Audio®

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THE AUTHORITATIVE MAGAZINE ABOUT HIGH FIDELITY • FEBRUARY 1980

47425

Whyte – A "Digital" AES

PICKING CAPACITORS – JUNG & MARSH

INTERVIEW – DR. TOM STOCKHAM

ANOTHER VIEW OF TIM – CORDELL

WITH ONLY ONE EXCEPTION, THIS IS THE MOST REMARKABLE TAPE DECK IN THE WORLD.

But without exception it's the most remarkable cassette deck.

Today, a thousand dollars or more is standard fare for a professional quality cassette deck. But when Pioneer designed the new CT-F1250, they not only raised the performance standards of high quality decks, they also lowered the standard price.

Metal tape capability is something most new high quality cassette decks have in common. But while many of them have just been modified for this advancement, the Pioneer CT-F1250 has been specially designed for it.

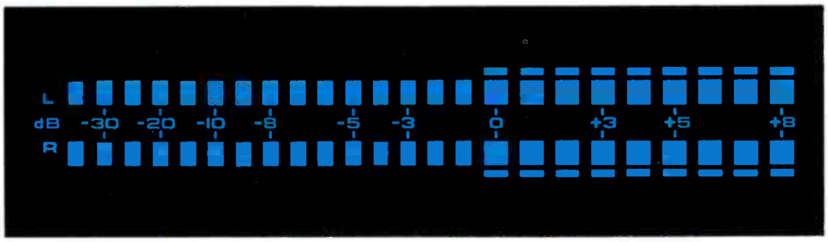
Metal tape capability for far greater dynamic range and far less distortion.

Instead of the two heads found in most metal capable tape decks, the CT-F1250 has three. And it's these three heads that keep us way ahead of the competition.

Our new "small window" erase head makes a big difference in making sure all metal tapes are wiped completely clean. And our Uni-Crystal Ferrite recording and playback heads give you greater frequency response and better wear-resistance than the ordinary ferrite and Sendust alloy heads you'll find on most other tape decks.

But you don't get distortion-free recordings just by using your heads.

Instead of the single capstan tape transport system you'll find on some tape decks that are nearly twice the price, the CT-F1250 has a closed-loop dual capstan system, similar to that found in our remarkable RT-909 open-reel deck. This system keeps the tape in perfect contact with the heads at all times. So you are assured of getting everything that's on the tape. Nothing more; nothing less. What's more, the CT-F1250 has a Quartz-Locked Direct Drive capstan motor that senses the slightest deviation in speed and automatically corrects it to keep wow and flutter down to an unbelieveable 0.03%.



Pioneer's 24-Segment Fluroscan Meter gives you an instantaneous picture of what you're listening to.

It's engineering innovations like these that make the CT-F1250 so remarkable. But equally remarkable are the features that make the CT-F1250 so easy to operate.

Like our specially engineered Tape Calibration System that lets you quickly set bias level, Dolby adjustment, and record equalization for the best possible signal-to-noise ratio, the lowest distortion, and the best high frequency response.

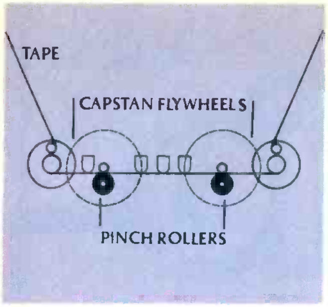
And our 24 segment Fluroscan meter that works on Pioneer's own microprocessor to give you a more accurate reading of what you're listening to. It even has Peak, Peak Hold, and Average Buttons that let you record without fear of overload.

In addition Pioneer's CT-F1250 has a digital brain with a memory that controls four different memory functions. Plus pitch control. Mic/line mixing. Independent left/right input/output controls. And more.

By now, it must be obvious that the CT-F1250 was designed to push up the limits of cassette deck performance. But only Pioneer would do it, without pushing up cassette deck prices.

Pioneer's easy-to-use Tape Calibration System guarantees optimum performance from every tape.

WITH ONLY ONE EXCEPTION, THIS IS THE MOST REMARKABLE TAPE DECK IN THE WORLD.



Pioneer's Closed-Loop Dual Capstan Tape Transport System ensures constant tape to head contact.

But without exception it's the most remarkable reel-to-reel.

Today, many audio manufacturers are putting a lot less into their tape decks and charging a lot more for them. But when Pioneer designed their new RT-909 open-reel tape deck they made certain it had every conceivable feature an audiophile could expect.

And one feature that was totally unexpected. A reasonable price.

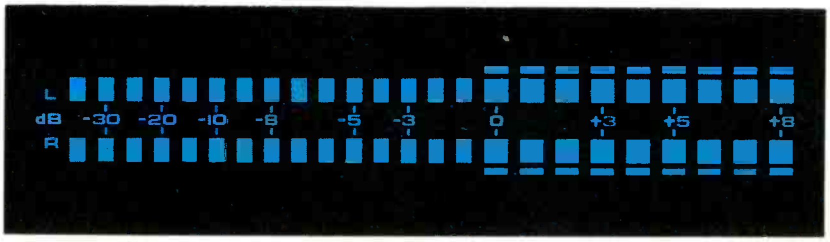
Even if you pay $1500 or more for a so called "professional" quality tape deck, you'll probably still be getting a conventional single capstan tape transport system that is prone to wow and flutter.

Pioneer's RT-909 has a specially designed closed-loop dual capstan system that isolates the tape at the heads from any external interference. So you get constant tape-to-head contact. And constant, clear, accurate sound.

And while many of the expensive new tape decks have old fashioned drive systems that drive up heat and distortion, the RT-909 doesn't. Instead, it has a far more accurate DC motor that generates its own frequency to correct any variations in tape speed. And keeps wow and flutter down to an unheard of 0.04% at 7½ ips.

What's more, the drive system of the RT-909 is unaffected by fluctuations in voltage. So a drop in voltage doesn't mean a drop in performance. The RT-909 also has a logic system that ensures smooth, accurate speed change.

Most professional quality tape decks are designed for use outside the home. So the convenience features most audiophiles enjoy are nowhere to be found. The RT-909, on the other hand, offers automatic reverse, automatic repeat, and a timer controllable mechanism that lets you record a midnight concert even if you can't stay awake for it.



Pioneer's 24-Segment Fluroscan Meter gives you an instantaneous picture of what you're listening to.

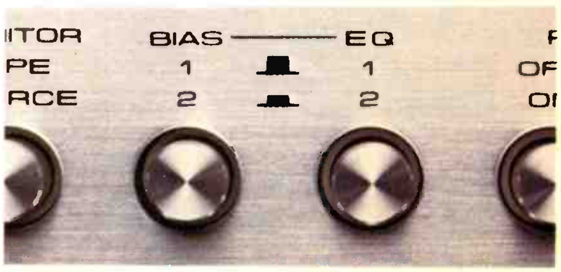
Examine our heads and you'll see Pioneer engineers at their very best. Our playback heads, for example, have a new "contourless" design that makes them more sensitive. They increase frequency response upwards to 28,000 hertz, and extend it all the way down to 20 hertz. So you not only get greater range than any other tape deck, but also any other musical instrument.

Of course, these features alone would make Pioneer's RT-909 quite a remarkable tape deck.

But the RT-909 also has a Fluroscan metering system that gives you an instantaneous picture of what you're listening to. A pitch control that lets you listen to music in perfect pitch even if it was far from perfectly recorded. Four different bias/equalization selections so you can use many tapes and get maximum performance from them all.

Obviously these advancements are very impressive. But there's still one thing even more remarkable than the technology we feature. It's the price we feature.

PIONEER®
We bring it back alive.



Independent bias and equalization for maximum performance from any tape.

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February 1980 — Audio — Vol. 64, No. 2

"Successor to RADIO, Est. 1917"

Feature Articles

Equipment Profiles

Workbench Profile

Record Reviews

Audio in General

About the Cover: Although nobody's going to hand you the facts about capacitor selection on a silver platter, Walter G. Jung and Richard Marsh come close in the first part of their article on this subject on page 52. Model: Ben Fine. Photo: Photographic Illustrations, Philadelphia.

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Now Pickering takes the Stereohedron® Series one step beyond excellence with the new XSV/4000. Technical advances in both design and construction have made this degree of perfection possible.

A lightweight, high energy, samarium cobalt magnet and shaped-for-sound Stereohedron Stylus tip are major innovations that eclipse previous performance standards in four crucial areas. Improved tracking ability. Expanded frequency response range. Wider channel separation. And featherlight treatment of the record groove.

XSV/4000 ... the next generation of sound.

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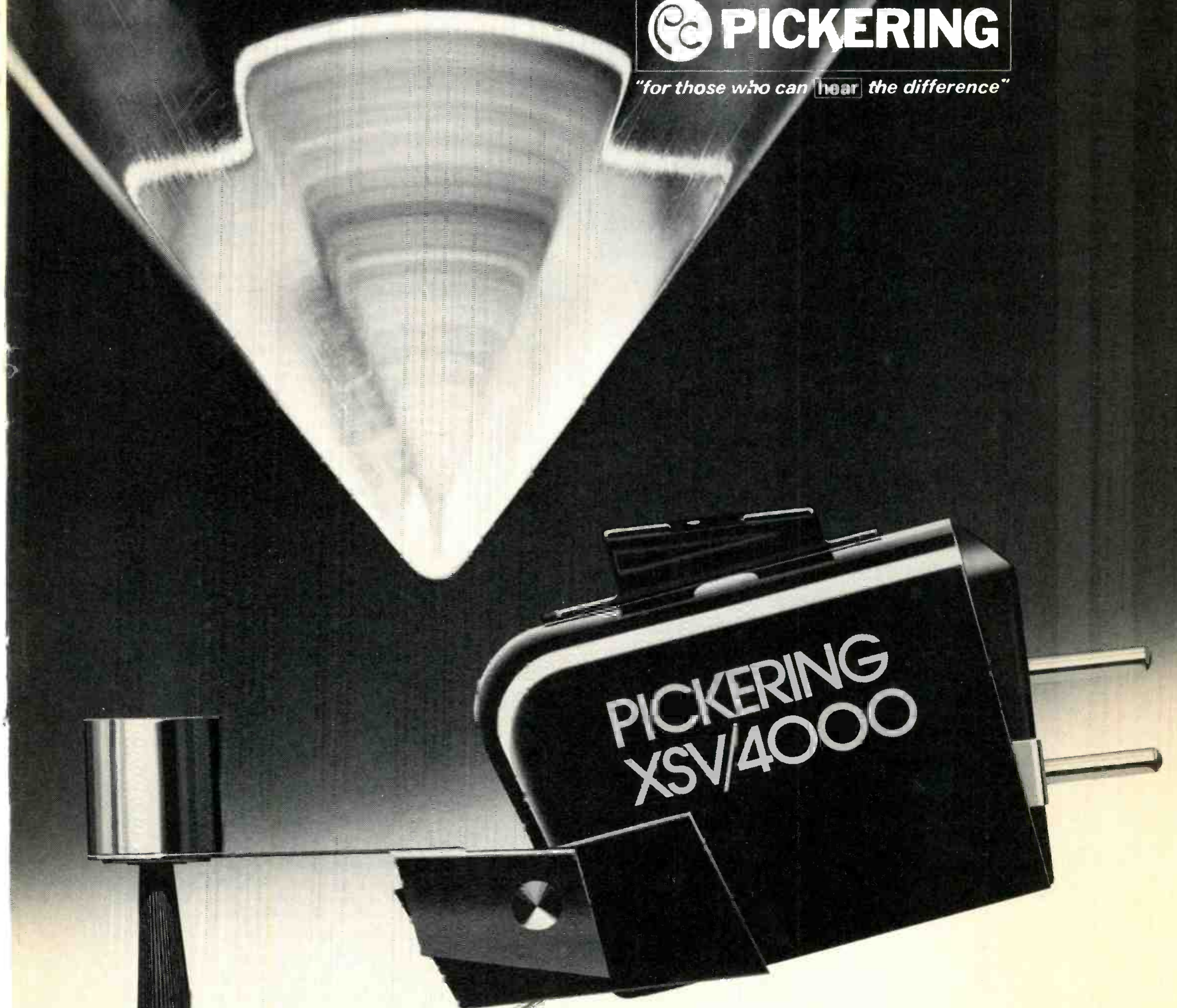

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A Letter To Our Readers

In this our 33rd year, *Audio* is pleased to announce the name of our new parent company, CBS Publications, Inc. Since their first publishing venture in 1971, the acquisition of *Field & Stream,* CBS Publications has experienced continual growth. By the end of 1973, they had acquired five magazines including *Road & Track, Cycle World, Sea, World Tennis,* and *Pick-Up, Van & 4WD.*

With the acquisition of Fawcett Publications in 1977, CBS experienced exceptional expansion. Included in this acquisition (one of the largest in CBS' 50-year history and one of the largest in publishing history) were *Woman's Day, Rudder* (later merged with *Sea), Mechanix Illustrated,* and the Fawcett paperback book line, which publishes over 1,300 titles annually. Most recently they began a newspaper magazine group with the acquisition of *Family Weekly,* the Sunday supplement which appears in 350 newspapers throughout the U.S. In addition, CBS publishes more than 60 newsstand specialty magazines.

This year they bring *Audio* into their ever-expanding magazine fold under the auspices of the CBS Consumer Publications Division. It is only natural that CBS — with its background in broadcasting, recording, research and development, consumer audio products from manufacture through sale, and publishing — should round out their Special Interest Magazine Group with *Audio,* the original magazine about high fidelity.

Looking forward to the '80s, we feel that the resources of CBS Publications, Inc. (one of the largest magazine publishing companies in the U.S.) will enable us to expand, improve, and at the same time retain the high standards set by you, our readers.

Jay L. Butler
Publisher

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A Telarc Digital

Tour De Force!

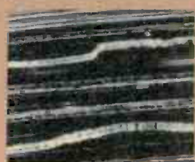
Tchaikovsky "1812" Overture; Capriccio Italien; Cossack Dance from Mazeppa
Erich Kunzel conducting the Cincinnati Symphony Orchestra

It's stirring, familiar music. Superbly played by the Cincinnati Symphony under the sensitive baton of Erich Kunzel. And captured with all its warmth and emotion in the 100-year-old Cincinnati Music Hall. But what of the huge bells? And what of the fabled cannon? They are there—literally in full force—providing dramatic proof of the superiority of digital mastering of the untapped capabilities of today's disc recording.

Not For Every System

We'll be perfectly frank: not every system—even some of the finest—will be able to successfully track the remarkable grooves on this record. And even if your cartridge and tone arm can track the record, the full impact of the sound may escape you unless you own an outstanding amplifier and speaker system. In short, this record will challenge every part of your system in every respect.

Most difficult to track and reproduce is the authentic 19th century cannon whose initial "crack" as the powder is ignited is



This 12x enlargement shows the incredible groove modulations during the cannon shots ...probably the most demanding low frequency signals ever cut on disc.

followed by pressure waves as low as 6 Hz which can easily be seen on the finished disc. Even with maximum recommended tracking force, many tone arm/cartridge combinations may be incapable of following these remarkable groove excursions*. And the "boom" is well below the useful range of all but the most sophisticated speaker systems, coupled to amplifiers with generous reserves of power.

At the other end of the scale, the tumultuous bells provide a challenge to high frequency tracking and a stringent test of the mid-range and tweeter components. Add the full resources of the Cincinnati Symphony—captured as only the Soundstream digital system and Telarc microphone technique can—and the result is a record which will challenge your ideas about equipment performance and the limits of disc recording capabilities.

This landmark recording is just one of several new digitally-mastered Telarc releases. Available at most Audio-Technica dealers and wherever audiophile recordings are sold. If not available locally, write us today for our current StandarDisc catalog of digital, direct-to-disc, and advanced analog recordings. AUDIO-TECHNICA U.S., INC., 33 Shiawassee Ave., Fairlawn, Ohio 44313. Dept. 20A.

***If your cartridge/tone arm combination is unable to track this spectacular recording, your Audio-Technica dealer can recommend several A-T cartridges and tone arms capable of meeting the rigors of this advanced digital recording technique.**

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ADD THESE EXCITING TELARC DIGITAL RECORDINGS TO YOUR COLLECTION

TCHAIKOVSKY Symphony No. 4, Lorin Maazel, Cleveland Symphony TEL-10047

MOUSSORGSKY Pictures at an Exhibition/Night on Bald Mountain Lorin Maazel, Cleveland Symphony TEL-10042

AUDIO-TECHNICA PROFESSIONAL AND HOME PRODUCTS FOR BETTER SOUND

Tape guide

Herman Burstein

Exercising Your Options

Q. The owner's manual for my tape deck calls for microphones with impedance of 10,000 ohms or less. Would you explain the difference that the mike impedance makes in recording? The mikes I am using now have dual impedance of 150/50,000 ohms, so I use the 150-ohm option. But when recording, I turn the mike level to maximum and still do not get a very high level indication on the VU meter. Is this due to the low impedance? What would happen if I tried to use the 50,000-ohm connection of my mike? — Tom Bouts, Arvada, Colo.

A. A microphone with low-impedance output supplies a small signal, but in exchange you can run a long cable to the tape recorder without significant treble loss. There is also less danger of hum pickup. A microphone with high impedance provides a greater amount of signal voltage, but requires a short cable — at most 20 feet — to prevent treble loss. I suggest that you consult your local audio dealer for a step-up transformer with 150-ohm primary and approximately a 10,000-ohm secondary. If your dealer can't help, write to the manufacturer of your microphones. There is a possibility, although I am dubious of it, that you can use the 50,000-ohm output of your mikes without significant problems of distortion or treble loss. Try it and see.

Tap Toe Through the Playback

Q. When I play a disc, all sounds fine. But if I make a tape recording of the disc and press the monitor button on my preamp, each little bounce of the tonearm makes the recording sound as if the tape is bouncing up and down on the playback head. If I record but leave the monitor button in the out position (thus listening to the program source instead of the tape playback), then the tape machine records very little of the bouncy sound. — David Mann, Pasadena, Calif.

A. Your trouble may originate in a microphonic component in your tape deck or preamp, more likely the latter. Perhaps you can expose the insides of your equipment while in operation and go tapping around with a pencil eraser to see if this guess is correct. Should tapping accentuate the problem, you may have located the source of the problem.

Pick Up a Piezo

Q. Why is it that a turntable with a magnetic cartridge cannot be used for recording 8-track tapes directly on my 8-track recorder? — Marc Kelley, Kenosha, Wisc.

A. The problem probably lies in the fact that the output of a magnetic pickup requires equalization (bass boost and treble cut), whereas your recorder does not supply such equalization. Also, the voltage output of the pickup is quite low, and your recorder probably does not provide enough amplification. If you employ a piezoelectric (crystal or ceramic) pickup, you would probably have a signal with sufficiently flat response and enough voltage for recording. If you don't get enough bass response with the piezoelectric pickup, try mounting a capacitance of several hundred pF between the hot and ground terminals of the pickup (one capacitor for each channel). You'll have to experiment to discover the proper value of capacitor for flattest bass.

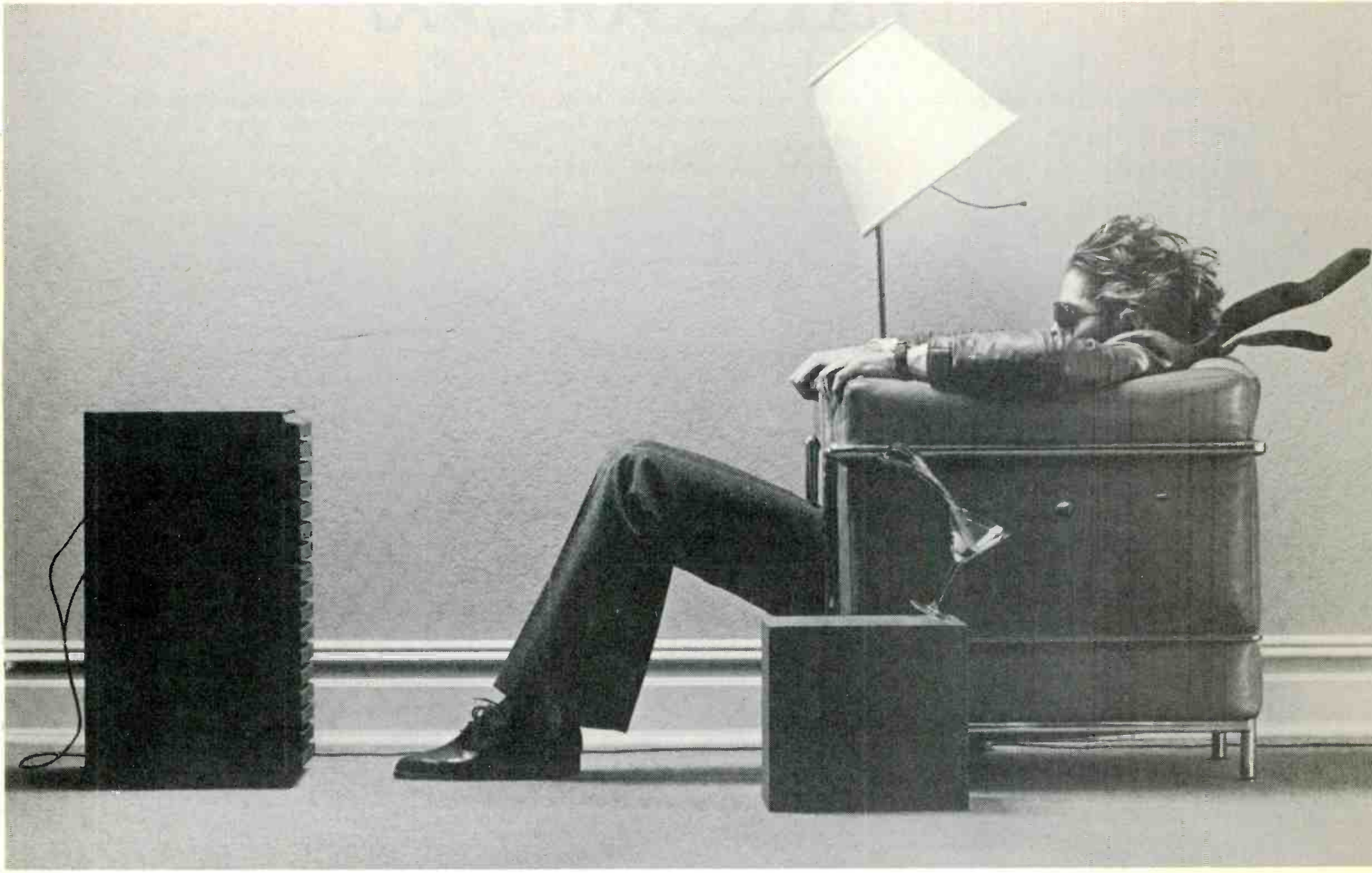
Digit Counter Usage

Q. Is the digit counter on most tape recorders used as an index for each particular machine, or does the counter actually measure footage? — Arthur Pushkin, West Hempstead, N.Y.

A. The digit counter is usually hooked up to the mechanism that turns the take-up reel and normally does not measure actual footage. Therefore you may easily get different counts on different machines for the same tape footage. (However, one or two expensive decks recently introduced do count actual footage.)

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.

AFTER 500 PLAYS OUR HIGH FIDELITY TAPE STILL DELIVERS HIGH FIDELITY.



If your old favorites don't sound as good as they used to, the problem could be your recording tape.

Some tapes show their age more than others. And when a tape ages prematurely, the music on it does too.

What can happen is, the oxide particles that are bound onto tape loosen and fall off, taking some of your music with them.

At Maxell, we've developed a binding process that helps to prevent this. When oxide particles are bound onto our tape, they stay put. And so does your music.

So even after a Maxell recording is 500 plays old, you'll swear it's not a play over five.

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IT'S WORTH IT.

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The Audio Interview

Gary Stock

Dr. Thomas Stockham—On The Future Of Digital Recording

One of a series of interviews with the audio industry's innovators and thinkers.

Dr. Thomas Stockham is uniquely qualified to comment on the future of high fidelity. In 1968, as a professor at the Univ. of Utah, he developed one of the first digital recorders capable of high-quality music reproduction. The company he founded and now heads, Soundstream, Inc., of Salt Lake City, Utah, specializes in digital recordings produced using equipment designed by him and his company. Among the 50 records produced via the Soundstream system are a widely acclaimed RCA series of Caruso transcriptions, restored using digital sound processing, and the master tape of Fleetwood Mac's recent Tusk album. The company is among the best-known recording firms in the world.

Stockham talked with Audio at the recent Audio Engineering Society Convention in New York, in the Waldorf Astoria's Cole Porter Suite (graciously made available by the Society). There the conversation ranged over a broad spectrum of topics, from the sound system for Disney's classic "Fantasia" to some suggestions to help recording engineers maintain musical objectivity. Excerpted here are Dr. Stockham's thoughts on high fidelity's direction in the coming decades.

Audio: As you view the future of audio, how do you see the musical storage media—disc, tape, credit card-style plate, whatever—shaping up over the next 10 or 15 years?

Stockham: First, I do not see video cassettes adapted to digital being a substantive and permanent addition. The main problem is the problem of copying. High-speed duplication of digital is even more difficult than duplication of analog, because the bandwidth of the basic digital information—not the sound but the codes—is much greater than in analog. The bandwidth of a basic audio code at normal speeds is equal to the bandwidth of a high-speed analog duplication. Some fundamental breakthroughs in tape copying could change this, but in spite of promises over the years, there has not yet been anything demonstrated that is really practical. So, I see the adapted video cassette as a kind of bridge, and perhaps it could hang on as a home recording vehicle.

> **"... size and shape and feel can be as important as any of the technical characteristics."**

Relative to a disc format, I find it curious and at the same time natural that video discs should be adapted to digital-audio applications. Technically, it is an obvious direction to go in, and there are as you know, two fundamental approaches. One is to take the video disc player and create audio discs and a digital adaptor of some sort, perhaps built-in. This will allow you to play television programs and digital audio on the same machine. And then there is the alternative approach, which for example the Philips Compact Disc has taken (See "Audio ETC," *Audio*, Sept., '79), to use video technology but reshape it completely for audio only. Perhaps both of these approaches have a place. I personally prefer the audio only direction, because one of the things we have learned in the last decade or two about new storage media is that the shape and size and feel can be as important as the technical characteristics. Why, for example, should the Philips Compact Cassette have been of any usefulness or had any success in the record business? For the most part the technical quality of a cassette is somewhat poorer than that of a disc. Well, it's compact, easy to carry around, one can quickly take it out of the player, and so on. In short, it has appealing physical characteristics above and beyond the sound characteristics.

Audio: You then think that smaller is the route we may take?

Stockham: I think that we may see a smaller digital record, of higher quality than today's records, with nominally the same amount of program material,



MEMOREX HIGH BIAS TEST NO. 2.

WHICH HIGH BIAS TAPE WINS WITH "LUCILLE"?

The legendary "Lucille" is a Gibson ES 355 made especially for B.B. King.

Select any blues solo where B.B. King really lets "Lucille" sing, and record it on your favorite high bias tape.

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We're convinced you'll have a new favorite for two important reasons:

1. At standard record levels, no high bias tape has a flatter response across the <u>entire</u> frequency range.
2. The signal/noise ratio of MEMOREX HIGH BIAS is unsurpassed by any other high bias tape at the critical high end.

In short, you can't find a high bias cassette that gives you truer reproduction. And, after all, isn't that what you buy a high bias tape for?

Is it live, or is it
MEMOREX®

For unbeatable performance in a normal bias tape, look for Memorex with MRX_3 Oxide in the black package.

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The new

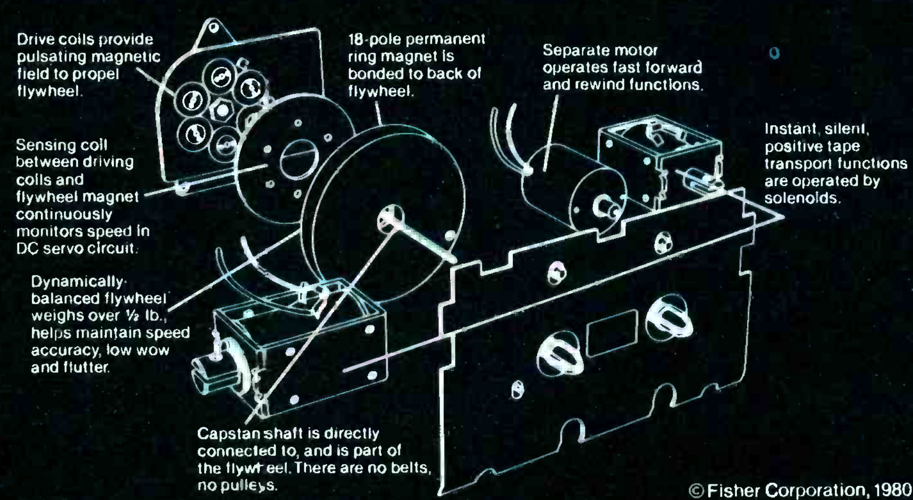
Direct Drive and solenoid controls in a new cassette deck.

Here is the very latest cassette deck technology. The new Fisher DD300 Cassette Deck has direct drive tape transport for lasting, unvarying performance, feather-touch solenoid electronic controls for superior operation and metal tape compatibility for the ultimate in frequency response. There's an incredible amount of advanced engineering packed into this new Fisher cassette deck.

Direct Drive tape transport. The rugged capstan on the DD300 is directly driven by a high-torque 18-pole brushless, coreless DC flywheel motor, optimized for the critical record and play transport functions. It glides silently at a steady 360 RPM. And, it eliminates the problems of conventional high speed DC brush motors and drive belts. Wow and flutter are down to an amazingly low 0.04%. A separate motor is provided for fast forward and rewind. No compromise.

Feather touch electronic controls. Goodbye to the old "clunk-clunk" of manual controls. A feather-light fingertip touch sets the DD300 in motion. An IC logic circuit actuates the solenoid transport function for instant, silent, positive action. LED's light up to continuously display what functions are in operation.

Metal tape compatibility. If you want to try the new metal particle tape you've been hearing so much about, the DD300 is ready. Get set for an astonishing improvement in signal-to-noise, dynamic range and a frequency response of 30Hz-18kHz ± 3dB. Get set, too, to make recordings that rival studio-produced tapes.



It's what you'd expect from the new Fisher. We don't have the space to list all the other features of the new Fisher DD300. Features that are indicative of the high technology of the new Fisher. We invented high fidelity over 40 years ago. And we've never stopped innovating. If you're ready for the latest cassette deck technology, see the new DD300 at your Fisher dealer.

Fisher Corporation, 21314 Lassen Street, Chatsworth, CA 91311

FISHER

The first name in high fidelity.®

or even more. But who is to say that we won't have a multiplicity of digital audio media? We have at least three analog media that are commercially viable right now, and I would think that one would expect more than one medium in digital, certainly not right away but after a while.

Audio: Have you at Soundstream done any work relative to digital disc development?

Stockham: Soundstream has done no explicit product development as far as a digital disc is concerned. However, we are extremely interested in this and active in the area.

Audio: How fully is digital audio developed at this point, in your view?

Stockham: Well, nothing is ever fully developed. If you mean by fully developed that digital recording is capable of doing something interesting for the consumer, then I would say "yes." We have produced with our customers, to date, 50 long-playing records, all hybrids—analog records with digital mastering and recording. Nippon Columbia has produced twice that or more. 3M has done some; Sony has done some. Digital is taking its place in the entertainment industry, so it is in that sense developed.

". . . a properly designed digital system should not sound any different from a direct connection to the source . . . ."

Audio: Do you think that there is likely to be any significant audible improvement as time goes on, or do you think the present specifications place digital audio systems essentially beyond the discrimination of the human ear? Are there any audible differences between the various available digital recording systems, for instance?

Stockham: I have not heard them all together, so I couldn't tell you. I believe, however, that the properly designed digital systems available today are developed enough, from the point of view of audio fidelity, that the differences between them are comparable to the differences between high-quality amplifiers of different brands.

Audio: Extremely subtle, then.

Stockham: Well, subtle, let's say, or at least rather small. That does not mean, of course, that *all* of the available systems have been properly designed. I've heard some that sound very good, some that don't sound very good at all. I do not imagine that the sound of a digital system would be an area in which one would expect a big stride forward from the best we have now.

Audio: And yet there has been some resistance to digital on the part of some engineers and reviewers, who claim it sounds artificial in some way. How do you feel about that?

Stockham: The best information I have is that a properly designed digital audio system should not sound and does not sound, in my experience, any different from a direct connection to the source or a very, very high-quality amplifier. Within the scope of the experiences that I've had, I cannot detect any differences between the direct and the digitized material.

Audio: Then you're inclined to think that these remarks are "politically" motivated?

Stockham: I don't know what basis they have. I suspect a bit of skepticism, a bit of nervousness, a bit of "digital isn't good for my business" motivation. Whether that is really true

TDK's new improvement has nothing to do with the sound. It's the package.

Each TDK package is now designed to catch your eye as never before. Clean, modern lines. Bright new colors. Bolder designations in front. Full tape description in back, including sound characteristics, formulation, bias and a frequency response chart to let you know precisely what you're buying without having to hunt for a salesman.

And don't expect the improvements to stop there. Inside there are complete recording and cassette care tips. Invaluable for preserving the life of each cassette, even though each TDK cassette is protected by a full lifetime warranty.* There's also a convenient, tear-out index card to help you build a perfect reference system.

Once inside, TDK couldn't stop improving. There's now a wider cassette window. Through it you'll be able to watch two red double hub clamps registering tape direction as they turn. Just when the improvements seem to end, TDK tape technology begins. TDK SA's cobalt adsorbed gamma ferric formulation continues to set the high bias standard around the world. TDK AD, the tape with the hot high end, is now Acoustic Dynamic. You'll see it in brand new blue and silver colors. TDK D, another member of TDK's dynamic series, makes many premium normal bias cassettes sound ordinary and overpriced.

That's all we have to report for now. But there will be more to come. Part of TDK's philosophy is: when every improvement has been made, improve again.

TDK

The machine for your machine

*In the unlikely event that any TDK cassette *ever* fails to perform due to a defect in materials or workmanship, simply return it to your local dealer or to TDK for a free replacement.

Supplier to the U.S. Olympic Team

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or not, some people may reach that conclusion.

Audio: Where you stand depends on where you sit.

Stockham: That's right. I have no truly objective evidence that any of the comments are true, and I've never had anyone offer to show how I or anyone else can hear the difference. I know that objective, measurable differences exist; you put a signal through any device and what comes out will be different in some way from the signal that goes in. The question is whether or not these are audible, either on an absolute scale or in a way that anybody, even a finicky person, really cares about. I've concluded that the differences between direct and digital are either subjectively null or very, very trivial. Even if we say that there are some differences, which I claim there aren't, I'm absolutely certain that with digital you get a big bushelful of benefits, and whatever you give up is mighty small.

Audio: How do you, as someone who has contributed to the state-of-the-art technology, envision the home music system changing during the next couple of decades? What sort of sequence do you see?

Stockham: I see the next major change being probably in the area of the digital audio disc we have discussed. You will be able to go to the store and buy a piece of plastic with digits on it, and a player to play it on. It will be connected to your present hi-fi system much like a cassette deck. And you will be able to play these records. It won't mean that you cannot play analog cassettes also or the analog records you have. It will be simply another input source.

But I envision another funny phenomenon happening when this disc player becomes available. I don't think people understand yet just how *good* these digital discs really are. For those who are really into listening and into hi-fi, as your magazine's readers are, the experience of hearing a digital master-tape-quality record is going to be the wave of the future. Just as an example, I was playing a high-quality direct-to-disc record in my home one evening, and I had some guests in — 10 or 20 couples. We had recorded the same piece of music at the same time on digital tape, and I had set up the digital recorder in the back room. When I started the disc, I pushed the start button on the digital tape recorder, so they would be in synchronization, then came out and let the disc play for awhile. During a quiet passage I just switched over without anybody noticing, in a place where the music did not change character in any way. Conversations were going on, and a few true-blue audiophiles were listening at the front of the room. When the digital music came up, fully 70 percent of the people in the room just fell silent.

Audio: Dumbstruck, as it were.

Stockham: Something happened. There was an involvement, a force of presence, something, that just enveloped them. And I've seen this again and again in playing our digital tapes. The involvement level goes way up; people are no longer exposing themselves to the music. They are becoming involved in it.

"...I'm absolutely certain that with digital you get a big bushelful of benefits, and whatever you give up is mighty small."

Audio: And you believe the advent of digital audio will involve a larger number of people more deeply?

Stockham: Right. Involve a much larger number of people who will feel that listening to recorded music is a more involving experience.

Audio: After the digital discs become available, what then?

Stockham: The major technological advances that still have to be made have to do with recording techniques, including microphone development and mike placement techniques, and with loudspeaker development, the whole transducer field. Attention is going to be returned to the sound radiation problem, new solutions to the questions of how you take the recorded sound and display it in the air. That will involve the loudspeakers themselves, and also the loudspeaker placement. It will involve a certain amount of signal and ambience processing. And, while I'm not advocating that multiplicities of channels should be aggressively sought by people, I think that it is an area that will receive a lot of attention. There are substantive improvements to be made here. We have made some progress on the problem of how to launch sound into the air, but we remain as far from being where we want to be as the mid-'50s mono record was from today's audiophile discs. A

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Audio etc.

Edward Tatnall Canby

Distortion! A fascinating subject both for the audio engineer and the avid listener. It is the very obverse of fi.

At last fall's AES Convention in New York, for instance, there was a memorable give-and-take at one of the morning technical sessions on a new aspect of this old subject, TIM. "TIM" for Timothy, otherwise known as Transient InterModulation. I'm not about to enter the Timothy fray nor any other of the sort, but I do approve. I also love to argue about distortions and I have my own ideas, as derived from the listener's hot seat. TIM has merely reached that point where before we can cope with it, even measure it, we have to codify and standardize and fence it in. It happens all the time and it needs to. Hence the big arguments.

Of course audio distortions tend to occur simultaneously, all at once, in the natural audio state. But we don't work that way. We have to isolate before we can measure, and we have to discover before we can isolate. So each of the great major types of distortion, the obverse of fi, has had its big moment in the engineering limelight over these years, almost like a series of high-level fads. If they're arguing TIM right now, wasn't it Ph.D. last year? That's phase distortion. And some time before that, quite awhile, we went into a prolonged hassle over plain IM, without the T, measured by nice continuous pairs of clean sine waves. Then there was T by itself, minus IM. Big thing, back then, even if TIM would seem to be a close younger relative. Transients, mixed, all kinds, like mixed nuts.

Back at our beginnings came the granddaddy of all distortions, the old original, now shortened to HD. It was the only kind I ever heard about when I got into this biz, and my earliest power amps were proud of their low, low four or five percent harmonic distortion. Honestly, truly. And don't think it wasn't audible. Most people enjoyed the sound, not having heard anything different other than live, which didn't really count. Good, solid harmonic distortion gave you a bright, metallic sound that could cut through the soggy layers of early audio out of low-pass pickups, cactus needles, and tubby speakers minus tweet. It was good. And it sounded loud, too. Sometimes I really miss it.

I take pleasure in the audible audio distortions because when they go away I can always hear the difference. Also, and maybe more important, because I find to my pleasure that each and every type of electronic distortion has its fair analog in live musical sound, not as distortion at all but *as part of the signal.* That's interesting.

