • San Francisco, CA 94126

FOR SALE

A BARGAIN! FR201 (not FR 2) unused $212. Stephen Sun, 212-784-2939.

A BARGAIN: TECHNICS EPA-100 $299, Lustre GST-801 $250, Super SDX-100 $250, Dynavector Ruby $180, All Unused (212)784-2939.

A BARGIN! JVC UA-7045 unused $170. Stephen (212) 784-2939.

ABSOLUTELY MINT: Pioneer RT 909. Light home use. 40 Maxell tapes. All packaging. $795 (803) 259-7803

ABATE THE HIGH COST OF YOUR NEXT AUDIO PURCHASE! DIRECT DISCOUNTS LTD. offers many of the finestlines of audio gear from budget equipment to typically non-discounted components, cartridges, speakers, etc. Whether you're a novice or seasoned audiophile, we believe that our incredibly wide selection, low prices and helpful advice could make us your one-stop audio bargain place. Some of the lines that we offer include ADVENT, AR, ADCOM, BOSE, dbx, DENON, ESS, HAFLER, HARMAN/KARDON, INFINITY, MITSUBISHI, NAD, NIKKO, ONKYO, PHASE LINEAR, SAE TANDBERG, THORENS and many many more. As an added service to our customers, we also offer video equipment (incl many of the Large-screen Tvs, VCRs, etc.) and even a new "wireless" extension telephone for less than $200.00 (sugg. retail $560.00). Just call us at (212) 254-3125 for additional prices or information, or send $2.00 for our current brochure to: DIRECT DISCOUNTS LTD., P.O. Box 841, Cooper Station, NY 10276. Shop with us by phone with your VISA or M/C. No sales tax charged to out-of-state customers!!

A BETTER NAD 3020!
The original 3020 modification is the best! Now also available for the 1020 NAD preamp, the Kindel Audio modification rivals any preamp for sheer listenability. Watch for forthcoming review in Absolute Sound. Kindel Audio, 1710 Newport Circle, Suite O, Santa Ana, CA, 92705.

HARMAN-KARDON HIGH TECHNOLOGY SEPARATES, RECEIVERS, CASSETTE DECKS. BEST PRICES - IN STOCK - IMMEDIATE SHIPMENT. EAST: 305-462-1976 WEST: 213-243-1168.

AAA SELECTION OF HIGH-END AND QUALITY Components, speakers, cartridges, tonearms, turntables, accessories, or whatever. Write or call, you'll be glad. Ask for specials list. Many surprises. Audio Unlimited, 1798 Technology Drive, San Jose, CA 95110 408/279-0122 1-6pm.

SONEX

SONEX is a specialized acoustical treatment material manufactured from a high density open-cell urethane which is then formed to our own proprietary shape for optimum absorption and deflection.

SONEX is an excellent product for in-home audio system applications and will contribute a marked improvement to any existing hi-fi.

When properly applied SONEX will:
- Reduce slap echo
- Smooth frequency response
- Lower noise levels
- Eliminate problem standing waves
- Control room flexure

For further information and a free brochure write:

Esotech Inc.
7778 Mitchell Rd.
Minneapolis, MN 55344
(612) 934-5790

Dealer inquiries welcome

ARE SPEAKER CONES CLONES?

Loudspeaker excellence—the ability to reproduce the whole audio spectrum with definition and coherence—is the single most important key to satisfying sound reproduction. Your system will be as good as your speakers—and no better. The great news is that you can now **build** a speaker system that comes closer to your goal of superb sound by doing it yourself. The clue is in the cone. **No two cones off any manufacturer's production line are identical.** The variations can be as much as 35% from the manufacturer's norm.

What is the answer? You can measure the important behavior parameters in any driver with a basic meter or two and then, following what we now know about how drivers behave in boxes, build a system whose performance is superior to what you can buy. Like fine tuning a stock car, you can alter a stock speaker system to achieve the utmost possible with mass produced drivers, crossovers, and enclosures.

All it takes is know-how. Fortunately a new publication, SPEAKER BUILDER can give you all the know-how you need to build your dream speaker from scratch—or to customize the stock speaker you now own.

SPEAKER BUILDER's authors are exploring the theory behind speaker operation and sharing the results. They are also offering hands-on projects that turn theory, measurements and calculations into superb sounding systems of every sort. The range includes ported boxes, closed boxes, infinite baffles, horns, electrostatics, transmission lines, ribbon tweeters, and air motion transformers. SPEAKER BUILDER gives special attention as well to that vital subject: crossover networks. We explore both the mysteries of passive as well as active, or electronic types.

Why pay for a heavy cabinet to be shipped to you across half the country or the world when you can buy the panels at your local lumber yard, buy only the drivers, and assemble the super speaker system you have always wanted for yourself.

A one year's subscription to SPEAKER BUILDER, four issues, is just **$10**; only **$18** for two years of information packed issues. Use the coupon below, or telephone your charge card order today.

SPEAKER BUILDER **Magazine** A91
P.O. Box 494A, Peterborough NH 03458 USA

☐ Enter my subscription to *SPEAKER BUILDER* for one year only at **$10.00.**
☐ Make that a two year subscription at **$18.00.**
☐ Check enclosed ☐ Charge to my
☐ MasterCharge Visa ☐ charge card.

☐☐☐☐ ☐☐☐☐☐☐☐☐☐☐☐

Expire___/___ (603)924-6526
Name ____________________
Street & No. ____________________
Town ____________State______ZIP______

I understand the unexpired portion of my subscription will be refunded after my first issue if the magazine is unsatisfactory for any reason. Make checks and money orders payable in US$ only to Speaker Builder. Rates above are for USA only. Outside USA add $2.00 per year for postage.

FOR SALE

ADCOM-AMBER-ALLISON-AUDIBLE ILLUSIONS- AUDIOPRO-APATURE-CIZEK-DCM-DNR-DYNAVECTOR-FRIED-GRACE-GRADO-ISOBASE-LAST-LUXMAN-MAXELL-MOBILE FIDELITY-MONSTER CABLE-NAD-NILES AUDIO-JR-SOUND CONNECTIONS-STAX-STD AND MORE . . .
SOUND STAGE AUDIO
A MUSICAL EXPERIENCE
184-10 Horace Harding Expressway
Fresh Meadows, NY 11365
(212) 762-3220 EXIT 25 L.I.E. Service Road

ADIRONDACK AUDIOPHILES Northern New York State House of Hi-Fi is now open with Mariah, Polk Audio, DCM Time Windows, NAD, Harman Kardon, Sota, Audionics, Apt-Holman, Hafler, Hegeman, Eumig, McIntosh, Marcof, Fidelity Research, Toshiba, Sony, Signet, Alpine Car Stereo, Denon, Shahanian, Conrad Johnson, RG Dynamics. For info. call 518-793-6639 Mon. to Fri. 10-9 Sat. 10-6. HOUSE OF Hi-FI, 50 Miller Rd., (Rt. 9) Glen Falls, N.Y. 12801.

Lyric

25 YEARS' EXPERIENCE . . . AND STILL AHEAD OF OUR TIME!

MARK LEVINSON • KOETSU • SPECTRAL • INFINITY'S IRS • GOLDMUND • THRESHOLD
and many more

1221 LEXINGTON AVE
AT 83RD ST.
212-535-5710
NEW YORK, NY

146 E. POST RD.
AT MAMARONECK AVE
914-949-7500
WHITE PLAINS, NY

FOR SALE

ABSOLUTELY BEST VALUE S.O.T.A. BUY DIRECT TAX & DUTY FREE. New model Mayware MC-2V moving coil cartridge, Ogura Nude 'Vital' super polished diamond stylus tip mass 0.19 mg. Same sound as $250 or more cartridges, incredibly only $69 I.M.O. Visa MC accepted. Mayware P.O. Box 58, Edgware, Middx. England.

ABSOLUTE SOUND
MICHIGAN'S HIGH ACCURACY AUDIO DEALER
Will ship postage prepaid anywhere in the United States

CONRAD JOHNSON	BOSTON ACOUSTICS
NAIM AUDIO	LINN SONDEK
DAHLQUIST	NAKAMICHI
MISSION	SPECTRUM
HAFLER	GRACE
NAD	APT
REGA	STAX
REVOX	ONKYO
SNELL	DELPHI
SPENDOR	BRYSTON
THRESHOLD	POLK AUDIO
HARMON KARDON	GRADO SIGNATURE

Or visit any one of our stores in Southeastern Michigan

DETROIT	— 12400 Morang	(313) 527-2244
ROYAL OAK	— 4354 N. Woodward	(313) 549-7550
ANN ARBOR	— 312 S. State Street	(313) 662-2026
E. LANSING	— 1045 E. Grand River	(517) 351-9300

Mastercard, VISA, American Express, Diners accepted

ACCURATE AFFORDABLE AUDIOPHILE EQUIPMENT at lowest prices available!! Specialists in Cartridges-Tonearms-Turntables-Headamps. Please call or write for price quotes & advice: HCM AUDIO, Box 2029-G, Chico, CA, 95927 (916) 343-0558

ACCURATE, QUALITY HOME/CAR AUDIO AFFORDABLY PRICED! Denco Audio, P.O. Box 6104-U, El Monte, CA 91734. (213) 961-6158 evenings, weekends. Send Stamp- MONTHLY SPECIALS, FREE CONTINENTAL SHIPPING, MC/VISA.

ACOUSTAT ELECTROSTATICS, P.S. AUDIO, PRECISION FIDELITY, SPICA SPEAKERS at generous discounts? Yes! Also Signature Speaker kits, Monster Cable- 69¢/ft (Add 75¢/10ft postage)
THE STEREO HOUSE, 86 JOYA LOOP
LOS ALAMOS, NM 87544(505)672-9263
VISA AND MASTERCARD ACCEPTED

ACOUSTAT X — The Fabulous originals (with original 1C's) rare, most highly rated versions $1300. 716-663-8623 evenings.

A step nearer audio perfection.

REFERENCE MONITOR INTERNATIONAL, Inc. 2380 "C" Camino Vida Roble • Carlsbad, CA 92009

FOR SALE

AN INVITATION FROM
PENINSULA AUDIO
NORTHERN MICHIGAN'S ONLY HIGH ACCURACY DEALER

As you make your summer plans, we cordially invite you to include a visit with us at our beachfront listening rooms. As many of you know, it is particularly beautiful here during the summer months. As always, you will find a totally relaxing atmosphere, genuinely friendly and helpful people, and a selection of components offering musical accuracy, classic simplicity, and both initial and enduring value. We look forward to visiting with you and wish you an enjoyable summer—Gerry and Ted. By appt. VISA and MC. Pre-paid shipping. PENINSULA AUDIO, 867 SOUTH LAKESHORE DRIVE, LUDINGTON, MI 49431. (616) 845-6535.

ARC D76AN excellent condition. Original owner $850, Braun PS600 changer $150. (305) 395-7616 days, (305) 392-6716 eves.

FOR SALE

ANOTHER AUDIOPHILE PUBLICATION?
AUDIO UPDATE is published ON TIME. This bi-monthly includes modifications construction projects, improvement methods, data available nowhere else. It's provocative, informative, and a MUST if you enjoy audio. Annual: $12.00 USA/Canada, $14.00 elsewhere. MasterCharge/Visa welcome. AUDIO DIMENSIONS, 8888 Clairmont Mesa Blvd., San Diego, CA 92123. (714) 278-3310. TF

ANTI-SKATING for AR TURNTABLES!! Proven counter-weight design of nickels steel & aluminum construction. Install yourself in minutes. $7.95 postpaid. (Dealer inquiries invited.) AUDIO INNOVATIONAL PRODUCTS, P.O. Box 1607, Portsmouth, N.H. 03801.

ARE YOU SEARCHING FOR QUALITY, USED AUDIO GEAR? CALL OR WRITE **PLAY IT AGAIN SAM,** 12611 MADISON AVENUE, LAKEWOOD, OHIO 44107 (216) 228-0040 M-F 10-8, Sat. 10-6, Sunday 12-6. Used equipment **is** our business.

CRESCENDO

THE FASTEST GUN IN THE WEST ------ NORTH, SOUTH, and EAST

3D ACOUSTICS

175 Heritage Ave., Portsmouth, New Hampshire 03801
(603) 436-8003

Announcing . . .

High Performance Review

The New Magazine for the Perceptive Listener. Your guide to the dynamic developments in high quality audio.

The first audiophile magazine with:

- Technical Advisory Board: J. Robert Ashley, University of Colorado at Denver, Elliot Mazer, independent record producer and engineer, James A. Moorer, Lucasfilm, Ltd., Vincent Salmon, acoustical consultant.
- Comprehensive tests of equipment using state-of-the-art precision instrumentation from Bruel & Kjaer, Hewlett-Packard and Tektronix.
- Careful subjective listening evaluations. Results can be verified by your own listening tests.
- Authoritative reviews of over 60 recording per issue: Classical, popular and jazz releases from major and specialist labels—expert opinion on both performance and sound quality.
- Reviews of recent technical presentations at audio engineering conferences. What do the leading audio engineers and scientists say? Discussion of current controversial topics in audio.

High/Performance Review will help you find the best in high quality audio equipment, regardless of your budget. Most experts agree that tests-measurements must be combined with complete listening evaluations to identify truly excellent products. Our comprehensive resources will be used to provide you this important information. Recordings are the other half of an outstanding audio system. Our complete sound-performance reviews will help you find outstanding recordings for your collection.

Order your new subscription today at a special charter subscription rate of $24.00 for one year four issues. Don't miss out! The first issue, with over 120 pages of editorial material, is ready now. It has 18 equipment reviews from manufacturers such as Fidelity Research, Tandberg, Apt and Grace. The issue is printed on fine, library grade paper, with durable perfect binding. **High/Performance Review** will be an important part of your interest in high quality audio. Please join us by sending your subscription today.

Order Today! Money-Back Guarantee

High/Performance Review
Box 2989, Stanford, California 94305 U.S.A.

☐ Yes, enter my charter subscription today
☐ I enclose $24.00 by ☐ check ☐ money order

Name ______
Street, No ______
City State ______ Zip ______
Telephone (408) 446-3131, M-F 10-4 (Pacific time)

FOR SALE

ARC/VAN ALSTINE SP-3A-1 $450; Mayware Formula 4 Mk. III $70; Grado Signature II $150; Pioneer RT 1050 15 ips ½ track with pair Neumann KM-83 omni condensers and acc. $1,000. Visonik-David 502MO for auto $130 pr. All subject to dickering. Todd at 1-319-236-1526 after 4 PM. Keep trying.

ARISTON RD11s with Formula 4 arm $500. 716-663-8623 evenings.

A&S SPEAKERS offers raw speakers and kits. Specializing in plastic cone drivers and high-end auto systems. Our brands include Audax, Becker, Philips, Foster, JVC, Jordan-Watts, SEAS, Dynaudio, Falcon Acoustics, and Peerless. Free price list. A&S SPEAKERS P.O. Box 7022, Denver, CO 80207 (303) 399-8609.

A SINGER'S DREAM!

REMOVES VOCAL FROM MOST STEREO DISCS
The Thompson Vocal Eliminator can actually remove most or virtually all of a solo vocalist from a standard stereo record and yet leave most of the background music untouched! Not an equalizer! We can prove it works over the phone. Write or call for a brochure and demo record below. COST: $295.00

Time Delay/Ambience

Superior:
- **Realism**
- **Frequency Response**
- **Versatility**
- **Dynamic Range**

Time delay is new to consumer audio. Recording Studios have been doing it for years. They have developed much more realistic systems than are presently offered for consumer use, with One notable exception......Our TAD-4.

Call or write for a 24 page brochure on our line of 18 products. Included will be a product review of the TAD-4 and a demo record which will allow you to compare our TAD-4 with other units. At $650 we aren't cheaper...... We're Better!

Write to: **LT Sound**, Dept. AU, P.O. Box 338, Stone Mountain, GA 30086, Phone (404) 493-1258

FOR SALE

ARC EQUIP FOR SALE

D-76-G exc cond w/carton $625; D-100 (a) mint, original carton $625; D-100(b) new in box, $835; D-52 exc cond $565; D-52(b) new in box, manual $795; D-51(n) exc cond, carton $535; D-76(a)(G) mint cond, carton, manual $875; EC-21 crossover X-tra freq kits, new in box rack mt $475; EC 2(a) crossover good conditon with schematic $225; MCP-1 head amp w/outboard p.s. $125; RPR-1 remote power receptacle factory sealed box $295.

OTHER EQUIP FOR SALE

MAC MA6100 integrated amp just back from factory check out, mint condition, carton $425; MR-71 Turner very good condition recently aligned $365; MAC-C-26 preamp exc cond w/carton $295 MAC performance tested; MAC-C-28 preamp late serial number mint w/case $395; MC 2505 power amp, exc cond $385; MC 2105 power amp exc cond w/wooden case MAC performance tested; (2) MAC C-8 mono tube preamps (brass faced) $135; Audionics CC-2 power amp new with warranty $365; Mark Levinson ML-1 serial number 2940 w/pls 150 p.s. mint, carton $975; precision fidelity C-4 preamp gold exc cond, carton $600; Conrad Johnson TR-1 step-up transformer, sounds great $125; Pair 25' #12 wire stranded with professional banana term $32; Grace 714 teak arm exc cond $135; Grace 704 tonearm exc cond $110; Rogers LS 3/5A'S walnut, mint, carton $375; MAC A-102(b) power amps good cond $350; Bryston 2(b) power amp exc cond w/carton $325. Call 317-283-1361, 8—4 M—F, Ask for Dave.

Audio and TV tubes factory boxed, speakers, semiconductors—low prices, free price list. Transisleteronic Inc., 1365-39th St. Brooklyn, N.Y. 11218 212-633-2800 TF

!!! ASTOUNDING !!!
THIEL Loudspeakers: models 03a, the new 04a, and the 02.
AUDIO CONNECTION, Verona, NJ (201)239-1799

ATTENTION LONG ISLAND and METRO NEW YORK AUDIOPHILES: Audition Frank Van Alstine modified Dynaco equipment in a home environment. Find out why audio reviews have been astounded by his latest modifications. Auditions by appointment only. Nassau (516) 541-0312. Suffolk (516) 277-5336.

CLAMP DOWN ON BAD VIBES!

The DS250 Disc Stabilizer by MONSTER CABLE tightens bass response, sharpens the image and improves the overall clarity of your recorded performances.

Get all the sound you paid for at your MONSTER CABLE dealer.

101 Townsend St. San Francisco, CA. 94107 (415) 777-1355 Telex 470584 MCSYUI

Available Worldwide MONSTER CABLE®

FOR SALE

AT LAST
AFFORDABLE ESOTERIC
Arms, Cartridges, Turntables, Amps, PreAmps, Tuners, Speakers, Accessories, Etc.; a huge selection at attractive prices. Call for prices or technical information, or write for catalog. AudioWrold Box 6202 G.R. MI. 49506. 616-451-3868 M-F 11 to 7. Visa and Mastercard welcome.

ATTENTION ALL DYNACO AND DYNA KIT OWNERS:
Frank Van Alstine can rebuild and/or repair your Dyna amplifiers, preamplifiers, and tuners. We have all new PC cards and all new highest quality internal circuits for most Dyna units. New POWER MOS-FET circuits for Dyna ST-150, ST-300, and ST-120 amplifiers. New J-FET circuits for Dyna PAT-5 and Bi-Fet preamplifiers. All new circuits for FM-5 tuners with phase-locked loop Mplx, new 8 stage differential IF, new buffered outputs, no drift, super musical, super sensitive. We rebuild all ST-400, 410, 416 amplifiers and can repair any, no matter how badly blown. External 100,000 mfd power supplies for ST-400 and 415. All new internal circuits for Dyna PAS tube preamps. New Noble precision stepped controls for all Dyna preamps. New Mos-Fet circuits for Dyna PAT-4 preamps. Improved audio circuits for St-70 tube amps. Rebuilt Nagatron, Sonus, and Grado phono cartridges. Read AUDIOGRAM, MR. AUDIO'S BI-MONTHLY, AND SENSIBLE SOUND for reviews on our equipment. No charge for repair labor when we rebuild your Dyna unit. We ship worldwide and have brand new 120 volt and 240 volt modified Dyna units available. For details and our recommendations on how to make a hi fi system sound like music, write or call:
JENSENS STEREO SHOP 2202 RIVER HILLS DRIVE BURNVILLE, MINNESOTA 55337 (612) 890-3517.

ATTENTION AUDIOPHILES:
SPECIAL OFFERING OF VERION PRODUCTS
General Resistance, Inc., the ONLY manufacturer of Verion MK1 Stereo Pickup Transformers, Triaxial Audio Cables, and GS1 Ground Strips has been authorized by Stipulation to sell the remaining inventory of those products:

MK1 Stereo Pickup Transformers (specify pickup impedance): $350 each.

Triaxial Audio Cable pairs: $30 per one meter, plus $5 for each ½ meter added to the pair. All Triaxial cables have RCA-type connectors, at one end, and either bar leads, RCA-type connectors, or male or female DIN connectors at the other. Be sure to specify length and choice of connector.

GS1 silver-plated 12" solid copper Ground Strips with hardware and grounding pig-tail: $20 each.

All above carry 5-year manufacturer's warranty.
Quantities are limited since there will be no further production.
Send official bank check or postal money order immediately to avoid disappointment. Orders shipped prepaid UPS in the USA. Others add shipping. No telephone orders accepted.
GENERAL RESISTANCE, INC.
130 S. Columbus Ave.
Mt. Vernon, NY 10553

ATTENTION DCM TIME WINDOW OWNERS

We now offer a convenient and attractive way to improve the sound of your speakers. The DCM Time Window, when raised 9 inches off the ground, has an airier and tighter sound: the image is raised and standing waves reduced.

THE DCM TIME WINDOW PEDESTALS are made of heavy duty wrought iron and suit the shape and appearance of the Time Window perfectly. They sell for $65. per pair. If there is no dealer nearby, order postpaid (Master Charge & Visa accepted) from

R.S. PARK AUDIO ASSOCIATES
5 SUNRISE PLAZA, VALLEY STREAM, NY 11581
(516) 561-7558
DEALER INQUIRIES INVITED

Audio Research SP-6B latest model new $1200.00 tel. (919) 2990553

AUDIO RESEARCH SP4A $550. 716-663-8623 evenings.

FOR SALE

ATTENTION: "FOREIGN" AUDIOPHILES AND DEALERS! Western World Audio Exporters can supply virtually ALL brands of hi-fi components, speakers, cartridges, etc. (incl. esoteric lines) at VERY attractive prices. Quotes, terms and availability furnished on request. Write To: WESTERN WORLD AUDIO EXPORTERS, 373 Fifth Avenue, Suite 1556; New York, NY 10016. TELEX—423826 SAKIUR.

ATTENTION owners of Pioneer, Kenwood, Sony, Teac, dbx, Technics, Harmon-Kardon, and most other late model components. Send for FREE detailed brochure on solid oak/walnut side panels. Incredibly low priced; $15.00-$25.00. FREE shipping in U.S. Wood Tailoring Co Box 11314, Portland, Ore 97211.

ATTENTION: Stax headphones, exotic tonearms, cartridges, substantial savings. Also Fulton products. Maury Corb, 713-728-4343, 11122 Atwell, Houston, Texas 77096.

ATTENTION . . . AUDIOPHILES
Northeastern's Largest Hi-End Audio Salon
Now has a larger selection of
Quality Components

Featuring:

Linn Sondek, Kenwood Purist Group, LS3/5A, B+W, Spendor, Supex, Stax, Adcom, Mitsubishi, Decca, Tandberg, DB Systems, I.M.F., Grado Sig., Shahinian Obelisk, Monster Cable, Dahlquist, Audio Pro, Grace, Avid, Marcof, Micro Acoustics, Dual, Strathclyde, Audio Source, S.A.E., Magneplaner, Carver, Dynavector, Audio Linear, Radian Research, Fulton, Promethean and Nagatron.

We Ship Anywhere In the World

The Sounding Board, Inc.
75 Franklin Avenue
Ridgewood, N.J. 07450
Call us at (201) 445-5006

AUDIO CONNECTION IN NORTHERN NEW JERSEY:
Tel: 201-239-1799, 615 Bloomfield Ave., Verona, NJ 07044. ADS + Audire + Clarke Systems + Denon + Dynavector + Grace + Grado + JG Acoustics + Kirksaeter + Lurne + Tonearm + Lustre + Nagatron + PS Audio + RG Research + Rogers LS3/5A, T75 Series II Tuner+ Satterberg + Sonic Developments + Spectrum + Spica + Supex + 3D Acoustics + Thiel + + Audio Source + CWD + Fulton + Last + LiveWire + Platter Matter + VPI Industries + more. Free Shipping in Cont. U.S.

AUDIO DEN AND POLK AUDIO
The Audio Den is proud to have on display and demonstration the amazing Polk Audio Monitor Series. Our customers say "Fantastic! Compares with the finest loudspeakers I have heard. Probably the best value in the history of Audio!!!" Audiogram™, from the Audio Advisor said, "We were so impressed that we could not believe the prices . . . Other $200 speakers simply do not come close to the standards set by the Model 10 . . . And at their price, they are simply a steal." Come in for an audition or write us for information on Polk or our other state-of-the-art products. Polk is shipped free in the continental U.S. Audio Den Ltd. 1320-34 Stony Brook Rd., Stonybrook L.I., N.Y. 11790, 516-751-3350. TF

★ **AUDIO EMPORIUM,** Acoustat, Amber, Apt/Holman, Audio Interface, Audire, B&O, Beyer, Boston Acoustics, Conrad-Johnson, Denon, Dynavector, Grace, Grado, Hafler, Lux, Magnepan, Marcof, Micro Seiki, NAD, Oracle, Polk Audio, RH Labs, Rega, Revox, Rogers, SOTA, Stax, Technics, 3D Acoustics, Threshold, Vandersteen. Open Tues, Wed, Fri, Sat, 10-6, Thurs, 10-8. Closed Sun & Mon. 414-354-5082, 6914 W. Brown Deer Road, Milw, WI 53223.

AUDIO RESEARCH AT CSA AUDIO DESIGN
Discover latest state-of-the-art Audio Research amps D60, D120. New performance plateau.
CSA AUDIO DESIGN
193 Bellevue Avenue
Montclair, NJ 07043
We ship anywhere. VISA/MC.

Audio Research D-110 Mint $1700 (603) 224-6721

FOR SALE

AUDIO EQUIPMENT UNUSED WITH BLANK WARRANTY CARDS:
INFINITY BLACK WIDOW GF-II $165, SME 3009-III $195, SONY XL55 $180, SHURE V15 IV $85, REVOX B790 $600, VERION MK-1P $285, STAX UA7-GF $225, SIGMA $260, SRX-III $155, SRM-1 $240, CPY/ECP-1 $320, **USED EQUIPMENT**: AMPEX AX300 $150, STAX SR3/SDR-5 $90, MICRO SEKI DDX1000 $350, ADC-LMF/1 $80, FIDELITY RESEARCH FR-1 MK3 $75, JANZEN 412HP $250, MARANTZ 2500 RECEIVER $600, SONY 2000F PREAMPLIFIER $300, 3200F AMPLIFIER $200, 5130 TUNER $150, TTS3000 TURNTABLE $100, PUA237 TONEARM $50, TC55 CASSETTE $90, SHURE 565 MICROPHONE $40, PANASONIC NV8300 VHS VIDEO RECORDER $550, All items negotiable. (312) 771-4660 9am/6pm CST

AUDIO GRADE POLYPROPYLENE AND POLYSTYRENE CAPS NOW FROM: .0015 to 5u 200 VDC 10% for your electronics contruction, upgrade mods and crossover networks. Build phase coherent line source arrays that have electrostatic like "speed" that are ready for PCM. Digital and D to D dynamics without strain. Subwoofer designs for seamless sonics, Polymer tweeters for timbre and "air", active biamp semi kit, and super air core coils. Catalog $1. 26 page Jordan Manual on spkr design $2. Transcendental Audio, 6796 Arbulus, Arvada, CO 80004. E. J. Jordan, Dynaudio, Polydax, Foster, JVC, Rowland Research. (303) 420-7356.

AUDIO RESEARCH SP3A-1, Bravura Ma 5100, MC c22, Mc 275, Mc mi71, 713-995-1856.

ACOUSTIC TEST INSTRUMENTS
USE TO ADJUST EQUALIZERS, OPTIMIZE SPEAKER PLACEMENT, ETC.

Complete Test Set	$399
Calibrated Sound Level Meter	$169
Fractional Octave Pink Noise Generator	$299
Handbook on Acoustic Testing	$6

Free broch: HALL ENGINEERING, Dept 04
P.O. Box 506, Martinsville, NJ 08836
(201) 647-0377

FOR SALE

AUDIONICS-NEW PRODUCT
We offer the complete Audionics line: BT2 & RS1 preamps, CC2 & BA150 amps, Space & Image Composer, LK1 turntable, RVR/RVP Revox replacement cards, LK1 turntable and the CX-20 DISC SYSTEM. By appt. Free shipping in U.S. We ship WORLDWIDE. Visa & M.C. OXFORD AUDIO CONSULTANTS, Box 145, Oxford, OH 45056. ITT TELEX: 427791. Cable: OXAUDCON. 513-523-3333.

AUDIONICS = VALUE
Audionics continues to stand the test of time as a cost effective product. If you are new to high end audio or an old audiophile, consider a product that you will want to keep. Audionics BA-150, CC-2 amps. RS-1 and BT-2 pre amps and the LK-1 Turntable. FREE shipping and advise from Audio House, 4304 Bryan Dr., Swartz Creek, Mich. 48473 (313) 655-8639 by appointment.

A-Z SELECTION OF STEREO-ESOTERIC COMPONENTS at Wholesale. Free catalog. Audio Unlimited, 1798 Technology Drive, San Jose, CA 95110. (408) 279-0122. 1-6 M-Th.

NEW TECHNOLOGY RAW SPEAKERS.
Leaf tweeters, the Wave Aperture™ system, the Nestorovic woofer™ system, polypropylene drivers, and more from Speakerlab, the highly acclaimed speaker design/manufacturing company. Send today for your free catalog of speaker systems, raw speakers and design guidelines.

Speakerlab
Dept. A19, P.O. Box C-30325
Wallingford Station-Seattle, WA 98103

The new Koetsu EMC-1B, or "Black", has been called a classic audio component. Retail price, $600. Also, the reintroduction of a classic—Accuphase; amps, preamps, integrated amps, tuner and crossover. Also available—Acoustique 3A speakers; and D&K's own connectors, cables and accessories—The Gold and Silver Connections, The Master Sound Cable, and the Electro Stylus Cleaner.

D&K IMPORTS
DEALER INQUIRIES INVITED
146 E. Post Rd., White Plains, NY 10601
914-946-3031

COMING SOON! THE NEW KOETSU TONEARM!

FOR SALE

AUDIO HEIGHTS
"We do things a little differently"
To serve your Hi-Fi and Video needs.
Call us at (212) 237-9847.
Amber, Allison Acoustics, Audio Pro, Aiwa, ADC, AR, ADS, AKG, Alpine Car Stereo, Audio Control, Bose, DBX, Tandberg, Thorens, Onkyo, Nikko, Sherwood, Ortofon, Micro Acoustics, Stanton, RG, Omnisonic, JVC, Hitachi, RCA, Ultravision Projection TV.

Fons — *International Mark I*
FONS CQ30 Finest belt drive electronic transcription turntable, $200 without tone arm.
Send money orders to:
LORD BROTHERS 1128 Bannock St., Denver, Colorado, 80204 303-534-7590 Will ship same day.
Full price $200.00 shipping included.
Or send 25% — balance plus shipping COD.
Colorado residents add tax *Ninety day warranty.*

• WE WILL •
NOT BE BEAT!
SUPER SELECTION · FULL WARRANTY · FAST DELIVERY
• HI-FI, HIGH END & VIDEO •

VISA CALL 203-932-4265 NOW! MAC
★ AUDIO PEOPLE ★
998 Orange Ave., West Haven, CT 06516

FOR SALE

Audio Research D-350B Amp	**$2000.00**
Audio Research D-110-B Amp.	1300.00
Audio Research EC-21 Crossover	450.00
Koetsu Cartridge	300.00

Telephone 216-524-1185

AUDIO RESEARCH D-79 $1900. Also sale of many many other demo items. 1) Cotter/Denon 6000 demo model, never sold—$900. 2) Oracle turntable brand new never sold $700. 3) Levinson ML3 used—$2,000. 4) Acoustats II's brand new—$800. 5) Vandersteens slightly used—$650. 6) Koss Model II's with Pyramid tweeters specially modified — $2,200. 7) Two Nakamichi 700 tape decks, used —$500 each. And much more. Call 813-447-1487 at 6:15 pm EST or after 11 pm EST or 813-461-2764 at 4:pm EST.

AUDIO, VIDEO, NOW TACTIO. You Touch the Message . . . Introducting the 3rd media and the first audiotactile product the Sonic Stimulator. Use it as part of your stereo. Touch It to you anywhere and feel wonderfully pleasurable visceral sensations. Sound effects have realistic tactual images, but music entertains the skin best. You can feel like you're in the concert hall. It's a personal sub-woofer. Turn your sound system into a touch system and tingle to the tune. The Beatles on your back. Bartok on your belly. Beethoven (wherever it feels good.) Want to know more about Tactio and the Sonic Stimulator? Examine our Touch System owner's manual one week, free. It Includes operating information, technical information, stories about the Touchie-Feelies and magazine reprints. You also get updates and invitations to preview demonstrations. The price of the manual is $10 which is applicable toward the purchase of our equipment. Tell your friends.
How Wachspress, Inventor. Auditac. Box 99141, San Francisco 94109

BEVEREDGE RM-1 PREAMP SERIAL #109 PRACTICALLY UNUSED $1695 (408) 449-2220 CA. EVES.

BEFORE YOU BUY-CHECK OUR PRICES. Send for free catalog featuring audio and video equipment and accessories at discount prices. House of Tape P.O. Box 191 Mineola NY. 11501

FOR SALE

BAY AREA AUDIOPHILES
Affordable "State of the Art" Audio

Dynavector	Grace	Sony
Micro Acoustics	Denon	SME
Fidelity Research	Onkyo	AKG
PS Audio	Shure	DCM
Audio Linear	Grado	Epicure
Audible Illusions	Marcof	Thorens
Pyramid	Amber	Gensis
Rogers	Eumig	Hafler
Satterburg	Supex	Mayware

ONE MORE STEREO STORE 408/946-0500
107 Dixon Road, Milpitas, CA 95035

BEDINI CLASS "A" AMPLIFIERS
We stock the entire line of BEDINI amplifiers ready to be shipped to you at HUGE SAVINGS. These are the world FAMOUS amps that were reviewed in The Audio Critic and Audio Alternatives magazines. We also have Crystal Clear Records' HAPI' Merlin Records' Profile Audio Furniture' Shahinian Acoustics' SOTA
We are also taking orders for the new SOTA Sapphire turntable, A TRUE REVOLUTION in design. Contact ESOTERIC AUDIO (312) 367-5595.

BEFORE SPENDING $200 TO $5000 ON AUDIO EQUIPMENT, YOU SHOULD HAVE A SOUND GAME PLAN. IN PURSUIT OF AUDIBLE PLEASURES helps you decide how to tune up your system inexpensively, where to make cost-effective Improvements, whether to upgrade, and how to select appropriate equipment while avoiding hype. A comprehensive, strategic guide; not just lists of equipment. $7.95 + $2.00 postage/handling. Moneyback guarantee. Far West Audio, Box 4419A, Irvine, Ca. 92717

B & O USES "ANY" CARTRIDGE with standard mounting centers after our modification kit or at factory. Effective mass 2.5 grams. Adjustable silicone damping. $199.00 with money back guarantee. JML Company, 39,000 Highway 128, Cloverdale, CA 95425. TF

CABLE TV DESCRAMBLERS AND CONVERTERS. Microwave antennas and down converters. Plans and parts. Build or buy. For Information send $2.00. C&D Electronics Inc., P.O. Box 21, Jenison, MI. 49428.

CARTRIDGES, TONEARMS, TURNTABLES, MOVING COILS — excellent selection at great prices. Free Catalog. Audio Unlimited, 1798 Technology Drive, San Jose, CA 95110. (408) 279-0122 1-6 M-Th.

CLARKE SYSTEMS' REFERENCE MONITOR: STATE-OF-THE-ART, the nearly ultimate, affordable At AUDIO CONNECTION, Verona, NJ (201) 239-1799.

AUDIO HOUSE — FLINT MICHIGAN

Mordaunt—Short	Adcom	Leach LSR&D	Promethean
Acoustat	Symmetry	Audio Pro	Ariston
Rogers	Conrad—Johnson	M&K	KM Labs
IMF	DB Systems	Audionics	Dynavector

Gonza wire is #12 gauge speaker wire 50¢ per ft, Keith Monks record. Sleeves 100—$25, samples $1.00. 4304 Brayan Drive, Swartz Creek MI 48473, 313-655-8639 by appointment.