Take IM, for instance. As I see it, IM corresponds to what musicians call beats. Sure, there might be a few li'l technical differences, but have you ever played a recorder (finger holes and no cassette) right next to someone else who is also playing a recorder? What you hear, in addition to the musical notes, is a shattering series of loud buzzes and beepings, seemingly inside your head, *bzzz, BZZZZZ, bheeee, Brrrr,* wildly different in pitch and totally unrelated to the music. These are sum and difference tones, which is to say, IM, but they are *not* distortion; they are "natural." You often hear them, too, in brass ensembles. (Oddly, a similar effect can be electronically generated — pure distortion — in faulty audio playback of the same music.)

Call Me Reproducible

Transients have any number of names in music, which is overpoweringly full of them — that's what we try so hard to reproduce. The now prized "chiff" of the old or Baroque organ is one transient that the 19th-century organ builders (misguidedly, according to present thought) were able to eliminate via "nicking" of the pipes, bleeding away the transients in favor of steady state. Then there is piano. I will not forget my first piano edits. Turn a piano tape backwards and you have a sort of wheeze box — no transients at the beginning and a sort of subdued cough (transients in reverse) at the end. But turn it frontwards, cut off the transient "head" — and you still have a piano sound. I was dumbfounded, the first time I heard this. The original transient burst is merely replaced by an electronic burst of distortion caused as the sharp edge of the steady tone goes by your tape head. But *is* it distortion? A question. Plenty of extant piano notes on a million different records have at least a few of these synthetic tone bursts, masquerading as perfectly good signal.

In singing and speaking there are glottal sounds, a breathy transient from down in the throat. And consonants — what else is a consonant but a bundle of transients? In almost every musical instrument there are deliber-

Sansui is breaking up a very successful relationship. The TU-717 has a new mate: The AU-719.

Sansui has just introduced an exciting new integrated amplifier, the AU-719. It represents the very latest developments in audio and electronics technology. It is so good, in fact, that it has replaced its rave-reviewed, best-selling predecessor as the partner of the TU-717 tuner.

The TU-717's performance has been extravagantly praised by professional critics and knowledgeable consumers alike. With advanced features like switchable IF bandwidth and specs like 81dB signal-to-noise ratio and 0.06% THD, it's only natural.

We expect the tuner's new mate to receive a tremendous reception and set industry amplifier standards for a long time to come. Here's why.

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What particularly distinguishes the new AU-719 amp is Sansui's patent-pending DD/DC (Diamond Differential/DC) circuitry that provides the extremely high drive current needed to reduce THD by adding large amounts of negative feedback without compromising slew rate or adding TIM.

Slew rate refers to an amplifier's ability to respond to rapidly changing musical signals. The slew rate of the AU-719 is an astounding 170V/μ Sec.

MAGNIFICENT MUSIC

Many modern amplifiers have extremely low total harmonic distortion specs. And that's important. But THD is measured with steady test signals and is not really representative of an amp's ability to deal with music. Sansui alone, with it's DD/DC technology, is able to provide both low THD and lowest TIM simultaneously. Instead of the harsh metallic sound you sometimes get on a conventional amp when the musical signals are complex, with the AU-719 you hear only magnificent music.

THD is less than 0.015% at full rated power of 90w/channel, min. RMS, both channels into 8 ohms from 10 - 20,000 Hz. Overall frequency response is awesome: DC - 400,000 Hz, +0, −3dB. Hum and noise are a super-silent −100dB on aux and −88dB on phono. The phono equalizer, which adheres to the standard RIAA curve within ±0.2dB from 20 - 20,000 Hz, also uses our unique DD/DC circuit for record reproduction that's second-to-none.

CONTROL YOURSELF

The unit is equipped with a full complement of versatile controls and connections to create the system and sound that's right for you, including two phono and two tape inputs, defeatable tone controls with switchable center frequencies, deck-to-deck tape dubbing and a very convenient 20 dB muting switch.

Audition the new AU-719 and matching TU-717 at your authorized Sansui dealer. We think it will be the start of a very successful relationship.

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ately induced percussive transients, from the bounce of a violin bow on the string to the *takataka* tonguing of wind instruments. As for nonpitched percussion, notably the drum, the sound is a mass of transients and not much else. So we musicians are quite familiar with transients, though not as distortion.

All of which I think makes clear what we mean by distortion. We are trying to be faithful to an original, a "given," and that includes the faithful reproduction of all these sound effects. We can only define distortion, then, in terms of a *prior model*, and the definition of that model can be a tough problem. Oversimplification is our greatest trap, the easy way out. The trouble with IM is that it doesn't include TIM; we get false readings when it comes to actual listening sound. On the other hand, what do you do about reproducing an "original" that is distributed over 24 separate tape tracks? Or how about the hi-fi reproduction of those electronic fuzz noises in pop music, deliberate electronic distortions (are they, though?) which must be distortionlessly reproduced! It's a slippery world, and no wonder there are arguments. I think, though, that it is reassuring to know that real-life natural sound so neatly parallels the unwanted, falsely generated electronic signals which in fact do constitute our carefully studied types of distortion.

As a listener, I tend to make my own categories of audible distortions, just as I hear them out at the very end of the long audio chain. I fancy that these categories do indeed have some relationship to those of the engineers in our business — that is, I am hearing what *they* are talking about. But as a musician I can never be sure; I only know what I like, as the music hater says.

Categorically Speaking

I have assembled for this month no less than three Canby Categories of audible distortion, and you may make what you will of them. The first, shall I say my 'first-order" category, is the kind which, if I am right, is caused by harmonics generated in the system, here, there, everywhere. It is very uncommon now, and usually unmeasurable, but it wasn't so in the past. We used to hear positively enormous quantities of this distortion back in the 78-rpm days, early through late. Vast harmonic content, variably transient, via the old shellac disc and its crude "needle" and cartridge and via many a brave new early loudspeaker. I can hear all those sounds in my head and

they weren't always so bad. Various terms come to mind, pro and con — we talked about buzz, blast, grind, needle chatter, and about worn grooves and worn needles, sometimes minus their points, or the tips bent into a hook. There were cracked crystals, strained speaker cones, tired tubes, and I don't know what else — the resulting sounds had a clear family relationship, from the gentlest to the most raucous. Harmonic? Mainly.

If so, that is important. Because every such distortion is directly related, for the ear, to the "fundamental" sound, the original signal. Harmonics make not only harmony but, more importantly, the whole range of audible tone color. So we were able to "read" this distortion to a remarkable extent as a kind of added coloration, often grotesque and hideous, but often relatively pleasant. Some brand-new speakers in early hi-fi were actually advertised as "golden" in sound — note the coloration — though this was perhaps to avoid the thought of a less flattering term, "tinny."

Yes, there must have been plenty of the other known distortions in these

"The ne to tru in our media the more we must b the tiny no that are sti strictly signal.

earlier reproduced sounds, even did not then recognize them. But . ly the biggest factor was harmonic tortion in enormously high perce tages. So I would think.

I cannot say exactly how my "second-order" category of audible distortion will look in the figures, but it is certainly a very different kind of unpleasantness, a new sound, cropping up mostly via late-model advanced circuitry though I first heard it myself on early FM. I still do. Strong adjacent FM station tries to butt in on your music. *Sput, sputter, splat*! Unmistakable and most unattractive. There is no harmonic message in this ugly sound and no coloration. It is just loud, jagged, a shattering, tearing noise that is completely destructive. I hate it. But I hear it more and more often.

Definitely this is the ugliest of all the gross distortions, far more unpleasant than any ordinary buzzing or blasting. If there is music in its origin, an occasional bit of musical pitch often gets through with the splat, but it is no more than a hideous gargle, not music. Purely indigestible, this stuff, and you can give me Caruso on an acoustic portable with a broken needle any day.

A particularly jarring example of this sputtery distortion was to be heard a good while back via those brave earlier four-channel "discrete" record systems. It came at the dramatic peaks of volume and particularly via the innermost record grooves. Few of us would care to listen to *any* music with that sort of loud sputter coming through every so often! The CD-4 people made heroic efforts to improve, and in their later demodulators the splats were gone. But, alas, it was too late. No more. Curious that here we were also dealing with FM circuitry, via the CD-4 supersonic modulation of the groove walls. Curious, too, that none of the "matrix" decode equipment I ever tried produced this splatty sort of distortion, not even those with logic. Probably just didn't happen to have the right elements in their circuits to

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An acknowledged world leader in loudspeaker design and engineering, KEF has developed a monitor-standard speaker system that is both small — only ¼-cubic foot in size—and truly "high" fidelity. While these objectives are not new, the Reference Series Model 101 speaker system represents the first time that both are available in one product.

The Model 101 is, therefore, ideal for use in locations where an accurate small speaker is required in keeping with the rest of a high quality audio system.

KEF Reference Series Model 101:

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System Design

Despite all the ingenious ideas that have been proposed by various speaker manufacturers over the years, the three basic parameters of Enclosure Volume, Bass Response and Efficiency are still related by unchanged physical laws. What is different is the thorough manner in which KEF engineers have, with the use of advanced technology, optimized the relationships between these parameters.

Starting with the premise that prospective Model 101 users will have substantial amplification available, KEF engineers achieved a response from this small enclosure of 90Hz–30kHz ±2dB (–10dB at 47Hz).

KEF's leadership in computer-aided digital analysis techniques enabled them to optimize the design of the drivers, crossover network and enclosure to achieve a Target Acoustic Response without repetitious trial and error experimentation. Much of this technology, which did not previously exist, has been applied to the design and production of a small high fidelity speaker system for the first time in the Model 101.

Once the desired prototype was completed, KEF applied the same unique computer-aided techniques developed for the production of the critically acclaimed Model 105, so that the sound quality originally achieved in the laboratory prototype will be available to every user.

In addition, the high standards of the computer-aided production and assembly procedures enable precision-matched pairs of stereo loudspeakers to now be offered. For example: every Model 101 driver is tested and matched to tolerances of better than 0.5dB, and crossover networks to tolerances of 0.1dB; each pair of drive units is matched not only to each other, but to the other components in the system as well.

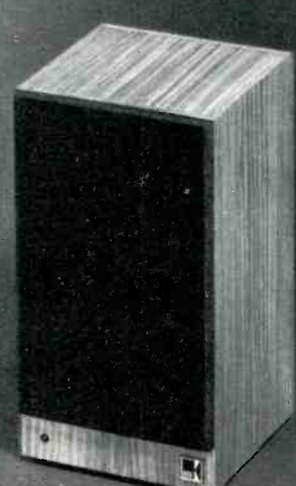
Loudspeaker Protection

The major problem with small, relatively less efficient loudspeakers is thermal overloading of the voice coils. KEF engineers have developed a unique self-powered electronic overload protection circuit, S-STOP (Steady State and Transient Overload Protector).

Musical peaks are generally of short duration, so tweeters can handle far in excess of their normal program rating. A similar situation exists with low frequencies and their effect on the bass unit. Consequently any form of fuse protection can reasonably limit the instantaneous peak handling ability of the system, yet fail to protect the system against a very high average power level. KEF's solution is to incorporate a protection circuit which takes into account the instantaneous power applied to each drive unit and also computes the length of time the signal is applied. The law under which it operates resembles very closely the temperature rise within the voice coil. A potentially damaging signal is immediately attenuated by about 30dB, and the full signal is automatically reconnected when it is safe to do so.

As a result, the Model 101, although only ¼-cubic foot in size, is fully protected against fault conditions when used with amplifiers of up to 100 watts per channel.

The Model 101 is obviously not your average "miniature" speaker system where the quality of sound or power handling capacity is compromised by the small size of the enclosure. Nor is it inexpensive. If you require a speaker system that is both small and truly high fidelity, visit your authorized KEF dealer for a thorough demonstration. For his name, write: KEF Electronics, Ltd., c/o Intratec, P.O. Box 17414, Dulles International Airport, Washington, DC 20041.



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nerely indicated that
here, too, was a modern circuit which if forced to malfunction would give forth not a harmonic blast but a second-order splat. There must be a lot more of this around, at least in the potential. Can any reader pin it down?

D-Lightful

I won't dwell long on my "third-order" audible distortion because, well, it gets into aesthetics. But I have to bring it up because it just happens to be our greatest concern these days — the hi-fi reproduction of unwanted noise, the sounds we never asked for but get anyway. Our equipment can't tell the diff. between noise and signal, and that is the rub. We are frantically going this way and that in our search for the means to get rid of noise without getting rid of signal too. We have gone far. Autocorrelators (excellent), new metal tapes, plus hopefully better disc surfaces, Dolby, dbx, direct-to-d, digital, maybe even some more uses of the letter "D" for all I know. Yet at home I still hear unwanted noises, just as you do. They are terrifyingly diverse — we have to scatter our fire. FM stereo may give out splats but it is also still pretty hissy. Even the natural ambient sound of a concert hall or church can get to be a big problem — but there we get into the aesthetics because that ambience is *part of the signal*, even a part of the musical effect, and therefore we must treat it with deference.

The nearer we come to true silence in our media background, the more careful we must be of all the tiny noises that are still strictly signal. Where we now have that new silence, in all-digital recording, via dbx encoded discs, even in a few direct-to-disc releases (by no means all of them!), we suddenly find exasperating new problems thanks to the ear's uncanny ability to hear ultra-low-level residual noises once they are unmasked.

Don't misunderstand me—I have been fascinated by my first batch of dbx noiseless discs and am certain that this is the most important new system we have seen in recent years that uses the still-viable LP record as its base. It has caused me absolutely no trouble since I got the levels of in and out adjusted properly—never a splat again. But there are a few mighty interesting further items to be noted in connection with dbx.

For example, on a number of dbx discs from various labels, I became aware that some tape editor had repeatedly cut off the die-away reverbs at the end of the musical segments *before* they had quite disappeared. Now that is an old fault, seldom heard today thanks to more aware and careful editing. So why here? I suspect that the answer is as you might guess—the noiseless disc has uncovered a new area of audible die-away where formerly the sound merged into general surface noise. Now we have to edit further down, virtually to zero. It's astonishing the way the ear can pick up these tiny faults, down in what used to be (still normally is) the proverbial mud. Caveat editor!

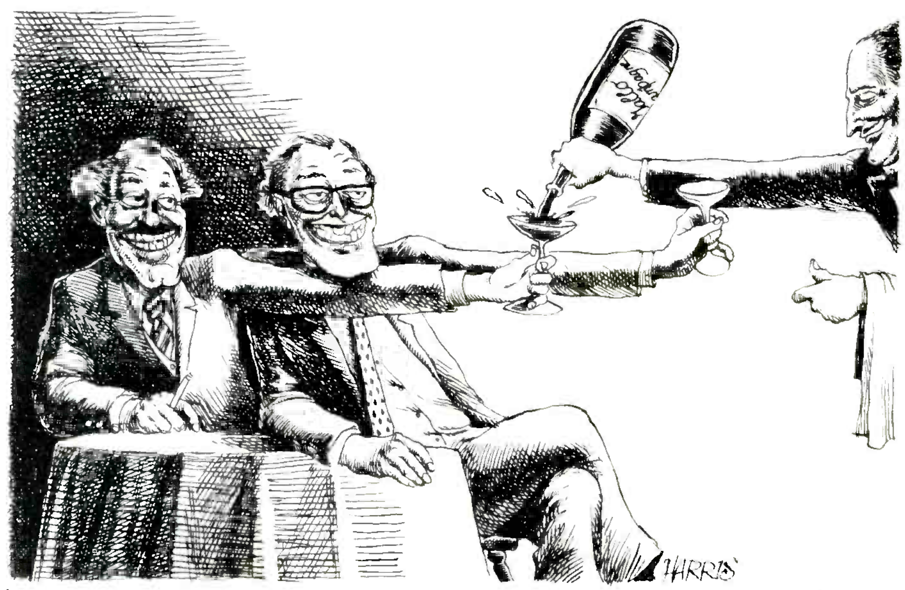
I also noticed on the dbx discs that the problem of built-in hall ambience is not always adequately solved. It is quite normal today for a record producer to fade hall noise down to zero between movements, where there is normally a strip of leader tape inserted to fill up the time. OK—we mostly don't notice this because once again the ambient noise blends into the surface sound. Now, alas, we must rethink this problem. On a number of dbx discs I became unpleasantly aware of these between-movement breaks, because not only is the ambient sound nakedly clear—distant buses, cars, faint clunks and bumps, even maybe the ghost of a voice or two—but the sudden fade-out for the leader strip leaves you thinking your system has just died. Total, disconcerting silence. And a clear disruption of the musical continuity.

We'll have to devise better ways, once it is established for the ear, to keep this ambient signal noise going (or fade it with care when it does have to go). In that way it is subliminal, which is the way it must be.

Well, the direct-to-disc boys and girls should be happy with this. No editing. Just one continuous play, straight through in real time, and ambience all the way. Just don't be tempted to close down your pots between numbers, you people. I'd much rather hear a few discreet coughs and a creaking chair than have to go through more of that unnerving sudden total silence in midstream. Aren't coughs and chair scrapes a part of musical performance? Is not silence, in this case, a clear distortion? You'd better start thinking so. **A**

Behind the scenes

Bert Whyte



Recessionary influences notwithstanding, the Audio Engineering Society held its 64th Convention, November 2 to 5, amid the somewhat faded splendors of the Waldorf Astoria in New York. Although rated as "the biggest AES Convention ever," there is no doubt that the present economic uncertainties are being closely monitored by many manufacturers. Let us say that the audio industry is sipping champagne, but it is of the domestic variety, not vintage French!

As you might expect, digital recording technology still holds the spotlight as the major topic of interest. 3M, which has been offering its 32-channel pre-mix digital recorder and 4-channel master recorder on a lease basis, is now making these units available on a direct sale basis. The 32-channel unit is priced at $115,000 and the 4-channel master recorder at $35,000. At the Convention, 3M introduced a 16-channel pre-mix digital recorder at $72,500, and a 16-channel update kit (to convert the 16-channel recorder to 32 channels) for $53,200. These new digital recorders are said to be available for immediate delivery. Also new from 3M were two digital-delay preview units for disc-cutting, a 1.3-second preview unit for $5,500, and a 1.96-second-delay preview unit for $7,400. The electronic editing system introduced at the 63rd AES Convention is priced at $7,500 and has recently been made available.

Much interest was shown in the new Mitsubishi X-80 digital recorder. This is a two-channel stereo recorder using quarter-inch tape at a speed of 15 ips. Its stationary head unit affords one hour of recording on a 10½-inch reel. The X-80 is a relatively light and transportable 143 pounds, lending itself to location recording. The unit uses 16-bit linear encoding with a sampling frequency of 50.35 kHz. The PCM signal is subjected to modified frequency modulation and is distributed among eight tracks on the quarter-inch tape, with a high recording density of 797 bit/mm. One auxiliary analog track and one SMPTE code address track are provided outside the digital tracks. The analog track permits normal tape-cut editing, with special circuitry allowing continuous phase-lock control across the splice point. The SMPTE code track allows electronic editing. Drop-out error correction is via cyclic redundancy check code, with interleaving and interpolation. Click-noise generation incidence is said to be extremely small. Frequency response is claimed to be within ±0.3 dB from 20 Hz to 20 kHz, while the dynamic range is said to be over 90 dB, with less than 0.02 percent distortion at peak levels. To make their digital recording system complete, Mitsubishi also offers the XE-1 electronic editor and a disc-cutter preview unit with delay times adjustable from 0.8 to 1.8 seconds. What caused quite a stir among the smaller independent recording companies were the Mitsubishi prices—"around $20,000" for the X-80 digital recorder, with the electronic editor at $8,000, and the disc-cutter delay unit at $7,000. In other words, for around $55,000 you get two X-80 recorders (one for recording, one for editing layout), the editor, and preview unit. This presently makes the Mitsubishi digital system the least expensive entry into digital recording.

Several From Sony

Sony continues to concentrate on digital recording technology. In fact, they now bill themselves as the "world's largest producer of digital recording equipment." Their exhibit in the ballroom of the Waldorf was almost entirely devoted to digital units, and they introduced a number of new products. Of prime interest was the PCM-3324 digital recorder. The system consists of a 24-channel transport with fixed heads, using half-inch video tape at 30 ips, with a separate rack mount for the digital audio processor. At 30 ips, this machine can record for 60 minutes on a 14-inch reel of Sony V-16 video tape. The recorder uses 16-bit linear encoding and has the facility of switchable sampling frequencies of 32 (some Europeans favor this), 44.056 (EIAJ standard), 44.1, 48, 50.0, 50.35, and 50.7 kHz. The track format is two digital tracks per channel, one track for SMPTE time code, and two tracks for

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High fidelity is the sum total of audio experience. It means not only superb styling but ease of operation. It also means the joy of listening, even in the midst of a frenetic work schedule. Just turn on the system, relax and forget your problems and experience an audio happening.

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

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

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

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

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

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

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

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

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

See your nearest Lux dealer for a unique listening experience.

LUX AUDIO OF AMERICA, LTD.
160 Dupont Street, Plainview, NY 11803 (516) 349-7070
11200 Chandler Blvd., North Hollywood, CA 91603 (213) 985-4500
In Canada: Lux Audio of Canada, Ltd., Ontario

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

analog audio. The analog tracks permit normal tape-cut editing, while the SMPTE track affords electronic editing and multi-deck synchronization. Punch in/out recording is also provided. There are analog as well as digital input/output connections for interfacing with existing analog and new generation digital studio systems. Sony has a new correcting code and modified cross-word error-correcting system in this unit. With the data blocks incorporating internal as well as external error-checking, there is a total of 41.7 percent redundancy for synchronization and correction. Sony claims this new PCM-3324 recorder affords digital-to-digital duplication with no signal quality deterioration.

While the Sony 1600 PCM with U-Matic VTR is now on the market and has been used for digital location recording, their new portable digital recorder, the PCM-3204 introduced at this AES Convention, would seem to be even more suitable for this type of use. The PCM-3204 is a 4-channel, fixed-head unit using quarter-inch video tape at 15 ips. At this speed, two hours of recording are possible with

Sony PCM-3324

14-inch reels of tape. As with the PCM-3324, the tape format is two digital tracks per channel, one SMPTE time code track, and two analog audio tracks. Thus, both tape-cut and electronic editing are possible. The PCM-3204 also uses the new error-correcting code. This recorder uses 16-bit linear quantization, with the same switchable sampling rates as the PCM-3324. Complete A-D and D-A conversion facilities and all digital circuitry are integral in the portable case. At nearly 250 pounds, it might be better to call this recorder "transportable," rather than portable! No pricing given yet, but this attractive "purpose-built" digital recorder would seem to be well-suited to classical location recording, especially of the miminum microphone "purist" variety. When available, I'd love to give this unit a good workout with something like *The Rites of Spring* or the Mahler 3rd Symphony!

Another item Sony introduced was their DRE-2000 digital reverberation system. This is a two-channel delay and reverberation unit, with a microcomputer to preprogram up to nine different modes of reverberation. Delay time range is from 0 to 255 milliseconds, with reverberation times from 0.1 to 9.9 seconds. The unit accepts 16-bit digital input and output signals directly and has built-in A/D and D/A converters. A single-cable remote control is supplied. Also new from Sony was the DSX-87 sampling rate converter. This two-channel unit with its own internal clock can convert in real time from 44.056 (for video-based PCM converters) to the 50.35 kHz sampling rate used in Sony's 3300 series open-reel digital recorders. Inputs are also available for external system clocks, allowing interconversion between other sampling frequencies in 7:8 or 8:7 ratios up to a maximum frequency of 55 kHz. The DSX-87 avoids the problem of leaving the digital domain, going to analog, and returning to digital when dubbing between recorders with different sampling rates.

The weakest link in your hi-fi system isn't in your system.

You could spend thousands of dollars on your stereo system and still not hear its full musical potential. That's because all hi fi systems, even the most sophisticated, have one weak link—*the music source itself.*

Dynamic range (the difference between the loudest and quietest music passages) is one of the primary elements that creates the power and excitement of a live performance. Records (even digital and direct-to-disc), pre-recorded tapes and radio broadcasts sound lifeless in comparison because they're missing more than 1/3 of this vital dynamic range. But add a dbx Dynamic Range Expander to any system, large or small, and the missing dynamics are amazingly restored.

dbx offers three state-of-the-art expanders that let every stereo system flex its musical muscles. The 1BX, 2BX, 3BX Dynamic Range Expanders provide as much as a 50% improvement in dynamic range, with the additional benefit of up to 20dB reduction of background noise. Any model will let you enjoy *all the music* you never heard from your record and tape library.

Don't let the weak link make your investment in a good stereo system worthless. Visit your nearest dbx dealer for a demonstration of the dbx dynamic range expander that best fits your budget. Experience all the emotional impact and realism that was missing from your music. Records, tapes and radio broadcasts never sounded so good.

dbx, Incorporated, 71 Chapel St., Newton, MA 02195. (617) 964-3210.

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Lastly, Sony showed their new PCM-100 digital audio processor, a sort of upgraded version of their original "consumer" PCM-1 unit. The PCM-100 can be used with either Betamax or U-Matic video recorders. The PCM-100 uses the new Electronic Industries Association of Japan (EIAJ) standard of 14-bit linear quantization with the usual 44.056-kHz sampling frequency. Dynamic range is claimed to be greater than 85 dB, with less than 0.05 percent peak harmonic distortion, and a frequency response flat within ±2 dB from 3 Hz to 20 kHz. It is interesting that Sony suggests that the PCM-100 is especially suited to mass duplication of digital music VCR tapes. One PCM-100 unit between two VCRs is all that is needed for digital-to-digital dubbing. Sony claims that even multigeneration dubs will be identical to the digital master.

Over At Pioneer

In other digital activity at the Convention, Pioneer made a very strong case for the dual-purpose PCM disc, showing their laser/optical PCM player for video and PCM audio discs. While their player can handle laser-scanned video discs and may have some compatibility with the Sony video disc, they emphasized its digital audio playback capabilities. The quantization is 16-bit uniform, with a sampling frequency of 50.35 kHz. Pioneer claims a dynamic range of 96 dB and a frequency response of ±0.5 dB from 2 Hz to 20 kHz. They also note their optical disc system has a bandwidth of 10 MHz, three times greater than ordinary home VCR systems. Playback is via a diode laser on the disc spinning at 1800 rpm. Interestingly, the Pioneer disc has four channels with more than 80 dB separation between channels. Now that is what you call discrete! With four-channel sound, playback time is one hour per side; with stereo playback, it is two hours per side. Imagine — most operas could be recorded on one disc of 301-mm diameter! I should note that at the recent Japan Audio Fair, JVC showed a 4-channel version of their PCM capacitance audio disc.

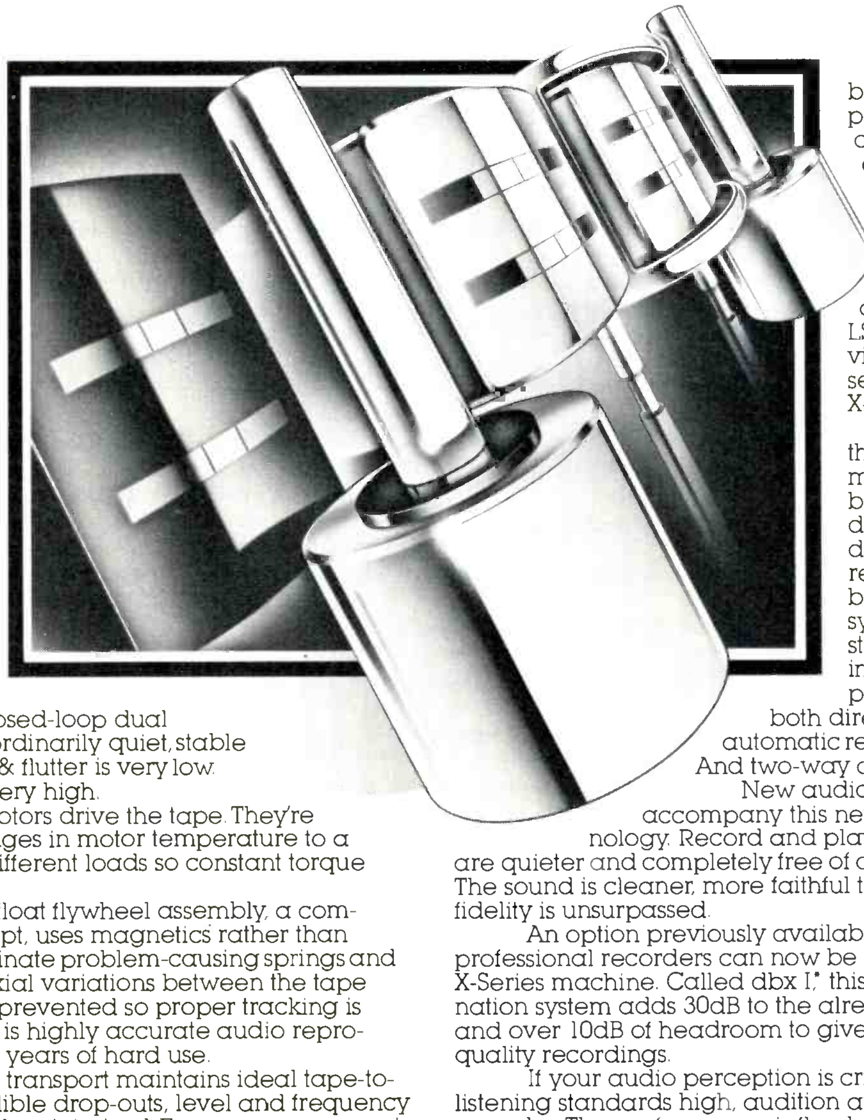
There was no digital recorder shown by Ampex. They actually have tested several experimental units but feel further research into digital technology is required to satisfy their criteria for a digital recorder. In the meanwhile, realizing that analog recording is very much with us and will be around for some time to come, they introduced a new generation analog recorder, the ATR-124. This is, in essence, a 24-channel version of the ATR-100 using two-inch tape. Ed Engberg, the Ampex de-

Ampex ATR-124

sign engineer who originally worked on the ATR-100 and is their newly appointed audio products manager, was kind enough to give me an operating run-through on this incredibly versatile machine, which appears to do everything for the studio recording engineer but shine his shoes! Even though 2-inch tape is used, the ATR-124 has the same kind of closed-loop, d.c. servo transport that maintains constant dynamic tape tension at each reel; in all operating modes, without pinch rollers. New flux gate record heads combine recording and sync playback windings on one head. As in the ATR-100, recordings are phase equalized. Input and output modules are transformerless. The ATR-124 handles up to 16-inch reels for longer recording time at 30 ips. There is programmable monitoring with memory, with a battery-powered backup memory in case of a.c. power failure. If there is something wrong with a particular channel (or channels), the VU meter for the channel in question will flash a red warning. With dynamic reel-tension controls, it is possible to intermix reel sizes, i.e. 5-inch with 16-inch. The ATR-124 "Setup Memory" will store four individual setups of 24 channels each. All controls are touch-sensitive membrane types, linked to microprocessors. The same is true in the remote control unit. There is a "rehearse" control button, permitting manual rehearsal of a setup before actually committing it to final recording. And on and on. Quite a machine!

Next month I'll wind up the AES 64th Convention report with a number of interesting items, including a new addition to the ultra versatile BADAP unit from Barclay Analytical that shows a color stereo display on a CRT and the *out-of-phase* components in a contrasting color display!

TEAC TODAY: THE X-SERIES.



You're looking at four new machines that have more in common with data recorders than audio recorders. Together they are called the X-Series. And they bring a totally new kind of technology to the open reel format.

Each X-Series transport is an instrumentation mechanism. For 15 years, this TEAC design has stood the grueling test of time in computer installations where dependability is worth millions.

The basic configuration is closed-loop dual capstan. It's extraordinarily quiet, stable and precise. Wow & flutter is very low. Speed accuracy very high.

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

Our Magnefloat flywheel assembly, a completely new concept, uses magnetics rather than mechanics to eliminate problem-causing springs and pressure plates. Axial variations between the tape and capstans are prevented so proper tracking is assured. The result is highly accurate audio reproduction even after years of hard use.

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

The brain behind the transport is our LSI control chip. It eliminates the need for mechanical relays so transport control is faster, more positive and reliable. The LSI also lets us provide full motion-sensing in the X-10 and X-10R.

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

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

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

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

TEAC®

*dbx is a trademark of dbx, Inc.

Audioclinic

Joseph Giovanelli

FM Distortion vs. Signal Strength

Q. I notice a peculiar effect from my tuner. I have it connected to a simple dipole antenna made from a 60-in. length of twin lead. I get plenty of volume and a strong signal on the tuning indicator from most New York-area stations, although I live 20 to 30 miles away. There seems, however, to be a harshness in the upper midrange and treble passages during the playing of orchestral music. The harshness does not seem to be present in solo and voice passages. I believe that I get a definite improvement when I connect my TV antenna to the tuner.

— Name withheld

A. The distortion you notice on your FM tuner may, in part, be caused by insufficient signal strength. In some tuners, the i.f. bandwidth increases with signal strength. This increase takes place even when the limiters begin working. I have noticed that in some tuners, especially those of older design, the i.f. bandwidth may be narrow enough under weak or even moderately strong signal conditions that the i.f. system cannot accommodate a fully modulated FM signal.

By connecting your tuner to an outdoor antenna, signal strength is increased, and i.f. bandwidth will increase. Hence, audio quality improves.

It may also be that the outdoor antenna is less subject to multipath reception than the indoor antenna. Such reception problems can lead to distortion. If possible, therefore, use the outdoor antenna. If this is not possible for some reason, try orienting the indoor dipole for best signal quality, regardless of signal strength.

Loudspeakers and SPL

Q. I have heard from friends that the Dahlquist DQ-10a speaker would create too much sound pressure for my neighbors to endure at "normal" listening levels, which for me are 85 to 90 dB as indicated on my SPL meter. I have been told that I should live in a detached home to use such a speaker. Is this true? — B.L. Byrams, Beltsville, Md.

A. Any speaker — Dahlquist or otherwise — can produce listening levels which will annoy neighbors. This fact is not a reason to buy or not buy any given speaker. For example, a stove is capable of heating up a frying pan to a point where the fat can catch fire. This is not a reason to get rid of the stove; rather, it tells us to use the stove with care. This same logic applies to the use of a loudspeaker system. Of course, any reasonably good (or better) speaker can be made to produce high SPL, but by turning the volume control down, the sound level won't be too loud for you or your neighbors. Use your sound system to suit your particular circumstances.

Tube Substitution

Q. Being of the old school, I still like and use tube amplifiers. The tube line-up of my present amplifier is: EF86, 6SN7GTB, two-6L6GBs and a 5U4GB.

I would like to have a complete kit of spare tubes. I have been considering the purchase of a pair of 6L6GCs and a GZ34 and substituting these for the 6L6GBs and for the 5U4GB.

Is there a reason why these substitutions should not be made? Do these tubes produce any change in operating conditions such as undesirable increased voltages? — John Kogler, New York, N.Y.

A. I see no reason why you cannot substitute the tubes as you have outlined. The GZ34 has a definite advantage over the 5U4. This tube will not warm up until the other tubes in the amplifier have done so, which will eliminate the high, no-load voltage that stands across the filter capacitors when the quick-heating 5U4 is used.

Eliminating this no-load voltage is especially useful now, inasmuch as the filter capacitors in your amplifier are, no doubt, quite old. The high, no-load voltage could otherwise cause these capacitors to break down.

The internal resistance of the GZ34 is a bit lower than that in the 5U4. This will result in slightly higher operating voltages, but will in no way impair the operation of your amplifier.

The 6L6GC is a bit more rugged than its predecessor, so this is a good change, too.

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

The Universal Expander

Dynamic range limiting during the production of records (and of FM broadcasts) has long been a source of irritation for music lovers. As playback equipment improves, the limitations of most program material become more and more obvious. The vast majority of records are produced with the lowest common denominator in mind—a system that is restricted in its ability to recreate natural dynamic range.

With the introduction of the Dynamic Expander, MXR's Consumer Products Group has achieved its goal of providing a signal expansion technique for all types of music compatible with the finest audiophile equipment available.

Enter the typical dynamic range expander: While dynamics are restored, a series of disturbing side effects becomes apparent. Because typical expanders cannot distinguish scratches, ticks, pops, and rumble from music, these noises trigger the expansion circuitry. More importantly, because most existing expanders have a fixed value release time, they seem to 'pump' with some music, and hiss or 'breathe' with other kinds of music.

In most cases these drawbacks have outweighed the advantages of expansion for the critical listener.

Enter MXR's Dynamic Expander: a linear signal processor with up to 8 dB upward expansion (restoring musical peaks) and as much as 21 dB downward expansion (reducing noise). MXR has solved the problem of 'breathing and pumping' by providing a variable release-time control that tailors the response characteristics of the expander to the program material.

A sophisticated level detection circuit discriminates between music and unwanted information such as rumble and scratches. To monitor gain changes, a unique LED display accurately indicates the expander's effect on the signal whether in or out of the circuit. A level control adjusts the detector's sensitivity to optimize the expansion for varying signal levels, and additional controls provide in/out bypass switching and versatile taping facilities.

The MXR Dynamic Expander preserves the bandwidth, stereo image, and spectral balance of the original signal even after processing. Dynamic range expansion that is musically natural will restore the excitement and nuance that makes live music so emotionally satisfying, and will let you rediscover your cherished recordings. Harnessing innovative technology and sophisticated production techniques, MXR continues its commitment to the music lover.

The expanding universe of signal-enhancing equipment from MXR's Consumer Products Group gives demanding music listeners maximum performance from their playback systems regardless of room acoustics or program deficiencies. The MXR Compander allows you to maintain the dynamic range of source material through open reel or cassette tape decks. Environmental equalization is easily achieved with your choice of stereo 10 band (full octave), stereo 15 band (two-third octave) or professional one-third octave equalizers all built to the exacting performance specs for which MXR is famous. See your MXR dealer.

MXR Innovations, Inc., 247 N. Goodman Street, Rochester, New York 14607, (716) 442-5320

MXR Consumer Products Group

The forum

Equipment Directory Specs

The Annual Equipment Directory published each October by *Audio* is certainly a service to the buying public since it contains so many specifications on so many pieces of equipment. But the reader clearly is invited to make comparisons among brands, and within a brand, using the published specifications as guidance. For example, a listener could rightly want to know how much money needs to be spent to achieve a certain level of performance, or where more money spent yields ever decreasing returns.

Unfortunately, in several key areas there is much left to be desired to make such comparisons useful. Obviously it is the manufacturers who must supply accurate data to *Audio;* no one organization could hope to make the 40,000 measurements necessary to publish such a comprehensive listing. But there are often conflicting standards which result in measured, but not real, differences. Even within one standard, setup conditions can also influence the results.

Outlined below are some of the more obvious areas where comparisons must be made with a grain (should I say a shaker?) of salt.

Phono Signal-to-Noise Ratio. Phono signal-to-noise is the specification with the largest deviation from reality. This is clear in just glancing down the range of stated signal-to-noise ratios; the range encompasses figures from 60 to 160 dB! This should be and is unbelievable, and the principal problem with it is that it sours people on the ability of competent engineers to make real, valuable measurements. We often hear the argument voiced that measurements don't mean anything because the instruments do not measure anything like the way we hear. In fact, IHF Standard A-202 specifies a "dummy" source impedance and appropriate psychometric weighting to closely associate measurements *and* listening.