AUDIO MODIFICATION MANUAL - 230+ pages step-by-step procedures for many common components. Data applicable to almost any unit. Tube circuitry emphasized. Applauded by AUDIO, STEREOPUS, HIGH FIDELITY, SOUND ADVICE, et al. Unique information provided no where else. $25 USA/CANADA, $27 elsewhere. California tax applicable. Master Charge/VISA Welcome. (714) 278-3310. AUDIO DIMENSIONS, 8888 Clairmont Mesa Blvd., San Diego, CA 92123

BEST IN THE WEST

NAKAMICHI	N.A.D.	MAGNEPLANAR
DAHLQUIST	LINN	HARMAN KARDON
ORACLE	POLK	TIME WINDOW
THRESHOLD	ADCOM	APT HOLMAN
ACOUSTAT	B&W	DENON
TANDBERG	SONY	HAFLER

ROCKY MOUNTAIN HI FI
812 Central Ave., Great Falls, MT (406) 761-8683

AUDIO HOUSE DEMO & USED SALE
Revox B790 $550, Revox B77 hi-speed ½ track new $1195, Revox equipment rack $195, Quad ELS $995, MTI 245 $395, Adcom GFA—1 $325, Spectlo—Acoustics 210R equalizer $195, Conrad—Johnson pre pre—amp $130, Supex 900 SE+ $135, Sound—Concepts $375, Harmon—Kardon ST-7 $135, Denon DP-755 $210, Davis Brinton phono preamp $75. 4304 Brayan Swartz Creek, MI 48473. 313-655-8639.

Are you hearing your moving coil?

Do you have a SOTA Head Amp?

If you do, then you are. If you don't, then you probably aren't.

In less than a year, the SOTA Head Amplifier has become the pre-eminent moving coil cartridge step-up. Musical finesse and elegance of design set it apart from the crowded field.

For 1981 we present a refined, second generation SOTA—plus a deluxe step-up with rechargeable batteries. Updates available.

And there is more from SOTA Industries. If you want to see your dealer's face light up, simply ask him about the SOTA Sapphire—the American turntable for the '80s. The time has come.

SOTA industries

P.O. Box 7075, Berkeley, CA 94707

innovative audio

DEDICATED TO MUSICAL EXCELLENCE

OUR DEMONSTRATIONS OF AUDIO EQUIPMENT ARE UNIQUE. WE OFFER UNLIMITED TIME TO EVALUATE THE VERY FINE COMPONENTS WE FEATURE. OUR EXTENSIVE LIBRARY OF QUALITY RECORDINGS ENABLES YOU TO DETERMINE WHICH COMPONENTS ARE OPTIMUM. OUR EXPERTISE WILL HELP YOU TO DECIDE WHAT IS BEST AS WELL AS TO ENSURE A PERFECT MATCH TO YOUR LISTENING ENVIRONMENT.

YAMAHA, NAKAMICHI, BRYSTON, APT-HOLMAN, COTTER, BANG & OLUFSEN, DAHLQUIST, NAD, BOWERS & WILKINS, QUAD, LINN SONDEK, BEDINI, SHAHINIAN-OBELISK, BOSTON ACOUSTICS, PYRAMID, OHM, KLIPSCH, INNOTECH, DENON, MARCOF, ADS, LS3/5A, REVOX, JVC PRO-LAB, FIDELITY RESEARCH, SIGNET, SUPEX, DYNAVECTOR, ETC.... FEATURING KLOSS VIDEO. DIGITAL AND DIRECT DISC RECORDINGS.

TRADE INS. BUY. SELL. USED EQUIPMENT. PROFESSIONAL REPAIR SERVICE & HOME INSTALLATION. CREDIT CARDS ACCEPTED. FINANCING AVAILABLE.

182 HENRY STREET • BROOKLYN HEIGHTS, NY 11201 • (212)596-0888

FOR SALE

CARVER IN THE SOUTH!
In stock! Fast, free shipping. READ BROS. STEREO, 593 King St. Charleston, S.C. 29403 (803) 723-7276. Also FRIED KITS.

CHICAGO SPEAKERWORKS designs and builds true audiophile speaker systems. Large selection of factory direct speaker systems, finest European & American drivers, kits, crossovers & accessories at lowest prices. Factory showroom open 7 days/week. Also: Hafler, Fried, Ortofon & more. Send $1. for catalog to: CSW, dept. A, 5125 N. Damen, Chicago, Ill. 60625 (312) 769-5640

CLARKE SYSTEMS IN THE NORTHWEST!
Are you searching for a speaker system that delivers true STATE-OF-THE-ART performance? Then you owe yourself an audition of the sensational Clarke Reference Monitor. At $1800 pr you won't be disappointed. We stock the entire Clarke line including the new LM satellite-subwoofer system for $650. For further information or appointment; RJ's Stereo 127 McMillan Dr. Longview, WA 98632 (206) 577-1196

CLOSE-OUT SALE Blank Ampex Recording Tape-1800', 7" reels. Fits all reel-to-reel recorders. Satisfaction guaranteed. $4.50 per reel; 5 for $17.50; 10 for $30.00; 20 for $55.00. All Postage Paid. Paragon Sales Inc. PO Box 301 Romeoville, IL 60441 (815) 725-9212.

CONNECTICUT: Advent, A.P.T. Holman, B&O, Boston Acoustics, Carver, Dahlquist, D.C.M. Time Windows Polk, Hafler, Harman/Kardon, Mitsubishi, Nakamichi, Ortofon, Micro-Acoustics, N.A.D., Stax, Yamaha, Cizek, Signet, QED, Teac, Marcoff, Audio-Phile Records. Will ship prepaid. Sounds Incredible, 39 Federal Road, Brookfield, CT.,06804. (203) 775-1122—phone quotes only. TF

CSA AUDIO DESIGN
Since 1972 bringing the "Audio Alternative" to the NY-NJ area. Audio enthusiasts everywhere know about our superior service and customer satisfaction. Discover our new expanded UPPER MONTCLAIR headquarters. Specializing in the finest array of stereo names available.
BEVERIDGE • B & W • BEDINI • AMBER • DCM • HAFLER • HAPI • EUMIG • FIDELITY RESEARCH • GRACE • JR • KEF • LINN-SONDEK • LUSTRE • NAD • PRECISION FIDELITY • KENWOOD "AUDIO PURIST" • QMI • REGA • SNELL • PLEXUS • AUDIO RESEARCH
Plus 50 more great names.
We ship anywhere in the USA freight prepaid. Call us at: (201) 744-0600. Discover courtesy in Audio.
CSA AUDIO DESIGN
193 BELLEVUE AVENUE
UPPER MONTCLAIR, NJ 07043
Sound System Design Consultants to HOME MUSIC LOVERS;
PROFESSIONAL THEATRICAL ARTS; and the AUDIO INDUSTRY.

DBX—2BX EXPANDER $300 OR BEST OFFER. (504) 834-7266 after 5 p.m.

DISTRIBUTORS, MANUFACTURERS AND IMPORTERS AND DEALERS - We are once again open to buy Closeouts, discontinued and surplus inventories from you. No quantities too large or too small. Any audio products considered. Call now and YOU GET IMMEDIATE CASH. Wack Electronic Inc., 5722 West North Avenue, Milwaukee Wisc. 53208. (414)442-3441

DOLBY FM CORRECTLY DECODED — $100. Also encode/decode KIT for recordists. Detailed information; reviews. AD INTEGREX, Box 747, Havertown, PA 19083.

ESOTERIC ACCESSORIES at truly affordable prices, including head amps, interconnects, turntable mats, speaker cable, arms, cartridges, and much more . . . a huge selection at low prices. Call or write for information and our free catalogue. AudioWorld, Box 6202A, Grand Rapids, MI 49506. 616-451-3868. Visa/MasterCard accepted.

ELECTRONIC CROSSOVERS — ALL TYPES Updated definitive booklet describes applications, how to improve speaker systems; $5.00 postpaid, credited to first purchase. Huntington Electronics, Box 2009-A Huntington, Conn. 06484.

HOW TO ANSWER BOX NUMBER ADS
When replying to an Audio Box Number Ad, please use this address Box No. — c/o Audio, 1515 Broadway, New York, N.Y. 10036

FOR SALE

COTTER CM/PSC/NFB/PW, mint $1895. (315) 437-1209.

. . . . . COTTER EQUIPMENT IN STOCK . . . . .
Limited quantities of Mitchell A Cotter equipment in factory sealed cartons are now available for immediate delivery:

B-2	Isolation Platform	$450.00
MK-2	Moving Coil Pick-up	$550.00
NFB-2	Noise Filter/Buffer	$500.00
PSC-2	Phono Signal Conditioner	$550.00
PW-2	Master Power Supply	$450.00

Free freight anywhere in continental U.S.
For More Information write to Audio Resources, P.O. Box 507, Selden, New York 11748
or call
Robert Borsody (212) 490-0994

DAHLQUIST DQ-10 OWNERS
Up-date your DQ-10 loudspeakers to State Of The Art performance with the DRT-1 Ribbon Tweeter kit and you will realize the amount of air, detail and transients you have been missing with the original tweeters. The DRT-1 kit comes to you complete with two Flat Ribbon Tweeters, two Soft Dome Tweeters, precision cross-over components and detailed instructions to replace the inexpensive piezo electric elements. $249 Postage paid in U.S. Visa, M.C., check or money orders welcome. RANDALL RESEARCH 719 Fernleaf Corona Del Mar, Ca. 92625 (714) 760-1539.

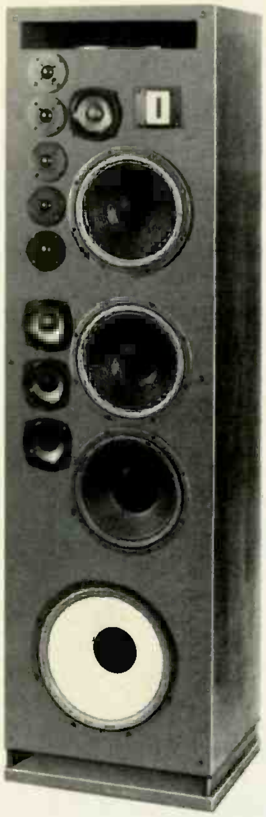
FOR SALE

DB SYSTEMS ELECTRONICS AND AUDIOPHILE ACCESSORIES ARE WORTH KNOWING ABOUT. Ultra-low distortion Preamps, Power Amps, Active Crossovers and more. ACCESSORIES include: DBP-10 Phono Alignment Protractor $19.95, DBP-6 Phono (capacitance) Equalization Kit $29.95, DBP-6MC Resistive Loading Kit $29.95, DBP-2J Switch Box $39.95 - DBP-2JAU with all gold (10) jacks $47.95, DBP-12 Audio Cable - 10 meter, 400 pF $59.95 - other lengths $15 plus $1.50 per foot, DBP-CK Cramolin Audio Kit contact treatment $11.95, GOLD PLATED CONNECTORS (eight per package): DBP-13J (¼") Phono Jacks $10.80, DBP-13JR (⅜") Phono Jacks $12.00, DBP-9AU Banana Plugs $10.80, DBP-13P Phono Plugs $7.20. Complete information available at selected audio stores or direct from DB SYSTEMS, P.O. Box 3470, Jaffrey, NH 03452 (603) 899-5121. Orders under $45 add $2.50 Handling. Dealer inquiries invited.

DENON'S DP75 SET INTO A VPI HW9 HYBRID BASE: A turntable unveiling new dimensions in sound. Call or write for details. AUDIO CONNECTION, 615 Bloomfield Ave., Verona, NJ 07044. Tel: (201) 239-1799.

DIAMOND NEEDLES and Stereo Cartridges at Discount prices for Shure, Pickering, Stanton, Empire, Grado, Audio Technica and ADC. Send for free catalog. LYLE CARTRIDGES, Dept. A, Box 69, Kensington Station, Brooklyn New York 11218. For fast service call toll free 800-221-0906. TF

BETTER LOUDSPEAKER PERFORMANCE



The VMPS Super Tower IIa/R in oiled walnut ($1199ea kit, $1699ea assembled). Available in theater black ($999ea kit, $1499ea assembled). 76x21½x17" (HxWxD) 300 lbs. Sold in mirror-image pairs.

The VMPS Super Tower IIa/R will reproduce a music signal with lower distortion, wider bandwidth, and greater dynamic range than any other production loudspeaker system regardless of cost.

With its rated THD of no more than 0.25% from 22Hz to 40kHz (1W input), the ST IIa/R offers a full order of magnitude less distortion than the best competitors, none of which even approach its high input sensitivity (101dB/1W/1m), maximum undistorted output levels (132dB/1m), power handling (500W rms), or bass response (-3dB at 17Hz). Innovative engineering features such as minimum phase response, biamp operation **without** an external crossover, a completely non-resonant, multiband bass system with integral slot-loaded 15" top-and-bottom firing subwoofers, 15" and 12" lowbass and dual 12" midbass drivers, high definition **polypropylene cone** midranges, and an extremely quick, high output ribbon supertweeter (-3dB at 50kHz) combine to provide you, the listener, with reproduction of awesome fidelity and impact.

Write for our brochures and a copy of Bert Whyte's article "Towers of Power" from the May 1980 AUDIO. Other VMPS speaker systems from $78 to $969 ea, including kit versions of the MiniTower II ($309ea), Tower II ($419ea), and Super Tower/R ($649ea). Prices include fully assembled cabinets and **free shipping** in USA. Also available: **VMPS Connections** (ultrahigh definition audiophile interconnects) from $20/pr.

VMPS AUDIO PRODUCTS
a division of Itone Audio
7301 Rockway El Cerrito CA 94530
(415) 526-7084

FOR SALE

ABSOLUTELY THE BEST VALUES IN AUDIO

NEW 3D ACOUSTICS CRESHENDO
DESIGNERS OF THE FAMOUS THREE PIECE SYSTEM
CREATE THEIR ULTIMATE SPEAKER—ONLY $750. PAIR

NEW! AMBER CONTROL CENTER
A SOLID STATE PRE-AMP TO RIVAL THE FINEST

NEW! NAD 3140/2140 COMBINATION
ALL THE VIRTUES OF THE 3020, MORE FLEXIBILITY AND A FANTASTIC AMOUNT OF POWER

THE STD TRANSCRIPTION TURNTABLE
EXCELLENT SUSPENSION RENDERING SUPERB ISOLATION, SUPER SOLID CONSTRUCTION, LINN PERFORMANCE AT HALF THE PRICE

THE CIZEK MODEL ONE
ALTHOUGH NOT A NEW SPEAKER, IT REMAINS ONE OF THE FEW SPEAKERS AT ITS PRICE RANGE TO ACCURATELY REPRODUCE MUSIC WITHOUT THE SONIC IMPURITIES SO OFTEN ADDED AT THIS PRICE RANGE. A TWO WAY WITH A UNIQUE CROSS-OVER DESIGN (FOR STABILIZING IMPEDENCE), IT HAS THE OPENESS AND DETAIL THAT WILL SATISFY MANY AUDIOPHILES AND A TIGHT EXCELLENT BASS THAT CAN ASTONISH YOU, YET DOESN'T ADD THE BOOM BOOM BASS THAT MUDDIES UP THE ENJOYMENT OF THE NATURALNESS OF MUSIC. IF YOU OR A FRIEND ARE IN THE MARKET FOR A PAIR OF SPEAKERS UNDER $500.00, THIS IS DEFINITELY ONE THAT REQUIRES AUDITIONING.

IN NEW YORK
SOUND STAGE AUDIO
184-10 HORACE HARDING EXPRESSWAY
FRESH MEADOWS, N.Y. 11365
(212)762-3220 EXIT 25, LIE SERVICE ROAD

IN TEXAS
THE AUDIO FILE
1202 SOUTH CONGRESS AVENUE
AUSTIN, TEXAS 78704
(512)443-9295
ONE BLOCK SOUTH OF RIVERSIDE

AMBER—70 MINT $389 (201)246-0944

AMBIENCE DECODER FOR REAR CHANNELS, $149.95. Literature 50c. Huntington Electronics, Box 2009-A, Huntington, Conn. 06484

FOR SALE

AFFORDABLE ESOTERICA
Central NY State
• APT • MISSION • LAST • BOSTON ACOUSTICS • • QED • HAFLER • BANG & OLUFSEN • CARTALIGN • • 3D • ACOUSTICS • NAD • PLATTER MATTER • KLIPSCH • • DCM • MONSTERCABLE • M&K • HARMAN-KARDON • • DUAL •
STELLAR STEREO
384 Elmira Rd., Ithaca, NY 14850 607-272-2644

AGFA & AMPEX 10½" & 7" OPEN REEL TAPES — THE BEST! THE FINEST CASSETTES: DIRECT TYPE II (C68 & C96) and ASF (C66 & C96). DIRECT-TO-TAPE RECORDINGS for the finest recorded sound available, called "Truly superb" by Charles Repka in AUDIO (Oct, 1980). Only available on real time duplicated reels & Cassettes, optional dolby or dbxII. Ampex video cassettes. WRITE for FREE newsletter subscription & current specials. Direct-To-Tape Recording Co., 14 Station Ave., Haddon Heights, NJ 08035.

ALAN AUDIO TAPE DECK REBUILDING. Complete, painstaking mechanical work, bias and equalization makes possible new-or-better performance, often for less than half the cost of a new machine. Lab equipped with Tek, HP, Leader, etc. Proof-of-performance on completion. Alan Audio, 310 South Washington, Bloomington, Indiana 47401. (812) 332-2192 10-7 M-Th, 10-5 F, EST.

AMAZING? ISN'T IT

The amount of nonsense that gets thrown around in the audio world. If you are sick of being treated like a 5-year-old child by shoe salemen masquerading as audio experts, you owe it to yourself to give us a call. Our opinions are based on a solid foundation of experience with the components we sell as well as those sold by our competitors. Most importantly we don't simply sell the finest audio equipment available, we arrange it in complementary systems designed to extract the greatest benefit from your audio dollars chosen from among the followng lines we represent:
ACOUSTAT, ACOUSTIC ELECTRONICS, AUDIO RESEARCH AUDIBLE ILLUSIONS, ADCOM, AUDIO INTERFACE, AUDIO CONTROL, CARVER, DENNESSEN, DCM, DECCA, DYNAVECTOR, ENTRE, FULTON, GRACE JR, LINN SONDER, LUSTRE, MARCOF, MERIDIAN, MICHAELSON AUSTIN, MONSTER CABLE, MORDAUNT-SHORT, MUSICAL FIDELITY, NAIM AUDIO, NAD, ORACLE, POWER LIGHT, POINT SOURCE, PRECISION FIDELITY, QUAD, REGA, ROGERS, SNELL ACOUSTICS, SOUNDLABS, SPATIAL COHERENCE, STRELIOFF SYSTEMS, STD, STAX, SUPEX, TANDBERG, THETA, TECHNICS, R&B
SOUND BY SINGER, LTD.
227 Lexington Avenue
New York, NY 10016
(212) 683-0925
We ship anywhere (A.E., M.C., VISA ACCEPTED)

AMPEX, MAXELL, TDK, FUJI, BASF at tremendous savings. Free catalog. Audio Unlimited, 1798 Technology Drive, San Jose, CA 95110.

AMERICAN AUDIOPHILE

WHERE THE DIFFERENCE IS MUSICAL ACCURACY AND THE GOAL IS TO SATISFY

HOME OF

AUDIO INNOVATIONS
AUDIO STANDARDS
AUDIO TECHNOLOGY
AUDIONICS
AUDIRE
B & W
CIZEK
DCM
DECCA
DENON
DUNLOP/SYSTEMDEK
DYNAVECTOR
GOLDLINE
GRACE
H.A.P.I.
IMPULSE
IVIE
JANIS
JMAS
KINDEL AUDIO
LEACH
LUSTRE
MARCOF
MARIAH
MORDAUNT-SHORT
NAD
NEXUS
P S AUDIO
PLATTER MATTER
PRECISION FIDELITY
QED
R G DYNAMICS
RGR
SHURE
SIGNET
SME
SPECTRO ACOUSTICS
SPICA
STAX
SUPEX
TANDBERG
THETA
3D ACOUSTICS
VANDERSTEEN
VPI
WIN LABORATORIES

REFERENCE AUDIOPHILE RECORDINGS

AMERICAN AUDIOPHILE
5 SUNRISE PLAZA, VALLEY STREAM, N.Y. 11581, (516) 561-7114
716 MADISON AVE, NEW YORK, NEW YORK 10021, (212) 751-9733

ALL SHIPMENTS PREPAID AND INSURED FREE THROUGHOUT CONTINENTAL U.S.

MASTER CHARGE & VISA ACCEPTED

FOR SALE

INTERFACE SPEAKER SYSTEMS BY E.V. BEST PRICES - IMMEDIATE SHIPMENT. (305) 462-1976.

IS IT THE BEST?

"A very good preamp has become an excellent one . . . now receives our best buy rating."
AUDIOGRAM, on the MKH 101 mod

" . . . outperforms units such as the Beveridge, Apt Holman, SP6-B, Spatial, teflon capped Spatial, Spectral, Theta, etc."
AUDIOGRAM on the MKH 101 SuperMod

The Musical Concepts modifications to the Hafler preamp and power amp bring you affordable musicality. Write for reviews. Dealer inquiries welcome.

MKH 101 mod kit $100 Installed $150
MKH 101 SuperMod kit $200 Installed $250
MKH 200 amp mod kit $45 Installed $95

Musical Concepts, 522 Impala Lane, Hazelwood, MO 63042. (314) 895-4984.

IVIE ELECTRONICS REAL TIME ANALYZERS, etc. Some very slightly used demonstrators at discount. Full factory warranty. Money-back guarantee. JML Company, 39,000 Highway 128, Cloverdale, CA 95425.

JANIS WOOFERS
are the best universal subwoofers available. Hear them together with the Interphase crossover amp at OXFORD AUDIO CONSULTANTS, Box 145, Oxford, OH 45056. 513-523-3333, ITT TELEX: 427791. Cable: OXAUDCON.

JBL: HARTSFIELD-PARAGON-LE8's-D131's 408-379-7965; Box 1211 Campbell CA 95009

JBL OLYMPUS AND STUDIO MONITORS Each pair of speakers contain S 8 System. BOZAK Speakers B-4000A, Classic Enc. DB Systems, DB-1, DB-2, and DB-5 with cabinets. All equipment Mint. (401) 943-4222 after 7:00 p.m. edt.

J.B.L. SPEAKER SYSTEMS AND COMPONENTS bought, sold and traded. 1-313-229-5191 or 5115 Red Fox, Brighton, MI 48116.

KEF 105'S, $1100.00/pair; McIntosh MC2105, $560.00; M&K Satellite-Volkswoofer System with stands, (demo) $650.00; Marcoff PPA-1 and PPA-1H (new), $85.00; Quad 303, $140.00; Dyna PAS-3, $120.00; Fairchild 260, $50.00; McIntosh MA-230, $275.00. Sound and Music, 90-92 King Street, Northampton, Mass. 01060. (413)584-9547.

KEITH MONKS CR500 RECORD CLEANING MACHINE Mint $700 call Andy (505) 662-9111.

KINETIC AUDIO SPEAKERS, in stock at excellent prices. Send $1.00 for the lowest prices and superior service on all Fine Audio Components. Sound Source, 11450 Overseas Highway, Marathon, Fla. 33050.

KIT BUILDERS! The Audible Illusions Mini Mite I represents a new generation of preamp kits, a return to the beloved tube sound — but without the common tube drawbacks. The Mini Mite I is the best buy in preamp kits on the market. The sound is extremely smooth, quiet, and detailed, with a sweet high end and a quick, remarkably tight bottom. The assembled version is still a bargain, but the kit is a steal. Reviewers love it. We promise you will, too. Heritage Hill Audio, 553 East Fulton, Grand Rapids, MI 49503, 616-451-3868. Visa & MasterCard accepted.

KOETSU, MIT and WIN cartridges, mint (315) 437-1209.

LEARN TO PLAY BETTER
through understanding Chords. Learn how Chords are used in creation of "musical ideas." Use proven approach to learn Chords. Take the "mystery" out of Chord use in music. For Free Information write today - MUSIC LEARNING SYSTEMS PUBLISHING - Dept. 11AM, RD3 Box 142, Olean, N.Y. 14760

LEVINSON ML7 (L3) mint $3995. LNC-2 100Hz/cards $100. (315) 437-1209.

Linn-Sondek Turntable/VPI,
Koetsu (201)746-2794

FOR SALE

LINN DISC SYSTEM ALWAYS IN STOCK! GENE RUBIN AUDIO. Pre-paid shipping. (213)571-1299.

LINN PRODUCTS, MODIFICATIONS & NAIM
We are pleased to offer the complete line of Linn Products: LP12, Asak, Ittok, PMS, DMS, SARA & KAN; the NIRVANA MODIFICATION for the LP12; and, Naim Electronics: head amp, preamps & amps. By appt. Free shipping. Visa & M.C. OXFORD AUDIO CONSULTANTS, Box 145, Oxford, OH 45056, 513-523-3333.

LINN SONDEK LP12, Mission 774 Tonearm, Cotter "L" Transformer, Sleeping Beauty Cartridge. $1,100 for all. (518) 3561688 evenings.

"LOWEST PRICES: BOSE, SAE, HAFLER, ADCOM, ADVENT, DBX, GRADO AND MORE. DYNAMIC SOUND, Box 168, STARKVILLE, MS 39759. (601) 323-0750. 1pm-9 pm."

LUXMAN MB3045 Power Amps $500.00. Kenwood L07M Power Amps $500.00. Mint 703-360-9214.

MARCOF PPA—1H (LATEST) $70 (201)246-0944

McINTOSH BOUGHT, SOLD AND TRADED. 1-313-229-5191 or 5115 Red Fox, Brighton, MI 48116.

McINTOSH C-26 Preamp $275 (503) 256-2350.

McIntosh MX-113 wal cab $650, S A E 3000 pre & 2200 pwr $500 pair, SAE 30pre & 31B pwr $275 pair SONY TC-FX6C $310, ST-J60 $240 ST-J75 $305 all new 203-777-1476

McINTOSH 5100 $350. McIntosh 1900 $650. Magnaplanar SMG (pair) $345. B&O M-70 (pair) $600. You pay shipping. 714-524-3737.

MENDOTA RESEARCH INTERCONNECTS—HHA now offers the finest audio interconnect available. Moneyback guarantee if not satisfied. Heritage Hill Audio, Grand Rapids, MI, 616-458-9202. Visa/MasterCard/COD available.

METAL FILM RESISTORS, RN55, 0.35 watt, 1% values from 10 ohms to 1 Meg, 25¢ each. 10 per value/$1.80, 50 per value/$7.50. Send stamped self addressed envelope for list of values and order form. New gold plated shielded RCA type phono plugs, $1.75 each. Minimum order $10.00. Quantity discounts available. Old Colony Parts, Box 243, Dept. A, Peterborough, NH 03458.

MIDLAND, MICHIGAN - SOUND DECISIONS (517) 631-3781 Free shipping: Audio Design • Cotter • B2 • Grafyx • HAPI II • Mirage • Nikko AIII • SOTA • Symdex • Thiel • Thorens • VPI • 3D Acoustics • '5213 Hallisy Ct 48640' Evenings & wkends.

MIRAGE IN THE SOUTH!
In stock. Free Shipping! READ BROS STEREO, 593 King Street, Charleston, S.C. 29403 (803) 723-7276.

FOR SALE

' ' ' 'MILWAUKEE! THE AUDIO EMPORIUM: Acoustat, Amber, Audio Perfection Cables, Audio Pulse, Audire, B&O, Beyer, Connoisseur, Conrad-Johnson, Dahlquist, Denon, Dynavector, Genesis, Grace, Grado, Hafler, Linn, Lux, Magnepan, Marcof, Mayware, Musical Fidelity, NAD, Peterson Links, Polk Audio, RH Labs, Revox, Rogers, Snell, Sonus, Stax, Sumo, Technics, Threshold, wide assortment of accessories and direct discs. Open Tues, Wed, Fri, Sat 10-6, Thurs 10-8. Closed Sun & Mon. 6900 W. Brown Deer Rd., 354-5082.

MINT WIN TURNTABLE $1695. like new (315) 437-1209.

FOR SALE

MICHIGAN AUDIOPHILES

Apt Holman	Grafyx	PS Audio
Adcom	Hafler	Rega
Boston Acoustics	Hitachi	Revox
Bryston	Isobarik	Snell
Conrad Johnson	Linn-Sondek	Spendor
Dahlquist	Mission	Spectrum
Dual	NAD	Stax
Grace	Nakamichi	Harmon Kardon
Grado Signature	Onkyo	Threshold
Naim Audio	Polk Audio	

ABSOLUTE SOUND

"Michigan's High Accuracy Audio Dealer"

Detroit, 12400 Morang Ave. (313) 527-2244
Royal Oak, 4354 N. Woodward (313) 549-7550
Ann Arbor, 312 S. State St. (313) 662-2026
East Lansing, 1045 East Grand River (517) 351-9300
We Ship Prepaid
VISA/M.C./AMER. EXPRESS WELCOME

MIXER made especially for tape duplication. Will produce enhanced high quality second generation tapes. KUHN ELECTRONICS, 4586 Carter Avenue, Norwood, OH 45212. TF

MOGAMI MOGAMI

Complete line of world renown high definition audio cables now available in U.S. Mogami is a world leader in the research and manufacturing of advanced audio and video cables.

TONEARM-INTERCONNECT-SPEAKER-MICROPHONE
GOLD PLATED PLUGS & CHASSIS JACKS
MOGAMI PRODUCTS DIV.
P.O. BOX 2027
CULVER CITY, CALIF. 90230 (213) 836-4288

New WIN cartridge (June '81 version) w/SPG-10 control unit and WIN ARM $1295. (315) 437-1209.

NEW ENGLAND ELECTRONICS EXCHANGE
provides a national marketplace for audiophiles buying or selling quality new and used equipment. Monthly newsletter subscribers enjoy the benefits of its nationwide distribution, equipment grading standards and the guarantee of full and prompt payment for products sold. Write or call free for a free sample newsletter or subscribe ($6.00/yr.) 617/491-3000. (7-11 PM EST/M-F) Box 82 Harvard Square, Cambridge, MA 02138.

FOR SALE

NAKAMICHI 1000 II — UNUSED, FULL WARRANTY, call for details. $995. (212) 595-7494.

NEW AND DEMO EQUIPMENT SALE

Levinson ML1	Preamp/D6 card	$1450
Levinson ML2	Power amp	1795
Levinson ML3	Power amp basic	1995
Levinson ML3	Power amp w/faceplate	2200
Levinson ML6	Preamp w/D6 card	3000
Levinson LNC2	Crossover system	1395
Stax DA80M	Mono amp	920
Stax DA80	Stereo amp	975
Dayton Wright SPA	Preamp w/MC amp	700
Michaelson & Auston TVA1	Vac Tube Power amp	1300
Michaelson & Auston TVA10	Vac Tube Power amp	650
Quad speakers	Electrostatic	1395 pr
Ivie 17A	Processor	1095

Contact Lloyd for more information Tues.-Fri. aft. 816-531-3109 1616 W. 43rd, Kansas City, MO 64111

NEW: STEP ATTENUATORS: Volume controls by Alps and Tech Labs for highest accuracy and perfect tracking. The Tech Labs has 24 position silver contacts and 1% MF resistors as a semi-kit. Rowland Research Strain Gage cartridge boards for Win Labs and Panasonic, what a difference this board makes for these cartridges. Phono preamp section boards, one with passive equalization. Electronic crossover boards with 18db/octave slope and optional 20db gain so you can bypass the hi-level section of your preamp, also a subsonic filter board. All for highest signal resolving detail. The new 8" Polypropylene cone driver that has an amazingly tight and articulate deep & midbass in our vented push-pull alignment; its 3db is 30 Hz and non-resonant. Similar alignment for the Dynaudio 8¾" driver with a -3db at 26 Hz. Dales-Jordan 50mm Modules for phase coherency and transient speed like electrostatics that do most of the work in yoru dream system. TA's Unbox semi-kit enclosures for the above drivers. JVC and Foster polymer ribbon super tweeters for detail, extended highs and "air". Crossover parts: Polypropylene and Polystyrene caps form 20pf to 10u, air core inductors with #12 and #16 wire, dealer inquiries invited. Mod kits for the Hafler amp and preamp and Dahlquist DQ-10. For more products, info, specs, charts, and graphs, send $1.50 for our catalog. The Jordan Manual is a 26 page text on sound and speaker design $2.50. TRANSCENDENTAL AUDIO, 6796 Arbutus St., Arvada CO 80004. 9-5 Mountain time 10-3 Sat. (303) 420-7356.

FOR SALE

NEW, USED and DEMO equipment for sale: Cotter NFB filter & pwr supply (used) $400; Satin M18e carts, (new) $150 ea.; Quad 303 amp (used) $250; Marcoff PPA-1 (new) $90; Luxman PD 444 w/SMEIII arm, $700 (used); GAS thoebe preamp (used) $325; Bryston 4B amp (used) $1000; Infinity Quantum Line 3 (used) $650 pr; Quad ESL spkrs. $795 pr; Luxman M4000 amp (used) $900; McIntosh C27 (used) $525; Luxman C1000 (used) $400; IMF ALS 30 (used) $550 pr. Yamaha C1 preamp (used) $1000; Yamaha A1 amp (used) $400; NAD 7080 (used) $450; JBL L65 Jubal (used) $550 pr.; Magnepan MGIIa (used) $675 pr; Van Alstine Model One $400 (used) Sony 8550 V-Fet amp (used) $280; IMF Studio III spkrs (used) $500 pr; Fried Model R spkrs (used) $375 pr; B&W DM 2-II demos, $800 pr. Audio Consultants, 1014 Davis St. Evanston, Il 60201, (312) 864-9565. All used equipment guaranteed 90 days parts and labor.

NEW, USED AND DEMO EQUIPMENT FOR SALE: Cotter NFB filter & pwr. supply (used) $400; Satin M18e carts (new) $150 ea; Quad 303 amp (used) $250; Marcoff PPA-1 (new) $90; Luxman PD 444 w/SME III $700; GAS Thoebe preamp (used) $325; Bryston 4B amp (used) $1000; Infinity Quantum Line 3 (used) $650 pr; Quad ESL spkrs, $795 pr; Luxman M4000 amp (used) $900; Luxman C1000 (used) $400: IMF ALS 30 (used) $550 pr., Yamaha C1 preamp (used) $1000; Yamaha A1 amp (used) $400; JBL L65 Jubal (used) $550 pr; Magnepan MGIIa (used) $600 pr; Van Alstine Model One (used) $400; B&W DM 801 (used) $2000 pr; Sony 8550 V-Fet amp (used) $280; IMF Studio III spkrs (used) $500 pr; Fried Model R Spkrs, (used) $375 pr; Audio Consultants, 1014 Davis St. Evanston, Il. 60201 (312) 864-9565. All used equipment guaranteed 90 days parts and labor.

NEW YORK AUDIOPHILES, AudioWorld can save you money. Not only do we offer bargain prices on audiophile equipment, we also eliminate the sales tax hassle for out-of-state customers. AudioWorld, Box 6202, Grand Rapids, MI 49506. 616-451-3868. M-F 11:00 a.m. to 6:00 p.m. EDT. Visa and MasterCard accepted.

NORTHERN CALIFORNIANS

It is our goal to make the joy of music possible for everyone. At any price we offer solid value, superior performance, and traditional service.

We operate on the theory that you as our customer will achieve the greatest long term satisfaction only through a careful analysis of your audio requirements. We strive to offer sober, highly cost effective solutions to meet your specific needs. Please stop in for a refreshing experience with music.

OUR SELECTION INCLUDES:

Magnepan	Audioics	Dahlquist
Tandberg	Threshold	Chartwell
Onkyo	Audire	B&W
JVC	Hafler	Cizek
AKG	P.S.E.	AVID
Denon	Lux	Stanton
Micro	Grado Sig.	AIWA
Connoisseur	Sonus	M&K
Soundcraftsmen	Grace	Rogers

HIGH FIDELITY SHOPPE
1511 North Main Street
Walnut Creek, Calif. 94596
(415) 932-2242
"WE BUILD BETTER SYSTEMS FOR YOU"

NORTHERN MICHIGAN—PENINSULA AUDIO

Cramoline Dynavector Grace Grado Hafler Last Mirage Monster Cable NAD Platter Matter Plexus Promethean Rega Rogers Satterberg Statibrush

By appt. VISA and MC. Prepaid shipping.
867 S. LAKESHORE DRIVE, LUDINGTON, MI 49431
(616) 845-6535, M-F 12-9, SAT 12-5

POLYSTYRENE BYPASS KIT

Use in conjunction with our DRT-1 Ribbon Tweeter kit for the Dahlquist DQ-10 or bypass your stock cross-over. The PC-1 kit includes 14 polystyrene capacitors with complete instructions for $12.95. Postage paid in U.S. Visa, M.C. or check welcome. Look for our review in AUDIO ALTERNATIVES soon.
RANDALL RESEARCH (714) 760-1539
719 Fernleaf Corona Del Mar, Ca. 92625

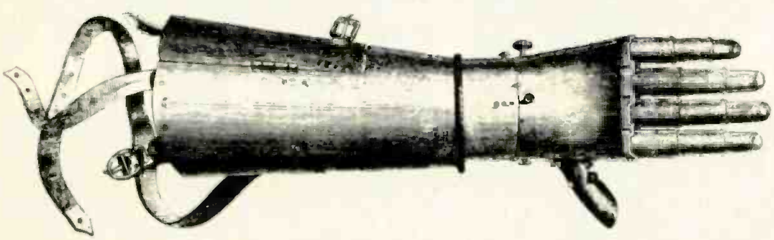
Houston and the Gulf Coast

Mark Levinson/Threshold/Linn/Apt/Holman/Hafler/Advent/Nakamichi/Denon
Magnepianar/KEF/Boston/Dahlquist/Adcom/NAD/Dennesen/Gold Line/Grace
Klipsch/Fidelity Research/DCM Time Window/Cizek/Signet/Cotter/Ivie Analyzers

AudioConcepts

2200 SW Freeway at Greenbriar Houston, Texas 77098 713/527-0774
Credit Cards Accepted Freight Prepaid in Continental USA

INTRODUCING THE LINN BASIK® TONEARM



...basic, solid engineering in the fine medieval tradition. At $149.00, it challenges the performance of arms costing three times as much. Listen for yourself at your authorized Linn Sondek dealer.