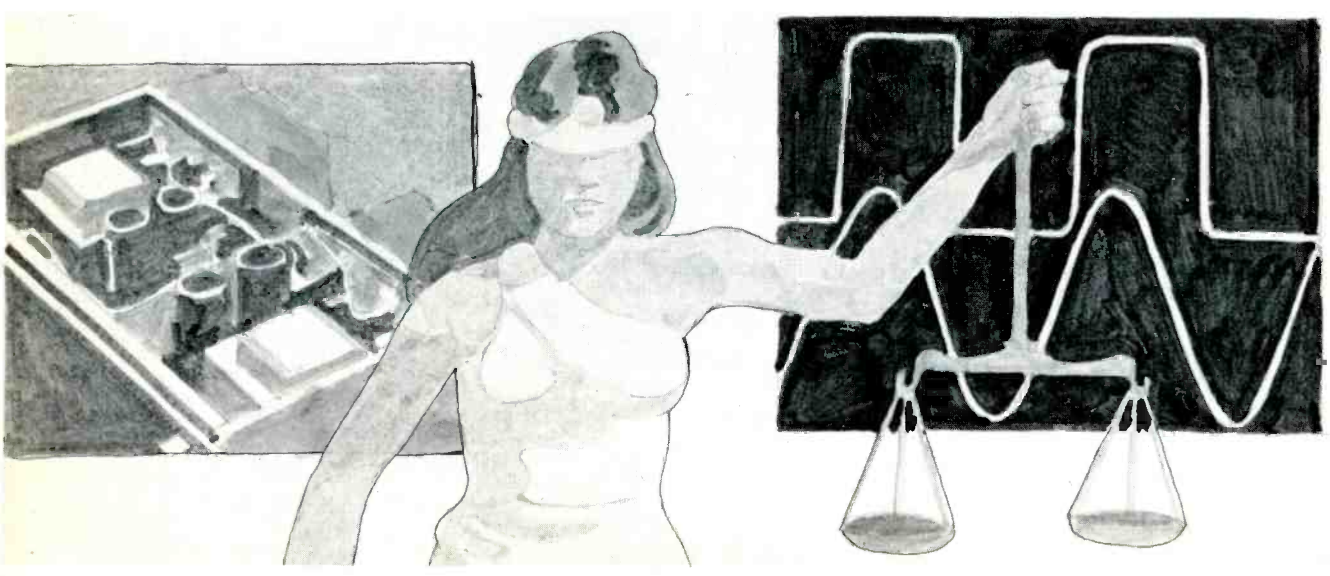
The extreme range of the signal-to-noise specifications should give away the fact that manufacturers are not uniformly using the standard. While probably none of the measurements is an outright lie, the range itself should tell us that the results are not credible for comparison. And this indeed is the case.

The problem is that some manufacturers are measuring with a shorted input, while others employ the cartridge-like source impedance specified by IHF A-202. The *real* problem here is that one can actually design for better performance with a short circuit than with a cartridge, then measure with a shorted input and get phenomenal signal-to-noise ratios which are not in any way achievable in practice.

The only way to obtain a signal-to-noise ratio, re: 5 mV, "A" weighted, with the IHF source impedance connected, would be to reduce the temperature of the source impedance to within 2 millionths of a degree of absolute zero! Any actual source impedance has associated with it a certain amount of noise due to the random motion of electrons in a conductor at room temperature (similar to the Brownian motion of electrons in the atmosphere). The only way to eliminate this noise would be to reduce the temperature of the source impedance or cartridge to absolute zero (one visualizes mad-scientist experiments with tanks of liquid nitrogen connected to tubes running down the tonearm to supply the cartridge with cold).

The noise level of the IHF standard source-impedance terminated with 200 pF and 47 kilohm is 78 dB below a 5-mV, 1-kHz input when "A" weighted. Since any realizable circuit will add some noise, signal-to-noise ratio numbers close to this have likely been measured in accordance with the standard and may be compared. Of course, some manufacturers are more conservative than others: Some give the limit of production, while others give the average.

Conclusion: One should look on all numbers greater than 78 dB as probably representing a shorted input con-



Why Yamaha speakers sound better than all the others. Even before you hear them.

To make a speaker that produces accurate sound is not simple. It requires painstaking attention to detail, precise craftsmanship, and advanced technology.

And that's where Yamaha comes in. We build all our speakers with the utmost precision in every detail.

As the premier examples of Yamaha loudspeaker craftsmanship, read what goes into the two speakers shown, the NS-690II and the NS-1000M. Then you'll understand why Yamaha loudspeakers sound better. Even before you hear them.

Precision Yamaha crafted cabinetry – **(1)** The walls on these, and all Yamaha speaker cabinets, are sturdily braced and crossbraced at every possible stress point. **(2)** The corner seam craftsmanship is so fine that it looks like the cabinet is made from one continuous piece of wood.

The back panels on these speakers are flush-mounted for maximum air volume within the cabinet. **(3)** Inside, a ¾" felt lining "decouples" the cabinet from the drivers to achieve acoustic isolation of the woofer from the cabinet. **(4)** Thick glass-wool also aids in damping the woofer for maximum performance.

Lift one of these Yamaha speakers. It's uncommonly heavy and sturdy. **(5)** We even glue and screw the woofer cutout from the baffle to the inside rear panel for greater cabinet rigidity.

Now knock on the cabinet. It will sound as solid and substantial as it is.

Precision Yamaha Drivers – **(6)** The drivers are mounted on computer-cut baffle boards with exacting, critical tolerances to insure precision fit. All Yamaha speakers are acoustic suspension design, and this precise fit is critical for an airtight seal and optimum woofer recovery.

The drivers on these, and all Yamahc speakers, are flush-mounted on the baffle board to avoid unwanted diffraction of the sound waves. **(7)** This is especially important because all our tweeters and mid-high range drivers are the maximum-dispersion dome type for the most natural reproduction of voice and instruments.

(8) We use chrome-plated machine screws (rather than wood screws) with two washers (regular and lock) to insure an unyielding mounting.

(9) The speaker frames shown are die cast rather than stamped. That's so they won't twist and alter the voice coil alignment during assembly and use.

Other Precision extras – All terminals are quick connect, screw-mounted assemblies.

(10) The wire leads are carefully soldered, not clipped.

All our speakers use full LRC crossover networks. These crossover networks are among the most advanced available.

Precision that stands alone – There's more. Much more. But, there is another fact of Yamaha loudspeaker construction that simply stands alone in the industry. Each component used in the two Yamaha speakers shown is manufactured by Yamaha. From the hefty die-cast speaker frames to the unique, ultra-low mass beryllium dome diaphragm. That's a statement no other manufacturer can make.

And therein lies Yamaha's story. If we put this much care and craftsmanship into the making of our components and cabinet structures, then imagine the care, precision and craftsmanship that go into the quality of the final sound. A sound built upon Yamaha's unique 98-year heritage as the world's largest and most meticulous manufacturer of musical instruments. From our most economical loudspeaker to our top-of-the-line models shown here, Yamaha retains the same attention to detail and craftsmanship.

Look before you listen. You'll be convinced that Yamaha loudspeakers sound better than the rest. Even before you turn them on. Then ask for a personal demonstration of these and other Yamaha loudspeakers at your Yamaha Audio Specialty Dealer, listed in the Yellow Pages. Or write us: Yamaha, Audio Div., P.O. Box 6600, Buena Park, CA 90622.

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dition and therefore not accurately reflecting the real-world condition of having a cartridge source impedance connected. Remember that design for a shorted input can yield worse results when a cartridge is connected than design for a cartridge source impedance.

Frequency Response. In the section on power amplifiers, "frequency response" was taken by many manufacturers to mean "power bandwidth." This was because of the inclusion of the phrase "at rated power" in the description of the column for frequency response, which implies that the question really asks for the "power bandwidth" rather than the "frequency response." Unfortunately, a number of manufacturers ignored the "at rated power" statement and provided a specification for low-level frequency response. This is clear because some of the claims stretch out to 250 kHz; I am certain they didn't intend this to mean that the unit will produce rated power at rated distortion, or lower, at that frequency! Furthermore, a specified frequency response without a statement of the deviations from flat in dB is practically useless.

Another influence on frequency response measurements, especially of preamplifiers and integrated amplifiers, is the fact that the setup conditions may change the response dramatically. For example, one could choose to rate the response only with a tone-defeat switch engaged. Or one could rate the response with the tone controls in but adjusted to give the flattest response, whether that response corresponded to the position marked flat or not. Also, naturally enough, most frequency response measurements are made with all filters disengaged, even though the action of the filters is intended to be infra- or ultrasonic and engaged in normal operation of the unit. Thus, the manufacturer who gives response under the standard operating conditions is penalized.

Wow and Flutter. *Audio* clearly calls for wow-and-flutter measurements to be made to the internationally recognized DIN 45 507 standard (which corresponds to the American IEEE and many other standards). Yet, it is obvious to anyone who has ever made these measurements that the quoted specifications greatly exceed those that could be expected to be realized in practice.

For example, in a recent Boston Audio Society test clinic, I measured one turntable-arm combination of Japanese origin which produced 0.12 percent DIN-weighted peak wow and flutter. The specification for this combination listed in *Audio* was 0.03 percent. Neither of these numbers would be important if both were inaudible. But Stott and Axon of the BBC found that the threshold for the perception of flutter among the most sensitive group of listeners was in the range of 0.12 percent peak. Thus, what we measured is probably audible wow and flutter to sensitive listeners with piano music program material, but 0.03 percent weighted peak is probably inaudible to listeners on music (although it could probably be heard on pure tones).

The difficulty is that there is a competing standard called JIS. This Japanese standard produces numbers which are highly optimistic compared with DIN-weighted peak measurements. Some manufacturers have signaled their use of the Japanese standard by adding the term "W rms," standing for weighted rms to the number, but others, however, clearly have not. In our measurements on 28 cartridge-arm-turntable combinations, the best measurement we got was 0.044 percent. The worst was 0.17 percent; the average was 0.09 percent.

Another difficulty is that the wow-and-flutter measurements on a turntable are influenced by the choice of arm and cartridge. If, for example, the peak in the frequency response (which occurs as a result of the resonance between the tonearm, plus cartridge effective mass, and the cartridge compliance) happens to land near a frequency equal to the eccentricity of a motor pulley, the flutter will be exacerbated. So a wow-and-flutter measurement without reference to a tonearm and cartridge is not too meaningful.

Also, in our measurements we used an aluminum-backed lacquer master which is very flat physically. We expect that slight warps on vinyl pressings would increase measured wow and flutter. If the frequency of the warp should land near the frequency of the tonearm/cartridge resonance, we might expect a fairly large factor of increase. So what we were measuring (and the way things are usually measured) may be hopelessly optimistic compared to practice.

These are but a few of the more blatant areas where specifications from one manufacturer do not correlate with specifications from another. And, of course, any such survey which can devote only limited space to an individual product does not tell the entire story on specifications for a unit. For example, most engineers believe that distortions other than total harmonic distortion are more annoying to the listener, yet THD persists as most important nowadays by government decree. The only hope of covering all of the various distortion mechanisms which are known is to conduct a large variety of tests; such a variety could not be published in a format like *Audio's* Equipment Directory, yet a variety is almost certainly more important than the THD numbers published.

Tomlinson Holman
Apt. Corp.
Cambridge, Mass.

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2. Holman, Tomlinson, "Noise in Audio Systems," AES Preprint No. 1418 (N-2) presented at the 61st Audio Engineering Society Convention, New York, November, 1978.
3. "Audible Effects of Mechanical Resonances in Turntables," Bruel & Kjaer Application Note.

The Editor Replies: Touché, Mr. Holman, and thank you for expressing one small part of the difficulties we have in putting together our Annual Directory. We do indeed ask for power bandwidth in an ambiguous manner, and it shall be changed this year.

While in the past we have viewed many specifications with a raised eyebrow, we have also treated them as axiomatically true — so long as they were responsive, that is in dB, rather than watts, if an answer in dB were being asked for. If the maker supplying the answer apparently knew what the question was, we have left the answer alone. Questioning the manufacturers' specifications, we have felt, is more properly left to reviewers in our Equipment Profiles section.

Each year, we hear from a number of irate readers (not to mention public relations agencies) asking why their favorite manufacturer has been omitted from the Directory. For the past three years, we have been fortunate to have enough space to reply that "neither makers nor products are deleted; we simply received no material." This year the deadline was some seven weeks after the Directory forms were sent out; phone calls were made and mailgrams sent as the absolute deadline approached. In the absence of material, we have felt that no listing is better than repeating that of an earlier year, and we do, of course, publish an Addenda. We are mightily sorry to leave anyone out, but we think it would be worse to include outdated specifications and old price information. A

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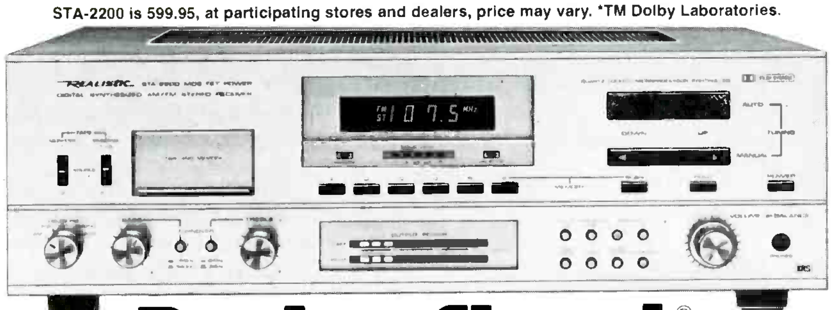
STA-2200 is 599.95, at participating stores and dealers, price may vary. *TM Dolby Laboratories.



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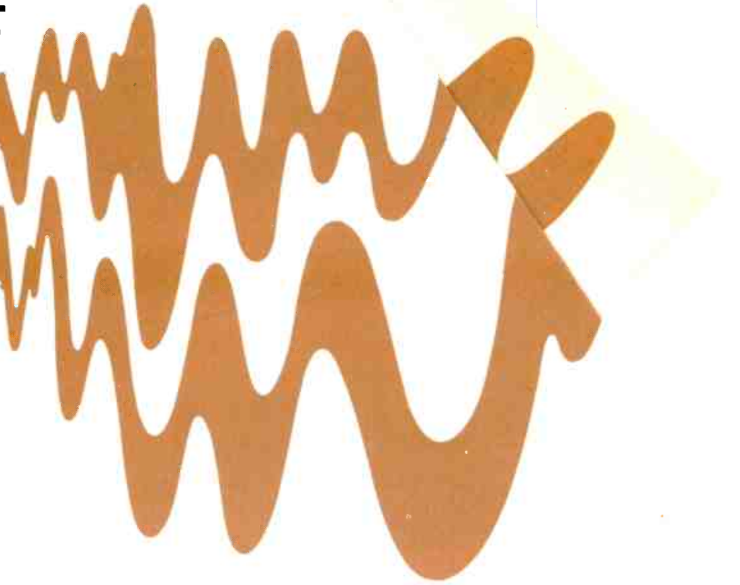
ANOTHER VIEW OF TIM

Part I



Robert R. Cordell

In recent years the use of large amounts of negative feedback in audio amplifiers has become controversial. Several people have examined the time-response properties of feedback amplifiers and have concluded that amplifiers which employ large amounts of negative feedback are prone to a form of high-frequency distortion called "transient intermodulation distortion" (TIM) [1-4]. Simply put, this distortion is said to occur when a signal changes too quickly for the amplifier to follow it properly.

The observation that a large amount of negative feedback causes TIM tends to run counter to the conventional wisdom that increased negative feedback generally improves a given amplifier's performance, so long as adequate stability is preserved. Several other researchers have recently questioned these findings and conclude that large amounts of negative feedback do *not* increase the possibility of TIM and can in fact improve amplifier performance as long as the amplifier has an adequate slew rate [5,6].

TIM is thus a popular subject surrounded by a certain amount of controversy. It has also become a frequently cited reason for degraded sound. Advertisements indicate that several manufacturers have been influenced by the discussions as well, some proudly pointing out that they use very little negative feedback.

Much of the misunderstanding and disagreement surrounding the subject seems to stem from inadequate consideration of the trade-offs and constraints involved in the application of negative feedback, especially as it relates to contemporary, real-world amplifier circuits. This is particularly true of feedback compensation. For this reason, we will take the time to review important negative feedback principles where necessary. Given a good understanding of negative feedback as it is applied to audio amplifiers, some of the TIM issues should become easier to resolve.

Before proceeding, we should point out that TIM, which is associated with negative feedback and its compensation, is only one form of high-frequency intermodulation distortion. The term "dynamic intermodulation distortion" (DIM) has been used to describe the general class of intermodulation distortions which depend on frequency as well as amplitude.. TIM is thus one form of DIM. Since the product of frequency and amplitude implies rate-of-change, and since the maximum rate-of-change that an amplifier can follow is called its slew rate, the term "slew induced distortion" (SID) has also been used as a label for DIM. These distinctions are, however, relatively weak and unimportant, referring more to the mechanism than to the measured or audible effect. Because it is the source of most of the controversy, we will concentrate on TIM; however, our discussion will consider other sources of DIM as well, some of which may in practice be more serious.

Transient Intermodulation Distortion

First, let's take a look at the popular TIM arguments to get some background. What follows is a sort of composite paraphrasing of many of the arguments which have appeared.

Feedback amplifiers operate on the principle that a large portion of the input signal is cancelled by feedback from the amplifier output, leaving a small signal-plus-error which drives the amplifier so as to produce the desired output. In amplifiers with large amounts of negative feedback, this signal-plus-error is forced to be very small and thus, in theory, low distortion results. Under these conditions, the net gain with feedback (closed-loop gain) depends almost exclusively on how much of the output signal is fed back; i.e., if one-tenth of it is fed back, the gain will be 10. The large feedback factor (ratio of gain without feedback to gain with feedback) is obtained by putting a large amount of gain in the forward-path or open-loop amplifier. The open-loop amplifier is thus very sensitive and will overload if the error, for some reason, gets at all appreciable.

All amplifiers have a finite delay from input to output. If a feedback amplifier is driven with a signal having a very fast rise time (like the leading edge of a square wave), there will be a brief interval during which the open-loop amplifier sees the full input signal, undiminished by negative feedback which hasn't yet gotten back to the input. Overload will thus occur and distortion will result. The more sensitive inputs of amplifiers with high feedback factors are that much more prone to such an overload.

Since this form of distortion is brought about by fast transients in the input signal and because an overload condition causes intermodulation distortion, the phenomenon is referred to as transient intermodulation distortion (TIM).

Returning to the origins of TIM, the situation is further aggravated by the additional slowness of response introduced in the open-loop amplifier by necessary feedback compensation. Each stage in a multi-stage amplifier introduces phase shift that increases with frequency. Feedback compensation rolls off the open-loop response so that the feedback factor falls below unity before enough excess phase shift accumulates to cause instability or peaking in the closed-loop response. The frequency where the feedback factor falls to unity is called the gain crossover frequency. In order to achieve a stable gain crossover frequency, the 6 dB/octave compensation roll-off must begin at some lower frequency. Amplifiers with large feedback factors (at low frequencies) have more gain to "get rid of" and must start their compensation roll-off at a lower frequency, resulting in a smaller open-loop bandwidth. An amplifier with 20 dB of feedback needn't start its roll-off until 100 kHz for a 1-MHz gain crossover, while one with 60 dB of feedback must start at 1 kHz. The latter amplifier, with heavier feedback compen-

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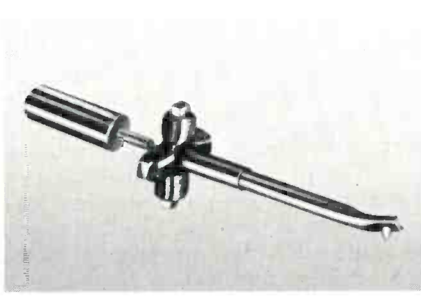
Not only does the Adcom Crosscoil provide more output, but its moving mass is extremely low permitting its use in a whole new generation of low mass, high performance tone arms.

Additionally, a newly developed "controlled compliance" cantilever assembly with an optimized stiffness to mass ratio insures that the cartridge/tone arm resonance will fall exactly where it should, above record warp and below audibility.



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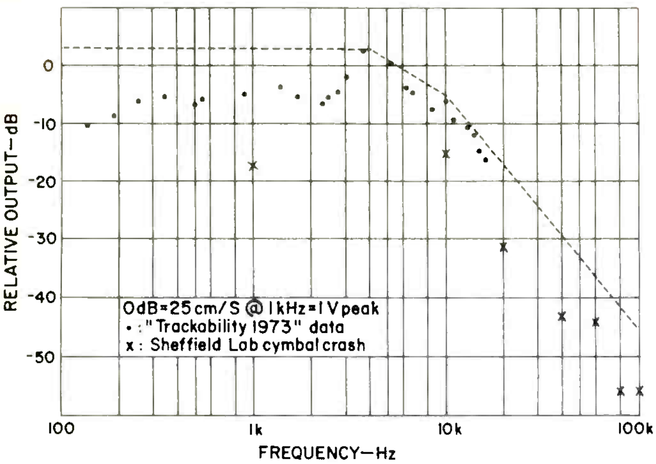

Fig. 1—Post-RIAA spectral distribution for phonograph records.

sation and a long open-loop time constant, is thus slower in responding to input signals.

In responding to a fast input signal (e.g., a square wave), a large internal voltage or current overshoot will be produced in order to quickly charge the compensating capacitor and overcome the effect of the long time constant it introduces. The large overshoot is produced during the interval between the fast input change and the time when the feedback catches up with the input, when a large difference or error signal is applied to the open-loop amplifier.

In some cases this overshoot may be 10 to 100 times as large as the nominal signal levels at that point. Unfortunately, the stages prior to the compensation point cannot always handle such a large signal without nonlinearity or outright clipping. If the overshoot causes these stages to clip or generate distortion, TIM results. When these overshoots are clipped, the amplifier is into the well-known phenomenon of slew-rate limiting.

It can be shown mathematically that if the input signal is bandlimited to a frequency less than the open-loop bandwidth of the amplifier, no overshoot can occur, even if the input signal is a bandlimited square wave. Thus, wide open-loop bandwidth eliminates the possibility of TIM caused by overshoots. Having wide open-loop bandwidth, in turn, places a limit on the feedback factor for a given gain crossover frequency. For example, if we choose an open-loop bandwidth of 20 kHz and a gain crossover frequency of 1 MHz, then we are limited to a feedback factor of only 34 dB.

The above explanationof TIM seems plausible enough, and it has appeared in various forms in many places. It is the origin of the popular belief that small feedback factors and wide open-loop bandwidth are necessary for minimizing TIM. Although it may at first glance seem convincing, this explanation is somewhat oversimplified and misleading. While some of the issues have been analyzed in great detail in technical papers, other more important considerations have been ignored. In several respects,the problem seems to lie with not seeing the forest for the trees. A few more recent papers have, however, done a very good job in lending insight and perspective to some of the more important issues [5,6].

The approach taken here will involve less detail and more scope and perspective. For example, we'll attempt to determine just how fast audio program signals really are. The length of the unavoidable time delay in the amplifier and how it is affected by feedback compensation is another important area in need of discussion. We will also examine the conditions governing overload of an amplifier's internal stages. This will be done in the context of a practical amplifier topology with realistic combinations of feedback factor and open-loop bandwidth. Recognizing that in addition to limits on amplitude, amplifiers are limited to providing a maximum rate-of-change at their output, much attention will be paid to amplifier slew-rate performance and its relationship to TIM. Finally, techniques for measuring amplifier TIM performance will be discussed.

Program Characteristics

Just as all real amplifiers are bandlimited, so are all real program sources. No program source will ever produce a square wave with razor-sharp edges. In fact, not only are program sources bandlimited in the small-signal sense, but they are more seriously limited in large-signal bandwidth, or power bandwidth. As an example, a fine tape machine might be flat to 20 kHz at low levels, but it typically cannot produce anywhere near full output at 20 kHz. Such restrictions are usually due to equalization which pre-emphasizes the high frequencies so that the subsequent de-emphasis at the reproducing end will reduce high-frequency noise. High frequencies will, therefore, overload the medium more readily than low frequencies. Such equalization characteristics are common to almost every type of program source, including phonograph, FM, and tape. As a result, the maximum high-frequency output of each program source is constrained to rather well-defined limits.

Since signals with a large rate-of-change or "time derivative" are generally the cause of TIM, we need a way of characterizing the tendency of a given program source to produce them. Such a measure should not be absolute, like time derivative, but rather should be relative so that it can be applied equally well at different points in the system regardless of signal level. We will therefore use the ratio of peak time derivative to peak amplitude expressed in "volts-per-microsecond per volt" (V/ μs)/V, and call it the normalized time derivative. The inverse of this quantity is similar to, but not quite the same as large-signal rise time. Knowing the normalized time derivative, we can go to any point in the system and, given the maximum amplitude at that point, determine the commensurate maximum time derivative.

With the exception of a microphone, the best source of fast program signals in the home is probably the phonograph. However, its performance is well-constrained by mechanical processes such as tracking. The performance is also well characterized. In Fig. 1, the dots are a scatter plot of maximum observed output levels at various frequencies from a survey of many records. These data were taken from the familiar trackability diagram widely published by Shure Bros. [7]. While the usual presentation is in terms of groove velocity, this information has been RIAA equalized and normalized to 25 cm/S at 1 kHz and 1 V peak. It shows what actually can be expected at the *output* of one's phono preamp (as shown, the data are not useful for points in the system prior to RIAA equalization, such as the phono preamp input). The data represented by the X's are spectral data for a single cymbal crash and were presented by Tomlinson Holman [8]. The crash is one from a Sheffield Lab direct-to-disc recording which is noted for its tracking difficulty.

With reference to Fig. 1, we see that the highest amplitude occurs at 4 kHz and is 1.35 V peak, while the highest time derivative occurs at 10 kHz and is 0.035 V/ μS. This results in a normalized time derivative of only 0.026 (V/ μS)/V. Thus, in a system subjected to a wide variety of material such as represented by the dots of Fig. 1, a point in the system which must handle an amplitude of 1 V peak with low distortion must handle a time derivative of 0.026 V/ μS with equally low distortion.

Before proceeding further, we should take note of the fact that an advanced treble control will tend to increase the nor-

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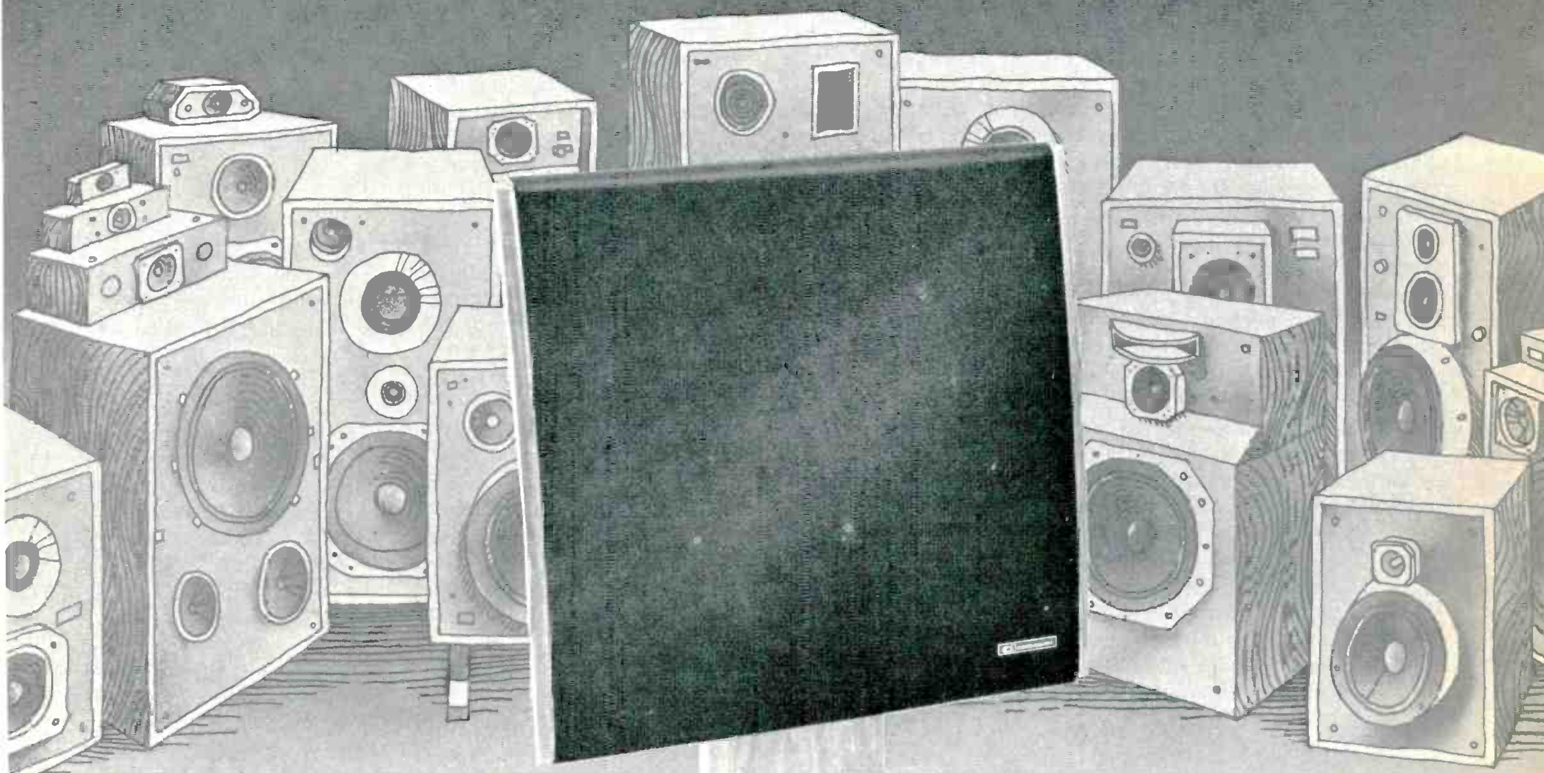

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malized time derivative of the program, but not as much as one might at first think. The reason for this is found upon further examination of Fig. 1. The peak time derivative will increase in proportion to the greater amplitude of the high-frequency signals. However, most treble control action occurs between 2 kHz and 10 kHz, meaning that the overall peak amplitude (occurring at 4 to 5 kHz in Fig. 1) will increase somewhat as well. Based on these observations, we can conclude that 6 dB of treble boost will increase the normalized time derivative by perhaps 50 percent.

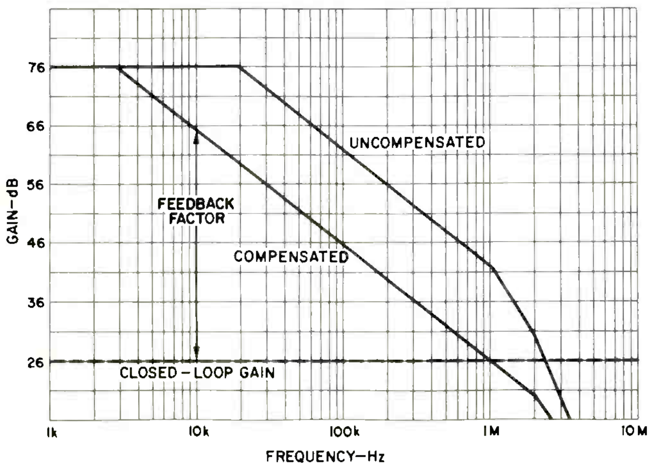
While the cymbal crash exhibits substantial ultrasonic content, its amplitude generally lies below the envelope of the other points. Notice that its mid-band recording level is actually rather low in comparison. Taken alone, the normalized time derivative for the cymbal crash might be fairly high, but the ratio of interest must be based upon the peak amplitude for *all* the music.

Even if the three highest points on Fig. 1 are ignored, an overall power bandwidth of less than 10 kHz is obtained, and a maximum normalized time derivative of approximately 0.05 (V/μS) /V results. By comparison, a 20-kHz sinusoid has a normalized time derivative of 0.126 (V/μS) /V.

Music, of course, produces many simultaneous points whose amplitudes and time derivatives add in some fashion to produce a total amplitude and a total time derivative for the complete spectrum. We can gain further insight by recognizing that for mid-band frequencies between about 500 Hz and 2 kHz, post-RIAA *amplitude* is directly related to recorded velocity. Above 2 kHz, post-RIAA *time derivative* and recorded velocity are directly related, i.e., a 50-cm/S, 10-kHz component produces the same time derivative at the output of the phono preamp as a 50-cm/S, 20-kHz component. This latter relationship is due to the integrating effect of the 2-kHz RIAA high-frequency roll-off. Knowing this, we can get a good idea of the normalized time derivative by assuming realistic values for the maximum total mid-band velocity and the maximum total high-frequency velocity. Notice that a smaller assumption for the maximum mid-band velocity yields a larger normalized time derivative. Keep in mind that the mid-band and high-frequency maxima need not occur simultaneously.

As an example, if we assume a maximum mid-band velocity of 25 cm/S and a large maximum high-frequency velocity of 150 cm/S (probably impossible to track), we arrive at a figure of 0.076 (V/μS) /V. Based on this figure, a 100-watt amplifier which can deliver 40 V peak with an 8-ohm load must *cleanly* reproduce signals with 3 V/μS time derivatives.

Fig. 2—Compensated and uncompensated power amplifier open-loop gain vs. frequency.



This figure may seem very small to some people, but the term "cleanly" is the key here. We are certainly not talking about the ultimate slew-rate capability of the amplifier, which generally occurs under nonlinear operating conditions. Clearly the amplifier must have some operating margin in order to satisfy the "cleanly" requirement. As we shall see later, in some cases this required slewing margin can be substantial.

Although it is very unlikely that any material will approach the 0.076 (V/μS) /V, figure, we can be even more conservative if we wish and simply say that a full-amplitude 20-kHz sinusoid, 0.125 (V/μS) /V, must be handled with adequate slewing margin. Requiring that a square wave bandlimited to 20 kHz, 0.25 (V/μS) /V, be handled cleanly would add yet another factor of two in conservatism.

Based on these observations, we may conclude that real audio signals are not nearly as fast as some would like to believe. However, this is not cause for complacency with respect to TIM. It merely gives us a more realistic perspective for dealing with the problem.

Low-Pass Filtering

It has often been suggested that a low-pass filter (LPF) be placed ahead of the power amplifier to assure that the program bandwidth does not exceed the open-loop bandwidth of the amplifier in order to minimize TIM [1-3]. Although we will see later that such a precaution has no bearing on TIM susceptibility, it is worth noting that the LPF will place a limit on the power bandwidth, and thus the time derivative, of signals applied to the power amplifier. In this latter respect, the LPF could prevent TIM if such a limitation were necessary. However, our earlier discussions showed that the power bandwidth of real audio signals is considerably less than 20 kHz. Assuming that an LPF cutoff of less than 40 kHz is unacceptable due to frequency-response error (-1 dB at 20 kHz assuming first-order cutoff), it is quite safe to say that such a filter will have no effect on TIM produced by program signals.

Ticks, pops, and mistracking may, however, produce considerably larger normalized time derivatives than program, at least in the case where wideband moving-coil cartridges are employed. Values as high as 0.1 to 0.2 (V/μS) /V may be encountered. However, even a step input will only be limited to 0.25 (V/μS) /V by a 40-kHz LPF. The filter will thus have only a limited effect on the smaller normalized time derivative of the ticks, pops, and mistracking. One also has to wonder how important TIM-free reproduction of these annoying signals really is. It is probably sufficient that slew-rate limiting not be encountered in the system under these conditions.

The only sensible reason for an LPF seems to be improved immunity to r.f. interference, if this is required.

Feedback Compensation

As mentioned earlier, feedback operates on the principle of feeding a portion of the output back to the input for comparison with the input signal. The loop so formed may be unstable if the phase of the signal is incorrect. Feedback compensation is employed to assure stability by controlling the net gain and phase shift a signal sees as it goes around the complete loop.

Since the role played by feedback compensation is crucial to the TIM distortion mechanism, and since in many TIM discussions it is not adequately considered, it is appropriate at this point to take a look at feedback compensation.

Because all real amplifiers have finite bandwidth, the gain and thus the feedback factor must begin to roll off at some frequency. In a multi-stage amplifier, each stage usually contributes one or more "poles" (6 dB/octave roll-offs) and accompanying phase shift. If at some high frequency we have

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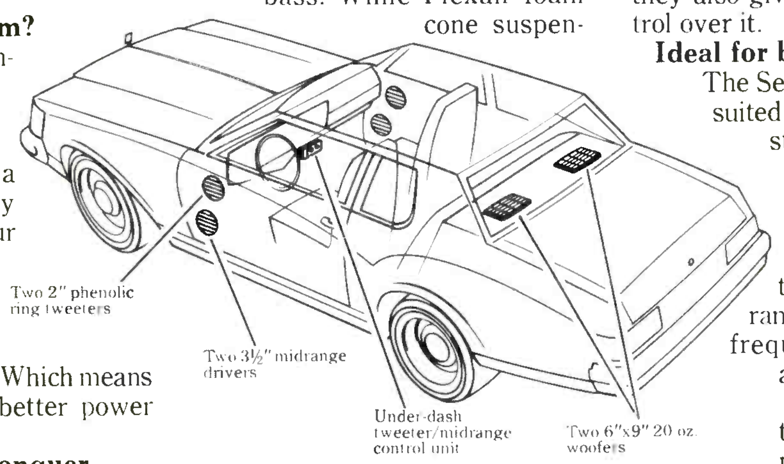

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too much phase shift while we still have gain around the loop, we will have positive feedback and thus an oscillator. For this reason, the frequency at which the feedback factor has decreased to unity (i.e., the gain crossover frequency) is very important in determining amplifier stability. To prevent oscillation, the phase shift accumulated beyond the fixed 180-degree loop inversion must be less than 180 degrees at this frequency. In general, good engineering practice requires that less than about 135 degrees be accumulated, leaving a phase margin of at least 45 degrees. In order to obtain the required stability, feedback compensation is employed to deliberately roll off the gain so that the feedback factor goes below unity before too much phase shift accumulates.

The open-loop gain as a function of frequency for a typical power amplifier before and after feedback compensation is shown in Fig. 2. The closed-loop gain is shown as a dotted line at 26 dB, and the feedback factor is simply the distance between the solid and dotted curves. It is important to remember that each roll-off contributes phase shift (phase lag or delay) which increases with frequency, but which can never exceed 90 degrees. At its 3-dB point, or "corner frequency," each roll-off generates 45 degrees. The gain and phase characteristics for a single pole are shown in Fig. 3. Notice that a single pole placed at a low frequency can create a great deal of high-frequency loss without ever introducing

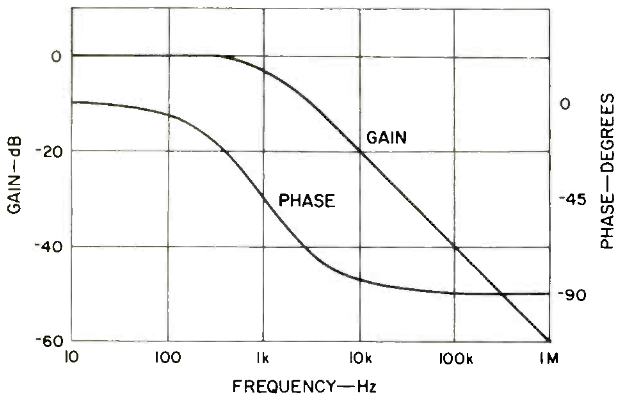

Fig. 3—Gain and phase characteristics for a 1-kHz pole.

more than 90 degrees of phase shift. This is the basis for what is called lag compensation.

A design with many poles situated below the gain crossover frequency will tend to be unstable, while one with only a single pole below this frequency will tend to be stable, even if that pole is at a very low frequency. The uncompensated amplifier in Fig. 2 crosses over at 2.4 MHz and has three poles below that frequency, while the compensated version crosses over at 1 MHz and has only one pole below the gain crossover frequency. As is the case in Fig. 2, the compensation network usually decreases substantially the frequency of one existing pole and may also significantly increase the frequency of another one. This effect is called pole splitting, and its double benefit further contributes to stability.