Distributed in the U.S. by Audiophile Systems, Ltd.,
6842 Hawthorn Park Dr., Indianapolis, IN 46220

FOR SALE

ELECTRONIC CROSSOVERS — From $97.00. For Bi-amp, Tri-amp, and Subwoofers. 12 or 18dB/octave. Free folder with reviews. ACE AUDIO CO., 532-5th Street, East Northport, NY 11731. (516) 757-8990.

ESOTERIC, High End, etc. A method that will allow 40% and greater off retail price. Method $10, refundable with first transaction. Audioworkshop, Box 18009, Seattle, WA. 98118

FASCINATING OLDTIME RADIO SHOW CASSETTES! Free Catalog! Sample $2.99. Heritage-A, 412 Redbud, Oxford, MS 38655

FAST, ACCURATE AUDIO NEWS AND COMMENT. Magazines are written months before you get them. Why wait? MYSTIC VALLEY AUDIO NEWS, the information service for audiophiles edited by well-known consultant Peter Mitchell, is printed BIWEEKLY and sent FIRST CLASS. Interviews with designers, how things really work, advance product news, test reports, current research, ad exposes, etc. $20/yr. $12/6mo. Mystic Valley Audio, 36 Circuit St., West Medford, MA 02155.

FIDELITY RESEARCH FR64ss arm w/B60, mint $695. (315) 437-1209.

FREE SPEAKER CATALOG!
Woofers, mids, tweeters, hardware, crossovers, grille cloth, plans, kits, information, much more. Discount Prices! UNIVERSAL SOUND, Dept. AO, 2253 Ringling Blvd., Sarasota, Fla. 33577 (813)953-5363.

FRIED SPEAKERS & KITS
State-of-the-art sound. Try our prices! Fast, free shipping. READ BROS. STEREO, 593 King St., Charleston, S.C. 29403. (803)723-7276. Also Hafler, PS Audio, NAD, Carver, more.

GENE RUBIN AUDIO — LOS ANGELES

PS AUDIO	LINN SONDEK	THIEL
NAD	LINN ITTOK	SPENDOR
HAFLER	LINN ASAK	ACOUSTAT
ADCOM	DYNAVECTOR	LS3/5A
DENNESEN	GRACE	3d ACOUSTICS
KM LABS	GRADO	CIZEK
CONNOISSEUR	REGA	PLATTER MATTER
LIVE WIRE	STATI BRUSH	V.P.I.

Pre-paid Shipping (213) 571-1299 (Pacific Time)

. . . HAFLER IN STOCK . . .
IMMEDIATE DELIVERY
We have a good supply of Hafler products in stock for immediate delivery . . . DH-101, DH-200, etc. freight pre-paid in the continental USA. We also carry Amber-Carver-Denon-Fidelity Research-Lustre-NAD-Polk-SAE. Call or write AUDIOTRONICS, 4200 Avenham Ave., Roanoke, Va. 24014 (703) 774-5757.

HAFLER DH-101 PREAMP
We expect to be in stock on this exciting new preamp by Dec. 12th. Kit price is $199.95. Custom wired and tested, $299.95. Immediate prepaid prepaid shipment shipment via UPS. THE AUDIBLE DIFFERENCE, 435 Tasso, Palo Alto, California 94301. (415) 328-1081. TF

FOR SALE

FREE 5.00 T-SHIRT

TDK: D-C60	1.35	TDK: Mar-C90	11.99
TDK: D-C90	1.69	TDK: LX35-90	5.39
TDK: AD-C60	1.79	TDK: LX35-180	16.69
TDK: AD-C90	2.39	TDK: LX35-90B	5.89
TDK: OD-C90	3.59	TDK: LX35-180B	18.59
TDK: SA-C60	2.19	TDK: GX35-90B	8.49
TDK: SA-C90	2.89	TDK: VHS: VAT-120	13.99
TDK: SAX-C90	4.49	TDK: VHS: Hi-Grade 120	21.99
TDK: MA-C90	6.39	TDK: HD-01 Cass. Head Demag	14.89

Free T-Shirt with every order over $75.00. Shipping, 3.50. We will honor any price in this book on TDK, Maxell, Scotch, BASF, and Ampex. 412-283-8621. M-F 8-4. Visa and MC. This ad good for 2 months. **Tape World,** 220 Spring Street, Butler, PA 16001. Dealers Welcome.

FRIED SPEAKER CABINET SALE!!! Reduced prices while supply lasts. (919) 945-5310.

GET INTO BROADCASTING! Learn how to receive free records, tapes, get an FCC broadcast license, start your own station. Free details. "Broadcasting", Box 130-N5, Paradise, CA 95969.

GET SOUND PRICES ON CAR STEREO SCANNERS - CB
Call or write Monday - Saturday 10-8 (312)960-1327. Visa/M.C. R.S. Engineering, 522 Sherman, Downers Grove, Ill. 60515.

GOING TO COLLEGE: Technics SL 1300 MK II — $350; Pioneer CT-F1000 — $400; SAE 1800 Parametric Equalizer $300. (907) 442-3665 after 8:00 pm PST.

GOLDMUND T-3 arm, mint, $1795. (315) 437-1209.

GOLD PLATED PHONO JACKS. Rear mount, gold plated solid brass jack, w/gold plated ground flag and hardware, $1.75 each. Will interchange with Audio Research Sp3A-1's phono jacks. Gold plated solid brass shield phono plugs, $2.00 each. Send stamped addressed envelope to flyer and order form. Minimum order $10.00. Old Colony Parts, Box 243, Dept. B, Peterborough, NH 03458.

GONZA WIRE is #12 gauge, twisted, SAFE speaker wire 45¢ per ft. TMA Record Sleeve 50 for $15, COD OK, Samples $1.00. Audio House, 4304 Brayan, Swartz Creek, Mich. 48473. 313-655-8639.

GRACE AND SUPEX
We offer the Grace 747, 707MK2 (Linn Mods for each), 704, F-9E and Supex cartridges. By appt. Free shipping. Visa & M.C. OXFORD AUDIO CONSULTANTS, Box 145, Oxford, OH 45056, 513-523-3333.

GRADO F3E+ (new) $25; G2+ (new) $125, will COD. Mark, afternoons, 616-451-3970.

GUSS 3-D SPEAKER SYSTEMS! Audiophiles who demand excellence find them overwhelming. From $3000 Installed. Telephone (212) 580-7401 or 787-1183.

FOR SALE

HAFLER DH — 200A AMPLIFIER
Mint Condition. Used under 30 hours $325. (212) 398-2466, days, (203) 637-8857 evenings.

HAFLER IN THE SOUTH!
In stock, the superb Hafler DH-101 preamp and DH200 amp. kits & factory assembled. Also new models. Immediate free shipping. Also Fried (Speakers, Kits), Carver, Vandersteen, NAD, Mirage, Audionics, PS, Klipsch, more. READ BROS STEREO, 593 King Street, Charleston, S.C. 29403 (803)723-7276.

HAFLER-NEW PRODUCTS
We are stocking the following: DH101K $199.95, DH101A $299.95, DH101AP $399.95, DH103 $19.95, DH104 $24.95, DH105 $24.95, DH110K $299.95, DH110A $399.95, DH110AP $499.95, DH112 $74.95, DH200K $329.95, DH200KE $339.95, DH200A $429.95, DH200AE $439.95, DH201 $24.95, DH202 $24.95, DH300A $449.95, DH300AE $459.95, DH500K $599.95, DH500KE $619.95, DH500A $749.95, DH500AE $769.95. By appt. Free shipping in U.S. We ship worldwide. Visa & M.C. OXFORD AUDIO CONSULTANTS, Box 145, Oxford, OH 45056, 513-523-3333. ITT TELEX: 427791. Cable: OXAUDCON.

HAFLER!! We stock the complete line of HAFLER electronics & accessories for immediate shipment. VISA & M.C. welcome. HCM AUDIO, Box 2029-G, Chico, CA 95927 (916) 343-0558

HARMAN-KARDON HIGH TECHNOLOGY SEPARATES, RECEIVERS, CASSETTE DECKS. BEST PRICES - IN STOCK - IMMEDIATE SHIPMENT. EAST: 305-462-1976 WEST: 213-243-1168.

HIGH END IN THE MIDWEST
Audible Illusion • Connoisseur • Meridian • Stax • KEF Precision Fidelity • PS Audio • Dynavector • Rega Grace Acoustat • Linn Products • Mordaunt Short Theta • Revox • Audio Innovations • Symmetry • And More
We stock one of the largest collections of Audiophile Albums in Mid-America
Try our modifications for improved high end
Bryston Mod-Any Model-**Dahlquist DQ10 Mod**
AUDIO RENAISSANCE, INC.
4122 Broadway Kansas City, MO. 64111
(816) 531-3261

HIGH MAIL ORDER PRICES?
NOT AT STEREO VILLAGE
ADC, Advent, AKAI, AR, Audiovox, Audio-Technica, Cerwin Vega, Clubman, Criag, dbx, Dual, Dahlquist, EPI, ESS, Fisher, Grado, Hitachi, Infinity, JVC, Kenwood, Koss, Klipsch, Maxell, Micro Acoustics, Mitsubishi, Nakamichi, Onkyo, Panasonic, Pioneer, Polk Audio, Sansui, Sanyo, Sony, Sharp, Shure, Sonus, Stanton, TEAC, Technics, TDK, Visonik, Yamaha and more!

HIGH MAIL ORDER PRICES?
Not at STEREO VILLAGE, 3021 Peachtree Rd. NE, Atlanta, GA 30305, (404) 233-5346.

HIGH MAIL ORDER PRICES?
Not at STEREO VILLAGE, 1067 Morrow Industrial Blvd., Morrow, GA 30260 (404) 968-0281.

HIGH MAIL ORDER PRICES?
Not at STEREO VILLAGE, 2411 Cobb Pkwy., Smyrna, GA 30080, (404) 953-1030.

HIGH MAIL ORDER PRICES?
Not at STEREO VILLAGE, 5029 Veterans Memorial Blvd., Metairie, LA 70002, (504) 455-1461.

HIGH MAIL ORDER PRICES?
Not at STEREO VILLAGE, 516 West Bank Expwy., Gretna, LA 70053, (504) 366-3238.

IDEAL ACOUSTICS
Performance verified equipment
Klipsch • McIntosh
NAD • Crown • Thorens • Signet
ADS • Nakamichi • DBX • Revox • Luxman
Open anytime by appointment.
Outstanding showrooms and service center.
110 Willow Rd. Starkville, MS 39759 (601)324-1020

INFINITY RS2.5 Speakers, $1,325; DB1 Preamp, $225; Professional Systems Eng. (PSE) Studio 11 Power Amp, $400; Nikko Alpha 2 Power Amp, $250. (413) 567-0157.

IN NEW ENGLAND...

No hyperbole — just the kind of knowledge, creativity, and dependability you expect from a dealer who represents these manufacturers.

mark levinson

ADS	Audio Pro	M.A. Cotter	Magnepan	Nakamichi	Symdex
ADS Pro	Bryston	Dahlquist	Marcof	Oracle	Vandersteen
Apt-Holman	Carver	Denon	Mirage	Pyramid	VPI
Audionics	Conrad-Johnson	DCM	M & K	Signet	Win Labs
		Dynavector	NAD	Supex	Yamaha
		Fidelity Research			
		Grace			
		Hafler			
		KEF			

5 listening rooms . . . New England's largest Audiophile record dealer . . . Keith Monks record cleaning . . . In-store service . . .
All shipments pre-paid.

TAKE 5 AUDIO

105 Whitney Ave., New Haven, CT (203) 777-1750 Master Charge, VISA, AMEX

M-W 10-6
Th. & Fri. 10-8
Sat. 10-5

FOR SALE

TANGENT LOUDSPEAKERS
We have the complete range of these value priced SOTA British Loudspeakers. Send SASE for rave reviews and prices. Woodburn Sound, 400 Highland Court, Iowa City, Iowa 52240 319-338-7547.

TAPCO and ELECTRO-VOICE, mixers, equilizers, amps, mics, and raw loudspeakers. Write for low mail order prices, Sonix Co., P.O. Box 58, Indian Head, MD 20640 8-9

THE AUDIOPHILE BEST SOUND PER DOLLAR SYSTEM
(under $2200)
Regaplanar 2 turntable
Rega Cartridge
Hafler DH-101A Preamp
NAD 4020 Tuner
Hafler DH200A or Morduant-Short Padgient II's
DCM Time Windows
SOUND BY SINGER, LTD.
227 Lexington Avenue
New York, NY 10016
(212) 683-0925
We ship anywhere (AE., M.C., VISA accepted)

THETA TUBE ELECTRONICS
Theta has just introduced an IMPROVED preamp, the 1B. It along with the OPT amp and head amp are available at OXFORD AUDIO CONSULTANTS, Box 145, Oxford, OH 45056. Free shipping in U.S. We ship WORLDWIDE. 513-523-3333, ITT TELEX: 427791. Cable: OXAUDCON.

TRANSCRIPTOR VESTIGIAL TONEARMS. FACTORY SEALED. WHILE THEY LAST $80. BUY 3 OR MORE $74 EACH. MONEY ORDER OR CERTIFIED CHECK ONLY. DEALERS CHECK ACCEPTED. FREE SHIPPING BOB WAECH. 2334 N. 59 ST. MILW. WI. 53210

ELECTRONIC X-OVERS—from $97.00. For Bi-amp, Tri-amp, and Subwoofers. 12 or 18dB/octave. Free folder with reviews. ACE AUDIO CO., 532-5th Street, East Northport, NY 11731. (516) 757-8990.

FOR SALE

THE INTERMEDIATE AUDIOPHILE SYSTEM
(Under $4,250)

Turntable:	REGA PLANAR 3
Cartridge:	DYNAVECTOR RUBY KARAT
Set-up:	MUSICAL FIDELITY
Pre-amp:	PRECISION FIDELITY C-7
Power Amp:	TRILOGY
Speakers:	SNELL TYPE 1
Tuner:	ROGERS T-75

SOUND BY SINGER
227 Lexington Avenue
New York, NY 10016
(212) 684-0925
We ship anywhere (A.E., M.C., and VISA accepted)

THE NEW TESTAMENT
Tubes are better and anyone who disagrees will be turned into a pi-lar of transistors by TUBE GOD. Our NEW TESTAMENT is a bimonthly totally devoted to tube circuitry. We reprint "Classics" of tube circuit design from long lost journals and magazines, and we interpret them for you with new schematics, with pc board layouts and kits. The NEW TESTAMENT will be a teaching book for beginners. Our blockbuster first issue, available now, features — 1. an interview with Julius Futterman, the genius behind the tube amplifier that has no output transformer, 2. a PAS mod that includes new 8 tube boards, passive eq and new regulated power supply, 3. cascode or cascade in preamps. — What are the sonic differences, — an IC regulated Bias supply for your tube amp, tube op amps, and a cascode input circuit for your tube amps and much more. Get the new tube religion for only $30 per year form TUBE GOD, 33 North Riverside Avenue, Croton-On-Hudson, N.Y. 10520, 914-271-5145.

UP-DATE YOUR DAHLQUIST
Dramatically improve your DQ-10's in regards to dynamic range, air and detail with our DRT-1 Ribbon Tweeter kit. An internally mounted modification complete with two Flat Ribbon Tweeters, two Soft Dome Tweeters, precision cross-over components and detailed instructions. $249 postage paid in U.S. Visa, M.C., check or money orders. Look for our review in AUDIO ALTERNATIVES soon.
RANDALL RESEARCH (714) 760-1539
719 Fernleaf Corona Del Mar, Ca. 92625

FOR SALE

TRADE UP to the MICRO CPU 100 fm tuner
It may have been out of the question at $2000, but the new retail is $995. Subtract even more for your trade-in and this magnificent tuner can be yours at a surprisingly low price. We offer very generous trade-in allowances on your old tuner or other audio equipment. A rare chance to own the best at a reasonable price (see Audio, Nov. '77). Write us for a quote, or better yet, phone after business hours and we can discuss your trade-in: (617) 874-0706, mon.-fri., 6-8 pm. (ask for Dick)
AUDIO CALIBRATION, box 250, Westminster, MASS 01473. TF

UNDERGROUND SOUND LABS
Glass Platter Pad - $17.00
Record Weight - $7.00
★ A.R. turntable mod kit complete with new suspension chassis makes your old A.R. state of the art. - $39.00
★ Optical turnoff for manual turntable controls T.T. and tape deck - $69.00
★ Audiophile quality speaker switch for Hafler units .2 ohms resistance $49.00
2125 CENTRAL AVE. MEMPHIS, TN 38104
(901) 272-1275

UNDERGROUND SOUND
Luxman ★ Hafler ★ Carver ★ AGI ★ Revox
Conrad Johnson ★ Kef ★ Rogers ★ Grado
Spendor ★ Sota ★ Marcoff ★ Denon
Dynavector ★ Audio Pro ★ Quad
2125 CENTRAL AVE. MEMPHIS, TN. 38104
(901) 272-1275

UP-DATE A CLASSIC
Read what DR. Laurence Greenhill has to say about our DRT-1 Ribbon Tweeter kit in the latest issue of AUDIO ALTERNATIVES July, 1981. In short, the classic Dahlquist DQ-10 loudspeaker has been reborn. Our internally mounted Ribbon Tweeter modification comes to you complete with two Flat Ribbon Tweeters, two Soft Dome Tweeters, precision cross-over components and detailed instructions for $249.00. Our PC-1 Polystyrene Bypass kit including 14 polystyrene capacitors should be used in conjunction with our DRT-1 kit or on all stock DQ-10 crossover boards. $18.95. Postage paid in U.S. Visa, M.C., check or money orders welcome.
RANDALL RESEARCH (714) 760-1539
719 Fernleaf Corona Del Mar, Ca. 92625

VACUUM TUBES, tube-peculiar parts. All kits/parts for circuitries described in our 230+ page Modification Manual. Write for list to AUDIO DIMENSIONS, 8888 Clairemont Mesa Blvd., San Diego, CA 92123. (714) 278-3310. 9-0

WIN TURNTABLE, used mint $1295. (315) 437-1209.