To summarize, the objective of feedback compensation is quite simple: Establish a gain crossover frequency low enough to achieve an acceptable phase margin. In a power amplifier, much of the phase shift at high frequencies is contributed by the output transistors, which typically have ft's (current gain-bandwidth products) of about 1 to 4 MHz. Output stages will tend to contribute rapidly increasing phase shift above this frequency. As a result, reasonable gain crossover frequencies for power amplifiers are generally in the range of 0.5 to 2 MHz.

A Typical Power Amplifier

To further put things into perspective, we'll now take a brief look at the operation of a practical power amplifier. This simple amplifier will provide a setting for the examples illustrating TIM considerations in the later sections. A simplified version of a popular amplifier topology is shown in Fig. 4. Transistors Q1 and Q2 form a differential amplifier which is the first stage of the open-loop amplifier. Here the feedback signal applied to the base of Q2 is subtracted from the input signal applied to the base of Q1. Notice that the feedback signal is divided down by R4 and R3, which set the closed-loop gain at about 20. Capacitor C2 allows full feedback at d.c. to assure a small output offset voltage.

The voltage difference between the bases of Q1 and Q2 is translated to a current signal which in turn drives the base circuit of the predriver, Q3. The resulting voltage signal at the collector of Q3 is delivered to the output with approximately unity gain by the complementary Darlington emitter-follower output stage. The primary purpose of the output stage is to provide current gain and thus present a relatively high-impedance load to the collector circuit of Q3. The collector current for Q3 is provided by a current source so that the only real load at Q3's collector is that presented by the output stage. This arrangement provides very high gain in the predriver stage, especially if the current gain in the output stage is high.

The uncompensated loop gain of this amplifier is shown in the top curve of Fig. 2 (assuming transistor betas of 50). Feedback compensation of this amplifier is provided by a single capacitor C3 connected from collector to the base of Q3. This type of compensation is often referred to as Miller-effect compensation.

At low frequencies, C3 is an open circuit and the gain is quite high. At higher frequencies, C3's reactance decreases, and it begins to form a tight negative feedback loop around Q3. At high frequencies, almost all of the signal current from Q1 flows through C3, rather than R2 and the base of Q3. Under these conditions, we can almost think of Q3 as an operational amplifier and its base node as a virtual ground. At mid- to high frequencies, the voltage at the collector of Q3 is then approximately the signal current from Q1 times the reactance of C3. Furthermore, the open-loop gain of the amplifier will simply be the transconductance (gm) of the differential amplifier (here about 10 mA per volt) times the reactance of C3. Since this reactance is decreasing with frequency at 6 dB/octave, so will the open-loop gain of the amplifier. When this gain decreases to 20 we are at the gain crossover frequency (f_x), since the feedback path establishes a closed-loop gain (G_c) of 20. The choice of 84 pF for C3 yields a reactance of about 2000 ohms at 1 MHz, thus setting the gain crossover at that frequency and yielding the lower curve for open-loop gain in Fig. 2. Expressed in general terms,

$$C3 = \frac{g_m}{2\pi f_x G_c} \qquad (1)$$

Notice that low-frequency considerations, such as feedback factor, do *not* influence the choice of C3.

Propagation Delay

Some authors have reasoned that an amplifier presented with a very fast transient will be without negative feedback for a short period of time until the feedback signal, having suffered inevitable delay, arrives to cancel most of the input signal [1,3]. During this delay time, it is reasoned, some stages in the open-loop amplifier may clip due to the unusually large input signal.

There is little question that such a problem will occur if a square wave with a 1 nS rise time is applied to an audio amplifier. However, to assess the practical likelihood of such

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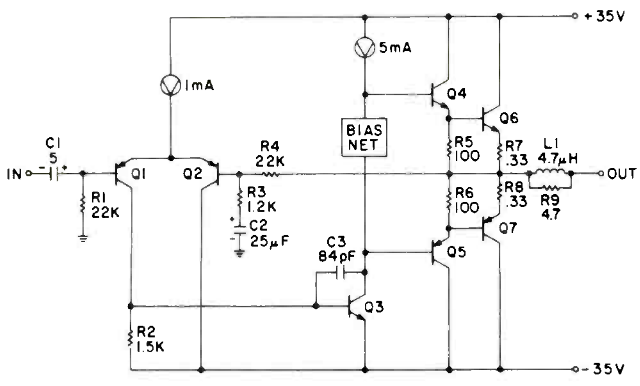


Fig. 4—Simplified schematic of a popular power amplifier design.

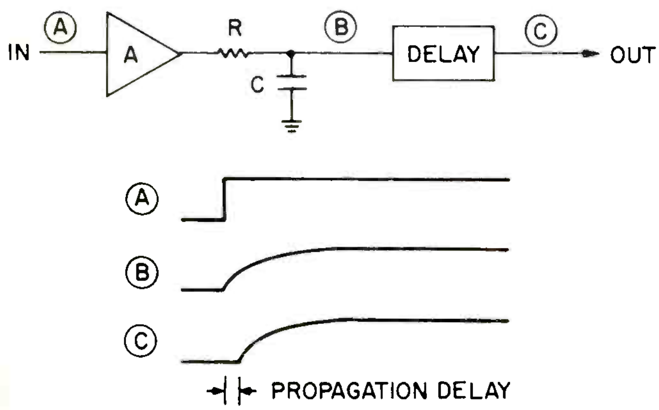
a problem, we must consider the time it takes a real program signal to rise, what the delay time really is (it is not the open-loop rise time as some have implied), and the overload mechanism of open-loop amplifier gain stages.

The open-loop amplifier can be modeled as a block of gain, a dominant first-order compensation roll-off, and a pure delay as shown in Fig. 5. Effects of the other nondominant poles are lumped in with the delay with little loss of accuracy. It is well-known that, following a step change at the input of a first-order RC low-pass filter, the output *begins to change* immediately, no matter how long the RC time constant; only the rate of change will depend on the time constant. Thus, after a sudden change at the amplifier input, the output will begin to change after the above-mentioned pure delay. This is the propagation delay time of the amplifier and is the delay time during which we must be concerned about overloading the amplifier in order to deal with the issue raised above.

The propagation delay time can be estimated by considering the phase margin of the feedback loop. If an amplifier has a phase margin of 45 degrees at a 1-MHz gain crossover, then the total forward path delay (assumning a flat feedback path) must be 135 degrees, of which about 90 degrees is from the compensation pole and 45 degrees is from the propagation delay. This works out to 125 nS. Most power amplifiers will have considerably less propagation delay than this.

It should be pointed out that it is incorrect to say that the amplifier is without feedback during this interval. The closed-loop amplifier is a linear system so long as the gain, roll-off, and delay elements of the model are linear. It is also

Fig. 5—A simple model of the open-loop amplifier showing time response to a step input. In practice, gain and delay are distributed throughout the amplifier.



a continuous system in spite of the delay, and feedback is present 100 percent of the time as long as no stages are clipped. The feedback is, however, continuously "out of date" by a time equal to the delay. Fortunately, the feedback equations readily take this into account in both the frequency and time domains.

Can a full-amplitude input signal, such as a bandlimited square wave, rise far enough in 125 nS to cause any amplifier stages to become nonlinear or to overload? The integrating action of the compensation will prevent stages beyond the compensation from overloading, typically leaving only the input stage before it to worry about (see Fig. 4).

Consider as a worst case a 2-V peak square wave bandlimited to 20 kHz. It will rise about 63 mV in 125 nS, and this *is* enough to drive some input stages into nonlinearity. This is particularly true of the differential pair without emitter resistors (local feedback often called emitter degeneration), as shown in the design of Fig. 4. With a 63-mV error signal driving it, its small-signal gain is less than half its nominal value. This nonlinearity would result in "soft" TIM under these conditions. However, most high-quality amplifier designs have enough local feedback of one sort or another at the input stage to allow good linearity in handling such an error signal. As we will see momentarily, such feedback is usually also an important ingredient in achieving high slew rate.

Feedback factor and open-loop bandwidth are clearly not relevant here, since designs with different values for these parameters could easily have the same input stage design and propagation delay. The important criterion here is to have an input stage that can handle large input signals, at least under transient conditions.

Slew Rate

Real power amplifiers are not only limited in terms of output amplitude; they are also limited with respect to the rate-of-change or time derivative of the output. When an amplifier is asked to deliver more than its maximum amplitude, it clips and produces a constant amplitude independent of the input signal. Similarly, if an amplifier is called upon to deliver a greater time derivative than its slew rate, the amplifier will go into slew-rate limiting and produce an output rate-of-change independent of the input signal. As with amplitude-induced distortion, slew-induced distortion (SID), or (TIM), has a gradual onset. It is non-zero below the slew-rate limit and rises as the slew-rate limit is approached.

Having discussed amplifier behavior during the propagation delay interval following a sudden input change, we must now determine if the amplifier can keep up with the time derivative called for by the input signal without being driven into nonlinearity by internal error signals (i.e., overshoots). This is basically a question of margin against slew-rate limiting, since slewing is the result when the internal overshoots are so big they are clipped. Recall that these overshoots are generally the result of the circuit attempting to quickly charge capacitances, particularly the compensating capacitor.

At this point it is important to emphasize that it is the *magnitude* of these overshoots which is important, not percentage; many papers in the literature have erred in emphasizing the latter [1, 2]. It should be clear that good margin against slew-rate limiting guarantees that the overshoots will not be large enough to cause nonlinearity and thus TIM.

How does feedback factor affect slew rate? By itself, not at all. For example, amplifiers with high feedback factors usually have the extra open-loop gain *after* the point of compensation. The most common example is the use of a current source collector load on the predriver stage, as in Fig. 4. Suppose for the moment that the predriver stage has a shunt capacitor at its input (base) for compensation (unlike Fig. 4).

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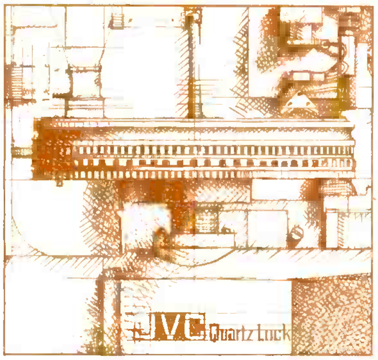

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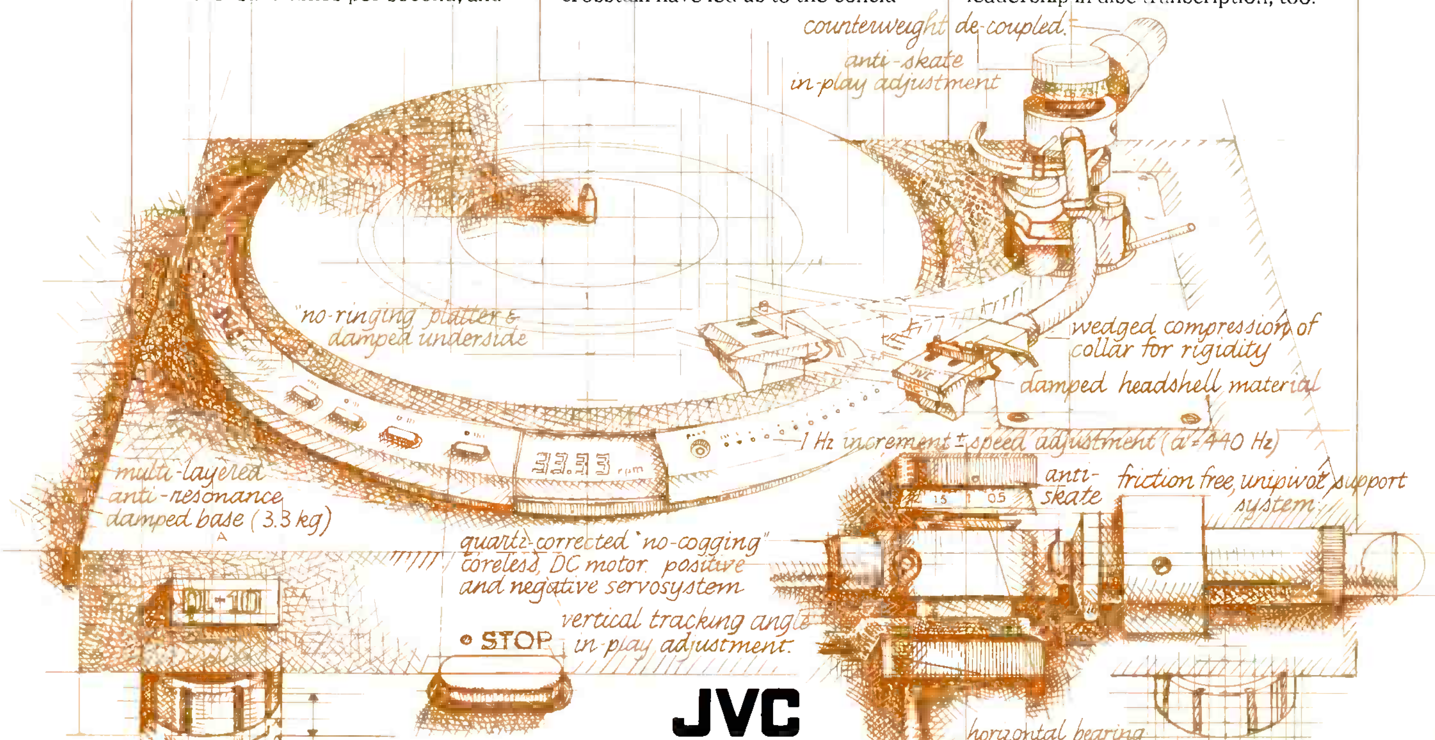

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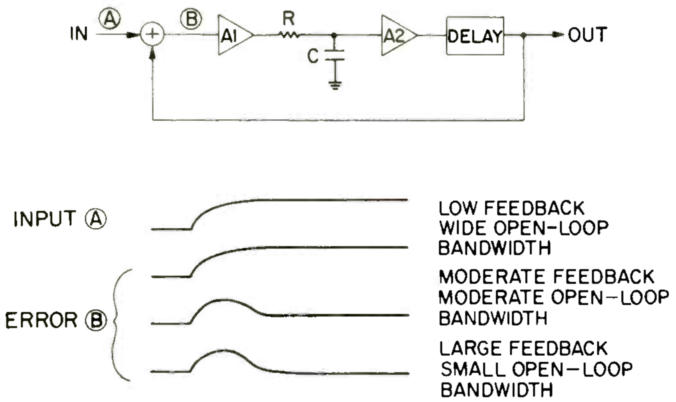


Fig. 6—A model of the feedback amplifier showing the error time response to a bandlimited step input for various combinations of feedback factor and open-loop bandwidth. Closed-loop bandwidth is held constant, and feedback is varied by changing only A2. Input level is assumed to be zero prior to the step.

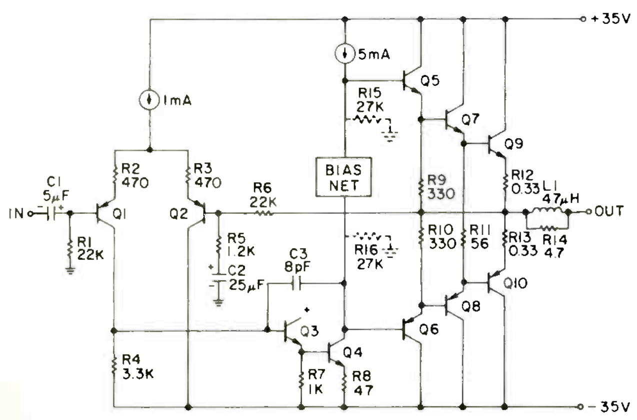
If we double the gain after the compensation by some means, we must double the value of the compensating capacitor to restore the gain crossover frequency to its original value. However, the added gain means that we now need only half the time derivative on the capacitor to achieve the same output time derivative, so the magnitude of the current overshoot charging the larger compensating capacitor is unchanged. The percentage overshoot is approximately doubled, however, because of the *smaller final value* as a result of the doubled d.c. gain. This is illustrated in Fig. 6. Even though the open-loop roll-off starts one octave lower, the input stage doesn't have to work any harder to achieve a given slew rate.

The situation is the same for amplifiers using Miller-effect compensation as in Fig. 4. Here, even the capacitor value is unchanged as the feedback factor is raised or lowered by varying the load impedance of the predriver (Q3). This is so because the feedback action of C3 controls the high-frequency gain rather than the load resistance. Amplifiers which are deliberately designed with low feedback factors typically achieve this by placing a physical load resistance from the collector of the predriver to ground [9].

If we assume that all of the signal current from the input stage can flow into C3, then the slew rate for the amplifier in Fig. 4 is about (0.5 mA/84 pF) = 6 V/μS. In practice, it will be somewhat less because of some current flow into R2 and Q3.

An improved amplifier is shown in Fig. 7 and is an example of an amplifier with a very high feedback factor. In addition

Fig. 7—Simplified schematic of an improved power amplifier.



to using a high-quality current source load for the predriver, triple Darlingtons are utilized in the output stage for extra current gain and hence a lighter load on the predriver collector node. Addition of the pair of dotted predriver load resistors, R15 and R16, will convert it to a low-feedback design with a 20-kHz open-loop bandwidth. The required compensating capacitance remains unchanged.

The open-loop gain for the high- and low-feedback versions of Fig. 7 is shown in Fig. 8. The gain crossover frequency for both designs is the same, and the only difference is increased loop gain at frequencies below 20 kHz for the high-feedback design. The slew rate for both designs is the same for a step input starting at zero volts. This further illustrates the fact that feedback factor and open-loop bandwidth have no effect on slew rate.

What *does* affect slew rate is the design of the input stage. For a given size compensating capacitor, an input stage with a higher output current capability will provide an increased slew rate. However, merely increasing the tail current of a simple differential pair stage, as in Fig. 4, will not work because that will increase the stage gain (transconductance) by the same factor. This would then necessitate a proportionately larger compensating capacitor to restore the gain-crossover frequency, and the slew rate would be back to where it was before. One popular solution is to use emitter degeneration. For example, we can keep the tail current the same, use emitter degeneration to reduce the gain, and then use a smaller compensating capacitor. This approach is used in Fig. 7, where R2 and R3 reduce the gain by a factor of 10. This permits a dramatic increase in slew rate. Local emitter degeneration is also desirable because it increases the overall linearity of the stage and permits linear operation up to a larger percentage of the ultimate slewing capability.

It is important to realize that the extra gain in most amplifiers with high feedback factors is not achieved by adding more voltage-gain stages, which would tend to increase nonlinearity and propagation delay. As can be seen from Fig. 7, the only elements which need to be added to achieve very high gain are emitter-followers. These stages are practically delayless and actually tend to improve linearity by isolating driving stages from the input nonlinearities of the next stage. Nonlinearities resulting from transistor beta dependence on collector voltage (Early effect) and current and junction capacitance dependence on voltage are reduced in this way.

It was mentioned earlier that a 100-watt amplifier would have to cleanly handle time derivatives up to about 3 V/μS for worst-case program material. How much margin against slew-rate limiting is required for clean, low-TIM operation? This depends very much on the particular amplifier design. A good design with plenty of local feedback and a linear open-loop response may require a margin of less than 1.5 to 1, while a really poor design with gross open-loop nonlinearity could require as much as 10 to 1. However, even the often-criticized 741 operational amplifier, when operated under reasonable conditions, requires less than a margin of 5 to 1.

A margin of 4 to 1 should be more than adequate for power amplifiers of reasonable design to guarantee that TIM produced by internal overshoots will be completely inaudible. Based on this and the previously discussed program characteristics, the 100-watt amplifier should provide a slew rate of at least 12 V/μS. This also gives us a 50 percent margin against slewing in the presence of a 0.2 (V/μS)/V full-amplitude pop or tick.

Notice that we've paid very little attention to what happens when outright slew-rate limiting occurs; rather, we've outlined the conditions required to stay in a rather linear region of operation where, at most, the nonlinearities are soft. This is mainly because TIM will become audible before slew-rate limiting occurs. However, it is worth noting that

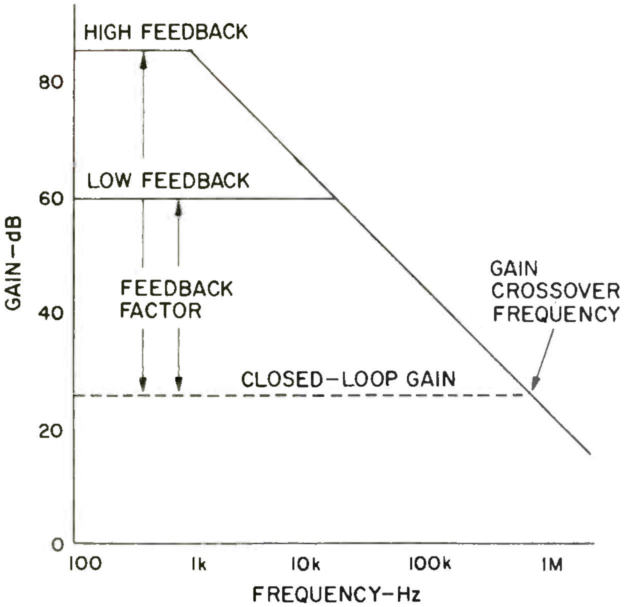


Fig. 8—Open-loop gain comparison of amplifiers with high and low feedback factors and equal gain crossover frequency. The major difference is the greater feedback in the audio band for the former case.

recovery from a slewing condition for most contemporary amplifier topologies is not affected by the open-loop time constant. This was not necessarily the case in some very early transistor amplifier designs in which a transistor could saturate during slewing and charge the compensating capacitor to an abnormal voltage. Recovery in modern amplifiers is not significantly longer than the time it takes the output to slew to the new signal value.

At this point, it should be clear that slew rate is the most important single parameter governing TIM performance, while feedback factor and open-loop bandwidth have no bearing on TIM. In Part II, we'll continue by looking at other causes of high-frequency or dynamic intermodulation distortion (DIM), why a large feedback factor is good instead of bad, and techniques available for measuring TIM in the lab.

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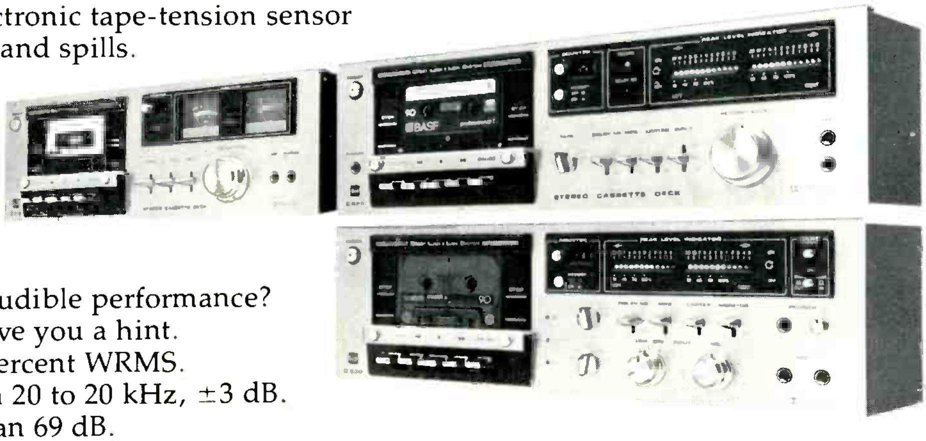

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From time to time we hear references to distortion and other nonlinear effects produced by *passive* circuit components, such as capacitors, used in audio circuits. However, only on rare occasion can anything be found in written form which attempts to *quantify* or otherwise document capacitor problems, particularly as they specifically relate to audio. Yet, distortions are produced by a wide variety of basic capacitor types, and in some cases forms of this distortion are rather easily measurable. Why there hasn't been more written on this topic is truly a good question, as in many instances the audible defects produced by capacitors can easily be the Achilles' heel of a given design. If this were not a truism, why else would there be so many audiophile modifications consisting essentially of capacitor upgrades only? The implications of this will be apparent when this article is fully appreciated.

While there has been no detailed overview or discussion of these problems in print, two articles are noteworthy, because they do in fact address this specific topic. In [1], Dave Hadaway gave a summary of relative quality rankings for capacitor types. More recently, John Curl [2] discussed some measured results for two capacitor types. Dick Marsh [3,4,5] has been specific in cautions against certain types, in several *Audio Amateur* letters.

What we hope to do in this article is cover capacitor basics, means of testing for impedance and distortion, and summarize with some selection criteria which will optimize sound quality. We will begin by discussing some simple (but deceiving, really) distortion tests. A summary of key capacitor performance defining terms is given in the sidebar entitled Capacitor Basics.

Signal Path Tests For Capacitor Distortion

One of the more frustrating aspects of the distortion problem vis-a-vis capacitors is that they do not always allow direct quantification as they typically operate in the signal path. A good example of this very point will be demonstrated below in the discussion of some THD tests on tantalum capacitors. By these THD results, one might be led to believe that tantalum types are adequate *when suitably selected*. Nevertheless, they still fail to measure up in auditioning and show poor electrical quality when measured by other methods — even though they may appear to be operating in a virtually distortionless fashion by THD tests.

Two series of THD tests were performed on two types of capacitors, tantalum electrolytics and ceramic discs. These tests seem to be representative, as different capacitors of the same variety produced similar results, and the results here generally correlate with Curl's [2].

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Tantalum Capacitor Tests

In the tantalum tests, a circuit was built in the form of a simple high-pass filter, as shown in Fig. 1. The general test circuit used is shown in Fig. 1a, and the details of various capacitor connections are in 1b. The 3-V rms generator and meter is a THD oscillator/analyzer combination. The general goal of this test is to examine the distortion sensitivity of the polar tantalum capacitor in handling bipolar a.c. signals.

As the different connections of 1b indicate, there are various ways that a polarized capacitor such as this can be connected. The circuit as shown in 1a is a simple a.c.-only circuit with no d.c. polarizing bias applied to the capacitor in test condition A.

For such a mode of operation, a tantalum capacitor will generate appreciable distortion when the signal conditions are such that there is appreciable a.c. voltage dropped across

Fig. 1—Tests of tantalum capacitors.

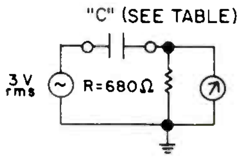


Fig. 1a—General test circuit.

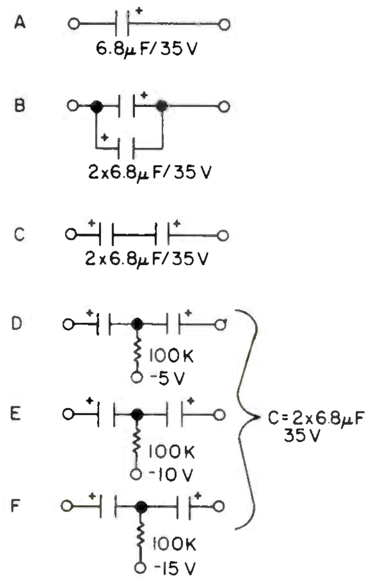


Fig. 1b—Test details of capacitor connections.

it. Or, stated another way, when its reactance becomes appreciable in relation to that of the load (here 680 ohms).

For condition A, the capacitor is a single 6.8-μF unit, and its reactance equals 680 ohms at about 35 Hz. To generalize, we will talk in terms of this frequency, which is the corner frequency, fc. As will be seen, it is a key to understanding this particular pattern of distortion behavior.

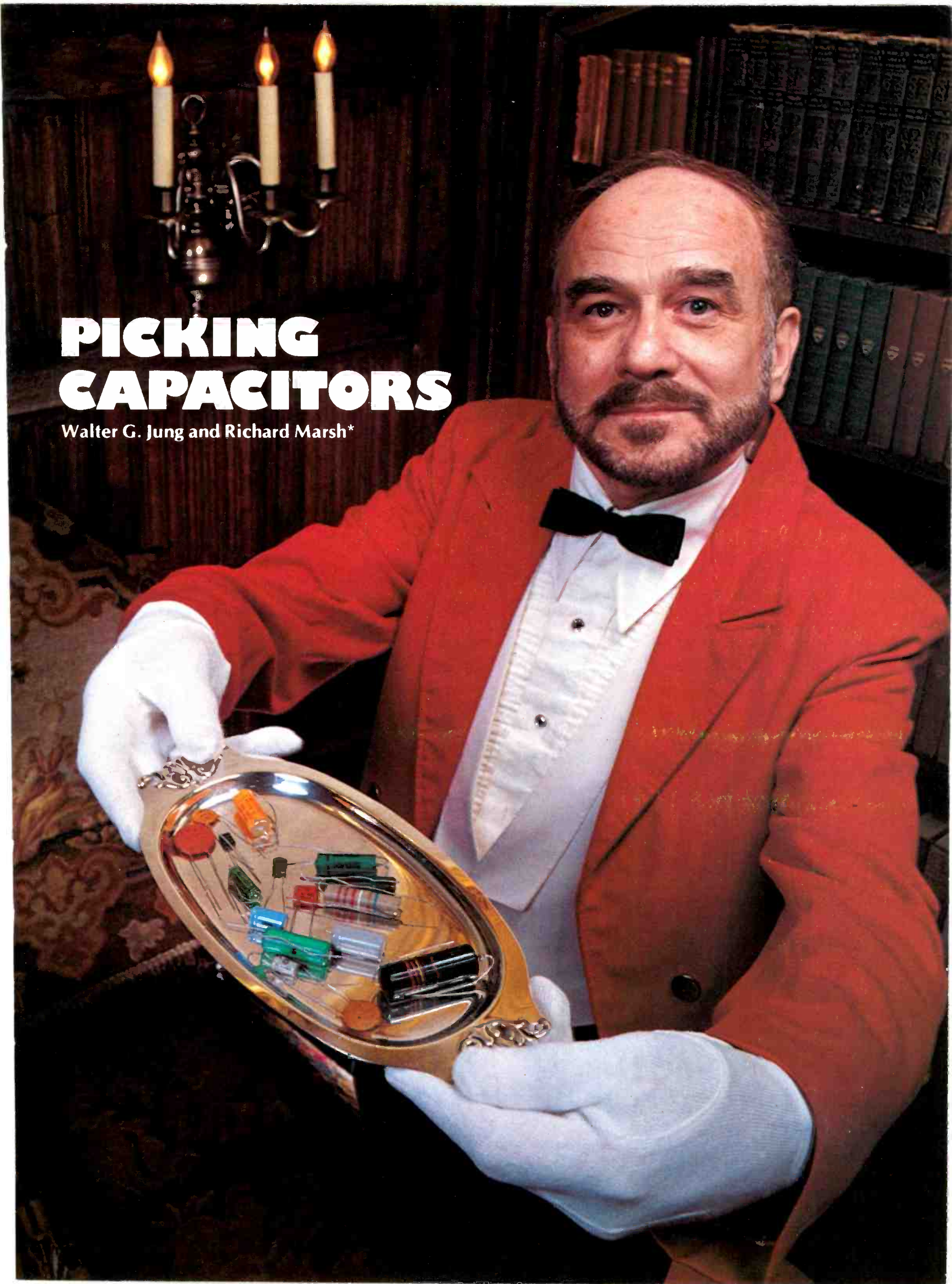
THD data were taken on this and the remaining connections, as shown in Fig. 2. For condition A, it can be seen that distortion is low at frequencies above about 10 times fc, but rises as fc is approached and nears 1 percent in level below fc when the capacitor sees a large a.c. voltage.

From these data, it seems somewhat analogous to regard a polarized tantalum operated thusly as a capacitor shunted by an imperfect diode. The distortion it produces is even order, which is shown in the distortion photos in Fig. 3. Since the device's a.c. characteristic is asymmetrical, it appears that circuit means which tend to minimize the asymmetry also tend to minimize the distortion produced.

As John Curl showed [2], a simple parallel connection of like capacitors, as in B, reduces distortion appreciably. Compared to condition A, condition B reduces the distortion at fc by a factor of 2 to 3 (Fig. 2).

PICKING CAPACITORS

Walter G. Jung and Richard Marsh*



The series back-to-back connection of condition C can reduce the distortion further, if the two capacitors happen to have complementing characteristics. The distortion products for condition C are also shown in Fig. 3 (at fc). However, it appears this particular connection depends strongly on the *match* of the specific units used. Also, unlike the connection of B, the series connection of C increases the net equivalent series resistance (ESR), which is usually not desirable as discussed later.

If the series connection is so effective, the logical question is, then, does polarizing bias applied to the junction help further? The answer is yes, with increasingly better results with more bias, as shown in conditions D, E, and F. However, even a relatively small bias, such as in D, is very effective, reducing THD at fc to 0.01 percent. This bias level is 5 V or just in excess of the greatest signal peak swing. The distortion for test condition D is shown in Fig. 3 at fc.

What this series of tests seems to say is that one should carefully control the a.c. signal developed across such a polar capacitor to minimize this distortion. If you use a simple single-capacitor connection with no d.c. bias, it appears that a just derating by a factor of about 10 times will minimize the distortion. In other words, if a given capacitor used for coupling is calculated to have an fc of 10 Hz, making it corner at

Capacitor Basics

A brief review of capacitor fundamental relationships is appropriate to a more complete understanding of the applications-oriented discussions of this article.

As can be noted from the physical diagram (Fig. B1), a capacitor consists of two plates or conductors separated by a dielectric or insulator and the whole is capable of storing electrical energy. Capacitance is determined by the area and spacing of the plates (dielectric thickness) and the dielectric constant which is symbolized by K. The K of a given material is a direct measure of its ability to store electrons as compared to air. Note that within a given size, capacitance can only be maximized by increasing K.

Table BI is a short summary of some of the dielectrics used in audio work. As can be noted, all of the film dielectrics have relatively low Ks, while the remainder, such as aluminum and tantalum oxides, are quite a bit greater. This is the reason why a 10-μF polycarbonate capacitor is so much larger than a 10-μF aluminum or tantalum electrolytic for a comparable voltage.

All capacitors can be modeled electrically by the equivalent circuit in Fig. B2. The elements shown here are actually parasitic, with the exception of C, which is an ideal capacitor. In practice a parallel resistance, R_P (sometimes called IR or *Insulation Resistance)*, shunts C, causing leakage. R_P is both temperature and voltage dependent. A series resistance, R_s (also often called ESR, for *Equivalent Series Resistance)* appears in series with C, limiting the minimum impedance. R_s is composed of plate, lead, and termination resistances primarily. For high-current circuits, R_s can represent a significant power loss, and it is desirably minimized. L represents the net inductance of the winding and leads. C is actually composed of C_1 and C_2, where C_2 and R_{DA} comprise the dielectric absorption model (discussed fully in text).

The losses in capacitors are described by the real and reactive impedances, as shown in the vector diagram triangle, Fig. B3, with the respective impedances as described by equations 2, 3, and 4.

In capacitor specification literature, the angles θ and δ are often seen. Both are used to represent losses, which can be described either by the term power factor (PF) or dissipation factor (DF). As equations (5) and (6) indicate, they are trigonometrically related.

An important point to be appreciated is that for very small values of R_s, PF and DF are nearly the same. Note also that both PF and DF can also be expressed in percentage form, as DF (%), as noted in equations (7) and (8).

Capacitor losses are also sometimes expressed in terms of Q or quality factor, a general figure of merit. Q is simply the inverse of DF, as shown in equation (9). The practical expression of this is that low DF capacitors have high Q.

An appreciation for the interrelation of these various capacitor loss elements can be gained by regarding Fig. B4, a hypothetical capacitor impedance vs. frequency curve. At relatively low frequencies, the value of Z observed is equal to X_c and follows the inverse relationship of equation (2). At some higher frequency, it reaches a minimum value, due to R_s. At this minimum impedance frequency, the capacitor actually acts as a series-resonant circuit, with maximum current limited only by R_s. Note that only if the capacitor were truly ideal

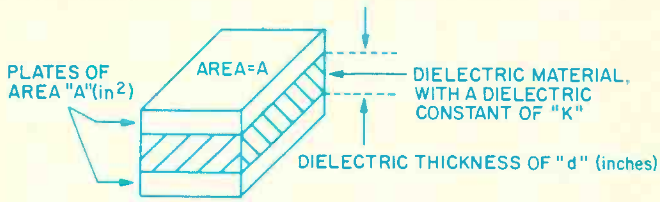


Fig. B1—Physical diagram of a capacitor.

$C = (KA/d)\ (0.225 \times 10^{-12})$farads (1)

See reference 15 for a thorough discussion of C.

Table BI—Dielectric constants of typical materials. Teflon through polyester are films.

Dielectric	K (vacuum = 1.0000)
Air (reference)	1.0001
Teflon	2.0
Polypropylene	2.1
Polystyrene	2.5
Parylene	2.65
Polycarbonate	2.9
Polyester	3.2
Glass	4.0 - 8.5
Mica	6.5 - 8.7
Ceramics	6 to several thousand
Al oxide	7
Ta oxide	11

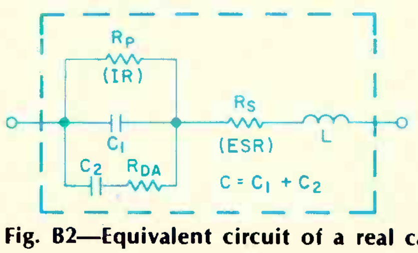


Fig. B2—Equivalent circuit of a real capacitor. C = capacitance in farads, L = inductance in Henrys, R_s = equivalent series resistance in ohms, R_p = parallel resistance in ohms, and C_2 and R_{DA} = dielectric absorption portion of equivalent circuit.

Capacitor Terms

Capacitive reactance $= X_C = 1/2\pi fC$ (2)

Inductive reactance $= X_L = 2\pi fL$ (3)

(Note: equations 2 and 3 apply for sine waves—see text.)

Impedance $= Z = \sqrt{R_s^2 + (X_c - X_L)^2}$ (4)

1 Hz will minimize the distortion produced by this particular mechanism. However, as alluded above, this is not the whole story, as the discussions later will show.

Ceramic Capacitor Tests

In a second series of tests, the distortion produced by a common ceramic disc capacitor was studied. Data in the form of the THD vs. frequency for this test are shown in Fig. 4. The first circuit used is a simple low-pass (LP) filter, with the capacitor under test as the shunt C arm. The values chosen for the test were R = 1K and C = 0.1 μF. A 100-V type was used for the capacitor.

would its impedance continue to fall indefinitely with frequency. On a log-log scale, this is shown as a straight (non-curved) descending line with increasing frequency (shown dotted in Fig. B4). It should also be noted that R_s is both temperature and frequency dependent (although not shown here).

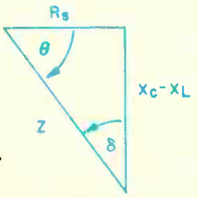


Fig. B3—Vector diagram of capacitor impedances.

Power factor = PF = cos θ = sin δ = R_s/Z (5)
Dissipation factor = DF = cot θ = tan δ = $R_s/(X_c\text{-}X_L)$ (6)
Note: For relatively low values of R_s, Z is approximately equal to $X_c\text{-}X_L$. Therefore, θ approaches 90 degrees and cos θ is approximately equal to cot θ. As a result, PF and DF are nearly equal for low Rs values.
DF (%) = DF x 100 = $100\,[R_s/(X_c - X_L)]$ (7)
PF (%) = PF x 100 = $100\,(R_s/Z)$ (8)

In practical terms, DF = PF with a discrepancy of under 1 percent for PF (%) values of 14 percent or less.

Quality factor or figure of merit =
$Q = (X_c\text{-}X_L)/R = 1/DF$. (9)
Example: A DF (%) of 0.1 percent in a capacitor results in a Q of 1000.

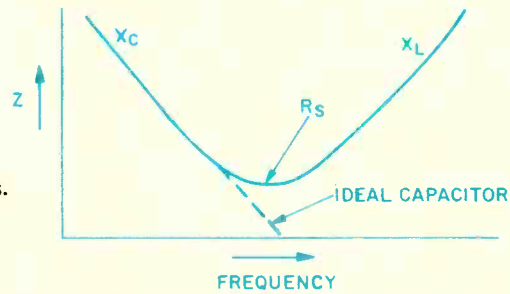


Fig. B4—Capacitor impedance vs. frequency.

A very interesting point which should be noted regarding equations (2) and (3) is that they specifically describe reactances for single-frequency, sine-wave conditions. In actual practice, music is comprised of a multiplicity of signal components simultaneously, and would be more accurately generally characterized as a transient waveform source.

As such, a transient pulse of period t is generally related to the f term more accurately, as
$f = 1/2t$ (10)

Note that for these conditions, we now must consider not only the fundamental frequency of repetition, but also all of the harmonics comprising the Fourier series with their exact phase and amplitude relationships if the waveform is to be transmitted accurately.

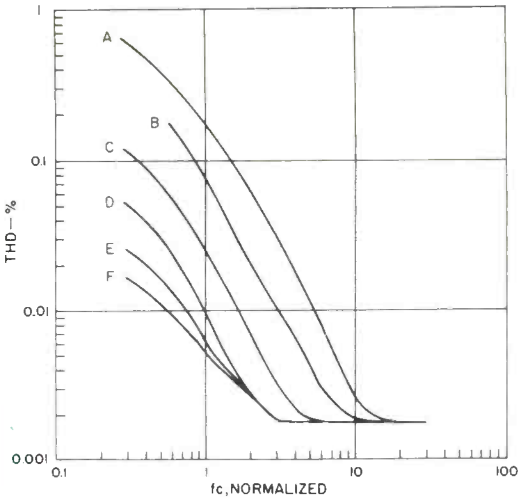
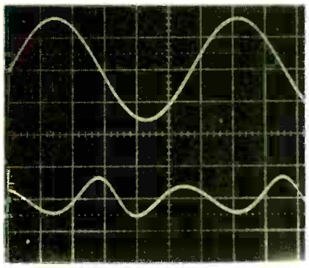
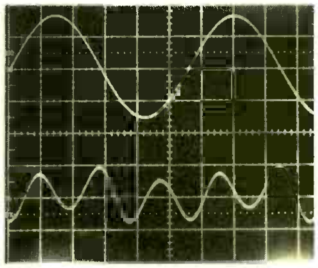


Fig. 2—THD in tantalum electrolytics as a function of corner frequency in a high-pass filter, various connections.

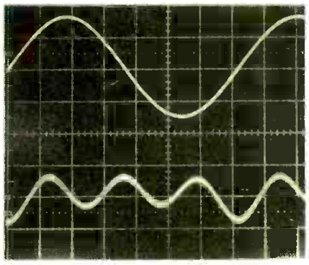
Fig. 3—Output vs. distortion photos for tantalum capacitors in a high-pass filter, various connections. For each photo, top is filter output; bottom is distortion products. Setup conditions as in Fig. 1b.



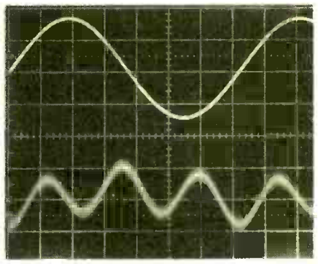
Condition A: fc = 35 Hz, distortion about 0.2 percent.



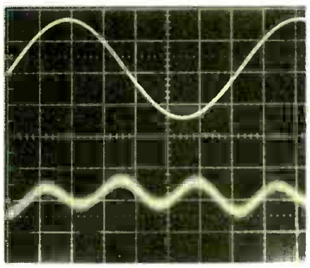
Condition B: fc = 18 Hz, distortion about 0.075 percent.



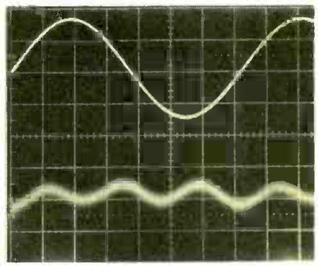
Condition C: fc = 70 Hz, distortion about 0.025 percent.



Condition D: fc = 70 Hz, distortion about 0.01 percent.



Condition E: fc = 70 Hz, distortion about 0.005 percent.



Condition F: fc = 70 Hz, distortion about 0.003 percent.

As the LP data show, distortion is produced well below the corner frequency, which in this case is 1800 Hz. The data shown are corrected, so the THD 100 percent set level follows the LP roll-off. Even as such, however, the higher harmonics are attenuated, and this data may be a pessimistic representation. An IM test might show even worse performance for this LP filter. Figure 5 shows the nature of distortion in 5a; as can be noted, it is third harmonic. By contrast, a

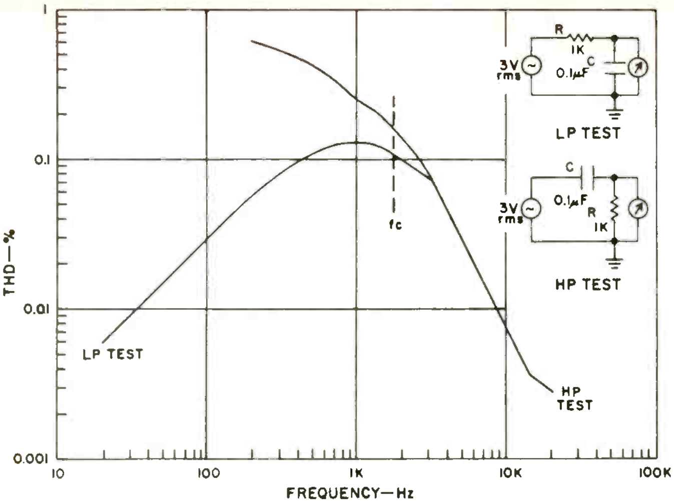


Fig. 4—THD produced by a ceramic disc capacitor as a function of frequency in low-pass and high-pass filters.

polyester type inserted into the circuit shows no discernible distortion (5b).

By placing the same ceramic capacitor in an HP filter circuit, the roll-off of harmonics can be circumvented. In this type of use, the voltage across the capacitor is highest at low frequencies. Thus nonlinearities will show up as higher harmonics, which are readily passed by the filter.

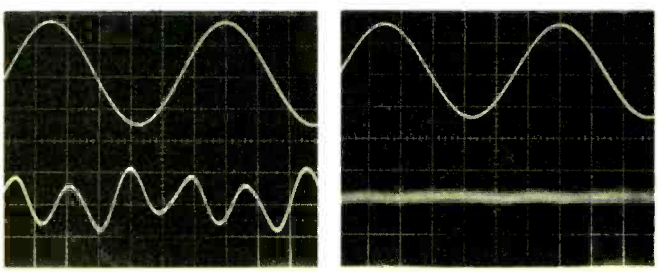
The data for the HP test show much stronger distortion at the lower frequencies, where the voltage is highest. We are not sure what should be interpreted as the common distortion-producing source in these two tests. One thing seems quite clear, however, and that is the simple fact that you cannot "work around" the distortion problem in ceramics. Our feeling is that they should simply be avoided anywhere near an audio signal path and probably just avoided altogether for audio. For example, some listening tests have indicated that they can produce audible distortion when used as supply *bypasses*, let alone coupling!

One obvious implication which emerges from the above is that a capacitor is *not* just a capacitor by any means. Of course, what we've discussed here are only two types of capacitors, and we really ought to make some general recommendations as to desirable types. This leads us more deeply into just what a capacitor is, and how this knowledge relates to audio.

Interpreting Capacitor Performance Data

One of the most important factors needed for a full and effective understanding of capacitor audio application criteria lies in interpreting data. Most of us have probably seen examples of impedance/frequency curves such as the one hypothesized in Fig. B4. However, considering such curves in the light of real data actually allows us to separate the men from the boys among capacitors — and also shows us which ones to use for audio.

Fig. 5—Output and distortion photos for ceramic and polyester capacitors in a low-pass filter circuit.



a—0.1-µF ceramic disc; fc = 1.8 kHz, distortion is about 0.1 percent.

b—0.1-µF polyester; fc=1.8 kHz, "distortion" is at residual level; 0.01 percent full scale.

Typical data of this nature for tantalum capacitors are shown in Fig. 6. Regarding this data and recalling the model of a real capacitor (Fig. B2), we see that under d.c. or low-frequency conditions, Rs and L are negligible, compared to the C and Rp combination. As the frequency increases, particularly above a few kilohertz, the effects of both Rs and L increase.

In these practical cases shown here (one of which is typical of good-quality Ta units), it can easily be noted that X_c does not follow the ideal capacitor -6 dB-per-octave pattern with increasing frequency.

Further examination shows that as frequency increases, X_c tends to decrease, while X_L increases in value. This of course means that the $(X_c\text{-}X_L)^2$ term of the Z formula gradually decreases until at some frequency, the term $(X_c\text{-}X_L)^2$ disappears.

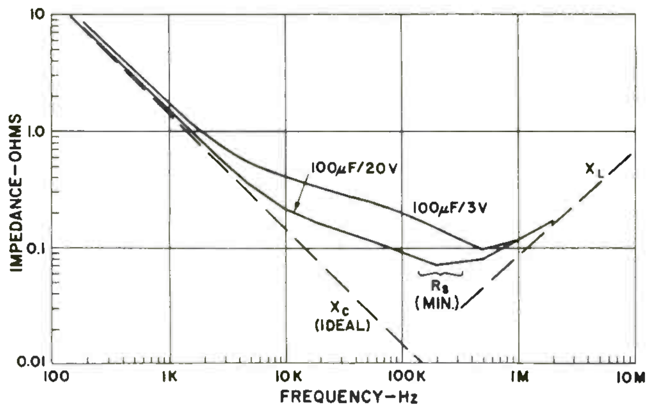
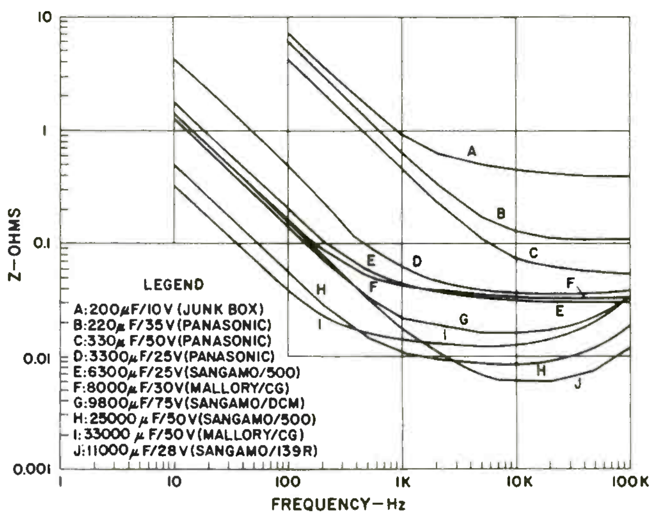


Fig. 6—Typical impedance vs. frequency curves for tantalum capacitors.

Fig. 7—Typical impedance vs. frequency curves for aluminum electrolytics.



Then the observed impedance is resistive or Z = Rs. This is the so-called series resonant frequency of the cap, which for tantalum and aluminum electrolytics will generally fall between 10 kHz and 1 MHz. From this, it should be apparent that if a capacitor is operated at a higher frequency than this, it will no longer be a capacitor to the circuit.

Although the discussion thus far has treated only tantalum electrolytics, this pattern of non-ideal Z vs. frequency behavior is actually inherent to *all* real capacitors to some degree. In the better quality dielectrics, Rs and L are lower and more closely controlled, and this is reflected in lower losses (DF), due to the lower parasitic parameters. This will be more apparent as we present data for other dielectrics.

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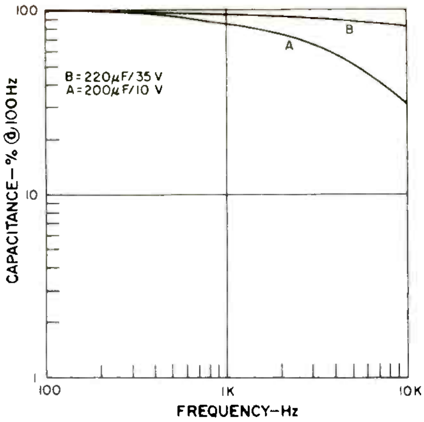
Fig. 8—Variation of effective capacity with frequency in aluminum electrolytics.



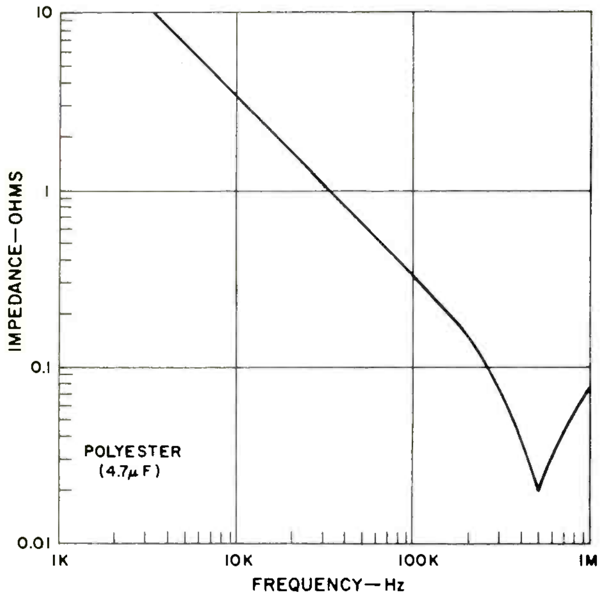
Aluminum electrolytics show a quite similar broadly resonant frequency, where Z = Rs (or ESR). Data for a wide range of aluminum electrolytics are summarized in Fig. 7.

As can be noted from these data, the resonant frequency is typically between 10 and 100 kHz. Note, however, that the *absolute* level of impedance is much lower in the case of aluminum, due to the availability of much larger values. Also, many of the larger electrolytics are designed to handle large ripple currents and thus have very low values for Rs, as can be noted.

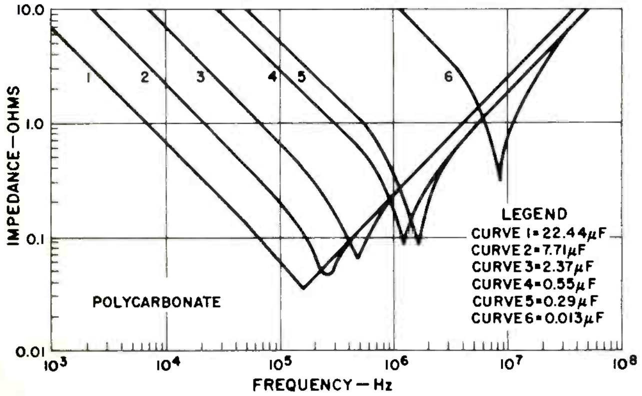
If these data are very carefully interpreted, a number of quite useful points can be drawn from it. Generally speaking, for two capacitors of similar value, the one with the higher voltage rating will show lower Rs (and DF, if viewed thusly). This can be seen, for example, between units A and B, as well as units F and G. And, it can also be seen in tantalum units (the two specific cases for comparison in Fig. 6 show this quite well).

One might at this point ask what is the disadvantage of a relatively high Rs (or high DF) in a capacitor used in audio.

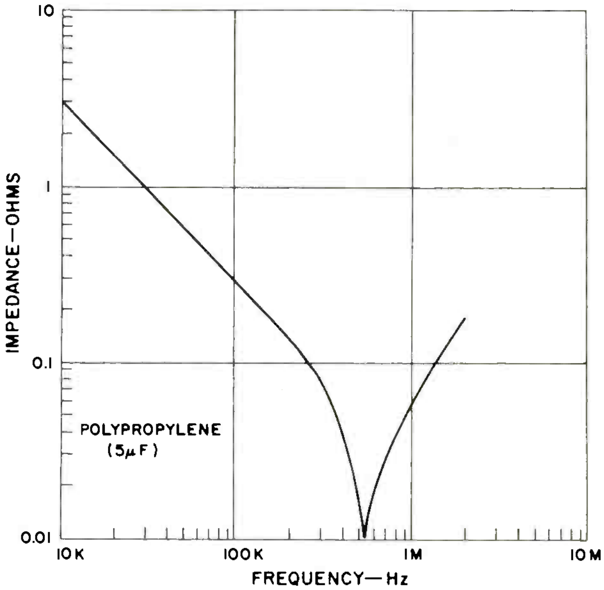
Fig. 9—Impedance vs. frequency for film capacitors using various dielectrics.



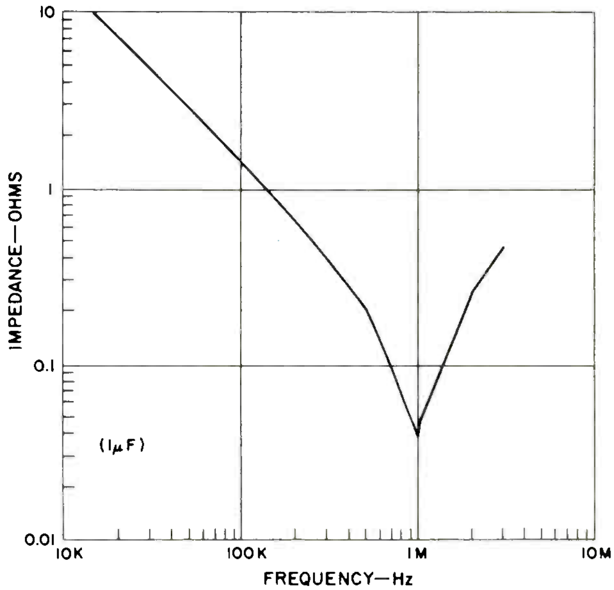
9a—Metalized polyester.



9b—Metalized polycarbonate. Material courtesy of Union Carbide.



9c—Metalized polypropylene.



9d—Parylene.

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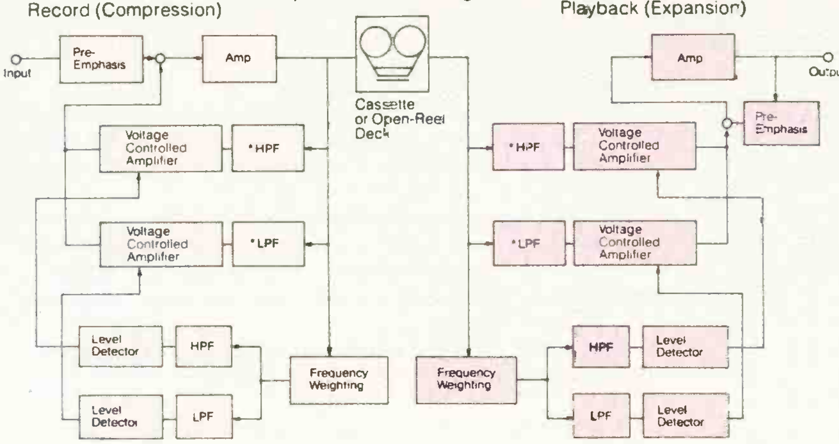

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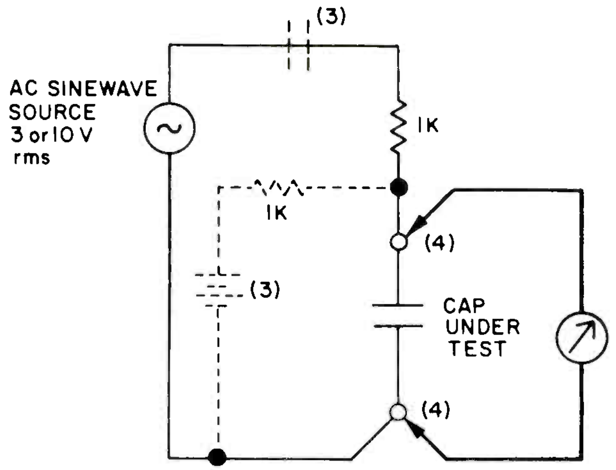

Fig. 10—Measuring capacitive impedance by oscillator and voltmeter method.

The answer can be had by regarding the data of Fig. 7 in a different light.

Using the capacitors A and B as illustrative examples, their actual effective capacitance values were calculated for various frequencies, using equation 4 to solve for C. The results, plotted in Fig. 8, clearly show the A unit (the higher Rs unit) to exhibit strong changes in capacitance with frequency. The B unit improves the situation relative to A, but still shows substantial capacitance change.

It is not at all hard to imagine how a capacitor whose value actually changes with frequency might distort an audio signal's integrity, particularly with regard to phase.

If we can visualize the complex frequency relationships of music passing through a capacitor (it doesn't really), while Z is simultaneously changing with the complex frequencies of the music, it is possible to appreciate how it can be relatively easy to upset the subtle harmonic/fundamental phase and amplitude relationships. Not only from the capacitance variation standpoint but also from the inductive behavior region. Used as a coupling capacitor, the resulting effects of high DF (L or Rs) are image blurring, and instrument harmonics/overtones are less accurately reproduced, with a general overall veiling of the sound. Use in a feedback path further complicates the matter, because we are using this signal to provide error correction. For example, if we consider the general transfer relationship for an amplifier where the gain = Zf ÷ Zin, it is easy to see that variations in Z with frequency which depart from the ideal will distort the relationship.

When we talk of film capacitor types, we find that the situation of less than ideal behavior regarding impedance vs. frequency is improved greatly. This is simply due to the fact that film dielectrics, such as polystyrene, polypropylene, polycarbonate, and polyester, have much lower dielectric losses. This is reflected in lower DF and Rs, as well as generally much more stable parameters with respect to frequency and temperature.

The impedance vs. frequency characteristics of a number of film-type capacitors are shown in Fig. 9. In general, it can be noted that they all show lower minimum impedances (lower Rs), and sharper dips around resonance. These points underscore the fact that the resistive losses can be much lower, in many cases below 10 milliohms.

Film capacitors also appear inductive above their series resonant frequency, due to inevitable parasitic inductance of the winding and/or leads. However, the inductive effects can be minimized, by suitable winding and termination techniques, which can extend the usefulness of a capacitor to substantially higher frequencies. Useful cues to look for in this regard are specified noninductive winding techniques and extended foil-welded-lead attachments.

Measuring Capacitor Impedance Values

Since the above points are so basic to optimum capacitor selection, it logically follows that most audio experimenters will want to have the capability to measure the various capacitor performance parameters. Since few of us have access to the necessary bridges (and if so, many of them can't measure Rs or DF), it seems necessary to devise a setup to measure these parameters. A setup we find most convenient to these purposes is shown in Fig. 10, and it was actually used to gather all of the data for Fig. 8.

This setup basically measures impedance (Z) by the voltage divider method, using a sine-wave generator and voltmeter. From the impedance data, C, Rs, L and DF can be derived. Table I and the notes describe the details of the procedure, which is written for either a bench voltmeter or an oscillator-analyzer combination. You should, of course, take appropriate precautions regarding bias voltages, polarity, and so forth. Also, be sure to use shielded leads on the voltmeter and connections direct to the terminals on low Rs units.

You will be pleased with how much power this simple little setup gives you in grading capacitors, particularly electrolytics. For example, you can use it to quickly weed out poor-quality units, such as A (a junkbox special). Given a few

Table I—Voltage to impedance conversion chart, with notes for various test conditions and using the circuit shown in Fig. 10.

Voltmeter Scale (Full scale, volts or percent) 10-V Source[1]	3-V Source[2]	Equivalent Impedance (Full scale, ohms)
1	100	100
0.3	30	30
0.1	10	10
0.03	3	3
0.01	1	1
0.003	0.3	0.3
0.001	0.1	0.1
0.0003	0.03	0.03
0.0001	0.01	0.01

Notes:

1) This scale applies to a separate 10-V source and a.c. voltmeter. The 1-V full-scale range is equivalent to 100-ohms full-scale range. (Multiply numerical reading X100 to get ohms.)

2) This scale applies to a Sound Technology 1700B or equivalent operated as a 3-V source. Use the "dB Volts" scale with 0.3 V rms equal to 100 percent. The 100-percent full-scale range is then equivalent to 100-ohms full-scale range and ohms are read directly.

3) The d.c. bias source, if required. Use input blocking capacitor equal to or greater than 100 μF, and OBSERVE POLARITIES!

4) On low ESR types, place the a.c. meter leads directly at the capacitor terminals for minimum lead length.

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If you use an audio oscillator and meter, you will most probably be limited to upper frequencies below 100 kHz or 200 kHz. However, you can use the same basic technique with a wide-range function generator as a sine-wave source and a high-gain scope as the readout device. This will allow testing of the smaller value film capacitors, which typically are series resonant at appreciably higher frequencies.

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Equipment profiles

Audio-Technica Lifesaver Record Care System

It has been several years since we performed comprehensive tests on a record preservative system from Ball Bros. known as Sound Guard. That product did an effective job of applying a dry lubricant coating to records to decrease stylus friction and thereby increase record life. More recently, we performed similar tests on an antistatic solution known as Permostat (distributed by Stanton Magnetics) whose primary function was to permanently reduce static charges on records. Both of these products accomplished their stated tasks in an exemplary manner, but serious record collectors intent on achieving best performance from their discs were faced with the need for two separate products, in addition to having to use a record-cleaning system.

Now Audio-Technica has come up with a record-care system which accomplishes both record preservation *and* almost total reduction of static charges on discs. Dubbed the Lifesaver system, it provides a slippery microscopic barrier against record surface damage and also contains a non-silicone antistat that disperses static charge fairly rapidly upon application.

Test Methodology

All of the tests undertaken by our lab involved the repetitive playing of specific test records. Although claims made for Lifesaver refer to 50 playings, our tests involved 100 repetitive playings of certain portions of the test records. Previous experience with similarly applied products has revealed that this number of plays is required to reveal easily discerned differences between treated and untreated discs.

For each of our tests, an untreated control record was subjected to the same number of plays (100) as the treated record. All measurements were made both after the first playing of the treated and untreated records and after 100 playings of each.

Laboratory tests were conducted using a CBS Catalog STR-130 Test Record. Band 4 of Side A of this record contains spot frequency signals covering the range from 20 Hz to 20 kHz, while Band 7 of the same side offers a 1-kHz steady tone which we used for making harmonic distortion measurements. The lead-out groove of Band 7 is also sufficiently long to serve as a "silent groove" band which we used to examine surface noise content for the treated and untreated discs.

Test Equipment Used

The chief measuring instrument used in all the tests was our Model 5L4N Tektronix spectrum analyzer mounted in a Model 5100 storage 'scope mainframe. For all tests, the sweep rate was adjusted so that a complete horizontal analysis took place in 20 seconds. Sweep was set to the linear position, and the horizontal scale for all distortion measurements was 1 kHz per division, while for noise spectral analysis it was set to 2 kHz per division in order to observe the entire audio band (out to 20 kHz).

The turntable used was an ADC/BSR Accutrac Model 4000 equipped with its own ADC cartridge adjusted to a tracking force of 1.5 grams. This unit was chosen because its programming feature enabled us to "punch in" up to 24 playings of the same band of the record to accelerate the tests and so as not to require our presence while the repeated playing sequence took place. To avoid any possibility of vinyl deformation caused by too-rapid repeat playing of the disc, we programmed the turntable to alternately play Bands 4 and 7 of the disc (including the lead-out groove after Band 7). Thus, each cycle took approximately six minutes.

Since Lifesaver makes claims for reducing static buildup to negligible values, we acquired an electrostatic field strength

Fig. 1—Electrostatic field strength meter used to measure voltage charges on test records.

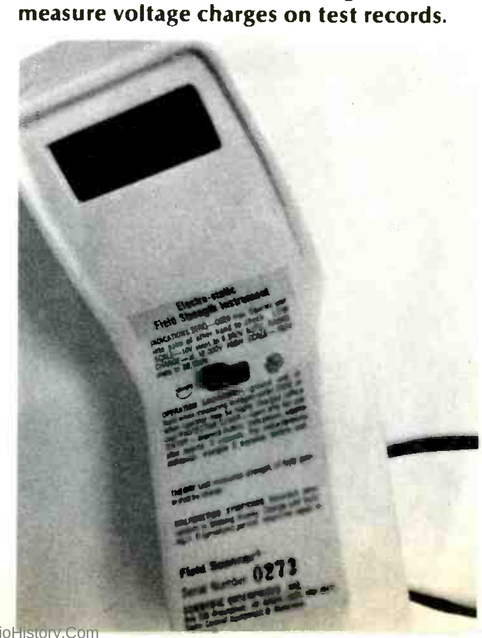


Table I — Electrostatic voltage readings (volts).

	Untreated Disc	Treated Disc
Removed from sleeve, held by edge	50,000	54,800
Placed on turntable	2,500	2,200
After first play, but before treatment, hand-held	43,000	33,000
After first play, but on turntable, before treatment	2,400	2,250
First post-treatment play, on turntable	N/A	390
First post-treatment play, hand-held	N/A	380
After 100 playings, on turntable	2,400	180
After 100 playings, hand-held	48,200	600

meter known as the Microstat Field Scanner, manufactured by Scientific Enterprises, Inc. (their Model 2B, pictured in Fig. 1). Via a digital readout, this instrument reads directly in volts over a range from 0 to 99,900 volts, positive or negative, when it is held at a distance of 10 centimeters from the surface to be measured.

Signals picked up by the cartridge were amplified and equalized by our laboratory reference preamplifier, the output of which was fed in parallel to a Sound Technology Model 1700B audio analyzer, a conventional oscilloscope (for monitoring results visually) and the aforementioned spectrum analyzer.

The Lifesaver Record Care System includes a two-ounce bottle of fluid (enough to treat approximately 30 discs on both sides), a velvet buffing pad into which one can slip the three middle fingers of one hand for effective buffing, and 30 small labels on which the date of treatment of each record can be noted. Suggested price for the kit is $12.95, and a six-ounce replacement bottle of fluid is available for $14.95. Treatment of the first 30 records costs around 43 cents, while subsequent treatments, using the six-ounce refill, would cost approximately 17 cents per disc.

The fluid of Lifesaver is applied by means of a jet spray pump which is affixed atop the bottle and manually operated. Once the entire surface of the disc is sprayed, the hand buffing device is used to thoroughly buff-in the product on the surface of the record. The liquid carrier of the solid lubricant evaporates quickly, leaving the microscopically thin coating uniformly distributed on the disc. Audio-Technica states that the coating is only three microns thick, but of course we had no way of measuring this.

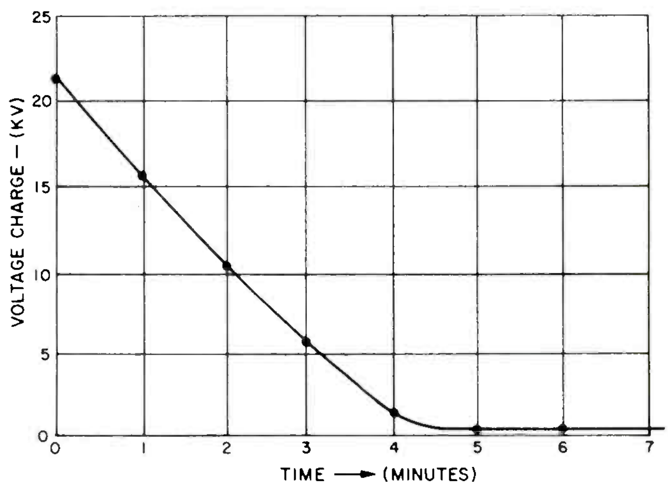
Test Results

We first determined that frequency response, as plotted using the spot frequencies of Band 4 of the test record, was not materially affected by application of the liquid, either after the first playing following the treatment or after 100 plays. Such differences in response that were observed for the untreated and treated records alike were so minimal and random that they can only be attributed to tolerances in the measurement system and, perhaps, changing ambient conditions of temperature which might affect the test preamplifier or even the cartridge itself to a minute degree. Thus, it can be safely said that application of Lifesaver in no way degrades tonal response from a recording.

Using the Microstat Field Scanner, we measured the electrostatic voltage charge of the untreated and treated discs at various times during the tests. The untreated control record was measured after rapid removal from its sleeve and, again, after placing it on the turntable. The disc was next measured after 100 plays, first while resting on the turntable and finally while held by its edge. The treated disc was similarly measured (including a before-treatment measurement to insure similarity between the two test discs). Results are shown in Table I.

It should be noted that immediately after buffing-in of the Lifesaver fluid, a charge is developed on the treated record. Initially, this voltage measured 22,500 volts when the record was hand-held by its edge. However, it quickly subsided, as shown in the graph of Fig. 2. After five minutes following treatment, the voltage charge, still measured with the record hand-held on edge, had decreased to a negligible 390 volts. Clearly, the fluid is an effective and long-term deterrent to static charge on records.

Fig. 2—Decrease in static charge after application and buffing of Audio-Technica's Lifesaver record preservative.



Harmonic Distortion Tests

Figures 3 through 6 reveal a clear picture of how harmonic distortion varies with repeated playings of discs, both for the untreated and treated test records used in these tests. In each of these spectrum analyzer 'scope photos, the spike at the extreme left is the desired 1-kHz test signal. The shorter spike immediately to the right of the fundamental is second-order harmonic distortion. This is largely a function of tonearm tracking geometry, and we will ignore it in this discussion since it remains fairly constant throughout the tests. Of interest, however, is what happens to higher order harmonics, beginning with the third spike from the left of each display. Figure 3 represents results obtained from a first playing of the untreated disc. Third-order component is down 51 dB compared with the fundamental (or 0.28 percent), fourth order is down 58 dB (0.13 percent), while fifth order is down 63 dB (0.07 percent). Combining these components mathematically (square root of the sum of the squares of each component

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The new E90 measures 45-3/8"H x 15-3/16"W x 14-3/4"D and has a typical frequency response of 30–18,000Hz ±3dB. The E70 is 32" x 13-1/2" x 14" with frequency response from 35–18,000Hz ±3dB. The E50 measures 25" x 13-1/2" x 13-1/2" with a frequency response of 40–18,000Hz ±3dB. The new E30 is 22-3/4" x 13-3/16" x 10-5/16" with a 45–18,000Hz ±3dB frequency response. Efficiency is 94dB at 1 watt and 1 meter for the E30, and 95dB for the other models.

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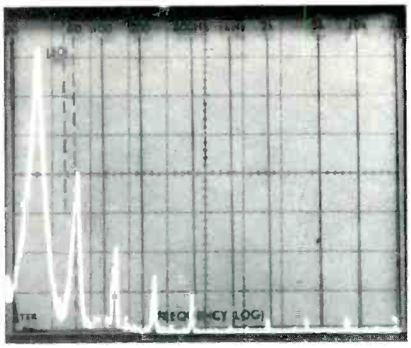

Fig. 3—Harmonic distortion of the untreated disc during first playing.

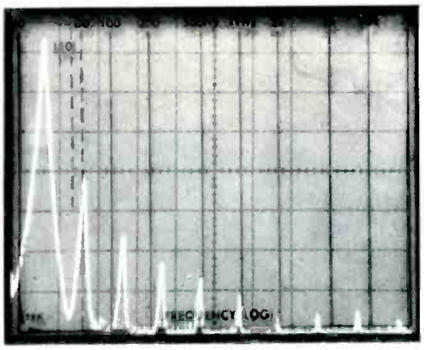

Fig. 4—Harmonic distortion of the untreated disc after 100 playings.

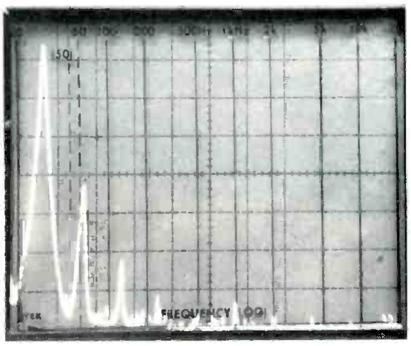

Fig. 5—Harmonic distortion of the treated disc, first play after application of Lifesaver.

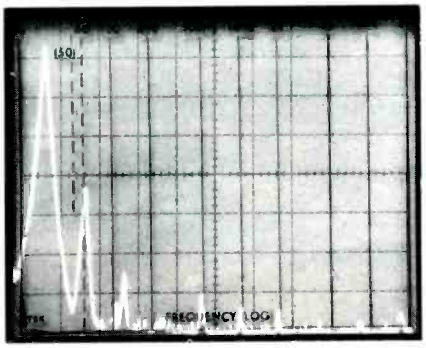

Fig. 6—Harmonic distortion of the treated disc after 100 playings.

divided by the fundamental amplitude), we come up with an overall distortion figure of 0.32 percent (ignoring the higher order components whose amplitudes are negligible in the calculation, as well as the aforementioned second-order component).

Figure 4 represents results obtained after 100 playings of the untreated disc. Third-order component has increased so that it is now down only 48 dB (0.4 percent), fourth order is at -55 dB (0.18 percent), fifth-order distortion is down 60 dB (0.1 percent) while sixth order, now significant, is at -63 dB (0.1 percent). The combination works out to a distortion figure of 0.45 percent — clearly an increase in distortion compared with the first playing.

Results obtained during first play of the disc after treatment with Lifesaver are shown in Fig. 5. Distortion components (ignoring second order) are at -56 dB, -65 dB and -67 dB, with no significant contributions of 5th, 7th, or higher orders. These values calculate out to a percentage figure of 0.21 percent. It should be noted that immediately prior to treatment, the record was similarly checked and yielded a figure of 0.34 percent, comparable with that of the control record. In other words, application of Lifesaver actually improved stylus tracking slightly even during first post-treatment play compared with that of an untreated record. The real payoff came after 100 playings, as illustrated in Fig. 6. Again, ignoring the almost constant second-order distortion components, other components observed were at -58 dB, -63 dB, -68 dB, and -68 dB (fourth-order component has virtually disappeared), adding up to a net distortion figure of only 0.16 percent — or approximately one-third as great as obtained after 100 playings of the untreated record.

Surface Noise Analysis

Figure 7 shows the distribution of surface noise on the untreated record during its first playing, from 20 Hz to 20 kHz. After 100 plays the experiment was repeated, and the results are shown in Fig. 8. Clearly, the noise level in the region from 5 kHz to 20 kHz is from 3 to 5 dB higher after this large number of plays.

The same experiment was now conducted with the treated disc. Figure 9 shows results obtained during the first post-treatment playing of the disc to which Lifesaver had been applied. Comparing these results with those obtained in Fig. 7, there is a very significant *reduction* in noise level in the region from 1 kHz to the end of the spectrum at 20 kHz. We made periodic observations of the noise level after 25, 50, 75, and 100 plays. At the 75th playing, the noise remained virtually as low as it was during the first post-treatment playing, and only after the full 100 playings did the noise level return to that which had been observed for the untreated disc. Compare the results shown in Figs. 8 and 10.

From these tests we concluded that Lifesaver significantly reduces surface noise on discs to which it is applied, but that the improvement is effective for between 50 and 75 playings, after which the product should be reapplied for further surface protection.

Subjective Tests

In addition to the laboratory tests described, we applied Lifesaver fluid to a variety of discs in our own record collection. While these discs were not subjected to multiple-play testing, we can verify that subjectively and audibly, Lifesaver did reduce surface noise content during playing of the treated records and, at least to our ears, in no way degraded performance quality. On the basis of these tests, we can sum up the benefits of Lifesaver as follows: It reduces static charge buildup on records to insignificant levels for up to 100 playings after application, it reduces the rate of increase of harmonic distortion during playback of discs for at least 100 playings after application, and it reduces surface noise heard during playback of discs for at least 50 playings.