If you love tube amplifiers try to imagine the best of their qualities only magnified. The Futterman Autograph Series of amplifiers are the only tube amplifiers in the world that use no output transformers. All output transformers have problems with inductance, transient response, poor low and high frequency response and ringing. The Futterman amplifiers are able to achieve maximum lucidity because they are not subject to the limitation of output transformers. Rated at 125 Watts at 16 Ohms the OTL-3's are $1400 per pair at fine stores. Send $2.00 for a series of technical papers describing these amplifiers to:

New York Audio Laboratories, Inc.
33 North Riverside Avenue, Croton on Hudson, New York 10520
(914) 271-5145

Music Lives Here

Ears Nova presents high quality music reproduction equipment in an environment which is relaxed and comfortable. With care and integrity we will help build a playback system in your home that is uniquely satisfying.

BANG & OLUFSEN · BEDINI · BRYSTON · CONRAD-JOHNSON · DAVID BERNING · DENNESEN · GRACE · KEF · LINN DISC PLAYBACK *(turntable—tonearm—cartridge)* · LINN ISOBARIK · MISSION · MITCHELL COTTER · NAD · NAIM AUDIO · PSE · QUAD · REGA PLANAR · ROGERS · SHAHINIAN · OBELISK · SNELL · SUPEX · THIEL · VPI

ears NOVA
749 Middle Neck Road, Great Neck New York 11024 (516) 466-5674
Shipping free in Continental U.S.

A UNIQUE AUDIO STORE
Goodwin's is unique among audio dealers, offering a few products which are acknowledged to be the best values or simply the best available. These components are properly set-up and may be auditioned in a comfortable, relaxed living room environment. Our reference is the Mark Levinson HQD system and the ML-5 (Studer A-80) with 30 ips master tapes. We operate by appointment to ensure a meaningful demonstration under nearly ideal conditions.

Goodwin's sales & service for: The reference Mark Levinson ML-1 & ML-6 preamps; ML-2 mono & ML-3 stereo power amps. The best sound/dollar Bryston 2B, 3B & 4B power amps.

The Linn Sondek LP-12 and the best value Rega Planar 3 turntables. The Goldmund straight-line tracking tone arm – our reference.

We also recommend: Symdex, Quad, Scheiber 360° decoder, Win Labs, Linn Ittok arm, Mitchell Cotter, FR, Sequerra, & Vandersteen.

If you would like to avoid the planned obsolescence of most stereo components and are interested in the finest music reproduction, please call Goodwin's for an appointment.
Goodwin's Inc. 33 Newbury St.
(617) 266-0608 Boston, MA 02116
Canadian export specialists

FOR SALE

ORACLE TABLE, Ex Cond., $675 or B/O. Steve (704) 483-9679.

PERFECTIONIST PRODUCTS. TA-3A tonearm: proper geometry throughout, 2.5 grams effective mass, $249.00. B & O 4002 Tonearm Modification (kit or factory) allows use with cartridges having standard .5" mounting, $199.00. Stainless steel ($2.50) and nylon ($1.00) cartridge mounting hardware. Tonearm Alignment Protractor, $3.00. Ivie Electronics test equipment (new or demonstrators). Veritone™ Interconnection Cable: .03 ohms, 11 pico-farads, and $4.00 per foot (any length) attached connectors (male or female): gold plated, heavy duty RCA, $2.50 each; Lemo or Posi-Lock, $10.00 each. Money-back guarantee on above. Audiophile records (Sheffield, Crystal Clear, Mobile Fidelity, etc.), and components (Hafler, Marcof, Audionics, etc.), list price. Shipping included. JML Company, 39,000 Highway 128, Cloverdale, California 95425.

PHASE 4000 $275, Thoebe $300, Sony NR335 $200. (414) 458-9559.

PHILIPS AND AUDAX LOUDSPEAKERS in stock at good prices with competent service. MADISOUND SPEAKER COMPONENTS, 431 W. Gorham, Box 4283, Wisconsin 53711 (608) 256-7337.

PROPER TONEARM GEOMETRY!! Optimum offset angle, overhang, vertical pivot height and angle. Resonance damping construction. Jewelled pivots. Height adjustable while playing records. Effective mass 2.5 grams. Damped cueing. Anti-skate bias. TA-3A with silicone damping, $249.00, "Universal" nylon hardware, $1.00; alignment protractor, $3.00. Prices include postage and money-back guarantee. JML Company, 39,000 Highway 128, Cloverdale, CA 95425 TF

PS................................. AUDIOPHILES: Western Michigan has a new audio salon featuring these fine lines—Amber, Audible Illusions, Dimensional Acoustics, Dynavector, Grado, Mirage, PS Audio, Rega, RG Dynamics, Spica, and more. Also, see the finest in audio furniture from Apres Audio. Write or call for more information or to audition our equipment. Heritage Hill Audio, 553 East Fulton, Grand Rapids, MI 49503, 616-458-9202.

PS AUDIO = SUPERB VALUE
Gene Rubin Audio (213) 571-1299 (PAC)

QUICKEST AIRMAIL DIRECT FROM TOKYO: All brands of Cartridges & Arms of Japan. Ask for latest Quotations with $1 for postage. JAPAN AUDIO TRADING CO., LTD., Saikaen Bldg., 4-33-21, Kamimeguro,Meguro-Ku,Tokyo 153 Japan.

QUICKEST AIRMAIL SERVICE DIRECT FROM TOKYO. All Japanese Cartridges, Arms, Headphones, Microphones, Tweeters and Turntable Accessories. Ask for Pricelists with $1 for postage. JAPAN AUDIO TRADING CO., LTD. Saikaen Bldg. 4-33-21 Kamimeguro, Meguro-Ku, Tokyo 153

RAW SPEAKERS, ACCESSORIES. Send 18¢ stamp. Meniscus Systems, 3275 Gladiola S.W. Wyo., MI. 49509

REGAL REGA RESEARCH
We are please to offer the complete line of Rega tables: Planar 2 & Planar 3 armed or armless. By appt. Free shipping. Visa & M.C. OXFORD AUDIO CONSULTANTS, Box 145, Oxford, OH 45056, 513-523-3333.

REGA PLANAR TURNTABLES IN STOCK! Pre-paid shipping. GENE RUBIN AUDIO (213)571-1299. (Pac.)

REVOX A-700-QUARTER TRACK, virtually unused $2500. R. Haun, P.O. Box 3691, Eugene, OR 97403.

RGR TOP RATED MODEL FOUR PREAMP at AUDIO CONNECTION, Verona, NJ (201) 239-1799.

HARMAN-KARDON HIGH TECHNOLOGY SEPARATES, RECEIVERS, CASSETTE DECKS. BEST PRICES - IN STOCK - IMMEDIATE SHIPMENT. EAST: 305-462-1976 WEST: 213-243-1168.

ROGERS LS3/5a, SATTERBERG, KENWOOD PRO, ADCOM, AUDIRE, CLARKE, Grace, Grado, Marcof, Micro Seiki, PSE, Thorens, LiveWire, HK, more ... EXCEPTIONAL AUDIO (213) 961-6158 evenings, weekends PST. WE SHIP FREE!! P.O. BOX 658, W. Covina, CA 91790

FOR SALE

ROGERS-NEW SPEAKER & CHARTWELL
The Rogers Studio One is a significant addition to the line of superb Rogers products. All of the Rogers speakers, electronics and Chartwell speakers are available at OXFORD AUDIO CONSULTANTS, Box 145, Oxford, OH 45056, 513-523-3333. Free shipping. Visa & M.C.

SIEMENS, TELEFUNKEN, GENALEX AND AMPEREX and other top quality audio tubes available at very competitive prices. Contact Jim Wallace at 1203 Success St., Pittsburg, PA 15212 or (412) 322-4706TF

SILVER AUDIO CABLES - hi quality, fine stranded silver coated copper conductors w/teflon dielectric and outer jacket. High conductance and propagation velocity. Low capacitance. Stereo pair w/gold plate RCA plugs w/relief springs: ½ meter=$20, 1m=$25, 2m=$40. Custom Lengths and connectors avail. Add $1.00 per order shipping. Texas residents add 5% sales tax. New offerings include a superior speaker cable - 13 ga. silver coated copper w/2 silver shields; ½" glass turntable "mat", remote switching acc., etc. Send SASE for complete product offerings. STEPHEN WORSHAM LABS, 3720 Maplewood Dr., Dallas, Tx 75205. (214) 528-8343

SNELL ACOUSTICS NOW AT DESIGNATION
For the smoothest octave-to-octave performance of any dynamic speakers—its Snell Acoustics. Come hear the affordable new Type I. It eliminates floor boundaries from your music. Come audition the newest version of the famous Type A. It's beautiful to hear and beautiful to see. For information and quotation: DESIGNATRONS STEREO STORES, INC., 260 Old Country Road, Hicksville, NY 11801. (516) 822-5782.

SPEAKER BIBLE
Buying those high quality drivers and putting them into boxes will never give you SOTA performance. It is an electrical and accoustical impossibility and we will prove it in our SPEAKER BIBLE. The SPEAKER BIBLE is dedicated to teaching you how to build non-diffractive, time aligned enclosures. We will show you how to build tubular midrange enclosures with special "decoupling" mounting technique. We also supply ported, infinite baffle and transmission line woofer enclosure, a horn loaded subwoofer, a modified Technics ribbon tweeter that rivals the T-1 and a special DQ-10 kit complete with new drivers and time alignment. To beat what is commercially available, learn the proper engineering of enclosures from the SPEAKER BIBLE. Send $2.00 to New York Audio Labs., Inc., 33 North Riverside Avenue, Croton-On-Hudson, N.Y. 10520, 914-271-5145

FOR SALE

SPENDOR-NEW SPEAKERS
In addition to the renowned SA1, BC1 and BC3, we offer TWO NEW Spendor speakers, the SA2 and SA3. By appt. Free shipping. Visa & M.C. OXFORD AUDIO CONSULTANTS, Box 145, Oxford, OH 45056, 513-523-3333.

STEREO REPRESENTATIVES NEEDED!!!LOWEST POSSIBLE PRICES!!! OVER 100 BRANDS!!! KRASCO Rep-AO, 998 Orange Ave., West Haven, CT 06516.

SUFFERING FROM FEEDBACK DISTORTION?
Why pay over $200.00 for some turntable isolation platforms when we offer the reasonable alternative. The TIP-I Isolation platform, attractively finished in oak, uses the properties of high mass-loading and sound absorption to effectively fight feedback. The TIP-1, in kit form, costs just $49.95 (plus shipping) and $10.00 in easily obtainable materials you provide. Send check or money order for $49.95 to: SEA Industries, PO Box 2045, Hawthorne, CA 90250 (CA residents add 6%). Pls allow 6-8 wks for delivery.

TANGENT ACOUSTICS U.K. Ltd. The designer of the fabulous RS-2 has returned. United States distributors for Tangent speakers are:
LANDES AUDIO INC.
327 Main Street
Orange, N.J. 07050
(201) 674-4000

TAPE HEAD REFINISHING - Precision method full frequency response. $15.00 ea. One day service. E. Maher, 5 Evans Place, Orinda, CA 94563.

THE DAVID BERNING INCREDIBLE TF 10 pre-amp and EA-230 amp in stock. THE MOUNTAIN EAR, Box 774, Aspen, CO 81612. 303/963-3269

THE AUDIOGRAM an irregular newsletter by serious music listeners by-passes the trivial and establishes the best for sure value. Issue #16 includes:
the best preamp (surprise)
the best tube amp
the best headamp
the best MM
the best MC and transformer (surprise)
the best small speaker
USA and Canada $12.00 (4issues); 1st class
Foreign rates $17.00 (4 issues); airmail
Audiogram, Box 27406, St. Louis, MO. 63141

SOUTH CAROLINA'S ONLY HIGH-END STORE the finest audiophile equipment: British American Sound, P.O. Box 1247 186 King Street, Charleston, SC 29402 TF

Please refer to the absolute sound® Vol. 5 No. 20 (December 1980) for a review of this significant loudspeaker.

Inception Audio Ltd.,
21 Progress Avenue,
Scarborough, Ontario,
Canada, M1P 4S8
Tel. (416) 298-3434

mirage SM-1

TAPE AND TAPE RECORDERS

LIFETIME GUARANTEED CASSETTES — Studio mastering quality, back-coated cassettes in precision five screw cases. For a sample C-60 send $2.00 to J&M Recording Service, P.O. Box 3172, San Bernardino, Ca. 92404 (714) 884-8489

NAME-BRAND RECORDING TAPE, custom loaded. Available in cassettes, reels, cartridges. Huge savings from manufacturer. Also low everyday prices on Maxell, TDK, Ampex, Scotch, BASF, etc. SASE new catalogue. MJS, 2514 Seaboard Ave., San Jose, CA 95131. (408) 262-8793.

OPEN REEL TAPE — Mostly Ampex, used once (unboxed) 7" 1800' or 2400' — 50 Reels for $60.00 (Postpaid) 3600' 10½" Reels $2.00 each. Sample reel $1.50 AUDIO TAPES BOX 9584-Z ALEXANDRIA VA 22304

PRIVATE COLLECTOR, Operas, Musicals. Contact for exchanges, deals, Paul, Box 2114B, Hull, Canada J8X 324.

RADIO PROGRAMS

CATALOGS. Broadcasts, soundtracks. Personalities of Thirties, Forties. Box 225, New York, N.Y. 10028. TF

RADIO SHOWS ON TAPE. Huge catalog $3.00. Nostalgia, Box 82—A, Redmond, WA. 98052.

YESTERDAYS RADIO ON TAPE. Reels-Cassettes. Quality Sound. Reliable Service. Giant catalog $1.00 refundable with first order. ADVENTURES, Box 4822-A, Inglewood, California 90302. TF

RENT RADIO SHOWS: Make your own copies or just listen. Great way to build your collection reasonably. Catalog $1 refundable. OTR Rental, Box 1146, Livermore, Ca. 94550 TF

1930-1962 RADIO PROGRAMS. Beats Television!! Tapes $1.00 Hour! Established esteemed dealer. Informative 200 page catalog, $1.25. AM Treasures, Box 192 AU, Babylon, NY 11702.

PLANS & KITS

TAPE-SLIDE SYNCHRONIZER, multiprojector lap-dissolve plans, $5.50. With mixer, compressor, preamp schematics, $8.50. The Millers, 1896 Maywood, S. Euclid, OH 44121. TF

PUBLICATIONS

TERRIFIC SWAP OFFERS NATIONWIDE
Rcvrs., amps, TTs, Audio, Ham Gear, Etc. 5 issues $2! "Electronic Trader," Box 73-A, Folly Beach, SC 29439. T.F.

RECORDING

AUDIOPHILE RECORDS AND CASSETTES: Direct to disc, digital, half-speed, and Japanese imports. SUPER SOUND RECORD SERVICE, 312-486-6667, P.O. Box 82A Forest Park, IL 60130

DIRECT TO DISC AND DIGITAL RECORDINGS: All labels at low prices. Telearc, Discwasher, Audio-Technica, Sheffield, Denon PCM, Crystal Clear, Mobile Fidelity Labs. . .WE HAVE THEM ALL!! (and more!!) Send for FREE price list and Newsletter or $2.00 for descriptive catalogue DISConnection, P.O. Box 10705 Tampa FL 33679.

FREE SOUNDTRACKS & CASTS CATALOG! Personalities! ST/OC Valuebook: $4. RTSA 711 W. 17th G-1 Costa Mesa, CA 92627. TF

PROTECT YOUR LPs. POLY SLEEVES FOR JACKET 12¢, ROUND BOTTOM INNER SLEEVES 10¢, SQUARE BOTTOMS 6¢, POLY LINED PAPER SLEEVES 15¢, white jackets 35¢, POSTAGE $2.00. HOUSE OF RECORDS, HILLBURN, NEW YORK, 10931. TF

"**RECORD JACKETS.** Replace old, torn, LP jackets with clean, glossy, pure white or black jackets. Plastic lined inner sleeves, 78 sleeves, opera boxes. Free catalog. CABCO A6, Box 8212, Columbus, Ohio 43201." TF

THOUSANDS OF LIKE NEW LP's and prerecorded tapes. Catalogue—$2.50. House of Records, Hillburn, New York 10931. TF

TAPE RECORDINGS

ON OPEN REEL from master tapes. Philips, Argo, Telefunken, Vanguard, Unicorn. Catalogue $1.00. Barclay-Crocker, Room 1470-A, 11 Broadway, NYC, 10004. TF

BUSINESS OPPORTUNITIES

CABLE FM BROADCAST STATION. Unique no investment/experience business makes money! Others work for you! Free Details "CAFM," Box 130-N3, Paradise, CA 95969

CAMPUS REPRESENTATIVES, High Performance Loudspeakers and Electronics. Audioworkshop, Box 18009 Seattle, WA. 98118 (206) 323-4987 after 5PM.

Want money? Hate hard work? Lazy way to big money. Cleaver plan $2.00 (Refundable) Noble, Box 10033, Houston, TX. 77206.

SERVICES

CUSTOM RECORDING SERVICE, Tapes, discs, and cassettes. Stereo and mono. Live and copies. Editing. Masters and pressings. High quality at reasonable rates. Joseph Giovanelli, Audio-Tech Laboratories, 2819 Newkirk Ave., Brooklyn, N.Y. IN9-7134 TF

NASHVILLE RECORD PRODUCTIONS WILL PRESS HIGH QUALITY PURE VINYL RECORDS FROM YOUR TAPES. SEND FOR SAMPLE RECORD AND PRICE LIST. ALSO FINEST DISC MASTERING. 469 CHESTNUT ST., NASHVILLE TENNESSEE 37203 TF

HOW TO ANSWER BOX NUMBER ADS
When replying to an Audio Box Number Ad, please use this address Box No. — c/o Audio, 1515 Broadway, New York, N.Y. 10036

FOR SALE

WANTED: Marantz and McIntosh tube equipment. Western Electric and RCA products. Tony Thomas 3303 E. Denny Way Seattle, WA. 98122 (206) 323-4987

WISCONSIN HAS: Audionics, Acoustat, Denon, Hafler, Audio Control, NAD, Polk, Grafyx, Adcom, Stax, Grado, Luxman, Dahlquist, Micro-Seiki, Grace, and Aiwa. We invite specific inquiries. The Sound Seller, 1706 Main Street, Marinette, WI. 54143. (715) 735-9002.