As a final note, we found that Lifesaver is compatible with at least two of the most popular cleaning formulations, which should be applied to a disc prior to treatment with Lifesaver. Because of the antistatic protection afforded by Lifesaver, subsequent cleaning of records becomes much easier (the dust particles are not held so tenaciously to the surface as they are when records carry a high voltage charge),

Continued on p. 95

B•I•C Model T-4M Cassette Deck

Manufacturer's Specifications
Speeds: Two, 1⅞ and 3¾ ips.
Frequency Response: 20 Hz to 21 kHz, ±3 dB, at 1⅞ ips; 20 Hz to 24 kHz, ±3 dB, at 3¾ ips.
Signal-to-Noise Ratio: 68 dB at 1⅞ ips, 72 dB at 3¾ ips, both with Dolby N-R.
Wow and Flutter: 0.05 percent at 1⅞ ips, 0.03 percent at 3¾ ips, both W rms.
THD: 1.3 percent at 1⅞ ips, 1.0 percent at 3¾ ips, both at 0 VU.
Dimensions: 17¼ in. (43.82 cm) W x 10 in. (25.54 cm) D x 6½ in. (16.5 cm) H.
Weight: 18 lbs. (8.18 kg).
Price: $849.95.

The B•I•C Model T-4M has to be one of the most sophisticated cassette decks to be reviewed in these pages, and some idea of its versatility can be had by a look at the controls. There are no fewer than 23—and that's not counting the tape transport buttons! Among the features of this "loaded" deck are metal-tape capability, a digital display instead of a rotary tape counter, built-in 400-Hz and 10-kHz signal generators, variable speed control, bias control, monitor head, dual capstans and, that B•I•C innovation, two speeds.

The front panel is finished entirely in black with white lettering, while the case is nicely made from rosewood. The cassette compartment is over on the left, and underneath is a row of feather-touch logic controls for tape transport plus an on-off switch. To the right are eight lever switches for speed change (1⅞ and 3¾ ips), equalizing, bias, record, Dolby, MPX, monitor, and record calibration. The last-named switch activates the 400-Hz or 10-kHz generators, while the record switch has a third position marked *Mute* which stops the recording signal from reaching the tape. Next to the calibration control is the variable bias control followed by three ¼-in. phone sockets, one for headphones and two for microphones. Above them are two large knobs and three small ones, the first two being dual-concentric mike-line input controls, while the other three govern the pitch and output, and headphone levels. At the top is the large digital-display tape counter, and next to it is a twin horizontal VU display consisting of 12 green and four red LED indicators for each channel. The first red light marks the Dolby level and 0 VU, and the green ones are arranged in -3 dB steps down to -36 dB. In between the VU and tape counter displays are metal-tape and clipping indicators, both LEDs, and to the right is a group of six small buttons controlling a microcomputer circuit for auto rewind, auto play, tape counter clearing, and memory functions. And that's it for the controls—with the exception of the *Eject* button, which is located way over on the left-hand side of the cassette compartment, conveniently placed near the top, and the two 400-Hz calibration controls just below. There are two motors, a servo-controlled model for transport and a d.c. type for spooling.

One more thing: The bias adjustment switch is marked 400 Hz and 10 kHz, and it might be thought that alignment at these frequencies will not produce optimum results. However, the actual high-frequency signal was measured at just over 16 kHz, a modification which was confirmed by a footnote in the instruction manual, which mentions that the deck is set up for TDK AD and SA and for Scotch Metafine.

Laboratory Measurements

As usual, the first test was for playback response from a standard tape, and the output was within 1 dB from 70 Hz to 10 kHz, with a rise of 2 dB at 40 Hz as shown in Fig. 1. As the T-4 has metal-tape capability, one of the new TDK MA-R C-

Fig. 1 — Playback response from standard 40 Hz to 10 kHz test tape.

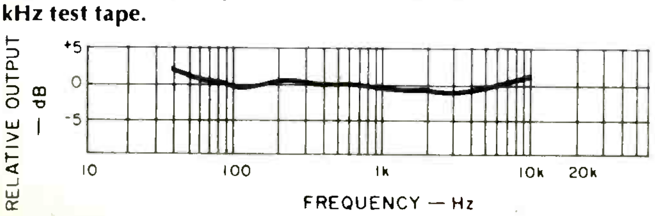

Table I — Signal-to-noise ratio, dB, referenced to 3 percent THD, "A" weighted. Add 8 to 9 dB for Dolby N-R.

Tape	1⅞ ips	3¾ ips
TKD MA-R	53.5	56.5
Scotch Metafine	53.0	56.0
Fuji Metal	54.0	57.0
Maxell UD XL-I	55.0	58.0
Fuji FX-II	56.0	58.5

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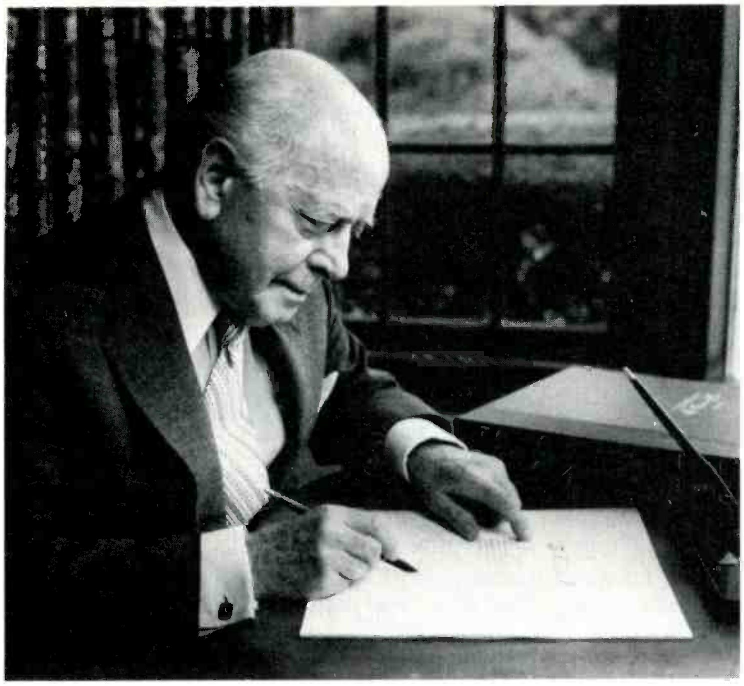

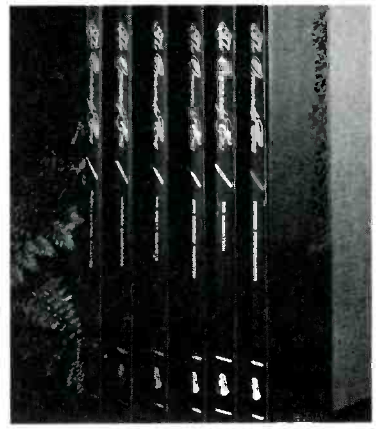

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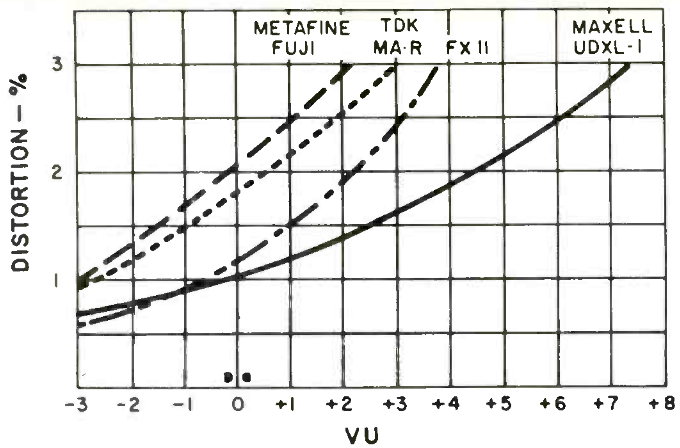


Fig. 6 — Distortion vs. level at 1 kHz for five tapes.

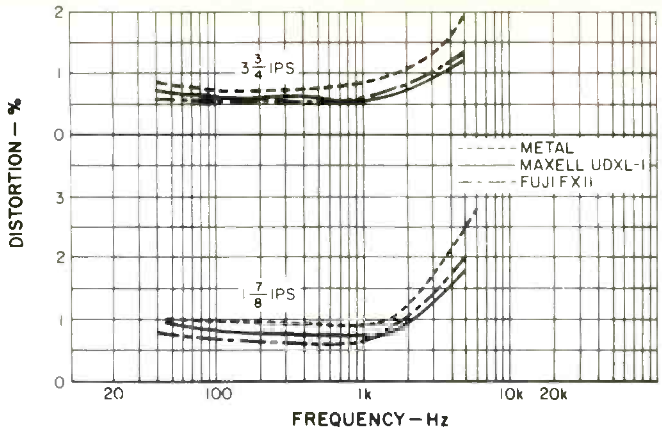


Fig. 7 — Distortion vs. frequency.

easy. I am sure many people will find the built-in microprocessor most useful as it enables many functions to be selected automatically. For example, there is a choice of automatic rewind, auto play, continuous play, or stop with two memory reference points selected with the aid of the counter display. As mentioned earlier, this is quite large and the brightly-lit half-inch figures can be seen from a considerable distance — unlike most conventional digital counters!

Now for a few words about the metal tapes: It is apparent that the designers of the T-4 have settled for a wider frequency range, with increased headroom at the higher frequencies, rather than taking advantage of better headroom in the midrange. Even so, the results show a significant midrange improvement over "ordinary" tapes. But note that the signal-to-noise ratio is not affected to any extent.

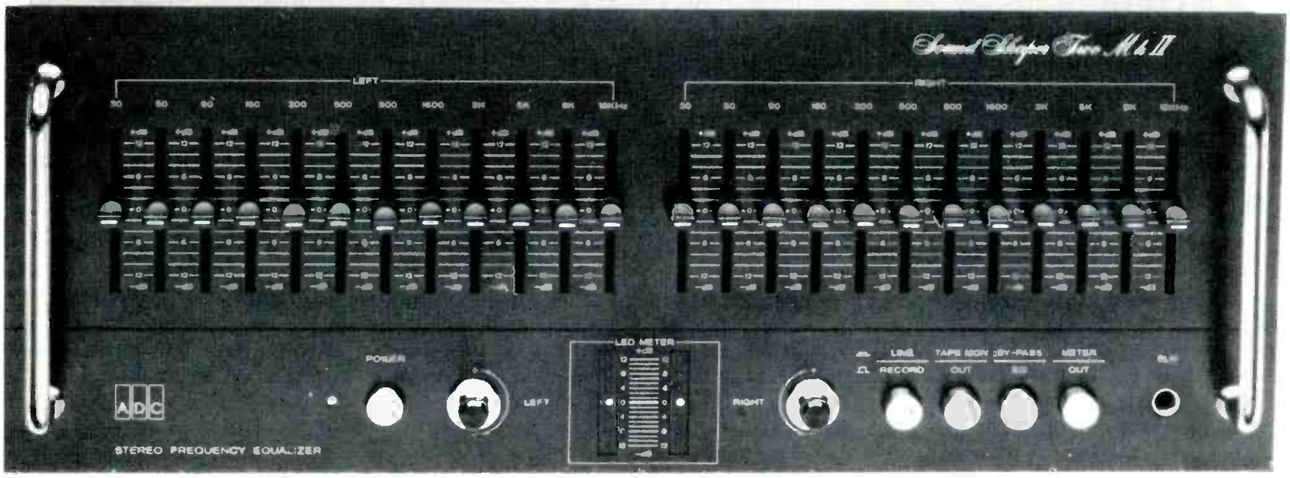
How about the 3¾ ips speed? Is it really worthwhile? Well, a glance at the graphs certainly confirms a wider frequency range, and recordings made at this speed have an audible extra brilliance and clarity — particularly noticeable with direct-cut discs, but the playing time is reduced by half. For most purposes, the 1⅞ ips speed will be found to be perfectly adequate.

Overall, the deck must be considered as one of the very best available today, and it offers a surprisingly good value for dollar. (Editor's Note: A quick count of cassette decks priced at $1,000.00 or more in our October Directory found some 18 decks in this price range — E.P.) Some features, such as the microprocessor unit, are almost unique to this deck, while others are more usual, but still quite well worked out. An extremely versatile and very sophisticated cassette deck, one which should appeal to the most discriminating user.

George W. Tillett

Enter No. 91 on Reader Service Card

ADC Sound Shaper Two Mark II Stereo Equalizer



Manufacturer's Specifications
Frequency Response: 5 Hz to 100 kHz.
Control Frequencies: 30, 50, 90, 160, 300, 500, 900, 1.6k, 3k, 5k, 9k and 16k Hz.
Control Range: ±12 dB.
Gain: Unity.
Output: 9 V min. into 10-kilohm load.
Harmonic Distortion: 0.02 percent.
IM Distortion: 0.02 percent.
Hum and Noise: -85 dBV.
Impedance: Input, 75 kilohms; output, 10 ohms at 1 kHz.
Dimensions: 16⅜ in. (416 mm) W x 6¼ in. (159 mm) H x 6¾ in. (172 mm) D.
Weight: 7.2 lbs. (3.3 kg).
Price: $280.00.

The ADC Sound Shaper Two Mark II stereo equalizer combines very good overall performance with unusual flexibility in providing 12 boost/cut controls per channel. Each of these vertical sliders is scaled ±12 dB, with a worthwhile detent at the zero/flat-response position. Note that the spacing of the filter center frequencies is less than an octave, facilitating more accurate equalization. The large handles on the front panel appear appropriate for rack mounting, and there is an adaptor kit available as an option for that purpose. The left- and right-channel level meters are in a single assembly, with vertical, facing scales covering ±12 dB. Adjacent pots set the LED metering sensitivity for zero indication over a range of input levels.

The Mark II is typical in that it is designed to be inserted into the tape monitor loop of a preamp or receiver. There are unity-gain adjustment pots and the required phono jacks on the back panel, as well as sets for tape recorder in and out, and an unswitched a.c. outlet of 200-watt rating. Push button switches on the front panel provide choices for EQ of program to tape recorder, EQ of program back to preamp/receiver, EQ on tape playback, or EQ bypass. The LED meters can also be switched off, if desired. A front-panel phone jack allows connection of the output of an SLM (sound level meter) to be indicated on the right-channel meter. ADC has an accessory SLM with test record available as an option.

With minor exceptions, all of the circuitry is on three PCBs, with some of the larger inductors mounted on the smallest of the three. A large vertical one is connected directly to the boost/cut sliders, with the RCL components mounted on the interior side of the card. The other large PCB has all other circuitry. Soldering was very good, and inter-board connections were with wirewrap. All parts and adjustments were clearly marked.

Performance

All filter center frequencies were close enough to the designations for EQ use. The attenuations in cut were just slightly greater than the scale indications. The discrepancies in boost were greater, with +13.5 dB actual at "+12," but this is still quite acceptable for high-fidelity system EQ. The shape and bandwidth of the filters were examined with varying degrees of boost and cut. The shapes were quite consistent from section to section, as shown in Fig. 1, the maximum boost and cut plots. At the maximum boost, filter Q was about 2.2 or, stated another way, the bandwidth was about ⅔ octave. One-octave bandwidth (Q=1.4) was secured with 9 dB boost. These figures tell us that considerable boost can be introduced with limited ringing. This is a desirable characteristic, an advantage over some units that have very peaked responses. It is best, however, to restrict boost for a maximum Q=1, which was at +8 dB. With all sliders in detent, the response for either channel was flat from less than 10 Hz to 100 kHz, with small effects from loading.

The output impedance was only 8.2 ohms at 1 kHz, and fell slowly to 6.8 ohms at 20 kHz. It rose at the lowest frequencies, reaching 220 ohms at 20 Hz, certainly not to be challenged by the standard IHF load, 10 kilohms in parallel with 1,000 picofarads. The input impedance was satisfactorily high out to 20 kHz. The IM distortion at 1 V out was 0.029 percent with a high-Z load, 0.036 percent with the IHF load. These figures are a bit above the 0.02 percent specification, but the manufacturer's test conditions are not given in the instruction book. IM distortion of 0.1 percent was reached with 2 V out. With 1 V output, THD was 0.008 percent at 10 Hz, 0.01 percent at 1 kHz, 0.019 percent at 20 kHz, and 0.1 percent at 58 kHz. Distortion figures were slightly higher with the IHF load. With 2 V out, the results were 0.014 percent for 20 Hz,

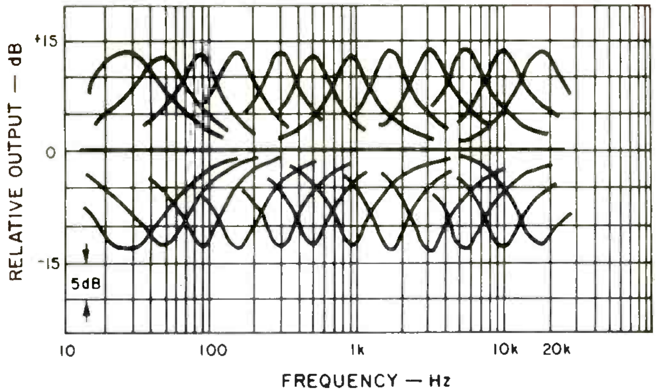


Fig. 1 — Frequency responses of individual filter sections at maximum boost and cut.

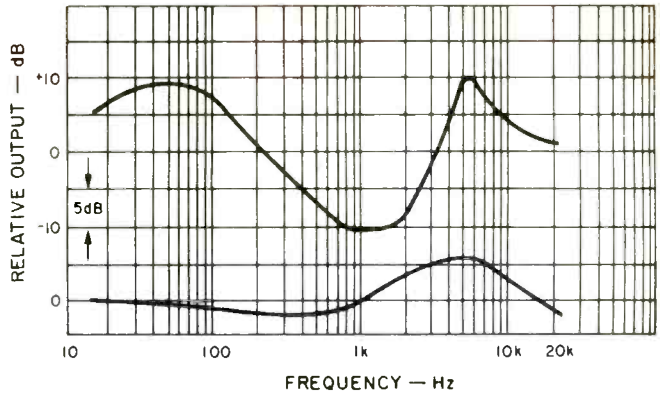


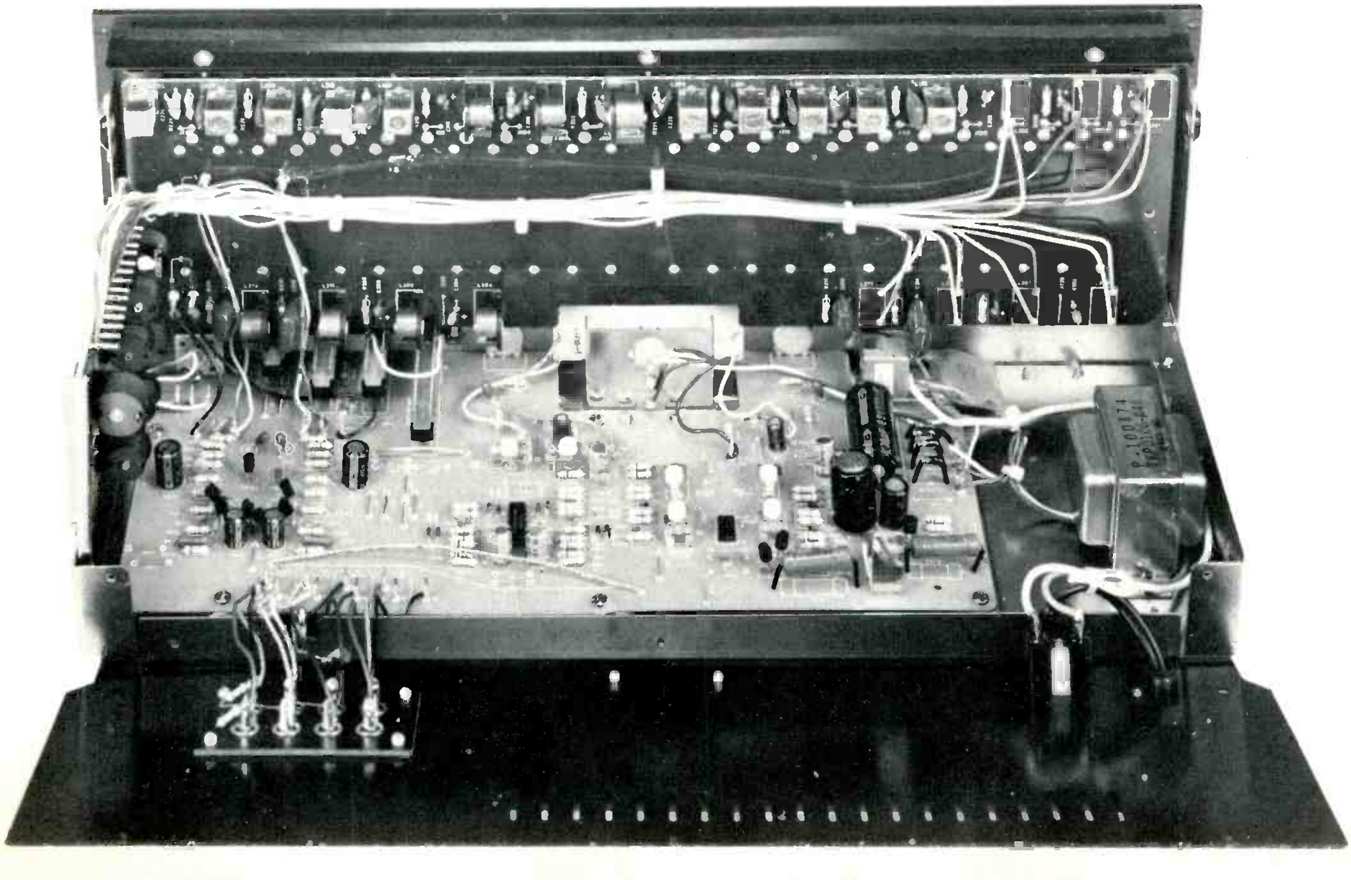
Fig. 2 — Top, swept frequency response with 50- and 90-Hz filters at +6, 300 Hz at -4, 900 and 1600 Hz at -8, and 5 kHz at +10; bottom; swept response of EQ used to improve system response (see text).

0.018 percent for 1 kHz, and 0.026 percent for 20 kHz with the high-Z load, certainly very good. With the IHF load, all figures were somewhat higher (0.022 percent at 1 kHz). The maximum output level of the Mark II was 10.2 V at 20 Hz, 11.1 V at 1 kHz, and about 8 V at 20 kHz, which is plenty high enough, even if the last figure is under the specified 9 V.

The 8-V output at 20 kHz showed what appeared to be current starvation on the positive peaks. Slew rate was checked with a 100-kHz square wave. In the positive direction, slew rate was 2.0 V/ μS. In the negative direction, it was 10 V/ μS. These results were consistent with the fact that THD was less than 1 percent at 111 kHz with 2 V out. At 1 V out, the response did not fall 3 dB until 400 kHz.

Excellent signal-to-noise ratios were measured with the ADC equalizer. With 1 V out, the figures were 99.3 dBA with that weighting, and 95.7 dB for CCIR/ARM weighting. Unweighted, but with the measurement bandwidth restricted to 20 Hz to 20 kHz, the noise was down at -89.0 dBV. The values given here would change directly with changes in the output level relative to 1 V. With all of the filter controls in detent, there was a 0.3 dB drop in level when EQ was switched in, not significant.

The meter pots allowed setting the indications to zero for inputs from 70 mV to a very high 10 V. The scales cover ±12 dB with markings every 2 dB, accurate within 0.2 dB. The dynamic response was very slow, requiring about 1 second for a charge of 20 dB, and about 2 seconds to discharge. This slowness, however, provides smoothing which facilitates reading the average levels of music or noise test signals. The meter indications are affected by the input level, the EQ slider settings, and the meter pot settings, but they do not necessarily show what the output levels are. It would be pos-



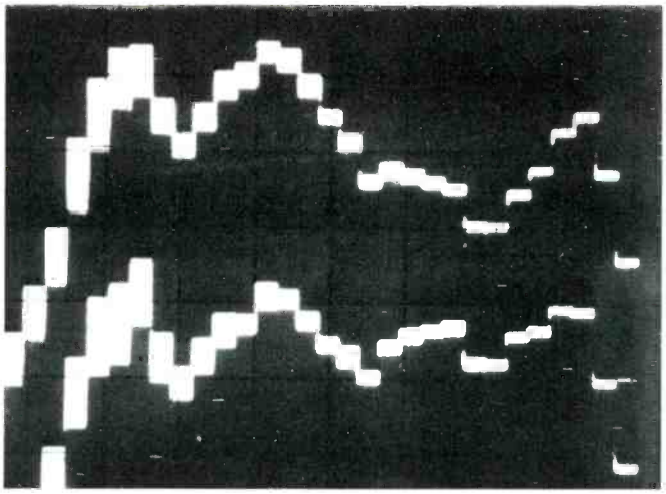


Fig. 3 — RTA display of system response. Top, before EQ; bottom, after EQ. (Vertical scale, 5 dB/div.)

sible to switch in EQ with a startling change in level, to say nothing of possible damage. *If* the meters are zeroed before making EQ adjustments, and the combination of boost/cut is made so that the meters stay at zero, the EQ in/out levels *will* match. The instructions do not suggest this procedure, but they do caution on the possible level shifts.

In-Use Tests

Equalizers can be fun to play with, but they really are much more than toys. For a little fun, however, some of the filters were arbitrarily boosted and cut, just to see the effects (Fig. 2). The swept-frequency plot shows that all of the transitions from one region to the next are smooth. For a practical case, the output from a small bookshelf speaker was displayed on a ⅓-octave RTA (Fig. 3). The response to the pink-noise drive showed a number of peaks and dips spread over 12 dB, but with fairly good output out to 20 kHz. While observing the display, the Sound Shaper was adjusted to reduce the peaks and bring up some dips: 30 Hz to +4 dB, 50 and 90 Hz to -3 dB, 160 Hz to +4 dB, 300 and 500 Hz to -3 dB, 3 and 5 kHz to +5 dB, 9 kHz to -2 dB, and 16 kHz to -4 dB. The net result was a reduction in the spread for the whole band down to 5 dB, a significant improvement, confirmed by listening. A swept response of the Mark II with the EQ used is smooth and looks simpler than what might be expected with the 10 adjustments made. The reader should be aware of the fact that good, total sound-system response requires high-performance loudspeakers, well matched to the acoustics of the room. An equalizer can perhaps bring a fair speaker, as was used here, toward excellence, but it cannot solve severe problems such as crossover holes.

The instruction book has good text and illustrations, in general. The "typical response curves" shown are not really typical, because they show the results with maximum boosts and cuts, settings to be avoided if possible. There is a general discussion of possible applications and the sonic effects of adjustments in the various ranges. The manual would be of greater help with the inclusion of actual examples, e.g. improving speaker response with before and after curves, using EQ to match a tape type to a recorder, etc. The ADC Sound Shaper Two does its job well, and in use there was no sense of any extra complication in handling the 12 channel controls, rather than the usual 10. The Mark II does offer finer frequency resolution than other such units, along with low distortion, high signal/noise ratios, and high slew rates.

Howard A. Roberson

Apt/Holman Control Preamplifier

Manufacturer's Specifications
Frequency Response: 20 Hz to 20 kHz, ±0.5 dB.
Maximum Output: 7 volts.
THD: 0.01 percent.
IM Distortion: 0.01 percent.
Phono Sensitivity: 1.25 mV for 0.5 V output at 1 kHz.
Phono S/N: 74 dB, "A" wtd., for 5 mV input.
Phono Overload: 100 mV.
High Level Sensitivity: 0.32 V.
Dimensions: 15.04 in. (38.20 cm) W x 3.30 in. (8.38 cm) H x 9.32 in. (23.67 cm) D.
Weight: 12 lbs. (5.45 kg).
Price: $493.00 East, $502.00 West.

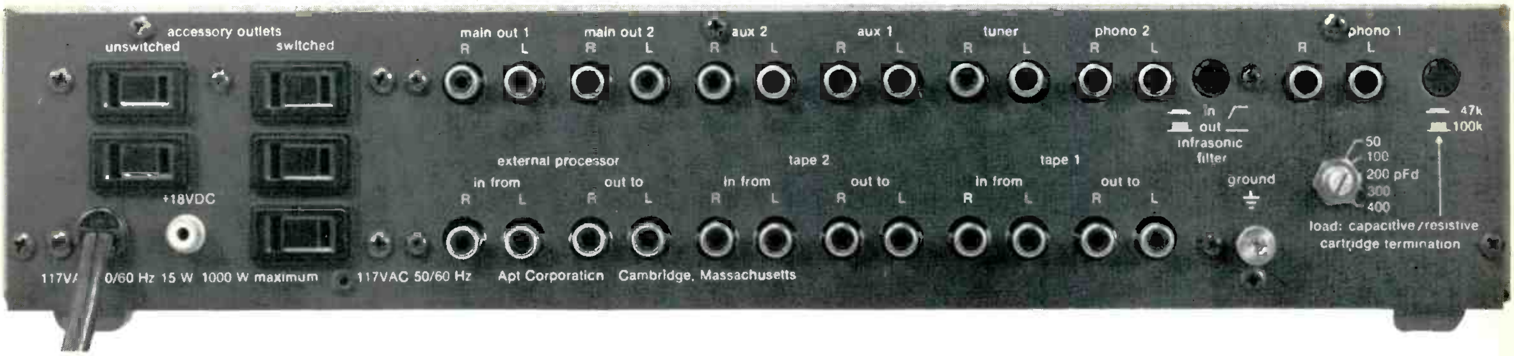
During the development of a rationale for generating new and more useful tests of the performance of control preamplifiers, it seemed wise to take a fresh look at the functions which they are meant to perform. A control preamplifier, such as the Apt/Holman unit which is the subject of this report, provides two main functions. Besides amplifying low-level signals, it provides control and switching functions. Many designers appear to concentrate most of their effort in designing excellent amplifiers while tending to ignore the control and switching functions. Others provide very good control and switching capabilities but provide less in terms of sonic quality.

It also seemed desirable to ascertain whether certain audibly perceived qualities might be related to technical measurements. Because of the high performance level of modern control preamplifiers, this is not an easy task. Certain data are presented in this report which may appear unusual at first, but by being able to compare them with similar data in future reports, it may be possible to more easily assess differences between units. Both the amplifying and the control/switching functions were investigated, and information is presented concerning the quality of each.

The Apt/Holman control preamplifier displays a high level of attention to design details related to both amplification and control/switching functions. It is definitely the result of extensive investigation into some very important factors which affect the quality of reproduction. Tomlinson Holman, who, while at Advent Corp., developed a novel phono preamplifier for the Advent Model 300 receiver, has done a great deal of just such investigation. In fact, a number of articles and technical papers by Holman and his colleague Frank Kampmann are available from Apt Corp. as reprints. The amount and quality of their research are very impressive. The separate Owner's Manual and Service Manual are also worthy of mention, since they are truly exceptional in their thoroughness, detail, and clarity. It would be impossible to cover every detail of such an engineering tour-de-force as this unit represents in a short report. However, an attempt will be made to cover the most salient features and make appropriate comments. The reader is also advised to take advantage of the literature which is available from Apt Corp. or its dealers for there are features which we will not have adequate space to cover completely.

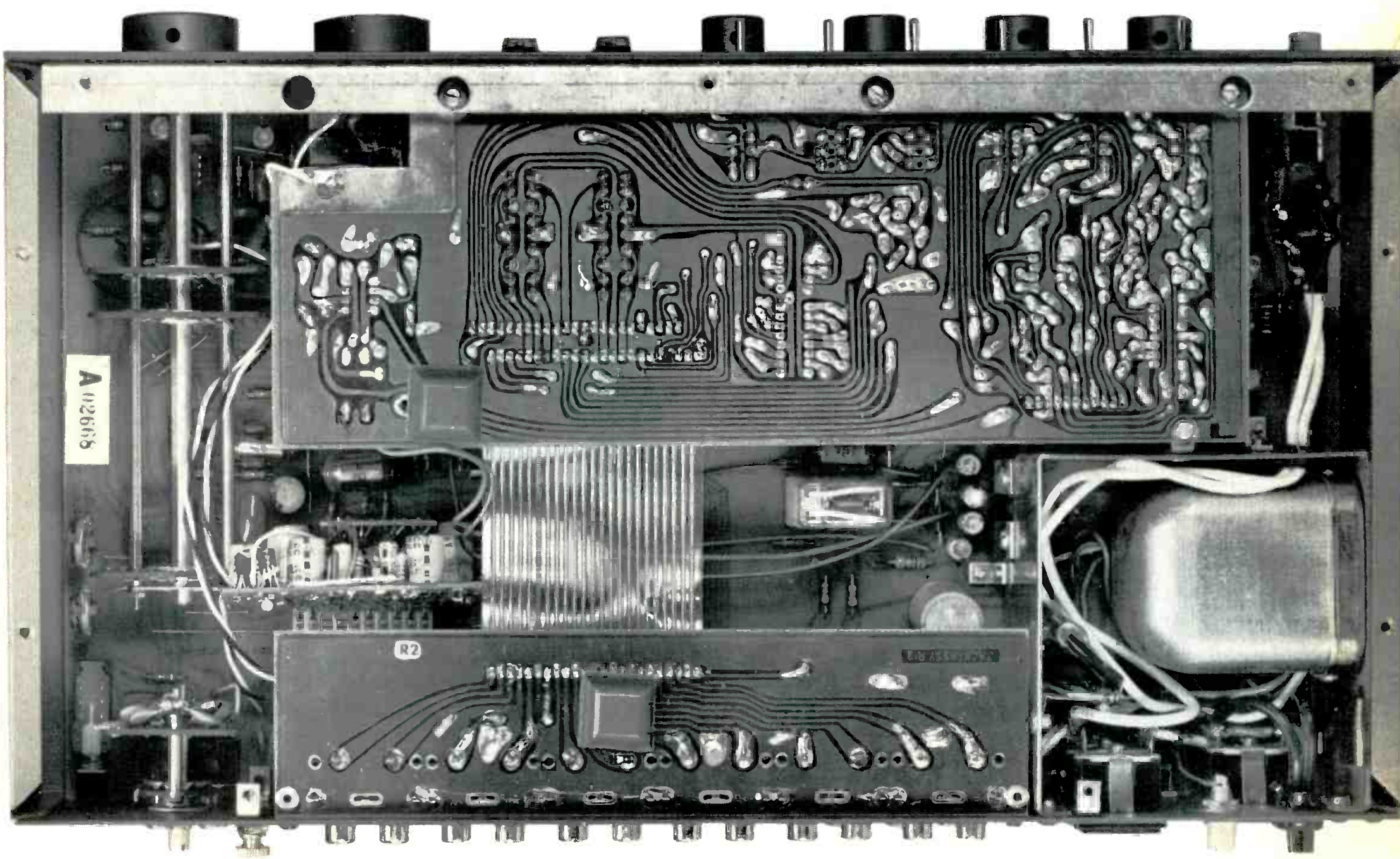
The Apt/Holman control preamplifier has a number of well-thought-out functions. Beginning at the phono inputs, of which there are two, a unique control is provided for each which allows the channels to be balanced for any phono cartridge. By using another unique control on the front panel, which allows a left-minus-right condition, the phono balance control can be adjusted for a null while playing a mono record. This feature provides a means of compensating for differences between the left- and right-channel outputs of phono cartridges, which are almost never exactly the same and will have a bearing on the accuracy of stereo reproduction.

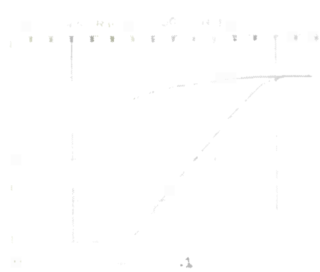
The control on the front panel, which is definitely unique, is called *Mode*. This control provides a continuous change from *L+R* (full counter-clockwise) through *Stereo* (detented center position) to *L-R* (full clockwise). The *L+R* position provides minimum stereo separation (mono). As the control is rotated past the center or *Stereo* position, a reduction of the center or mono information is affected. Apt Corp. recommends its use for varying the depth of the apparent stereo image. Another use, which may prove to be disconcerting to many record companies, is for determining just how "stereo" a record really is. Since the L-R information represents the stereo information, as opposed to the L+R or mono information, listening briefly to any program material with the con-



trol in the L-R position will allow a determination as to just how much stereo information is really present. The *Mode* control is well designed from the standpoint that proper level is maintained while changing from *L+R* (mono) to *Stereo*. It reduces the level to each channel by -6 dB when in the L+R mode, which is proper. The L-R mode showed a reduction of -5.5 dB to each channel.

Phono 1 provides a switch selection of either 47 or 100 kilohms. A second switch provides for selection of 50, 100, 200, 300, or 400 pF. Apt Corp. also provides a listing of many cartridges and arms which is a great assistance in determining the correct matching required for optimum performance. A very helpful infrasonic filter is also provided, which is controlled by a switch on the back panel. It very effectively reduces the ill effects upon the system caused by record warps and eccentricity, cartridge/arm resonance, and turntable motor vibration. It is recommended by Apt Corp. that the filter be left in for all normal listening, which is why it is located on the back panel. It also functions on all inputs since, for instance, a radio station may have a cartridge/arm resonance situation which could degrade the sound. Figure 1 shows the effectiveness of this filter in removing these kinds of undesirable subsonic signals. Figure 2 shows the time delay of the infrasonic filter at 20 Hz for the left channel. The 15.5-mS delay should cause no serious problems. A 16.8-mS delay was found in the right channel with the filter activated. This means that there is an interchannel time differential of 1.3 mS. Without the filter, the delays are 3.25 and 3.35 mS for the





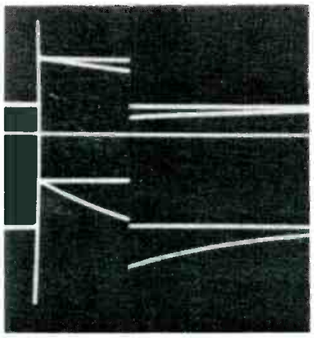


Fig. 1A — Frequency response with the infrasonic filter vs. response with no filter. (Note frequency scale multiplication factor of 0.1.)

Fig. 1B — Response to 5-mS pulse, with input and output overlaid. Low-frequency components of the square wave are delayed.

left and right channels respectively, which might have some effect upon systems which use a subwoofer. Experimenting with the polarity of the loudspeaker leads between the subwoofer and the upper-range loudspeakers, plus careful room placement of the loudspeakers, should ameliorate any problem in the bass range due to this delay. The effect of phase shift or time delay between channels does not really affect localization; however, it can affect how well the bass is propagated in a given room by a pair of loudspeakers. Since the natural modes of a room and the location of the loudspeakers already play a major role in this, the interchannel delay should be just one more factor to consider. Common-bass subwoofers can be more directly affected by the interchannel time differential at these frequencies, since the output will not be added algebraically if the input from the two channels is not exactly in phase. *(Editor's Note:* The manufacturer points out that this amounts to a summing error of about 0.03 dB at 20 Hz.— *E.P.)*

Phono 2 may also be adapted for low-output moving-coil cartridges by using appropriate plug-in modules which Apt Corp. is making available for specific cartridges. During our evaluation, we used the Model 201A pre-preamplifier module, as we had a Denon 103D cartridge available, for which this model was specifically designed, and the combination provided excellent performance. Reproduction with records was very clear and detailed with good signal-to-noise ratio. Stereo imaging was excellent with true stereo recordings. (Besides using the *Mode* control, we use a stereo display to determine whether a source has time-differential information or whether it is mostly mono.)