WOOFERS-MIDS-TWEETERS-CROSSOVERS AT TREMENDOUS SAVINGS. EV, BECKER, SEAS, POLYDAX, PEERLESS, PHILLIPS, EMILAR, GAI AND MANY OTHERS IN STOCK FOR IMMEDIATE DELIVERY. SPEAKERS FOR HI-FI, CUSTOM AUTO, REPAIRS, PRO-SOUND AND MUSICIANS. LARGEST SELECTION OF PARTS AND ACCESSORIES IN THE U.S. FOR SPEAKER BUILDERS AND HOBBYISTS. SEND $2.00 FOR THE ALL NEW '81 CATALOG (REFUUNDABLE WITH FIRST PURCHASE) TO SRC AUDIO DEPT AD3, 3238 TOWERWOOD DR., DALLAS, TX 75234.

THE $ENSIBLE SOUND — ISSUE (LUCKY)#13 First loudspeaker reviews anywhere of: Fourier 1, Rogers Studio One, Harbeth HL-III, Fulton 80B, 3D8, Mitsubishi MS-10, Celestion 130, Polk RTA-12B, Vandersteen 2B, AR-48s, Black Shadow, Thiel 03a, Kindel Phantom, B&W DM14, Cosmos Omnistatic, Quad ESL-63, Infinity IRS-III, Fried A/2, Sound Lab R1+2, IRS, Acoustat II & III, KEF 105.2, Mission 770 plus more. Also, a complete roundup of virtually EVERY turntable on the market. If you don't read us you are probably paying too much or being conned, or both. Join us — $18/4 issues, $35/8; back issues available . . . 403 Darwin, Snyder, NY 14226

THIEL LOUDSPEAKERS IN STOCK! Prepaid ship. Gene Rubin Audio (213) 571-1299 (PAC)

THORENS TURNTABLES — BEST PRICES — IN STOCK — IMMEDIATE SHIPPING.
EAST: 305-462-1976 WEST: 213-243-1168.

THE BOSTON AUDIO SOCIETY INVITES YOU to join and receive the monthly B.A.S. SPEAKER with reviews, debates, scientific analyses, summaries of lectures by major engineers. The BAS was the first to publish info on TIM, effects of capacitors, tonearm damping, tuner IM dist., Holman's and Carver's designs, etc. Sample issue $1, sub. $12/yr. P.O. Box 7, Boston, MA 02215.

christopher hansen ltd
apart by design

MARK LEVINSON
QUAD • GOLDMUND
KOETSU • ORACLE
THRESHOLD • KEF
LINN • TANDBERG
BEVERIDGE • NAD
MAGNEPAN • REGA
BRYSTON • ROGERS
PYRAMID • FR
HARMON KARDON

213/858-8112
MC • VISA • AE

serving an international clientele which demands the finest in product and service.

integrating music systems of unparalleled performance with the finest architecture and interior designs, is our particular specialty.

six forty-six north robertson blvd.
los angeles, california 90069

FOR SALE

TOP -RATED CARTRIDGES UP TO 70% OFF!! We offer just about all of the finest phono cartridges on the market at the lowest possible prices. Our selection includes several brands that are typically sold at the full retail price. Call or write to us for prices on ACUTEX, ADC, DYNAVECTOR, GRADO, NAGATRON, ORTOFON, SHURE, SONUS, STANTON and more. Just call (212) 254-3125 or write to: DIRECT DISCOUNTS LTD., P.O., BOX 841, COOPER STATION, NY 10276. We accept M/C and VISA and will ship COD if requested.

VANDERSTEEN IN THE SOUTH!
In stock, the superb new Mod. 2B. Fast, free shipping.
READ BROS. STEREO
593 King St., Charleston, SC 29403 (803)723-7276
VISA & M/C OK. Carver. Hafler. PS. Mirage.

THE BIG "10" SYSTEM (Under $10,000)

TURNTABLE:	Oracle or Linn Sondek
TONEARM:	Linnitok
CARTRIDGE:	Linn-Asak
SET-UP:	Audio Interface
PRE-AMP:	Audio-Research SP6-B
POWER AMP:	Audio-Research D-120
SPEAKERS:	Snell Type A's or Acoustat Monitor III's
TUNER:	Rogers T-75
TAPE DECK:	Tandberg TD-20A

SOUND BY SINGER
227 Lexington Avenue
New York, NY 10016
(212) 683-0925
We ship anywhere (M.C., A.E., and VISA accepted.)

THETA PREAMP WITH THETA HEADAMP $950, Oracle turntable with Ittok arm, Asak cartridge $1100. All prices firm 609-795-1507 eve.

THE BEST OF RAMPAL: WORKS BY GLUCK, VIVALDI, BEETHOVEN & DEBUSSY. Digital LP/Cassette $7.98. Specify. Free catalog: Musical Concepts, Box 53AA9, Cedarhurst, N.Y. 11516.

MONTANA'S BIG SKY COUNTRY
Own the finest stereo-audio store in the middle of Montana's great outdoors. In college town, 90 miles North of Yellowstone National Park. Contact Don Vaniman,
THE OLD WEST COMPANY
P.O. Box 669
Bozeman, Montana, 59715.
Office 406-587-0792 Home 406-586-6770

AUDIO ALTERNATIVES

ISSUE FOUR
AUG, 1981

HAFLER	*THRESHOLD*
SNELL	*LINN*
GARROTT	*LUSTRE*
KOETSU	*BRYSTON*
SUMO	*DENON*
LEVINSON	*BEDINI*
PYRAMID	*D&K*
ACOUSTAT	*PETROFF*

ACOUSTIC ELECTRONICS
MUSIC REFERENCE
MONSTER CABLE
RANDALL RESEARCH
. . . AND MORE

SPECIAL ARTICLE: *The elusive visitor: AC Line phenomena & audio reproduction.*

PLUS: *The 1981 C.E.S. & lots more SEM!*

WE SHOW YOU THINGS NO ONE ELSE CAN

$18 USA/3rd Class
$22 USA & Canada/1st Class
$36 Overseas

P.O. Box 466
Midlothian, Va. 23113
(804) 744-2453

Audio by Caruso

• ACOUSTAT • AGI • ARGENT • AUDIO PRO • AUDIRE • BOWERS & WILKINS • CM LABS • CONRAD-JOHNSON • COUNTERPOINT • THE DAVID BERNING CO. • DAYTON WRIGHT • DECCA • DENNESEN • DYNAVECTOR • ELECTRO RESEARCH • FRIED • GRACE • HEYBROOK • KEITH MONKS • KENWOOD AUDIO PURIST • LAST • LEACH • LUSTRE • J.A. MICHELL • MARCOF • NAD • PETERSON AUDIO • POLK AUDIO • PS AUDIO • RGR • R.H. LABS • SHAHINIAN • SOTA • SPICA • STRAIGHT WIRE • SUMIKO (The Arm) • SUPEX • THIEL • THRESHOLD • VPI • WIN LABS

13831 South Dixie Highway, Miami, Florida 33176 (305) 253-4433
Write for literature on specific items.

• SUMO ELECTRIC	• SPATIAL	• DRACO CPU FM TUNER
• TECHNICS R&B	• KOETSU	• HAFLER
• STAX	• DYNAVECTOR	• JR
• B&W	• MUSICAL FIDELITY	• LINN SONDEK
• KEITH MONKS	• THETA	• SUPEX
• LOCI TONE ARM	• NAKAMICHI	• VPI
• AUDIO PULSE	• YAMAHA	• FULTON
• THE DAVID BERNING CO.	• TANDBERG	• PS AUDIO
• MONSTER CABLE	• JANIS	• GRACE
• J.V.C. LABORATORY	• GRADO	• PYRAMID
• S.M.E.	• POLK AUDIO	• APRES AUDIO
• KEF	• LUSTRE	• GOLDMUND TONE ARM
• HILL PLASMATRONICS	• SPICA	• DENON
• SNELL ACOUSTICS	• PSE	• COLONEY AB-1 TURNTABLE
• QUAD ESL SPEAKERS	• MARCOF	• MUSIC REF. RM-4
• PRECISION FIDELITY	• DAHLQUIST	• PROMETHEAN

the listening room

590 Central Park Avenue, Scarsdale, N.Y. 10583
Mon., Thurs., 10-9 P.M. Tues., Wed., Fri., 10-7 P.M./ Sat., 10-6 P.M.
Ample Free Parking • Credit Cards Accepted
We Ship FREE Anywhere in the Continental U.S.A.

914-472-4558

WANTED TO BUY OR TRADE

ATTENTION TUBES WANTED: McIntosh, Marantz, Arc, Western Electric products. Top price. Maury Corb 713-728-4343, 11122 Atwell, Houston Texas 77096

BASE FOR THORENS TD 124. G Arndt, 2162 Grand Oaks, Altadena CA 91001

BUY MCINTOSH AND MARANTZ TUBE EQUIPMENT. Leland 713-995-1856.

I'LL BUY OR TRADE tube gear by McIntosh, Marantz, Western Electric, and Audio Research. Top dollar paid! (215)324-4457

JBL-150-4C, Minigons, Hartsfield, Olympus Wood Grills, Blue Prints, & Misc. Call Collect 1-313-229-7378 pm est.

MARANTZ MODELS 2, 3, 6, 7, 8, 9 & 10B; McINTOSH C-22, MC240, MC275 & MC3500. Sam Aberst, P.O. Box 5455, Beverly Hills, CA 90210 (213) 552-6985.

MARANTZ 7 & 9; McIntosh C-22, MC-240, MC-275 & MC 3500. PAY THE BEST PRICE: (213) 278-3430; 8633 Airdrome St., LA, CA 90035.

McINTOSH OR MARANTZ (any model) TUBE TYPE tuners, pre-amps, power amps, and WESTERN ELECTRIC amps, drivers, horns, speakers. PAY CASH. David Yo, 213-576-2642 P.O. Box 832, Monterey Park, CA 91754

WANTED TO BUY OR TRADE

WANTED: MARANTZ AND McINTOSH TUBE EQUIPMENT. Western Electric and RCA Products. Tony Thomas, 3303 E. Denny Way, Seattle, WA. 98122. (206) 323-4987.

PAY CASH FOR MCINTOSH C-22, MC-275, 240 ETC. MARANTZ 2,7,9 etc. ALSO WESTERN ELECTRIC PRODUCTS 213-576-2642. David Yo, P.O. Box 832, MP., CA.91754.

USED AUDIO:
QUAD of England, McINTOSH, AUDIO RESEARCH, DYNACO, LEVINSON, MARANTZ tubes, JBL, WESTERN ELECTRIC, ElectroVoice PATRICIAN 600 and most other esoteric separates, mc. carts, tonearms, tuners, amps. NO MASS MERCHANDISE, please. Call collect (617) 969-2727 or write: Bob Heenan, Box 782, Brookline Village, MA 02147. Also soon starting audio museum for USA audio from 1930's to date. Interested consignors with FISHER, SCOTT, PILOT, RCA et al. and suggestions please contact. (617) 969-2727

WANT! JENSEN CN — 100 3-Way Speaker. Marino 9 Grant Ave, Mohegan Lke, NY 10547 (212) 528-4930

Accurate Audio

Presents the **LUNA-TEC.** Custom made, rounded oak cabinets for NAD Components (3020, 4020A, 7020, 3140, 6040, 6140). $55 each includes shipping in Continental U.S.A.

A.A.
P.O. Box 6231
Laguna Niguel,
CA 92677

Audio's Classified Ads Are Your Best Marketplace For Used Equipment!

Bob Heenan goes public and opens America's foremost audio facility. Outstanding selection of used high end audio and tube classics. All unconditionally guaranteed and priced fairly. Grand opening fall, 1981 with below cost specials, free Boston Symphony tickets and more. Send for free catalog and price listings.

USED EQUIPMENT

BUY — SELL — TRADE — RENTALS — CONSIGN — LEASE — BROKER

Q-AUDIO

95 VASSAR STREET
CAMBRIDGE, MASSACHUSETTS 02139 USA
617-547-2727 617-969-2727

Sales and shipping worldwide

VISA AMEX M/C

AD INDEX

BERT WHYTE

Much to the discomfiture of many audio people, the SCES has become a video showcase of really astounding proportions. Three years ago at the SCES video was so low key, it was almost nonexistent. Now video equipment is proliferating so fast that before long, even mammoth McCormick Place may be hard pressed to accommodate all of it.

Yet in spite of the flood of all this video gear, the main action at this 1981 SCES was in the area of video software. Such wheeling and dealing! Such hustling! Such surprising defections and pairings of odd bedfellows! We all know that the competing videodisc systems are incompatible with each other, and we all are aware of the various software alliances that have been made with the three videodisc companies. Now it would appear that the loyalty of software companies to the videodisc systems with which they originally signed agreements is shortlived. For example, the MagnaVision and Pioneer LaserDisc people had a software deal with MCA, the RCA CED disc folk had deals with Paramount Pictures, MGM, Columbia and others. The JVC VHD system to some extent brought up the rear with a tie-in with Thorp-EMI. At the SCES we learn that, of all things, MCA has agreed to make its huge catalog of movies available to the VHD camp. Next, Paramount decides they will work with the LaserVision people. Then Magnetic Video, which is a subsidiary of 20th Century Fox, also agrees to a deal for an initial 40 movies with the LaserDisc companies. Next thing you know, United Artists is signing a deal for movies with the VHD folks. CBS, which is building a big pressing plant for the RCA CED discs, says they could add VHD pressing facilities at a later date. All of this is raising havoc among the videodisc companies. Just when one of them thought they had an edge on their competitors because of superior software deals, these new deals and alliances have put them "out of joint." Offhand, the one who seems to have been the chief beneficiary of all this maneuvering is JVC's VHD system. With no product due on the market until the fall of 1982, and a weak software position, they were not in a very good situation previously. Now with their new software acquisitions, more companies are opting for the VHD system. I have no doubt there will be more crossing of lines in the future, and the fur will continue to fly!

As I point out in this month's "Behind The Scenes" column, the huge Matsushita Technology Today exhibit was heavily oriented towards video with some fascinating high-technology equipment on display and demonstration. Imagine a projection TV system with an 8½ by 11¼ *foot* screen? The system uses a newly developed 13-inch CRT, which provides very high brightness levels. Three 13-inch monochromatic CRTs (red, blue and green) have new electron guns with a large main focus lens and a new type of prefocusing lens. The system projects images through a magnifying lens onto a flat plastic screen, and the system can be adapted for either rear or front projection. The CRT unit is contained in a floor- or ceiling-mounted box. Depending on image size, throw distance can be as little as 3.8 yards. The system provides high resolution and a high light output of over 300 lumens. A big advantage is that the screen can be viewed from as wide an angle as normal motion pictures. The uses of such a huge screen in such areas as medical education are obvious, and the system is expected to be introduced in the United States in late 1982.

One of the most fascinating glimpses of the future was Matsushita's SHF (Super High Frequency) DBS (Direct Broadcasting Satellite) system with new high-definition television camera and receiver. The SHF DSB system operates way up in the 3-GHz to 30-GHz band. When combined with the high-definition TV system, we are talking about a TV picture with 1125 scanning lines, instead of our present NTSC 525 scanning lines. The picture quality is better than 35-mm film. You have to see it to believe it. Matsushita showed an early high-definition TV system some years ago, and the picture resolution was superb. This updated version is even better. Among the factors accounting for the extremely high picture quality are a new low-noise SHF-to-r.f. converter, an easy-to-install dish antenna, the 1125-scanning line color TV camera, and a high-definition TV signal transmission system using fiber optic technology.

The next item from Matsushita is one dear to my heart . . . three-dimensional TV. Here two specially designed TV cameras are positioned slightly apart, but focused on the same image, in the same manner as human eyes. Video signals from the right and left cameras are fed alternately to the TV monitor or video recorder. The reproduced images of the two different fields are viewed through

Illustration: Ann Newmann

The huge Matsushita Technology Today exhibit offered many fascinating glimpses into the future of video development.

special eye glasses with electrically operated photo-electric shutters synchronized with the change of the recorded image. The synchronized effect gives you the depth of the three-dimensional image. The best part of the system is that, although it is based on our NTSC TV system, it will work just as well with PAL, SECAM and, most significantly, with the high-definition 1125-scanning line TV. Imagine the impact of a 3-D picture in that system! Needless to say, this would be a major step forward in medical education and in the study of complex industrial processes. Matsushita claims that because all elements of the 3-D system are from standard parts, it will be made available in the near future at a reasonable cost.

Another marvel from the Matsushita exhibit was their micro-video system . . . a combinaton video camera and video tape recorder. The solid-state system employs a newly developed single-chip charge priming device (CPD) image sensor. This new sensor permits very compact construction, and the unit is the size of a standard Super 8 camera. The unit uses a video cassette slightly smaller than a standard audio cassette. Yet the 7-mm wide tape is of a metal-evaporated, high-density "Angrom" variety and affords two hours of recording with very high picture quality.

A very important product from Matsushita is their high-speed VHS video duplicating system. Present VHS videocassettes are made by lengthy real-time duplication. This unit uses a special contact-printing process that can make duplicates of two- or four-hour mode tapes in less than four minutes. I saw the prototypes of this machine several years ago, and now this updated unit has been tested by a number of the bigger videocassette duplicators. The unit costs about $100,000 and while acknowledging that the system works quite well, the duplicators wonder if it is cost effective. I think it is strictly a matter of price here, and if the price were to come down, it might well become cost-effective. One very intriguing aspect of this machine is that it can be modified without too much difficulty to produce high speed duplicates of PCM cassettes. This could be quite significant in making prerecorded digital cassettes available for the SV-P100 digital cassette recorder. (There are other interesting items from the Matsushita Technology Today exhibit, and I will cover more next month.)

As you might expect, you could hardly turn around at the SCES without bumping into videodisc players or videocassette recorders. The videodisc players of the competing systems all worked quite well in their various displays, and, while there were new models from companies just getting into the videodisc market, they were standard units with few distinguishing features. The VCRs continue the process of refinement. Of note was Toshiba's new V-8500 Beta VCR, which features helical scan with four heads. Two of the heads are devot-

How do you build a cassette deck like a 24-track professional recorder?

Build the 24-track first.

The new Revox B710 cassette deck comes from a unique company founded by Switzerland's Dr. Willi Studer. For decades Studer has been making the world's most respected studio master recorders...the legendary machines used to record everything from the Beatles' *Sgt. Pepper* to WFMT's Chicago Symphony broadcasts. Now this engineering expertise has been applied to the first and only Revox cassette deck. There's nothing else like it on the market today.