Apt has paid a great deal of attention to eliminating such things as r.f. interference, crosstalk from unused channels, and extraneous signals, all of which would cause deleterious effects in the program. There are two high-frequency filters; a front panel switch selects either an 8-kHz filter, which is useful in removing noise and distortion from older records or poor radio broadcasts, or a 40-kHz ultrasonic filter, which can be used to reduce possible slew-induced distortion in the following power amplifier by band-limiting the signal being fed to it. These filters are removed from the circuit when the tone-control defeat switch is activated. If the signal to be amplified were composed of only frequencies from 20 Hz to 20 kHz, then this filter would be unnecessary. Unfortunately, this is not the case, since, particularly in high-quality, wideband systems, higher frequency signals seem to abound. A good moving-coil cartridge can have strong high-frequency components as high as 200 kHz (see John Curl's *Forum* in *Audio*, Sept., 1979). The exact reason for this could be the subject of a separate article. Suffice to say, such high-frequency components can raise havoc in an audio system unless they are effectively dealt with, as they are by the Apt/Holman control preamplifier. We feel, as does Apt Corp., that the 40-kHz ultrasonic filter is best left in for most program material. The center, detented position of the tone controls provides absolutely flat response, so there should be no adverse effect from their being left in the circuit in order to utilize the 40-kHz filter. Amplitude vs. frequency-response

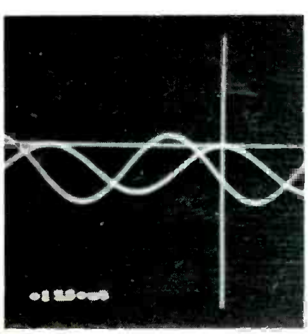


Fig. 2 — Response with the infrasonic filter to 20 Hz with input and output overlaid in the left channel, which shows a 15.5-mS delay. See text.

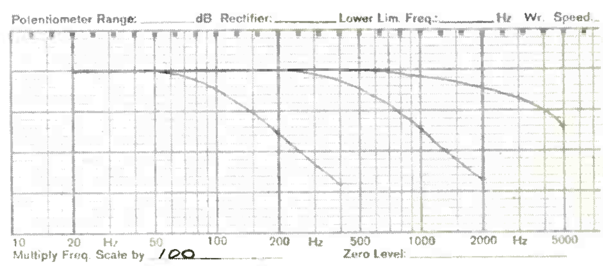


Fig. 3A — Frequency responses of the two high filters vs. response with no filter.

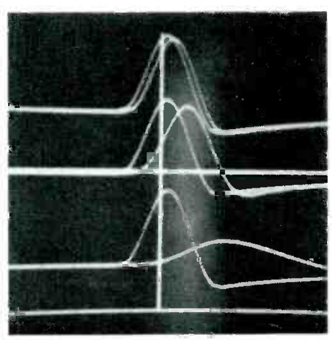


Fig. 3B — Response to 30-kHz cosine pulse for the two high filters and with no filter, input vs. output, showing time delay.

	1 kHz	10 kHz	20 kHz	40 kHz
No Filter, 2.5- μS Delay	0°	5.6°	11.3°	28.1°
40-kHz Filter, 7.0- μS Delay	0°	22.5°	50.6°	101.3°
8-kHz Filter, 20- μS Delay	0°	95.6°	140.6°	168.8°

Fig. 3C — Phase delay.

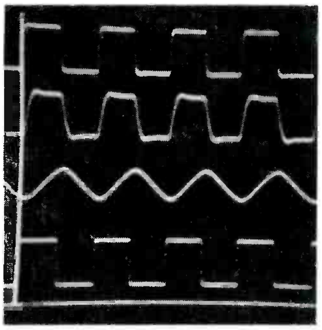


Fig. 4 — Response to 10-kHz square wave. From top, with no filter, with 40-kHz filter, with 8-kHz filter, and input.

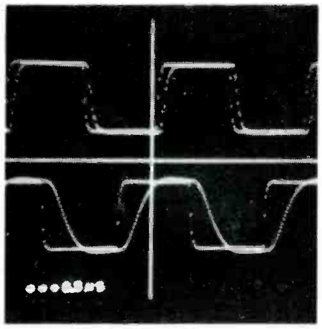


Fig. 5 — Rise time. Top is with no filter, 3.0 μS. Bottom is with 40-kHz filter, 8.5 μS. Both are overlaid on the input, a 20-kHz square wave with 1.5-μS rise time.

curves for the Apt/Holman control preamplifier with no filter and with the 8-kHz and 40-kHz filters are shown in Fig. 3. Data are also shown for the time delay and phase delay. Figure 4 shows the effect of these filters upon a 10-kHz square wave. Figure 5 shows the rise-time with and without the 40-kHz filter. The rise-time for the 20-kHz input signal is also shown for comparison. There are some who will argue that the effect of the 40-kHz filter can be heard, and they are correct. However, the "edge" they may hear, without the filter, may be due, possibly, to the strain placed upon the power amplifier and loudspeakers in trying to cope with ultrasonic frequencies. Since it is a subjective judgment as to whether the 40-kHz filter is better left in or out in any given situation, we can only recommend that it be tried and thank the manufacturer for allowing us the opportunity to do so.

To clarify the reason why tone bursts are much less revealing than the tests we have chosen, Figs. 6 and 7 are presented. The output signal is shown as the upper trace, while the lower trace shows the input signal. This consists of 10 cycles of 10 kHz or a 1-mS burst. One has to look very closely at the trailing edge of the burst in the upper trace of Fig. 7 to see the tiny effect caused by the 40-kHz filter.

Figure 8 shows the effect of the 40-kHz filter upon the phase delay at 5, 10, and 20 kHz. The delay is fairly uniform over the audible range and should be as innocuous as the delay caused by playing a record a year or more after it has been recorded. Figures 9A, B, and C show the interchannel phase effects at 2 Hz, 20 Hz, and 200 kHz. All filters are removed except that Fig. 9B shows the effect of the phase difference between channels with the infrasonic filter activated.

Figure 10 shows the tone-control curves. The treble controls are moderately effective in adjusting for differences between records and even for loudspeakers with different high-frequency energy slopes. It might have been better to have moved the zero or "hinge" point up to 3 kHz so that high frequencies could be compensated without affecting the midrange. *(Editor's Note:* According to the manufacturer, the action of the treble control was chosen for best equalization of overly bright upper-midrange material without excessive loss of top-octave response.—*E.P.)* Two different switch-selectable bass contours are provided. One set of bass contour curves has been heavily researched by Holman and Kampmann and is the subject of an engineering report published in the *Journal of the Audio Engineering Society* (a reprint is available from Apt Corp.). The result is a bass con-

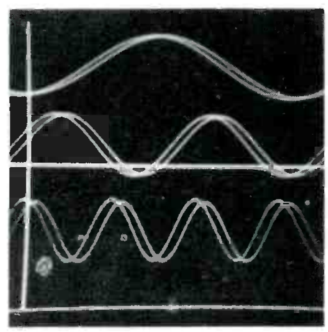


Fig. 8 — Response to various steady-state signals with the 40-kHz filter and the input overlaying the output. Top is 5-kHz signal; middle, 10 kHz; bottom, 20 kHz. A slight delay can be seen between the input and the output of each set of signals.

trol which is actually usable by a serious listener. Figure 11 shows the last 22 steps of the 32-step volume control from full on to about the 9 o'clock position. Steps from about 4 o'clock to 12 o'clock are about 1.5 dB each and very uniform. For anyone concerned with playing back recorded material at realistic levels or evaluating different playback devices, with repeatability, this is a boon. More importantly, the channel-to-channel balance or tracking of this control, which affects stereo localization, is within 0.2 dB over the last 22 steps, from full on to about 10 o'clock, which is amazing. In fact, it is within 0.3 dB over the whole 32-step range, which is even more amazing.

Some other technical facts worthy of brief mention: The output overload point at 1 kHz was 7.75 volts rms into 300 ohms. The actual impedance was found to be 313 ohms. The overload appeared to be uniform from 20 Hz to 20 kHz. The input clipping points, for a 1-kHz input signal, were 144 mV rms at the Phono 1 input and 13 mV rms at the Phono 2 input which had the Model 201A pre-preamplifier module installed. The gains of the right channel of Phono 1 and 2 were variable over a total range of 5.8 dB and 5.5 dB respectively, which are more than adequate to balance the interchannel output difference of any phono cartridge. The output capability of the separate headphone amplifier is shown in Fig. 12. This lists the maximum output voltage just before clipping, for various resistive loads, which should represent most possible headphone impedances.

The compensation for the RIAA standard disc-recording characteristic curve is within the 0.2-dB tolerance claimed by Apt Corp. A great deal has been written lately concerning the necessity of achieving very close accuracy in RIAA compensation, and tolerances to within 0.1 dB and even less have been mentioned. This is really only necessary if one is com-

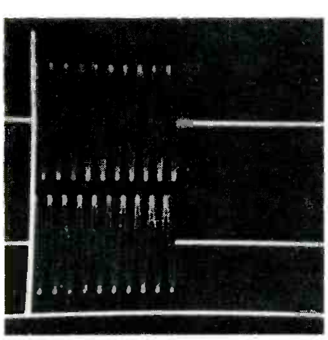


Fig. 6 — Response to 10-kHz tone burst of 1-mS duration. Top is response with no filter; bottom is input. No change is discernible.

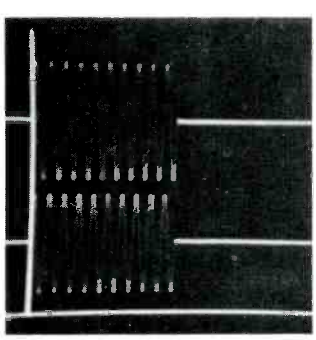


Fig. 7 — Response to 10-kHz tone burst of 1-mS duration. Top is response with 40-kHz filter; bottom is input. A very slight change on the trailing edge of the burst can be seen.

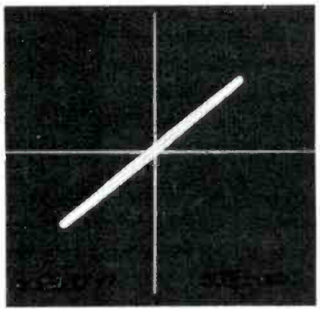


Fig. 9A — Interchannel phase, 2 Hz, no filter.

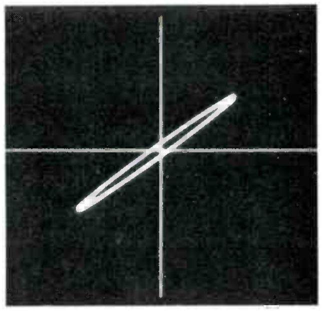


Fig. 9B — Interchannel phase, 20 Hz, infrasonic filter.

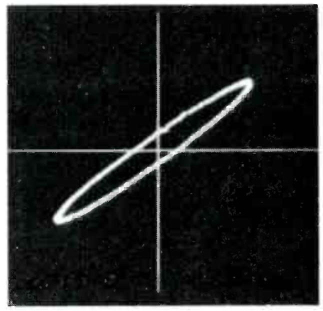


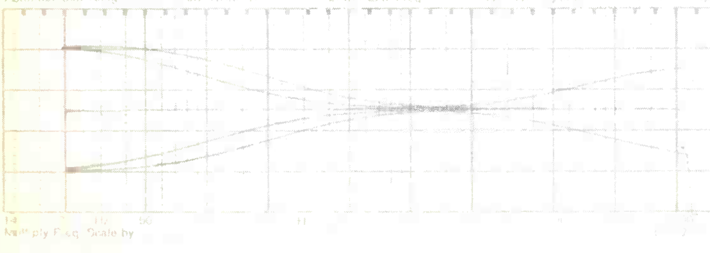
Fig. 9C — Interchannel phase, 200 kHz, no filter.

paring the audible differences between two preamplifiers while playing the same recording with the same phono cartridge/arm/turntable through the same loudspeakers during a comparison. In such a case, it is imperative that the amplitude vs. frequency response of the two preamplifiers be adjusted to be extremely close from the RIAA phono input to the output. It should be emphasized, however, that there are much greater differences between records due to the spectral balance adjustments made by the producer or engineer during recording. In fact, if the same master tape were used to generate disc masters by two different disc mastering facilities, they would have audible differences, due to different spectral balances, of far greater magnitude than that caused by a preamplifier having an RIAA compensation error of even ± 0.5 dB. A closely maintained tolerance of the RIAA compensation is certainly a worthwhile goal, however, and Apt Corp. is to be commended for their achievement.

The absolute polarity of signals is not affected by the Apt/Holman control preamplifier. Since almost all sounds in nature are unsymmetrical, that is, the air pressure variations around the normal ambient pressure may not vary up and down equally over the period of the sound, then this should be taken into account in any good sound-reproducing system. It turns out that a reversal of the polarity of reproduced sound opposite to that which it had in nature is clearly audible. Neglecting this fact has often caused judgments to be made as to the quality of reproduction which were erroneous, and this has been particularly true about judgments concerning the differences between sound-reproducing components. From our experiments over the past number of years, it also appears that listeners have no difficulty in determining the exact polarity which is the same as the polarity of the natural sound.

The Apt/Holman preamplifier was tested to determine if polarity reversals occurred between any input and output, including the tape dubbing and external processor loops. No reversals happen under any conditions. (During all auditions of equipment, attention is paid to the absolute polarity of signals through the total system. This has been the case for all previous reports generated by us for *Audio*.)

Fig. 10 — Tone-control response curves. Maximum positions are shown. Two bass contours are switch selected, and a tone-control defeat switch also removes the high filter.



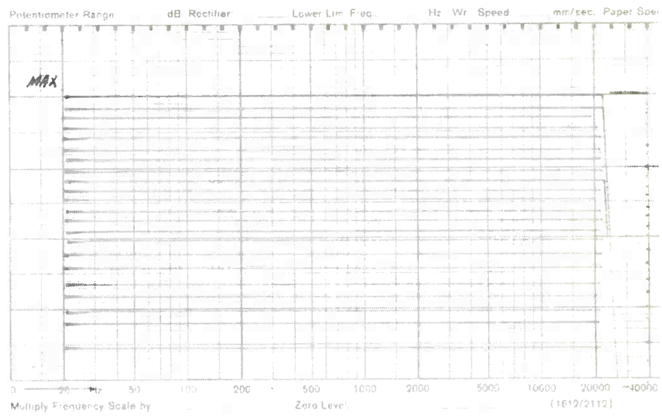


Fig. 11 — Volume control attenuation in the left channel, showing 22 steps of the 32-step control. Vertical scale is 1 dB per division. Tracking between left and right sections of the control is within 0.2 dB over this range.

Load, ohms	Output, V rms
100 k	9.40
1 k	6.80
500	5.60
200	3.28

Fig. 12 — Maximum output of the headphone amplifier at 1 kHz for various loads.

The Apt/Holman control preamplifier was auditioned in two ways. Listening comparisons were made with some other high-quality units during an extended audition over a period of months. Sources included radio, records, and tapes. Various cartridge/arm/turntable combinations and three different amplifiers were used as well as four different pairs of loudspeakers, including a pair of Time-Aligned® reference standard loudspeakers. A second Apt/Holman control preamplifier was also auditioned during this period. At the conclusion of all the testing and listening, it is our conviction that the Apt/Holman control preamplifier is capable of extremely high-quality sound reproduction given good ancillary equipment and program source material. The excellent channel-to-channel balance, stability while handling musical transients, and its ability to cope with less than ideal program material all make it an excellent choice. Its reasonable price simply constitutes "icing on the cake." *Edward M. Long*

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BASF DIN Calibration Cassettes

Manufacturer's Specifications
Recording Azimuth: 90 degrees, ±2 minutes.
Reference Level: 250 nWb/m, ±5 percent at 315 Hz.
Distortion: Less than 3 percent.
Frequency Deviation in Response Section: ±3 percent.
Level Deviation: Less than ±1 dB from 31.5 Hz to 2 kHz, less than ±2 dB from 4 to 6.3 kHz, and within +2, -3 dB from 8 kHz up.
Reference Tape Section: To DIN Standard 45-512.
Track Configuration: Full width.
Prices: See text.

After commenting in recent past about the lack of availability of BASF calibration cassettes for a fair period of time, it was a distinct pleasure to receive two samples for evaluation. BASF Systems offers three calibration cassettes and one test cassette. There are DIN calibration tapes for 120- and 70- μS equalizations, and the third calibration tape is a Dolby-level cassette with 400 Hz at 200 nWb/m. The test cassette is for wow and flutter checks with a 3,000-Hz tone recorded. The price for a DIN calibration tape is about $100.00, and the Dolby-level and flutter tapes are about $20.00 each.

At this point, it is appropriate to discuss "DIN" and what it means to tapes and tape recorders. First of all, "DIN" is the abbreviation for "German Industry Standard." It's not confusing when you know that "German Standard" in the original language is "Deutsche Normen." National standards in the United States are issued by ANSI (American National Standards Institute). These national standards are not international standards unless they have also been issued by an international standards organization such as ISO or IEC (International Electrotechnical Commission). Standards are generated very slowly, however, particularly on the international level, and it has been substantially impossible to hold back design and manufacture of tapes and recorders until there was a collection of international guidelines.

Because DIN standards established the basic framework of necessary benchmarks early in the development of the cassette format, they became the international basis for design and test. They remain the reference for many manufacturers throughout the world, even though many of them are still available only in German. A DIN calibration tape, such as the ones made by BASF, has sections for azimuth alignment and frequency-response checks, but it includes more — a blank section of tape that meets DIN requirements. This blank section is used to establish references for bias and record sensitivity, which helps to get consistent data reporting throughout the world. Here is a quote from one of 3M's Scotch data sheets which shows this manufacturer's reliance on DIN: "Using the blank section of DIN *Bezugsband* reference tape, the reference bias is determined looking at 6.3 kHz output peak bias, and then increasing bias until the output level drops 2.5 dB." That quote helps to point out the fact that if anyone needs to establish references to DIN requirements, he *must* have a DIN calibration tape with its blank tape section.

Performance

DIN-Calibration Tape (Fe): There is a considerable length of yellow leader at both ends of the tape, which helps to minimize tape-tension variations. There is also a section of leader between the test-tone section and the blank tape. Because of the probability that the user will record on the blank tape, the erase-prevention tabs have not been removed, so caution is in order. The first tone of 315 Hz (noted as an IEC standard) is at 0-dB reference level, 250 nWb/m, and runs for 30 seconds. Then, for head alignment, there is a reference tone of 315 Hz for 8 S, followed by a 10-kHz tone for 60 S, both at -20 dB. The frequency response tones are all at -20 dB and have a duration of 8 S each. The order is as follows: 315, 31.5, 40, 63, 125, 250, 500, 1000, 2000, 4000, 6300, 8000 and 10,000 Hz, and a return to 315 Hz. Finally, the sequence from 4 kHz is repeated twice, very helpful if you have to recheck that data at the highest frequencies. A note enclosed by BASF states that a correction table was not included because flux deviations were controlled to be within ±0.5 dB, and so the results confirmed. There was no evidence of distortion in any of the waveforms. The measured frequencies were very consistent, indicative of careful setting in the recording process. Indications were about 0.2 percent high, from a minor speed discrepancy. The azimuth of the recorded signal appeared to be a few minutes off, measurably different from the other calibration tape. The phase jitter between track outputs was very low, indicative of smooth tape motion.

DIN-Calibration Tape (Cr): Leader is used in similar fashion in this tape, but because it is red in color, it is somewhat difficult to differentiate the test-tone and blank-tape sections from the leader. Erase prevention tabs have not been removed. The levels, frequencies, and sequence of tones are exactly the same for this 70-μS tape as for the 120-μS tape above, with the exception that there is a 12.5-kHz tone added to the response test portion. Levels, waveforms, and responses showed the same high performance as the Fe tape. Indicated frequencies were about 0.4 percent higher than nominal, but were consistent in percentage offset, indicating a speed discrepancy. Recorded azimuth appeared to be very close, with acceptable phase jitter.

Although the price for a DIN calibration cassette may give some more than a little pause, it is good that BASF is offering them again in this country. For those who need to base tests upon DIN standards, these cassettes are quite essential. The present ones have both printed text and recorded instructions in English, which does make use more convenient than the earlier all-German versions. As reported above, all characteristics were equal to or better than specifications, with the exception of recorded azimuth (as played back) for the Fe cassette. It was plenty close enough for alignment by peaking amplitude, but would be misleading if inter-track phase comparison were used. *Howard A. Roberson*

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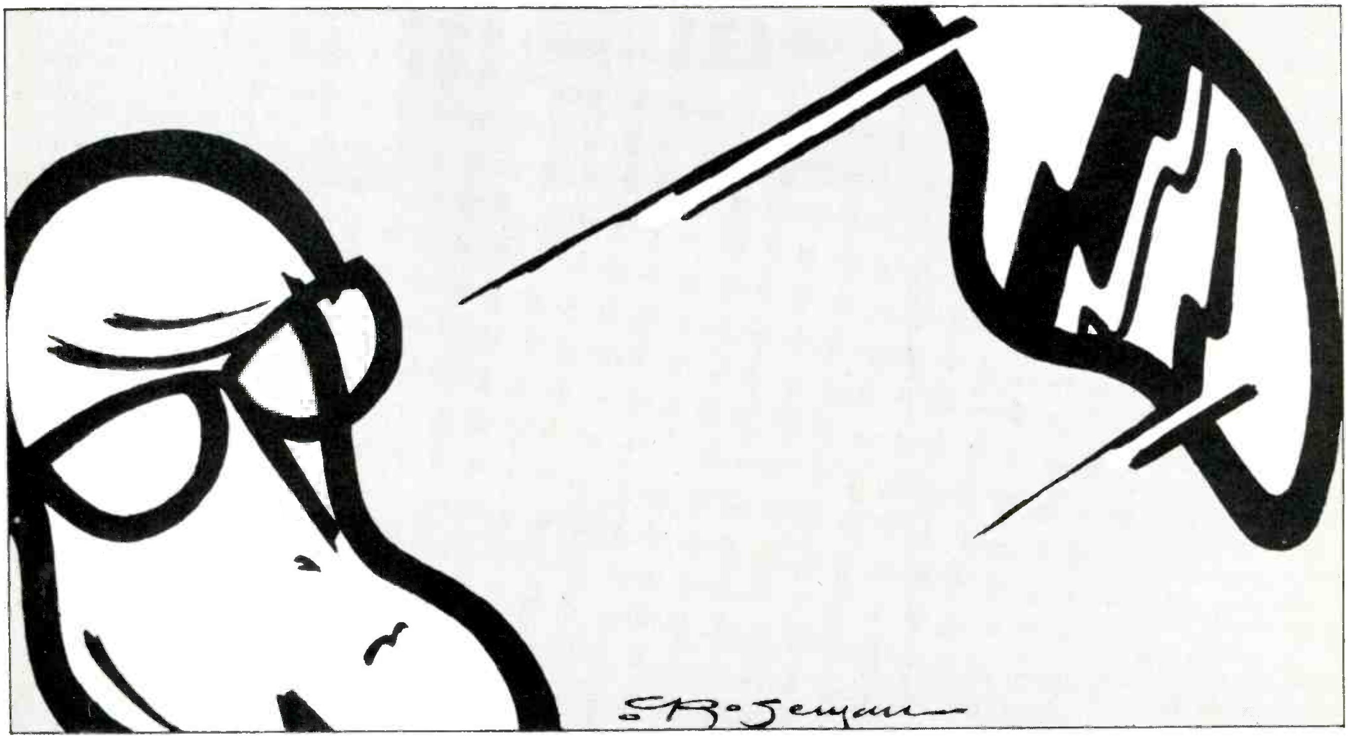
The column

Jon Tiven

Michael Tearson



Freedom at Point Zero: Jefferson Starship
Grunt/RCA BZL1-3452, stereo, $8.98.

At more than one time, in more than one incarnation, Jefferson Starship has been diagnosed as down for the count. In reviewing **Earth,** their last album, I referred to it as something like an overcooked, overdone turkey. Not long after the album came out, vocalists Grace Slick and Marty Balin both left the band. Then drummer Johnny Barbata was in a serious car crash. What would follow was open to speculation.

Aynsley Dunbar, veteran of much, became the new drummer, an inspired choice. Finally came the announcement that Mickey Thomas, the voice on Elvin Bishop's hit, *Fooled Around and Fell in Love*, would fill the remaining hole. Something of a shock, this 2-into-1 solution.

The new album is the vindication, for **Freedom at Point Zero** is an excellent, energized album of unabashed rock and roll music. Mickey Thomas couldn't fit into the group's sound better. He sings like neither Grace nor Marty, yet he can evoke both. His backing parts echo Grace's soaring free-flight vocal lines, and he does them eerily Slickly. On his showcase *Just the Same*, he takes the kind of song that would have been Balin's big moment and does it so completely differently that not only is Marty not missed, the song takes on a whole new feeling for Starship.

I don't know if there are any long-term radio classics aborning on **Freedom,** but *Things to Come* has real majesty and *Girl with the Hungry Eyes* has all the signs of a fine Starship signature. The title song is a Paul Kantner showcase. The first single, *Jane*, uses the Tower of Power horns nicely, while *Lightning Rose* has a fine, funky sax kicking it along.

Freedom at Point Zero is a more aggressive, optimistic, exuberant album than any Jefferson Starship has made in too long. This time out they have utterly cut loose the silky slickness that kept their last album Earthbound. By comparison, the new shot from the gate, with its big, rocking juggernaut sound, positively flies free. *M.T.*

Sound: B+ Performance: B+

The Glow: Bonnie Raitt
Warner Bros. HS 3369, stereo, $8.98

There are lessons to be learned here.

For years Bonnie Raitt has been an artist who has appeared to be on the brink of being a big seller. She has one of the most assured and distinctive vocal styles around. You can't mistake her touch, based in the blues with a real spontaneity. Clearly the idea behind **The Glow** is to give her at last the benefit of all the *right* packaging. Toward that end a new producer was brought into the picture with all attendant frills. The producer is Peter Asher who handles the records of Linda Ronstadt and James Taylor. Along with Asher comes crack engineer Val Garay, sessions cats like guitarist Waddy Wachtel, drummer Rick Marotta, sax player David Sanborn, bassist Bob Glaub, and keyboardist Billy Payne late of Little Feat and previous Bonnie Raitt albums. Another part of the package is cover designer John Kosh who has put a Ronstadt clone cover on the album very similar to his other current work for such pretty faces as Karla Bonoff, Carlene Carter, and Walter Egan.

Even the song selection echoes the formula Linda R. has followed to platinum heaven, altered slightly for Raitt's sensitivities. For instance, instead of Motown covers there are some Stax/Volt tunes. There are the chestnuts — Mary Wells' *Bye Bye Baby*. There is a Jackson Browne song, one from Tom Snow, a Tracy Nelson weeper, even a fashionable Robert Palmer song. Plus the first Bonnie Raitt original in ages.

But there is a serious central flaw to the master Plan: Bonnie Raitt is not Linda Ronstadt.

Yes, the album is real pretty and very well recorded. But its heart is cold and calculated, and that keeps the album earthbound. At times it is almost embarrassingly limp. Robert Palmer's *You're Gonna Get What's Coming* which *should* be an ideal vehicle for Bonnie instead is leaden and redundant. Jackson Browne's catalog has given Bonnie some of her best moments, but *Sleep's Dark and Silent Gate* is a very difficult song, a poor choice that just doesn't work. *The Boy Can't Help It* sinks beneath terminal cuteness. The closest the lady comes to cutting loose is on *Bye Bye Baby* and her own *Standin' By the Same Old Love*.

The last time they paired Bonnie Raitt with a Producer (with a capital P), he was soul legend Jerry Ragavoy. That promising union produced a forced and uneven album in 1974's **Streetlights,** ultimately a bitter disappointment. This time around the Producer is Peter Asher, and the result is **The Glow,** an album that suffers from terminal perfection. *M.T.*

Sound: B+ Performance: C+

Lost in Austin: Marc Benno
A&M SP-4767, stereo, $7.98.

Marc Benno's **Lost in Austin** appears headed straight for obscurity. And it's a pity because the album has a lot of spirit and charm and good times.

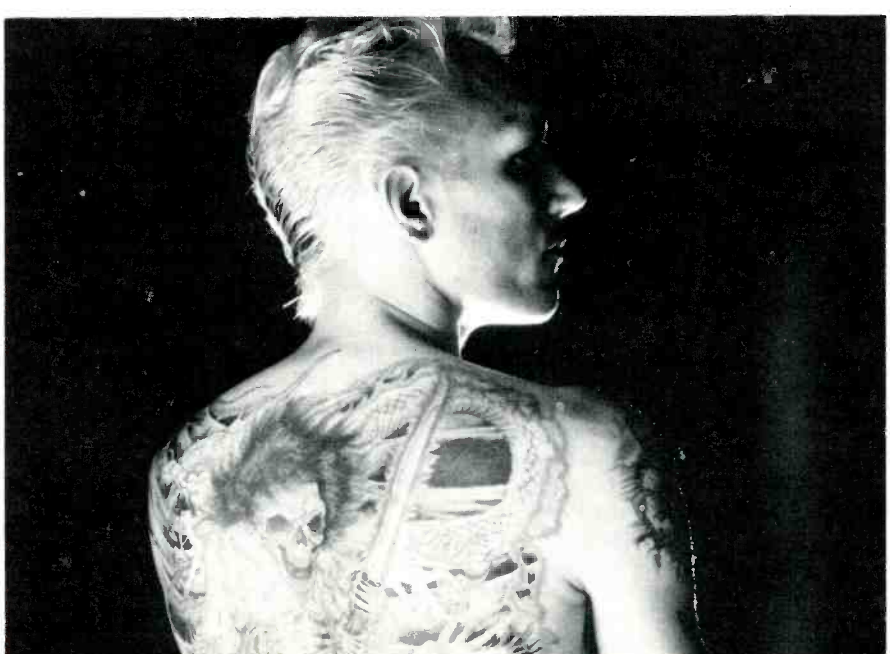
Marc Benno has been around for years. At the end of the '60s he made two dandy albums with Leon Russell as The Asylum Choir, and several solo albums followed. **Lost in Austin** is his first in quite some time. His producer is the very tasty Glyn Johns, and his backup band is Eric Clapton's '79 tour-

Jorma: Jorma Kaukonen
RCA AFL1-3446, stereo, $7.98.

Like his first solo project, **Quah, Jorma** is a very polished solo album for the former lead guitarist of Jefferson Airplane and Hot Tuna, but **Jorma** is far more produced. Jorma still plays everything, but this time he has added extra guitar tracks for effect, and his reedy voice is usually filtered or doubled. At once, the album projects intricacy and simplicity.

The songs are all Kaukonen originals instead of the country blues of **Quah.** As a collection, they are as good as any Hot Tuna set. *Roads and Roads &, Vampire Women*, and *Song for the High Mountain* I find the ones most attractive as songs. But the album cries out for a more full-blooded backing. *M.T.*

Sound: B Performance: B-



ing unit: E.C. and Albert Lee with Benno on guitars, Jim Keltner drumming, Carl Radle on bass, Dick Sims on keyboards, and Dickie Morrisey on sax.

Except for a goofy romp through *Splish Splash*, Bobby Darin's first hit, the album is all Benno songs. Some are real strong pieces of writing. Especially *Hey There, Senorita*. And *Hotfoot Blues*, too. *Last Train* and *Monterrey Pen* both chug along like the best J.J. Cale songs do. *Chasin' Rainbows* is a real pretty one.

As might be expected from the players, the playing is very tasty and loose, very much like Clapton's band sounded on **Backless,** Eric's latest. Johns' production basically stays out of the way where a slightly more aggressive stance might have given the album more bite, more sock. As it is, it rides somewhere between rock and country music and is neither.

Funny, but **Lost in Austin** keeps gravitating over to my turntable. Partly because of its amiable personality. Partly because of the flawed production. It's a paradox I hope to solve. But I keep playing it, which surely says something. *M.T.*

Sound: C+ Performance: B

The Beckmeier Brothers
Casablanca NBLP 7147, stereo, $7.98.

It's not that this is just an average band with no real distinction; what steams me is the rotten pressing and terrible, sibilant mastering job. Note that I checked three copies. The band never had a chance. *M.T.*

Sound: F Performance: C-

Tom Verlaine
Elektra 6E-216, stereo, $7.98.

In his solo incarnation, ex-Televisionary Tom Verlaine seems totally insular, an untouched autistic aesthete seeking The Ultimate Wandering Pitch. While in his group, Verlaine was flanked by erratic players who on any given night could be as horrible or as exciting as their drug consumption permitted. But the solo boy is supported by a rhythm section that resembles nothing so much as a metronome — Allan Schwartzberg and Patti Smith's Jay Daugherty give Verlaine the drum solidity that, coupled with Fred Smith's simple basswork, makes T.V.'s fragility all the more pronounced. The resultant album is a bizarre mixture of songs which seem artificially propped up by regular rhythms, Bob Clearmountain's state-of-the-art mixing, and occasional production tricks which come off like someone trying to polish a pair of sneakers.

What it comes down to is that Verlaine's voice isn't particularly easy to take, sort of a Lou Reed meets Alex Chilton; his guitar playing is amusing but technically unimpressive and has been highly overrated; his single most important contribution is his songwriting. Unfortunately, even though some of his songs are interesting (particularly *The Grip of Love* and Television tunes like *Breakin' In My Heart* and *Kingdom Come)* and demonstrate a lyrical gift, his vocal talents aren't strong enough to carry his melodies — he should either stick to simple rock

tunes like *Adventure* (a fine unrecorded Television song that resembled Z.Z. Top meets George Thorogood) or find someone to sing his tunes. As an artist, I can't see how he can find making records like this one and Television's swan song fulfilling — they seem to be experiments which result in a record, but the record never sounds like a finished or complete piece. Simply to be one of the pioneers of punk rock/New Wave is not enough, and the fact that his first two records, *Little Johnny Jewel* and *Marquee Moon* stand as his definitive works is evidence that he's got more to offer than this, however uncomfortable he must make himself to come across with it. *J.T.*

Sound: B+ Performance: B-

Two Sides To Every Woman: Carlene Carter
Warner Bros. BSK 3375, stereo, $7.98.
Carolyne Mas
Mercury SRM1-3783, stereo, $7.98.

Thanks to a soft-focus lens, Carlene Carter does a startling imitation of Rock Escort Extraordinaire Bebe Buell on the cover of her album, **Two Sides To Every Woman.** Since the release of her last LP, Carlene has married pop noteworthy Nick Lowe, but neither of these attempts to modernize her image have brought her any closer to actually arriving on the pop music scene. You can't take the country out of the girl, it seems, even if she puts on a punk tie and hangs around with our '70s equivalent of British mods.

Carlene has a passable, sometimes even pleasant voice that's sweet and twangy, but it is incapable of the dirty sound she often tries to convey. The growling delivery on *Swamp Neat Rag*, for instance, is a vocal roller coaster ride from note to note. She fares much better on light numbers, such as the opening song *Do It In a Heartbeat* that was co-written with hubbie Nick, even if it is a rewrite of the Motown classic *The Way You Do the Things You Do*.

Carlene's own songs are pure country with all of that genre's drawbacks; yodelling of sappy lyrics and twangy guitars invade much of side two of an album whose opening side isn't exactly innovative. What this act needs more than anything else is musical direction — except for the first tune none of these compositions generates any excitement. The musicianship is standard session competence without flash, Carlene's vocals pretty but emotionally unconvincing, and the material is throwaway stuff. Carlene, get hip or get out of the race . . . .

The debut album of Carolyne Mas, on the other hand, shows the lady to be a real rocker. Carolyne writes, with the help of guitarist David Landau, great Springsteenesque songs that convey considerable personality as well as musical expertise. The band on this LP plays tight and tough, notably guitarist Landau and sax player Crispin Ciao, the latter whose riff on *Stillsane* approximates the catchiness of the horn line on Rafferty's *Baker Street*.

Among the ballads in her repertoire, Carolyne performs *Snow* with the most beautiful and moving vocal on the album. She has a powerful voice and inventive singing style that never approaches the off-the-wall excesses of Lene Lovich or other New Wave atonals. As a former folk performer, her roots are closer to MOR than they are to punk, but Carolyne is a girl who knows how to rock. It helps to have an experienced rock musician for a collaborator, but it's Carolyne's musical resources that provide the basis of this respectably rocking LP. Carlene, meanwhile, failed to make the transition from country to rock, despite holding hands across the mixing board with pop figurehead Nick Lowe.

Sally Young

Carlene

Carlene Carter

Sound: B-	Performance: B

Carolyne

Sound: B+	Performance: A

Top Priority: Rory Gallagher
Chrysalis CHR 1235, stereo, $7.95.

If Eric Clapton followed through on what he started 10 years ago, **Top Priority** is probably what he'd sound like today—hard-hitting, blues-inspired rock with biting Stratocaster guitar. In fact, Rory's voice even sounds very much like Clapton's, which is not meant as a criticism since one would like to hear Eric the Cee singing something other than his laid-back hillbilly. Rory more than fills his shoes.

The group format is a simple three-piece, but they make enough noise to fill a room and a half; his rhythm section of long-time supporter Gerry McAvoy (bass) and former Alex Harvey Band drummer Ted McKenna are among rock's most solid and hard-hitting rhythm units. The biggest surprise here is that Rory's material is his strongest in years (particularly *Follow Me* and *At the Depot*), his guitar playing is in fine form, and there's a consistency to the elpee that his last few have lacked. True, there's very little new ground broken here, but as far as this approach can go, there's no one who takes it to the limits with as much gusto as Rory Gallagher. *J.T.*

Sound: A-	Performance: A-

Ain't Living Long Like This: Rodney Crowell
Warner Bros. BSK 3228, stereo, $7.98.
Right or Wrong: Rosanne Cash
Columbia JC 36155, stereo, $7.98.
Homemade Songs: Tracy Nelson
Flying Fish 052, stereo, $7.98.

Tracy Nelson has surprised a whole lot of people by never fulfilling her obvious potential as a major artist. **Homemade Songs,** 10 years after the first Mother Earth album **Livin' with the Animals,** is her first recording for a new label, Flying Fish, which alas is not by any stretch a major. Still, it is one of the best ones she has made. Tracy has often been accused of singing with all the emotion of an ice statue, but here she has let go some of her reserve. She opens whole new possibilities in Randy Newman's *God's Song,* the best-known song of the set. Her duet with Carlene Carter on Carlene's *Friends of a Kind* is wonderful. *You Don't Have to Move a Mountain* and *The Summer of the Silver Comet* show off the most relaxed and interested Tracy Nelson vocals in far too long.

Now, the Rosanne Cash and Rodney Crowell albums have an important common thread, namely Rodney Crowell who produced and supplied several songs for Ms. Cash's debut album.

Rosanne is from a musical family, to state the obvious. What else would you call it with parents like John Cash and June Carter? Her inclination to country music is quite natural. She takes to the setting of Emmylou Harris' Hot Band, the musical core of both Rosanne and Rodney's albums, like a fish to water. Like Emmylou's albums, there is not a note out of place or too unkempt. What matters most, I suppose, is that Crowell has gathered a marvelous batch of songs, half of them his own, and also that there are a few genuinely thrilling musical moments. Especially so when the key goes from G to C and Bobby Bare makes his vocal entrance in *No Memories Hangin' Round.* Also the country kick-ass version of *Man Smart, Woman Smarter* modeled after Robert Palmer's rock arrangement. Rosanne's original *This Has Happened Before,* a ballad, is a beaut.

It's a good debut album. The lady has the potential to be a voice we'll be hearing a lot more from, and she'll be more assertive with time.

We've heard more of Rodney Crowell than you might realize. Emmylou's albums, oddly excepting her "best of," contain at least one Crowell tune. And more and more discs from others have, too. But surprisingly, only six of the nine songs on Crowell's album are his own. The other three are all in the neglected chestnut category, and of them Dallas Frazier's *Elvira* stands out.

The really important stuff is the original material. Over and over Crowell finds a new casting and a new angle on the classic themes of country music, updating them gracefully into a current, ironic, gritty view. *Viola, an American Dream,* about a couple arguing about where to vacation on plastic money, could almost be country Randy Newman with its developed plot. *Leaving Louisiana in the Broad Daylight* is a superb song that Emmylou recorded. Here she and Nicolette Larson participate in the intricate harmonies. It's a violent slice of Cajun life played to a "T." Later on, Willie Nelson joins Emmy and Rodney on *Song for the Life.*

Ain't Living Long Like This could well be one of the long-term important debuts of 1979. Rodney dominates his album completely, in a way that Ms. Cash and Ms. Nelson just don't do on theirs. Indeed, Crowell dominates Rosanne's album, and very pleasantly so. He is a proven, quality songwriter who now demonstrates that he is a singing talent worth watching. A newspaper friend wrote of Rodney that he is truly one of country music's hidden superstars. Hyperbole perhaps, but I'll buy it. *M.T.*

Nelson	
Sound: B-	Performance: B-
Cash	
Sound: C+	Performance: B-
Crowell	
Sound: B-	Performance: B+

Here: Leo Sayer
Warner Bros. BSK 3374, stereo, $7.98.

When Leo Sayer's first album came out he was often compared to Elton John, which was quite funny as Leo was almost an Elton-in-reverse: Elton writes the music and sings the tunes with a partner (most notably Bernie Taupin) who supplies the lyrics, while Leo writes the lyrics and sings them but needs a collaborator to provide the melodies. The Elton/Taupin partnership was so integral to Mr. John's success that once they went their separate ways both of their careers took an aesthetic nosedive. Although they carry on with their solo projects, neither will be able to recreate the glories of their past. Sayer's musical inspirator, Mr. David Courtney (who also lent a production hand on the first album), left after two albums, and although Sayer's had one or two hits since the split, he's drifted from one musical style to another with the only common factor from tune to tune being his raspy voice. At last, **Here** reunites singer with the tunesmith, as Courtney returns to co-author three songs with Sayer as well as to oversee the entire project. The result is easily the best record Leo's made since his first.

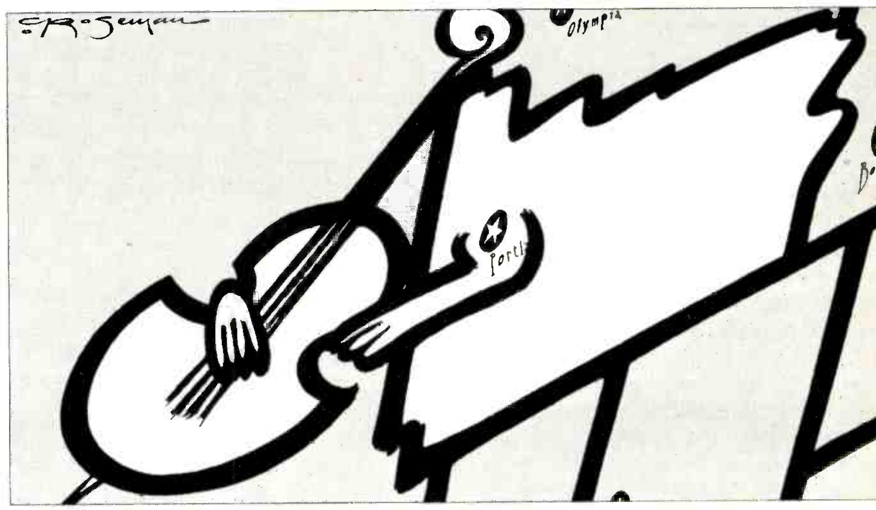
Initially I was surprised at Courtney/Sayer's choice for backing musicians, as they're primarily American, not to mention the fact that a few of them have contributed tunes to the album which are surprisingly good. In particular, Ray Parker, Jr.'s *When The Money Runs Out* is extremely strong — who says that session musicians can't write? The Courtney tunes are a delight to hear; in fact Courtney seems to have a good handle on what suits Leo's voice and lyrics the best. It might take another three years to get a public ready for the old Leo Sayer again, but it'll be well worth it to have the Courtney/Sayer complete artist rather than the occasional dance hit from the short guy. *J.T.*

Sound: B+	Performance: B+

Jazz & blues

John Diliberto

John Lissner



Roots in the Sky: Oregon
Elektra 6E-224, stereo, $7.98.
Introducing Glen Moore: Glen Moore
Elektra 6E-19, stereo, $7.98.
All the Mornings Bring: Paul McCandless
Elektra 6E-196, stereo, $7.98.

The name Oregon not only defines a group, but a whole aesthetic for creating music. Using improvisation and the sensibilities of European chamber music as grounding points, Oregon embraces several traditions, cultures, disciplines, and philosophies. Their sound is made even broader by a multi-instrumental virtuosity. Although they have maintained the same style for over eight years and several albums, that style has enough dimensions to be explored forever. **Roots in the Sky** is another trip through their global synthesis. Released simultaneously with it are two solo albums from Oregon members. These are especially illuminating in isolating Oregon's interwoven components, while at the same time showing how their aesthetic works outside of the standard group context.

Glen Moore, the bassist, also doubles on piano, viola, and violin. His solo debut is a move away from many of Oregon's traditions in his use of Jan Hammer on drums on three selections. They are the least successful of the album, as Hammer's drumming, like much of his keyboard work, is pedantic and rhythmically one-dimensional. His drumming is a lodestone to the otherwise dazzling string work of David Darling (cello), Zbigniew Seifert (violin), and Moore. In duet and trio settings with Darling and/or Seifert, Moore plays an introspective music reliant upon a balance between silence and sound, percussiveness and openness, improvisational intuitiveness and structural pliancy. On *Zbigy* they bring it all together in a misty dirge of long arco lines occasionally pierced by Moore's pizzicato bass.

All the Mornings Bring by Paul McCandless is more in the Oregon *oeuvre* because it is dominated by one of the instruments that makes Oregon's sound unique: McCandless' oboe. His distant cry dominates the album, but not to the exclusion of a carefully wrought concept. Extending Oregon's chamber aesthetic, McCandless employs trio and 10-piece settings, with a duo and solo thrown in to round things off.

His trios have that light movement and delicate interplay that mark the best Oregon work. Art Lande's piano is like liquid drops among the wood and metal of Dave Samuel's tuned percussion. McCandless' oboe swirls between Eastern dervishes and a Renaissance fair.

In his scoring for a 10-piece group, McCandless is able to translate Oregon's sound into a larger group setting. Using four woodwinds, two French horns, bass and tuned percussion, he combines long, sustained melody lines with deft improvisations that weave themselves into the scored instruments. His moods are varied and provoking: In *Palimpset* slow-moving lines and subtle shifts of color become the first morning sunrise after the holocaust; the title piece is bright and optimistic, and the final piece with this grouping, *Saraband*, is low, somber music to contemplate the turning of the earth.

Now that all its members have solo projects of their own (Ralph Towner and Colin Walcott have several solo albums under their own names), Oregon has collectively come up with a quintessential recording, **Roots in the Sky.** All the Oregon trademarks are there. Walcott's tablas, sitar, and percussion give them an Indian mystical quality. Towner's guitars have a pristine classical flavor that is sometimes countered and sometimes supported by Moore's bass. Finally, there is McCandless' oboe that cuts through it all with a universal appeal.

Roots in the Sky traverses many moods yet maintains a flow and unity. Oregon operates on several levels at once, and often seems to move into the area of visuals. The polyrhythms of the tablas are complex and energized. Coupled with Moore's often muscular bass work, Oregon seems to be flying over vast landscapes. American Indian flutes meet the African Doussn'gouni in an arid but percussively bubbling desert. The ominous *House of Wax* moves the sitar into an otherworldly setting stalked by the bass figure and odd sighs and scrapings. *The Roots in the Sky* are clawing for the ground in a piece driven by an ostinato bass line and hard, sharp soloing from Towner and Walcott.

The success of Oregon's synthesis is that it works on an unconscious level. Their music is as natural as the environments from which it is born, and the recorded sound reflects this. You feel as if they are playing in the middle of a quiet forest with clear reverberation and resonance. This is only marred by recording surfaces that are sometimes less than clean.

John Diliberto

Roots in the Sky

Sound: A	Performance: A

Introducing Glen Moore

Sound: B+	Performance: B–

All the Mornings Bring

Sound: A	Performance: A–

Milt Jackson & Count Basie, Volumes 1 & 2
Pablo 2310-822/3, stereo, $8.98 each.

I'm sorry to have to report that this recent collaboration by two of my all-time favorite jazz artists is disappointing. Perhaps I've heard Basie do *Corner Pocket* and *Shiny Stockings* once too often, and yet when the Basie band is in full cry, particularly at a live performance, hearing these familiar numbers, along with such items as the *920 Special* and *Every Tub* out of the band's '40s book, can be a joyful and exhilarating experience. Unfortunately, on most of the tracks on these two Pablo albums, the Basie band doesn't rear up on its hind legs and wail.

As for Jackson, he certainly has been one of the most satisfying and inventive soloists on the jazz scene in the past 30 years. Moreover, he has been in such superlative form on record of late that my expectations may have been unreasonably high. The idea of Jackson and the Basie band cooking together does make for great expectations, but the Pablo offerings lack vigor; much of the playing is tepid, often bland.

Maybe it's because the material is overfamiliar and lacks challenge; most of the selections are Basie classics or pop standards like *Moonlight Becomes You* or *On the Sunny Side of the Street*, with arrangements slightly revamped to allow Jackson room to maneuver his loping, sinuous solos through and around the Basie charts. The performances, of course, are always competent but lack the kind of joy and sheer kick that Jackson, Basie, and the Basie band can produce at their magnificent best. The Pablo sonics are not as scintillating as usual; the Basie brass passages in particular are a bit murky, lacking the detail and clarity that one expects in a big-band recording.

John Lissner

Sound: B	Performance: B

Old And New Dreams
ECM ECM-1-1154, stereo, $8.98.

If they were a rock band, Old and New Dreams would be called a supergroup. But these musicians are far beyond that transient category. Don Cherry, Dewey Redman, Charlie Haden, and Ed Blackwell have been exploring the outposts of jazz for the last 20 years. Many of their discoveries have been unearthed in the groups of Ornette Coleman, with whom they all played in different combinations.

Ornette's concepts serve as a point of departure for **Old and New Dreams,** and two of his songs strategically open each side of the album. *Lonely Woman*'s mournful lines echo off the walls of an empty room. Dewey Redman plays a supple and moody tenor that leads to Cherry's introspective trumpet. Charlie Haden's unaccompanied bass is sparse and points to the ends of desolation. *Open and Close* features one of those staccato Ornette heads that opens into a propulsive improvisation. Redman initiates the drive with a throaty, muscular tenor. Then Cherry takes over with a jagged foray that stops, starts, slides, and runs. Throughout these tunes, Ed Blackwell is a fount of percussive punctuations and commentary. His playing is spare, but perfectly placed.

From Ornette, **Old and New Dreams** moves into an area of more overt musical synthesis using various ethnic forms that the group has been experiencing over the years. Ed Blackwell's *Togo* uses a brief melodic head to frame a drum solo based on a Ghanese traditional that sounds like a buoyant tribal dance rhythm. On *Orbit* Dewey Redman uses his musette, a double-reed instrument that sounds like the Indian shenai. He combines with Cherry's elephant trumpet calls over a rolling Middle Eastern rhythm. Don Cherry's meditative trumpet cry opens his lovely *Guinea* unaccompanied. The band joins him with a loping ostinato rhythm, and Redman takes another fine solo as Cherry switches to piano to flesh out the melody.

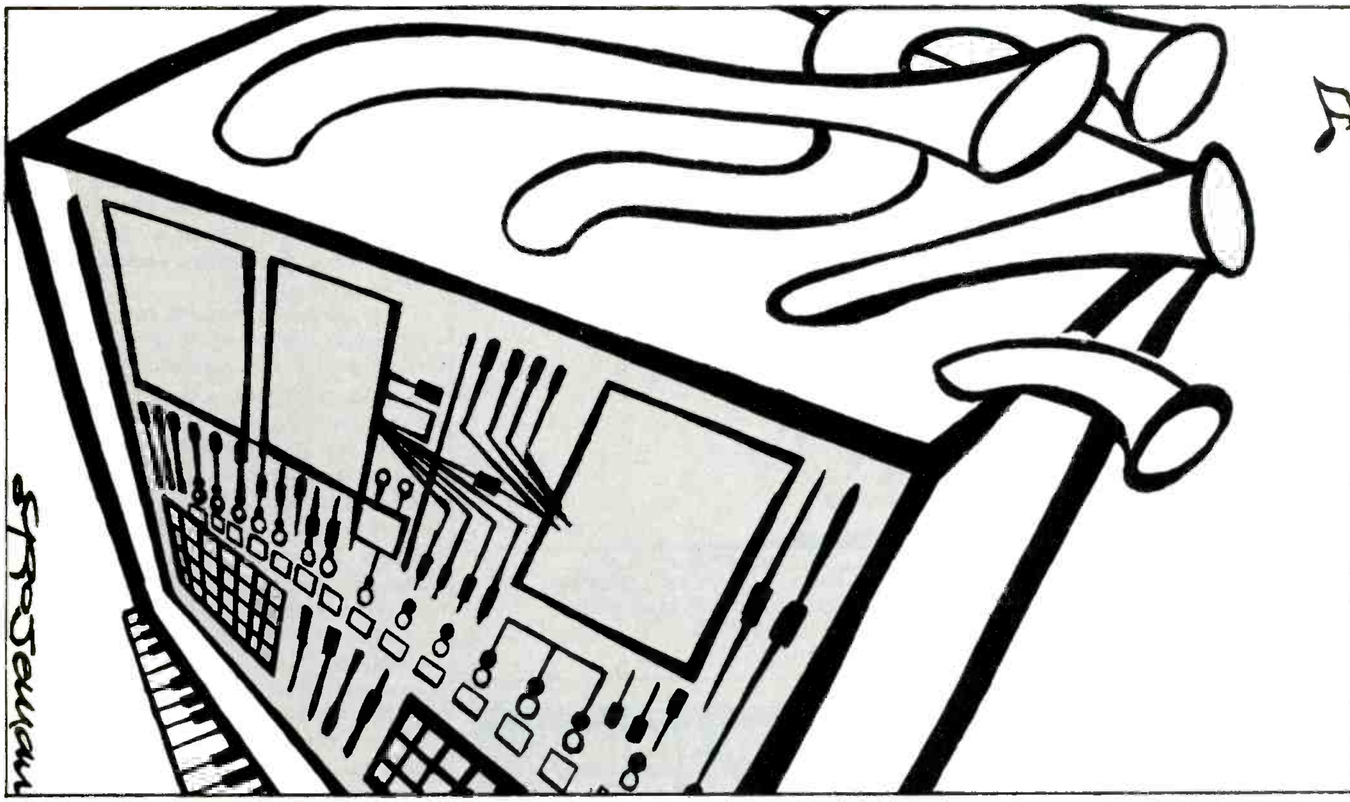
The album closes with Charlie Haden's haunting *Song for the Whales*. Haden is one of the few musicians able to infuse his music with politics and social consciousness, yet still make music that transcends all the rhetoric. He's done it with *Song for Che* and his **Music Liberation Orchestra** album, and now he does it with *Song for the Whales*. It begins with Haden's overdubbed bass quite accurately emulating the sounds of whales. Don Cherry comes in part way with his bleating trumpet joining in forlorn harmony. The entire band rolls in for a turbulent lament that closes with Haden's arco bass, alone once again.

As their name implies, Old and New Dreams embodies the past and points towards the future. That future is an exciting synthesis of ethnic music into a new-world music. Because of ECM's careful production, this music has an ephemeral quality that seems to be prodding the inside of our collective consciousness. This is yet another part of the synthesis, where technology doesn't just record the music, but adds to its dimensions. *John Diliberto*

Sound: A+ Performance: A

Classical reviews

Edward Tatnall Canby



The Allen Computer Organ at Chichester Cathedral. George Thalben Ball. **Chalfont C77-007,** stereo, $7.98.

COMPUTER organ? Here is a recital by an "eminent British organist" (since 1923) in a very eminent British cathedral of large size, playing an eminent and typical recital program for a large organ — BUT?

The big unanswered question is, are there pipes? Or is this an electronic organ? The Allen organ was one of the first electronic organs to attain real musical stature as a "classical" instrument, a very large and complex machine indeed, with a sound that satisfied most musicians who would not be caught dead near some other well-known electronic models. Is this that sort of Allen organ — a real monster in a very large cathedral space? Curiously, the record-liner notes say not one single word on the subject, though they do give a complete list of all 90 stops (including No. 90, Expression Off).

So, in the absence of such vital information, one listens! Good mystery sound. The organ is definitely a whopper and filling a very large space, with long reverb time. It is far from a "Baroque" type, rather of the old-fashioned sort, the Romantic organ of the second half of the nineteenth century; as such (and ignoring the electronic-or-no aspect) I would rate it as a very good and interesting instrument, with lively, bright, mellow colors and excellent clarity, beautifully integrated into its own acoustic space. Frankly, in a thousand years I would never suspect that this is an electronic and/or computer-controlled instrument — if it is.

The eminent organist is old-fashioned but lively himself, too. He plays with verve, good phrasing, an excellent ear for registration. His program, like so many, starts with "old" music in assorted mod arrangements, anathema to serious-minded Baroque purists but fun if you aren't; then moves on to the expected later virtuoso stuff, Romantic and mildly modern, both light and heavy and all extremely deftly played. Dr. Thalben Ball does not in the least show his age, I must say. A fine musical entertainer.

So does it matter whether this is a "real" giant organ or an electronic machine? Well, it does make a difference. Or does it?

Sound: B   Recording: B+   Surfaces: B

Renaissance Music for Two Lutes. Catherine and Robert Strizich. **Titanic Ti 15,** stereo, $8.00.

Two lutes. The lute, as you probably know, is the super-classical relative of the "classical" guitar, always an aristocratic instrument and for centuries one of the most sophisticated of all instruments, with many strings, wide range from high treble to low bass and an unusual capability for counterpoint, many strands of melody at once. Moreover, lutes are immensely varied in sound and structure and even in the tuning.

On this record a young husband-wife team plays two easily different sounding lutes—via stereo you can hear them on the left and right, each with its own different sound. The music is indigenous, out of the sixteenth century, both English and continental; the lutes are modern, 1973 and 1975, but patterned after old makers. It is highly ornamented frilly music, if you wish, full of scales and fast runs up and down, based on very simple almost folkish harmonies—except in the fantasies (fantasia, fancy), where counterpoint takes over. Some lovely names—*The Flatt Pavion* (shades of Lester Flatt), *The Gallyerd (Galliard)* to *the Flatt Pavion,* and *Twenty Waies Upon the Bels.*

The two young people are very serious and play perfectly together, but with a lot of "hesitation" in the rhythm and a certain slowness—common enough among classical guitarists as well as lutenists and in contrast, say, to the almost brittle verve of famed lutenist Julian Bream. Maybe these two are right—the lute never was an instrument for high jinks. If you find too much of a muchness, just don't play a whole side at a time. That's easy.

Sound: B Recording: A- Surfaces: B+

Stravinsky: Suite from The Firebird. Mussorgsky: Pictures at an Exhibition. Robin McCabe, piano. **Vanguard VSD 71264,** stereo, $7.98.

It is always interesting to hear familiar music in alternative versions for orchestra and for piano — whichever version may have come first or become best known. Stravinsky mostly wrote his big scores out first on the piano, but the *Firebird* on this recording was transcribed for virtuoso piano in 1928 by an Italian pianist, Guido Agosti, presumably for his own playing. As for Mussorgsky, the original *Pictures* were composed for the piano — in numerous confusing and semicomplete versions, enough to baffle any publisher. Fortunately, the great orchestrator Ravel got hold of the music and made of it the marvelous orchestral piece we know so well; few pianists have tried any of the piano alternatives and Vladimir Horowitz took artistic advantage of the confusion to make his own version, elaborated with Horowitzian brilliance, enough to intimidate lesser artists of the keyboard.

The pianist here is an American prodigy, out of Washington state, and she sounds American, too. Fabulous technique and power — that's an American specialty. A somewhat hard, domineering sound 'mid all the brilliance, also an American trait. (We worship machismo, even among women!) An occasional ugly sound, a coarse bit of phrasing, a subtlety missed. But not by much. Mostly, this McCabe music is persuasive and powerful, and I greatly enjoyed it.

It is perhaps only natural that one senses an ear tuned to the orchestral versions of these two works, the piano sounding as much as possible like the orchestra. OK — but the music in both cases can be played as piano music *per se.* It tends to sound different, that way, and in all truth might not please the listening ear that knows the orchestral versions. But just try the finale — that's all piano!

Sound: B+ Recording: A- Surfaces: B

Audio-Technica Lifesaver/*Continued from p. 67*

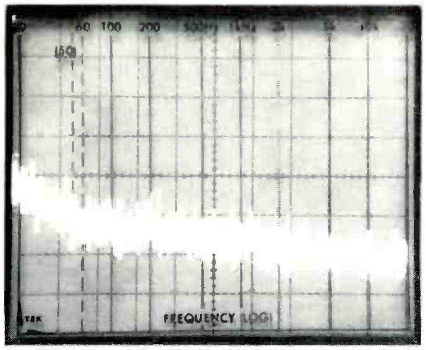


Fig. 7—Spectral noise analysis of the untreated disc during the first playing.

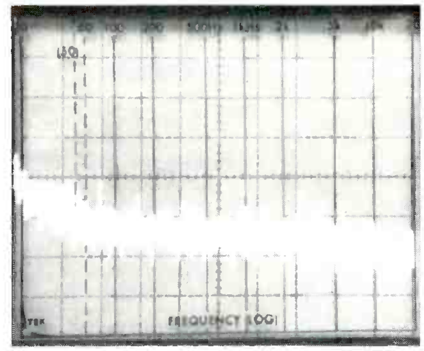


Fig. 8—Spectral noise analysis of the untreated disc after 100 playings.

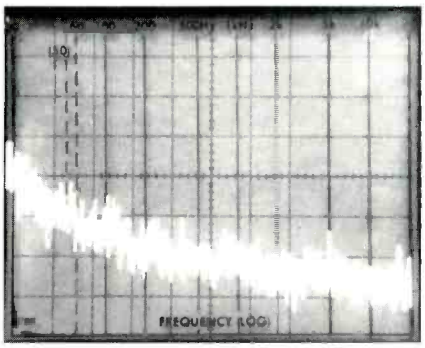


Fig. 9—Spectral noise analysis of the treated disc during the first playing after application of Lifesaver.

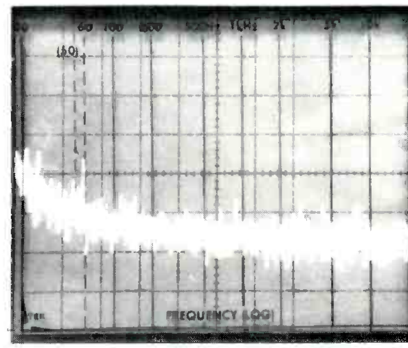


Fig. 10—Spectral noise analysis of the treated disc after 100 playings.

and dry cleaning is all that should be required if normal record care and storage are observed. All things considered, these are quite a number of benefits from a single record-care product. While we often take a skeptical view of any product that offers 2-in-1 benefits, this one really delivers on both counts: Record preservation and destaticizing.

Leonard Feldman

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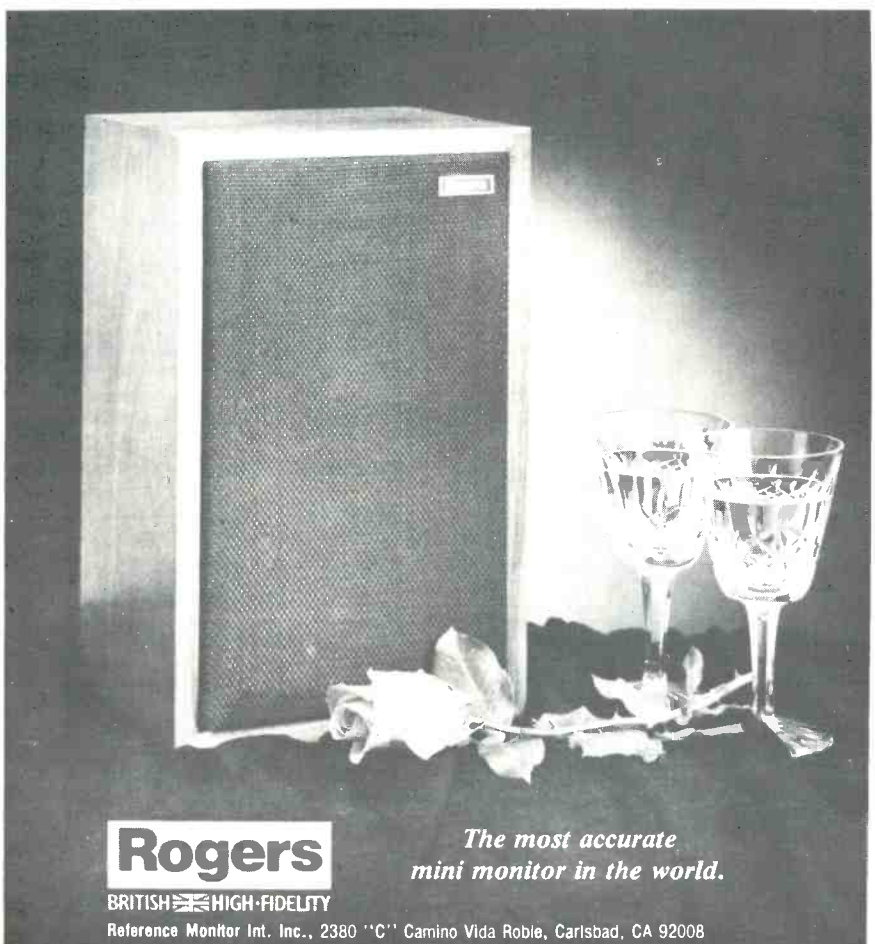

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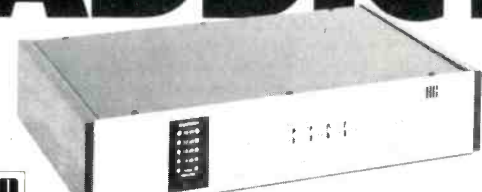

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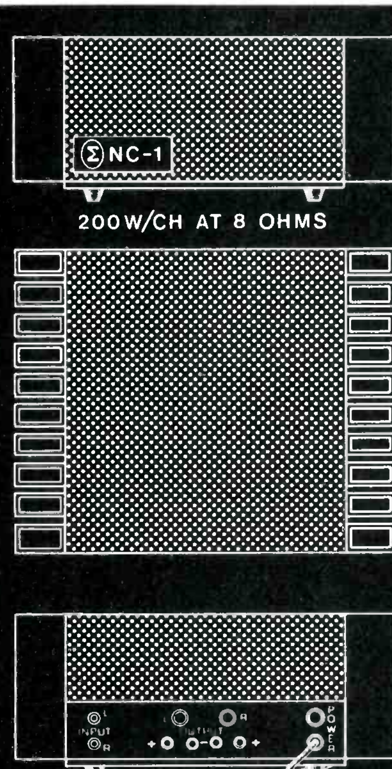

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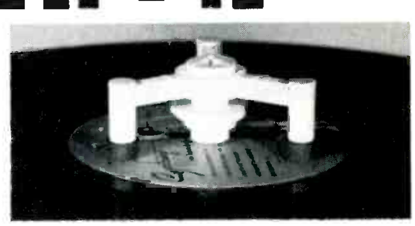

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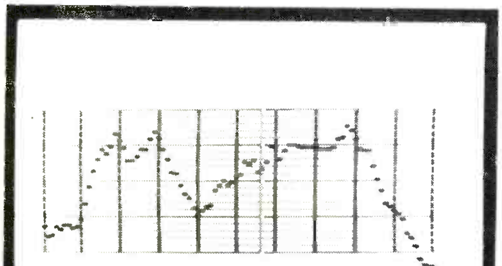

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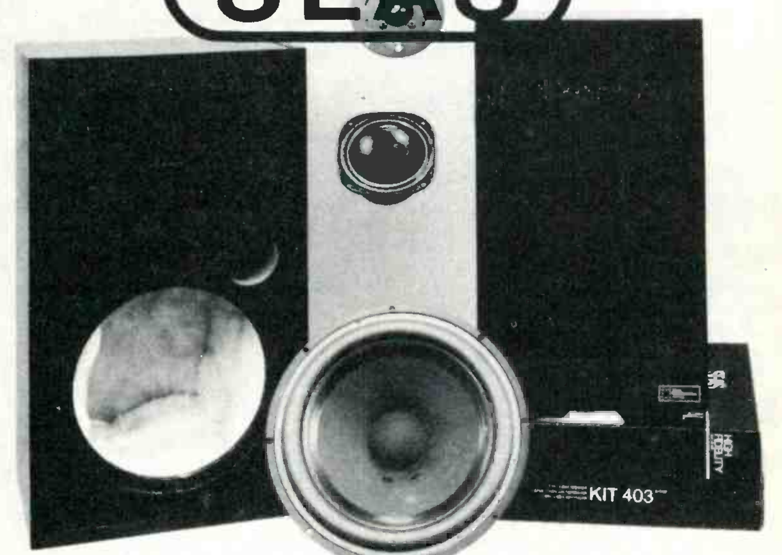

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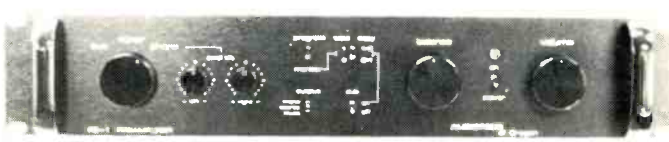

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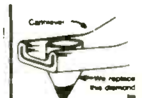

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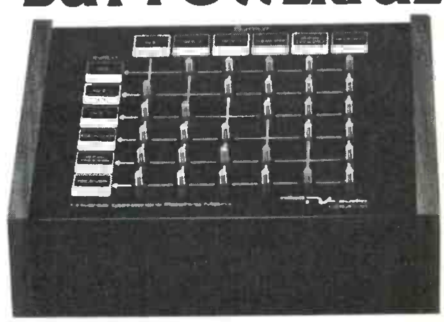

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DIRECT TO DISC AND DIGITAL RECORDINGS: All labels at low prices. Telearc, Discwasher, Audio-Technica, Sheffield, Denon PCM, Crystal Clear, Mobile Fidelity Labs. . .WE HAVE THEM ALL!! (and more!!) Send for FREE price list and Newsletter or $2.00 for descriptive cataloge DISConnection, P.O. Box 10705 Tampa FL 33679.

RECORDS

FREE SOUNDTRACKS & CASTS CATALOG! Personalities! ST/OC Valuebook: $4. RTSA 711 W. 17th G-1 Costa Mesa, CA 92627. TF

MILWAUKEE! The Audio Emporium: we have over 100 direct discs and other high quality LPs, most labels and constantly new releases. We also have the Keith Monks record cleaning machine. 6900 W. Brown Deer Rd. Open Tues. thru Sat. 10-6, (414) 354-5082. TF

RARE OUT-OF-PRINT LP's. Factory Sealed — 99c to $3.99 ea. Over 25,000 in stock. List — $1.00 Record Warehouse, Box 4617, Dept, AO, Rochester, New York 14613.

RECORD HOUND, Box 88A, Eagleville, PA 19408. Fills want list? Doggone right!!! 33⅓ specialist. Fast, friendly service. 10-0

"**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

RECORDSAVERS, POLY-LINED INNER SLEEVES TEN CENTS EACH, POSTPAID, MINIMUM 100. DEO, INC., BOX 452D, GLENVIEW, IL 60025. 6-0

RECORDS, RECORDS, RECORDS
Old, New & Direct Disc too! Send $1. for Complete Info, S.E.O.J., 519 Wheat, Johnstown, PA 15902. 4-9

SOUSA RECORDS. Free catalog upon request. Stanford. Box 36163, Grosse Pointe, Mich. 48236. 1-0

SWINGING THEATER PIPE ORGAN, Larry Vannucci plays Ain't Misbehavin', 10 others. $6.95 post paid: Alameda Organ, Box 2174, San Jose, CA 95109.

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VENEER SPEAKER CABINETS Hardwood Walnut Speaker Cabinets with grill. Routed or unrouted, front baffles, or complete **SPEAKER KITS.** Send self-addressed stamped envelope for complete brochure. **KUSTOMIZED SPEAKER SYSTEMS, 260-A GLENN CIRCLE, POWELL, TN 37849.**

WANTED TO BUY OR TRADE

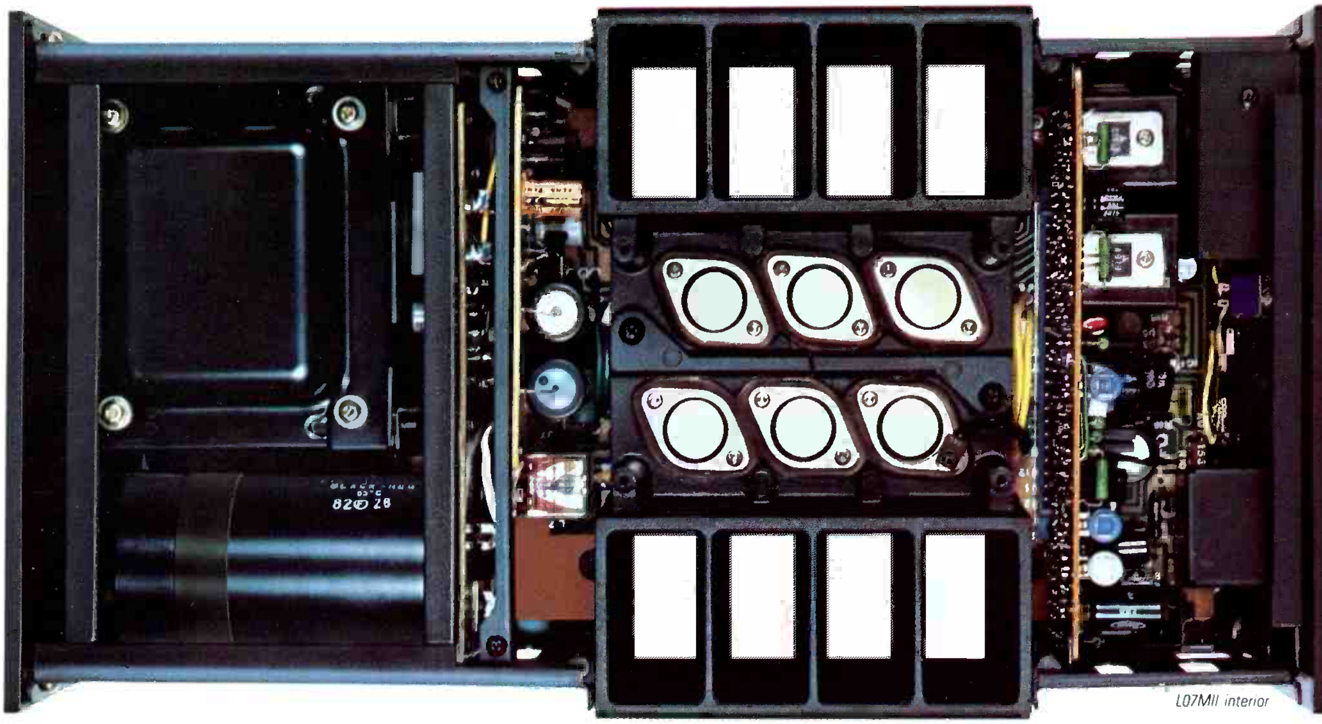
JBL HARTS-FIELD 1 or Pr. 313-229-7378. 2-9

Manufacturer Seeking Inventions. Advantek, 1100 17th NW, Washington, DC 20036. 10-0

McINTOSH OR MARANTZ any kind of tube amps: Pay top dollar (213) 278-3430, 8633 Airdrome St., LA, Calif. 90035.

McIntosh 3500 US urgently needed. Pay the best price. (514) 482-9372 call collect. 3-0

OPEN REEL pre-recorded tapes. Rock, folk, jazz, classical stereo, quad (8 - track quad also). A few of each for sale too. SASE. Ray, 1293 French Ave., Lakewood, Ohio 44107. 11-9



L07MII interior

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

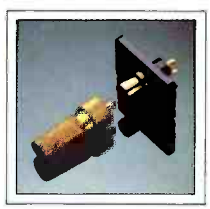
For the past several years, a special team of top Kenwood engineers have been re-inventing the amplifier using their most sophisticated innovations in circuit design.

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

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

L07MII rear

L07MII front

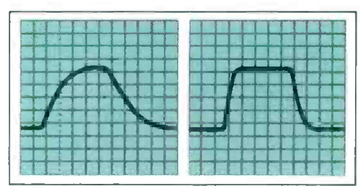


In fact, everything in this amplifier has been engineered to reproduce an input signal audibly free from distortion and coloration. And to achieve a frequency response previously unobtainable. Our DC amplifier improves ultra-low frequency phase shift and transient response. Even the pin plugs of the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

HI-SPEED™

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

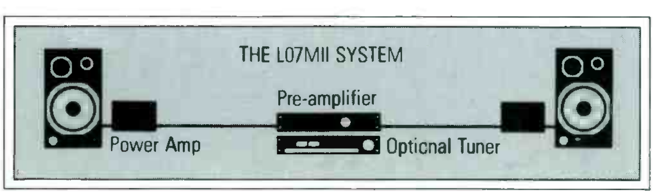
Of course, to appreciate the many design innovations requires much more space than is available here. Please write for full technical data at the address below. Or better yet, audition this remarkable amplifier system at a Kenwood Audio Purist Group dealer. If you have the ears to appreciate what the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



Typical "square" pulse waveform of conventional amplifier.

Pulse waveform of High-Speed amplifier.

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



AUDIO PURIST GROUP

KENWOOD®

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

Enter No. 42 on Reader Service Card

Technics RS-M95. When price is no object. But performance is.

There are countless cassette decks to choose from when your object is price. But when your only object is performance, look at the RS-M95 with metal tape capability.

The heart of the RS-M95 lies in its quartz-locked direct-drive capstan motor and its computer-controlled tape tension system. Together, they team up to provide constant tape tension, remarkably low wow and flutter and complete immunity from speed inaccuracy. So when you record an A flat, you'll hear an A flat. No more, no less.

But if more is what you want, you'll get it with metal tape. Because, compared to conventional tape, it gives you a frequency response with more dynamic headroom and more high end extension.

You'll also get the advantage of the RS-M95's three-head configuration: Source/tape comparison. What you don't get is azimuth error, because our HPF record and playback heads are not only precisely gapped, they're also precisely enclosed in a single housing.

To add to the RS-M95's three-head configuration, we added double Dolby*. So you can monitor your tapes with the full effects of Dolby noise reduction.

Another glowing feature of the RS-M95 is its two-colored fluorescent (FL) bar-graph meters. They're fast, thanks to a device attack time of just 5 millionths of a second. And accurate, thanks to a Technics high-slew-factor operational amp for absolute wave and peak detection.

Also included are 4-position tape selectors with bias fine adjustments. A built-in 400 Hz/8 kHz test tone oscillator. A separate, coreless DC motor for reel drive. A microprocessor tape counter with triple memory functions and feather-touch controls.

Technics RS-M95. Its performance is its only reason for being.

FREQUENCY RESPONSE (Metal): 20-20,000 Hz (±3dB). WOW AND FLUTTER: 0.03% WRMS. S/N RATIO (Dolby in): 70dB. SPEED DEVIATION: ±0.1%.

*Dolby is a trademark of Dolby Laboratories.

Technics
Professional Series

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