Professional Transport Design

The B710 follows the strict design principles set for our multi-track studio recorders. The transport frame is rock-solid die cast aluminum. Mounted inside are two Hall Effect direct-drive capstan motors, both slaved to the same quartz crystal for exact synchronization. The B710 has no belts, no pulleys, no clutches. Instead, two tacho regulated spooling motors work with the micro-processor to deliver smooth tape handling and gentle, jerk-free stops. Also, the B710's unique hinged headblock engagement system assures perfect azimuth alignment–a virtual impossibility with conventional designs.

Logical Features

The four digit electronic counter doubles as a 24-hour clock timer for programmable start/stop of record or play. After rewind, the counter automatically resets to zero at the exact beginning of the tape oxide. The cassette coding sensors automatically determine correct bias and EQ for the tape formulation (I, II or IV) inserted. Mic/line mixing, MPX filter, headphone volume control, and Dolby* noise reduction are all standard.

The Sound

As with all Studer and Revox products, the B710 will ultimately be judged on its ability to reproduce music with exceptional clarity...the sound you'd expect from a professional recorder.

Judge for yourself. Hear the B710 today at your nearest Revox dealer. Or, for more information, write or call Studer Revox America, Inc., 1425 Elm Hill Pike, Nashville, TN 37210 / (615) 254-5651.

**Dolby is a trademark of Dolby Laboratories.*

STUDER REVOX

Professional standards in audio components.

Video Distributors and Superscope both say they intend to rent playback-only video cassette units.

ed to still frame and slow motion, which they claim is accomplished with no snow in the picture whatever. Other features include super scan at 40 times normal speed, electronic tuning, solenoid controls, and wireless remote control. Same facilities in new V-9035 portable VCR. Among Beta models, Sony has a new very compact portable VCR, the SL-2000 Betapak, claimed to be cable-ready with such amenities as 14-day programming in the TT-2000 tuner/timer. The pair cost around $1500. Akai introduced its new VS-1, compact VHS video recorder. The unit has four heads, 2-, 4- and 6-hour playback capability, and 2- and 6-hour recording. It has an eight-event, 14-day programmable set-up, and allows bi-directional scanning at seven times normal speed. The unit has solenoid controls and an automatic tape-rewind facility. Akai is also offering some stereo videocassettes for playback on its VPS-7350 VCR. More are promised in the near future.

Hitachi is into stereo videocassettes too, for playback on its new VT-5800 VCR. Already in use in Japan, they have tied in with Magnetic Video Corp. who is said to be readying stereo versions of "Alien," "Black Stallion" and "Hello Dolly," among other productions. I feel compelled to comment that all this stereo videocassette activity is all very well, and we may even get the nod on stereo TV broadcasting from the FCC one of these days . . . but dear friends, has anyone considered the snail's pace at which VCR units operate? Their linear speed is less than the 1⅞ ips of an audio cassette, and the sound they make in mono is excruciating with the terrible wow and flutter. Pray tell, what price stereo? This is one area of quality where the stereo videodisc has it all over the videocassette.

Another interesting development at the SCES was the announcement from Fuji that they had developed metal-particle videotape and what they call vacuum videotape, which is a vacuum-evaporated tape like Matsushita's "Angrom." The metal-particle videotape must be used with special sendust heads and produces an increase of video output on the order of 13 dB. As for the vacuum videotape, it can be used with normal ferrite video heads and, at wave-lengths of one micron, can afford a 9 dB increase in sensitivity.

A company called Video Distributors of New England intends to sell a playback-only VHS unit for $299.95. They feel there is a market here and have ordered a production run of 12,000 units per month from their Far East supplier. Part of this thrust is predicated on the rapidly burgeoning cassette rental market. This is an ambitious undertaking requiring heavy capitalization, but Carl Forrest, one of the principals of the company, says they are geared up to carry out this venturesome marketing scheme in national distribution.

Joe Tushinsky, the ever-venturesome entrepreneur of Superscope, goes a step further than the playback-only videocassette machine. He is out to rent the whole package — playback unit, tape and all. Called "RentaBeta," these are special Beta-format cassette players packaged in a special high-density polyethylene carrying case. The customer rents the machine with the videocassette of his choice locked inside the player. There are no record facilities so he can't erase the tape. An indicator in the unit is supposed to register how many times the tape has been played and the customer is charged accordingly.

Now here is another item that was sure to be foisted on some unsuspecting souls . . . yesiree Bob . . . step right up and get your gen-u-wine mono-to-stereo converter. The Total Video Supply Co. is marketing their SA-100 TV stereo Adaptor. The company states that this adaptor "converts monophonic television audio signals into stereo signals that can be played through any home hi-fi system." A single lead attaches to the earphone jack of a TV set, they advise, and a circuit board inside the SA-100 converts the signal to stereo. Twin leads with phono jacks plug into the AUX inputs of your stereo amp or receiver. Volume is controlled by a rotary control on the adaptor. This miracle of modern technology can be yours for $24.95. It was to be expected that with all the talk of stereo TV in this country and rulings in its favor from the FCC expected any time, some sharpies would pull a stunt like this. Sure, they probably do some phase "diddling," but they don't even say "stereo simulation" or "stereo synthesis," or "stereo-like sound." They just baldly state mono is going to be converted to stereo. What next, fellows? Perpetual motion?

EDWARD TATNALL CANBY

Unfortunately for the business of audio and hi-fi, we now seem to be entering the age of the TV disc and its accessories. Which, you might think, signifies the end of the world for us in audio. Does hi-fi have to attach itself to the TV tail? So you might think! Is this the future for those of us who stick with audio on its own, to be minus pictures? I should hope not! Ours is not an insignificant medium at all, though much of what we have is simply irrelevant to TV, film, cassette or any other sound-and-sight medium. That's what we have to remember.

When sound and sight are combined in so many places, is there room for sound alone? That is the question for more of the hi-fi biz than you might think, and I do not refer only to my own special corner, classical music. These days, with so many ads and demos of TV wonders (mostly not here yet), I sense an overwhelming case of the jitters in the entire audio world, and it isn't confined to advertising and business. The feedback and feedthrough and feed-across affects all of us. Even the hi-fi writer in his private study. Too bad!

Too bad, because, if you'll take my grandfatherly point of view, I think it's all very premature. We aren't about to die though we may have some problems. True, a number of people and quite a few companies would like to make a million on TV discs, and everybody thinks it worth a try. Also true that a large number of outfits will lose their shirts, if they haven't already. But our business/technology world is inherently like that and we all know it. Why such big jitters, this time?

Somebody must be promoting the idea that the "revolutionary" TV disc and all the rest of its associated elements may mean the end or perhaps the decline of "pure audio" entertainment. That is, sound for sound's sake, minus even a hint of pictures. Dreadful thought I admit. Especially since that would mean the end or the decline and fall of the hi-fi biz, not to mention of the record biz. But calm down, folks. It isn't really that bad.

Let's think conservative. Orderly change is the name of the game, revolutions or no and no matter how big the ads you see. Today's gorgeous hi-fi may not be as glamorous as a laser disc (though even more expensive), but it will still be useful tomorrow and maybe even the next day. There are things it can do for us that *no TV disc will ever do*. It's a different medium.

Remember that classical music has already died a thousand deaths, been swallowed up 50 times by pop and rock and so on, but if you think it is dead at last, you are wrong. It survives because it is needed, because it does things that other music doesn't. Audio, sound for sound's sake, minus pictures, is no more likely to disappear the day after tomorrow than is classical music. Both are too useful, too soul-satisfying, too well established.

The TV disc is merely going to take the present world of TV and film into new areas where, even so, it will have the same sort of values we already know well. Did TV itself kill hi-fi?

Definitely, we will need adjustments in sound-only audio. It's expensive and getting worse. Too much performance, not too little. Maybe we are now at the gas-guzzler stage? Rather late for that, if you ask me, but there it is. Still, don't get the idea that hi-fi itself is doomed. Not a chance.

So let us think AUDIO, audio only, and I mean those exclusive values of high-quality sound that we have built up over so many years, not as an adjunct to pictures or anything else, but strictly for sound alone. We must define those values for ourselves, see where they are genuinely different from anything that can ever happen in the sound-plus-picture area, and then get on with our business, wiser and perhaps not sadder. We've been doing just this ever since the talkies came in, almost a half century ago, and then again when TV got started. Now we are merely in Round III.

There's an important aesthetic principle here that is too little understood. In those entertainments where sound and sight are combined, the ideal is always a balance between the two in interest and in quality; but it is a very precarious balance and only realized in a few miracle happenings such as top-flight ballet, a few operas, a lot of musicals both in the flesh and on film. There is an instability in the sound/sight combination: One or the other, the sound or the visual, generally takes over and becomes dominant.

Today, with music so widely used for background, the visible element is out in front most of the time. But things aren't necessarily this way, and especially in live performance. The early classical opera, for instance, was lavish to look upon but the action was visually limited; one listened to the music, ogled the audience, and watched the singers sing. The operas of Wagner, much later, are not so different in this respect. Scenery — of course. But action? Not much. The music tells all. As too many of us know, a

Illustration: Philip Anderson

Where sight and sound are combined, the ideal is always a balance between the two in interest and in quality.

Wagnerian singer can take a half hour to sing a couple of sentences of text, during which time there are several paces to the right, a few to the left, the hand gesture at officially traditional points in the music — and the feet get sore. Same with plenty of other operas. I remember Kersten Flagstad, in her later bulky days, doing Gluck — she stood magnificently at the top of a stage mountain on the right for so long that suddenly she began to topple and nearly came down. The audience gasped. That was a sight, if unintended.

As contrasted with live, the reproduced arts inevitably have a very different "feel" and balance, with quite different priorities. Though sound is present in every sort of film and TV, the picture is the dominant force. And this even though we do listen to sound track albums, musicals and so on without any pictures. We sense that the visible element is the dominating power, because it seems most directly to command the attention. And in a reproduced art, the dominant element, curiously, is the one that must have the greater "fi," the denser communication in entertainment "bits." Television "fi" is not exactly superb via any present system, to be sure, but even so it is a fact that TV sound as the nominally secondary element tends to an even lower fi. Look at any TV picture and then listen to the much worse TV sound.

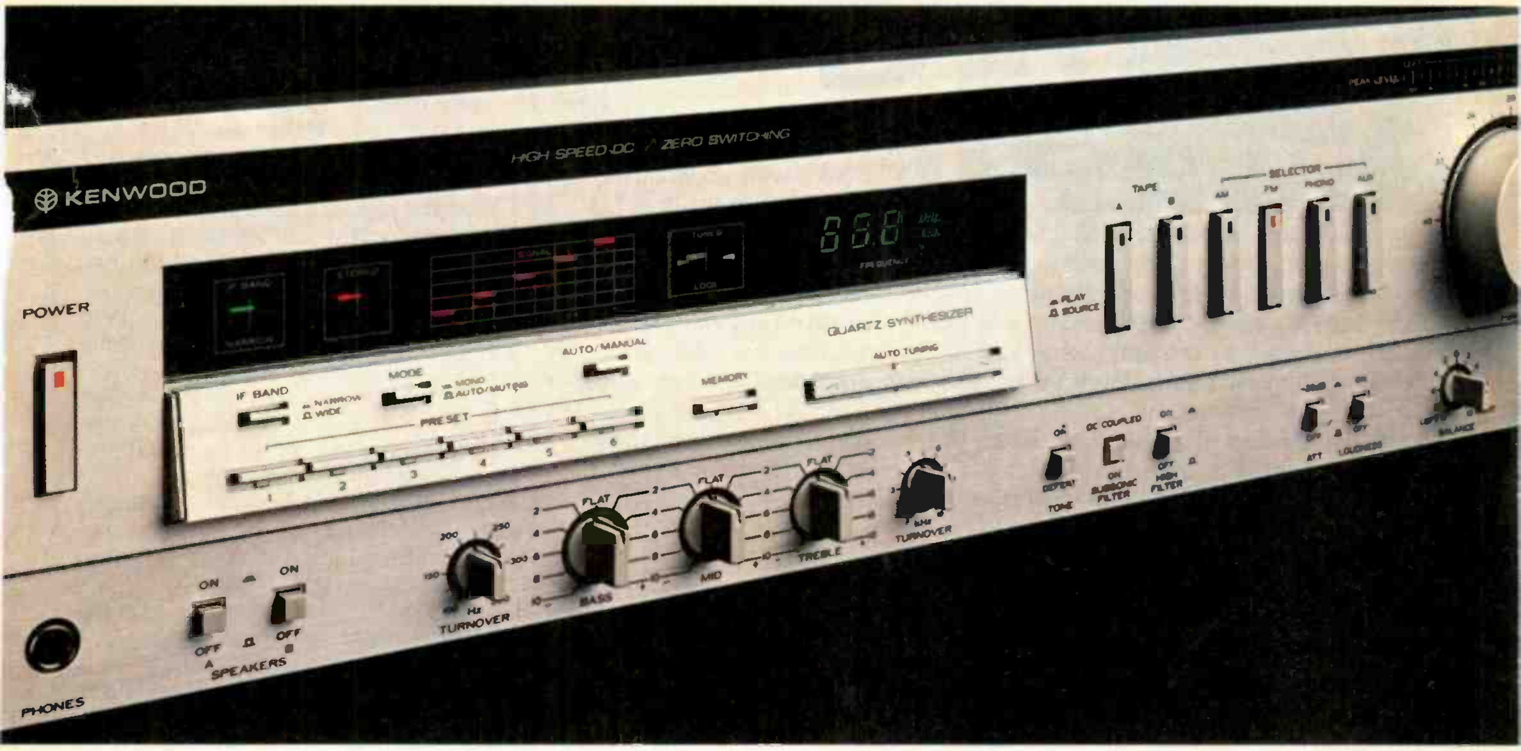
But do not deplore! This balance is *inherent in the medium*. It is natural and inevitable. It works. It has proved itself.

I do not think, for instance, that stereo hi-fi sound is required for better TV. For music, perhaps, if you mean classical. Drop in the bucket. As for pop and most other music, these sounds do OK via lo-fi audio and always have. They are designed to do so. Same with speech; what we need is intelligibility, not fi. Super hi-fi speech merely distorts the balance, makes the TV picture look fuzzier. The sound must match the picture, the superiority must always be on the dominant side — the picture.

As for stereo directionality, it is again fine for classical music, with a tiny visible concert stage and a huge big sonic stage for the sound. But by no stretch of imagination can you make this sort of sound a necessity for the whole TV medium! These "improvements" in what is a carefully adjusted balance only serve to confuse things. Will it be different for the TV disc, even though sonic improvement is technically feasible?

The reason that better sound, hi-fi, Dolby, stereo, has recently done good things for theater film is simply that the big projected image in the theater, with its pitch-dark surroundings, is more commanding and much better in the (photo) fi than the relatively small TV picture in its living room stance. Therefore, a superior theater film can take on improved sound and the two elements do indeed balance in quality, for dramatically improved impact. Interestingly, movie people have had vague feelings in this direc-

Its mother was a computer. Its father was a Kenwood.



THE KENWOOD KR-770 RECEIVER

We think our new KR-770 is the most intelligent high performance receiver in the world.

The heart of our new receiver is its remarkable brain. A microprocessor-controlled quartz synthesizer tuning section, which uses Kenwood's unique computerized digital frequency encoding system to provide incredibly accurate, drift-free AM and FM stereo reception.

There's also a lot of convenience engineered into our computer-memory receiver. Like automatic station scanning. Six AM and six FM digital tuning presets which you can program to instantly address your favorite stations. And a lithium battery powered memory-safeguard system to save the programming in your receiver's digital memory in case of power loss.

But there's more to our new KR-770 receiver than just brains. Take power, for instance. 80 watts per channel, minimum RMS at 8 ohms from 20 to 20,000 Hz with less than 0.02% total harmonic distortion.

HI-SPEED™

And for performance, the KR-770 provides a long list of innovative Kenwood engineering features. Like Hi-Speed™ circuitry for exceptional musical clarity. DC to give crisp, clear bass response down to 0 Hz. Our new Zero Switching output circuits to eliminate crossover distortion. And wide and narrow IF band circuitry to maximize FM reception.

You also get digital frequency read-out. LED indicators for power output, signal strength and function controls. Plus a built-in equalizer.

See your Kenwood dealer for a demonstration of the first computer good enough to be a Kenwood.

For the Kenwood dealer nearest you, see your Yellow Pages, or write Kenwood, P.O. Box 6213, Carson, CA 90749.

KENWOOD®

Enter No. 20 on Reader Service Card

tion ever since talkies first came in; there have been sporadic sudden "breaks" towards better theater sound, again and again, from "Fantasia" and Cinerama to magnetic tape and Dolby. Correct! We sense that this sound/sight medium, in the theater situation, can use better sound to go with its commandingly powerful picture. Proof again that we do seek a right and workable balance, in every medium according to its nature, even the most commercial.

We must take our TV, and our coming TV disc, for what they are. Video in any form and usage is not a partner for top-flight audio. Nor ever will be, I suggest. Unless we convert our homes into theaters, with huge, sharp, well-sized pictures in total darkness! Fat chance. Who wants to? The persistence of the theater movie even today, in the face of TV, proves that it, too, is a different medium in its own special ways. People are able to appreciate that difference and still go out and look for it.

Do you think they won't understand that hi-fi, without pictures, mainly for music, is also a different medium, a different and unique experience?

In a practical way, then, we in audio entertainment must be extremely wary of tying ourselves onto TV's ee-normous tail. The operation might be technically simple, what with digital, but the patient will likely die. Or be de-natured into something else which, for most of us in audio, would spell "compromise." Hasn't it already happened? For us, TV sound is a hideous compromise indeed, and not even stereo would rescue it. But you must understand that it is possible to look at it quite differently: *That is the sound which the medium demands*, and uses with immense success.

So I have a rueful respect for present TV audio because I do not at all believe it is merely a commercial expedient, nor even a compromise. We are very mistaken if we think that TV sound should be upgraded to match what we hi-fi folk consider proper in our art.

The TV disc picture is generally somewhat improved; so there is some leeway for moderately improved sound. Relatively speaking! In proportion. Keeping the balance, with the picture dominant in all but a few specialized music items. The audio is still tied to the picture, and the picture MUST be the better. It's still a TV picture in the living room, on the beach, boat, bar & grill, and so on.

So no matter how much the noise about television on disc (and on cassette, too, not to mention cable), the future of excellence in hi-fi audio is in our own medium and nowhere else. So let us not be distracted. We will not allow hi-fi to sink or to compromise for somebody else's reasons.


and when you switch over to the 770's
you will smile and say... it's magic
because there is nothing like it
under the sun!
Mission North America, 89 Galaxy Blvd., Rexdale, Ont., M9W 6A4 Canada
Mission Electronics, George St., Huntingdon, Cambs., PE 18 6BD England
Enter No. 25 on Reader Service Card